

AMPLIFIERS WITH OP-AMP

DOCUMENTATION

COMPUTER AIDED GRAPHICS
SEMESTRIAL PROJECT

COORDINATORS

STUDENT

Sl. Dr. Ing. Paul FARAGÓ

Radu Anca-Valentina

Sl. Dr. Ing. Mihaela CÎRLUGEA

.

Table of Contents

1.Introduction	3
2.Theoretical presentation	4
Non-inverting amplifiers	4
Inverting amplifiers	5
3.Experimental part	6
4.GUI elements	7
5.Conclusion.....	17
6.References.....	18
7.Appendix	19

1.Introduction

Short description of MATLAB

MATLAB is a software package for high-performance mathematical computation, visualization, and programming environment. It provides an interactive environment with hundreds of built-in functions for technical computing, graphics, and animations.

MATLAB stands for **Matrix Laboratory**. MATLAB was written initially to implement a simple approach to matrix software developed by the **LINPACK** (Linear system package) and **EISPACK** (Eigen system package) projects. It is **Multi-paradigm**, so it can work with multiple types of programming approaches, such as Functional, ObjectOriented, and Visual.

As its name contains the word Matrix, MATLAB does its' all computing based on mathematical matrices and arrays. MATLAB's all types of variables hold data in the form of the array only, let it be an integer type, character type or String type variable.

The development of the MATLAB started in the late 1970s by Cleve Moler, the chairman of the Computer Science department at the University of New Mexico. Cleve wanted to make his students able to use LINPACK & EISPACK (software libraries for numerical computing, written in FORTRAN), and without learning FORTRAN. In 1984, Cleve Moler with Jack Little & Steve Bangert rewrote MATLAB in C and founded MathWorks. These libraries were known as JACKPAC at that time, later these were revised in 2000 for matrix manipulation and named as LAPACK.

Short description of Amplifiers with Op-Amp and its components

The two major classifications of amplifiers with op-amp are the inverting and noninverting amplifiers. The crucial difference them is that an inverting amplifier is the one that produces an amplified output signal which is out of phase to the applied input. As against, a non-inverting amplifier amplifies the input signal level without changing the phase of the signal at the output.

What is an Op-Amp?

Operational amplifiers are considered as the fundamental component of analog electronic circuits. They are linear devices, used for the amplification of the DC signal. Thus, they're used in signal conditioning, filtering, and performing operations like addition, subtraction, integration, etc. The various components like resistor, capacitor, etc. present between the input and output terminals of the amplifier are used for amplifying the voltage level of the applied signal.

They are **three-terminal devices** that have two inputs and one output terminal. Out of the two input terminals, one is an inverting terminal while the other is noninverting.

2.Theoretical presentation

Non-inverting and inverting amplifiers are circuits built using operational amplifiers. The circuit has to be connected to a dual voltage source, $+V_{PS}$ and $-V_{PS}$, that limits the amplification to the corresponding values, V_{OH} and V_{OL} . They both have negative feedback, due to a negative feedback loop (NF), that keeps the differential voltage, $v_D = v_+ - v_-$, equal to 0.

NON-INVERTING AMPLIFIERS

Non-inverting amplifiers are called "non-inverting", as v_i is connected to the v_+ terminal of the op-amp.

They amplify the input signal, v_i with a certain gain, A_V , that depends on the values of the resistances and v_i . The output signal, consequently, will be either equal to, or A_V times bigger or smaller than v_i , but it cannot pass $+/-V_{PS}$. When v_o is smaller, the amplifier is used as an attenuator, and $A_V < 1$.

Due to the fact that it is non-inverting, the two signals v_i and v_o will be in phase.

INVERTING AMPLIFIERS

Inverting amplifiers are called "inverting", as v_i is connected to the v_- terminal of the op-amp.

They work just like non-inverting amplifiers, but the 2 signals, v_i and v_o , will be in anti-phase.

The formula for computing the gain:

$$A_V = v_o / v_i$$

The formula for computing the period:

$$T = \frac{1}{f}$$

$$x_o = X_o * \sin(2 * \pi * f * t)$$

The formula for composing the signals:

3.Experimental part

The algorithm for computing the gain works successfully. The two functions created for computing the gain of the non-inverting and inverting amplifiers are able to:

- Compute the period of the circuit (T) using a given frequency (f)
- Compose a signal with a given amplitude (X_o), a given frequency (f) and t, which grows from 0 to N*T, in steps of T/100, N being the displayed number of cycles
- Verify using a function \circ for NON-INVERTING: if one of the signals is >0 and one is <0 , which is required for the computation of the gain to be correct
 - \circ for INVERTING: if both signals are >0 or <0 , which is required for the computation of the gain to be correct
- Have modifiable values, using edit boxes
- Change the plots on "Enter" when the values are modified, using a button and a function

An example I used to verify the algorithm :

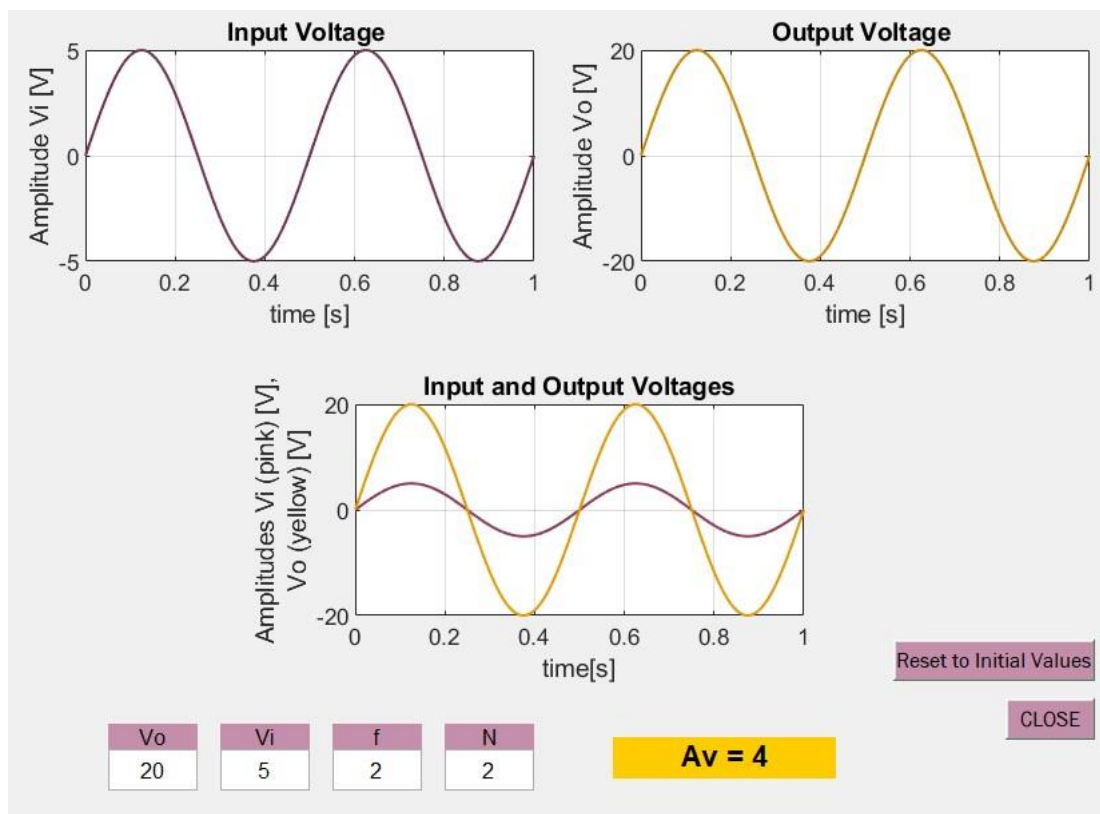
$$v_i = 5V$$

$$v_o = 20V$$

$$F = 2KHz$$

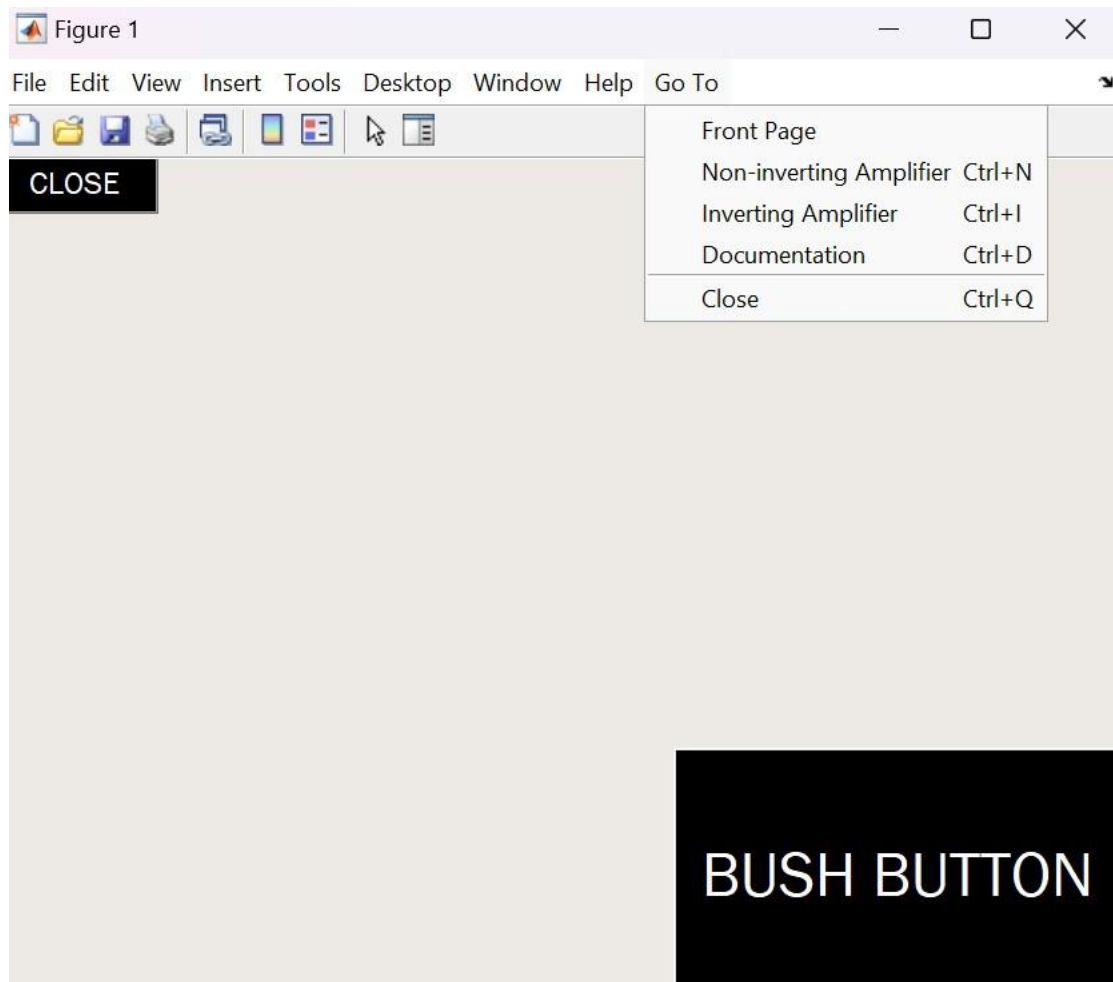
$$N = 2$$

- The result is correct: $A_V=4$ ($20/4=5$)
- The number of cycles displayed is correct: 2 ($N=2$)
 - The reset button works as intended.
- The values are modifiable and, in turn, they also modify the plots.



4.GUI elements

The main page, "GoToMenu", includes some parts of the project. The added menu "Go To" has 3 submenus. All the "CLOSE" buttons work, as well as the "Close" submenu as expected (they close the windows).



The "Front Page" submenu takes you to the webpage created by me using html and CSS.

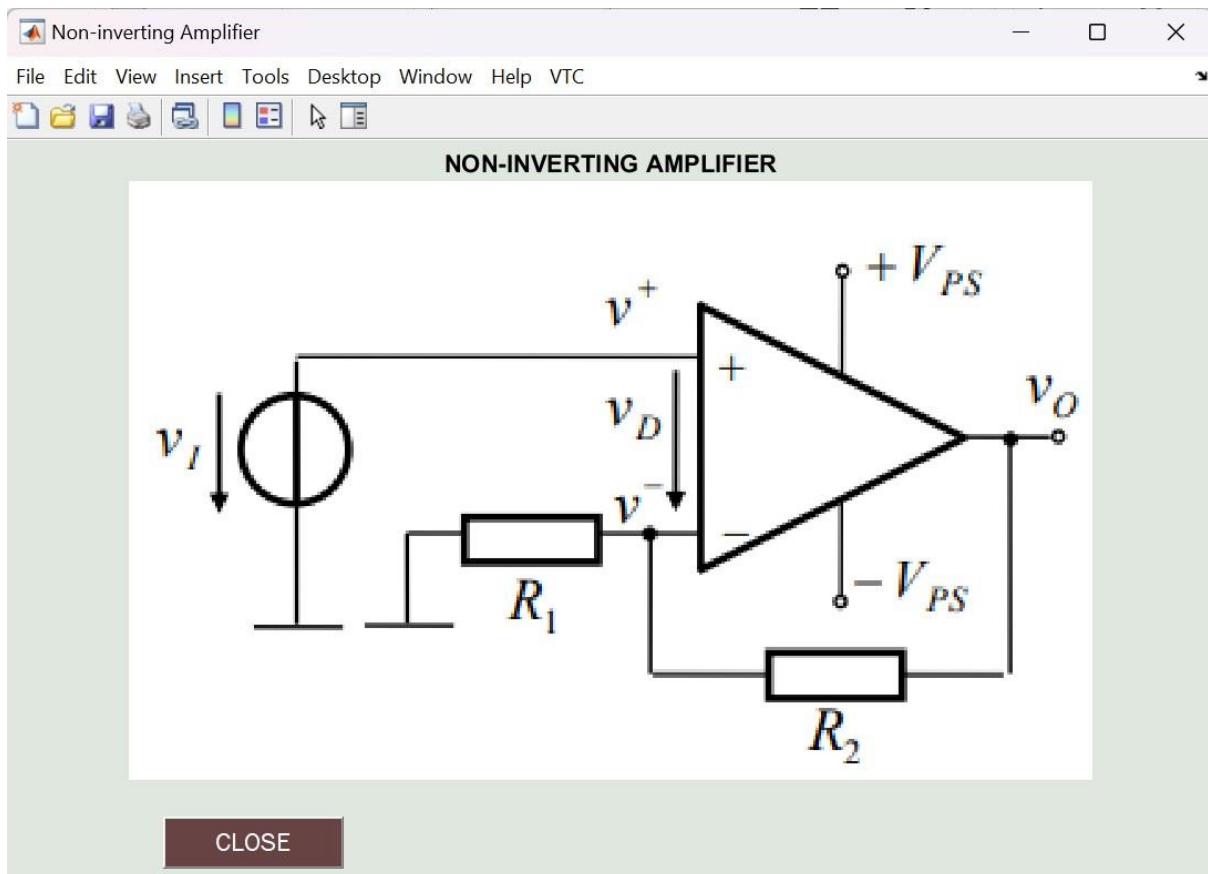


Coordinators
 SI. Dr. Ing. Paul FARACÓ
 SI. Dr. Ing. Mihaela CÎRLUGEĂ

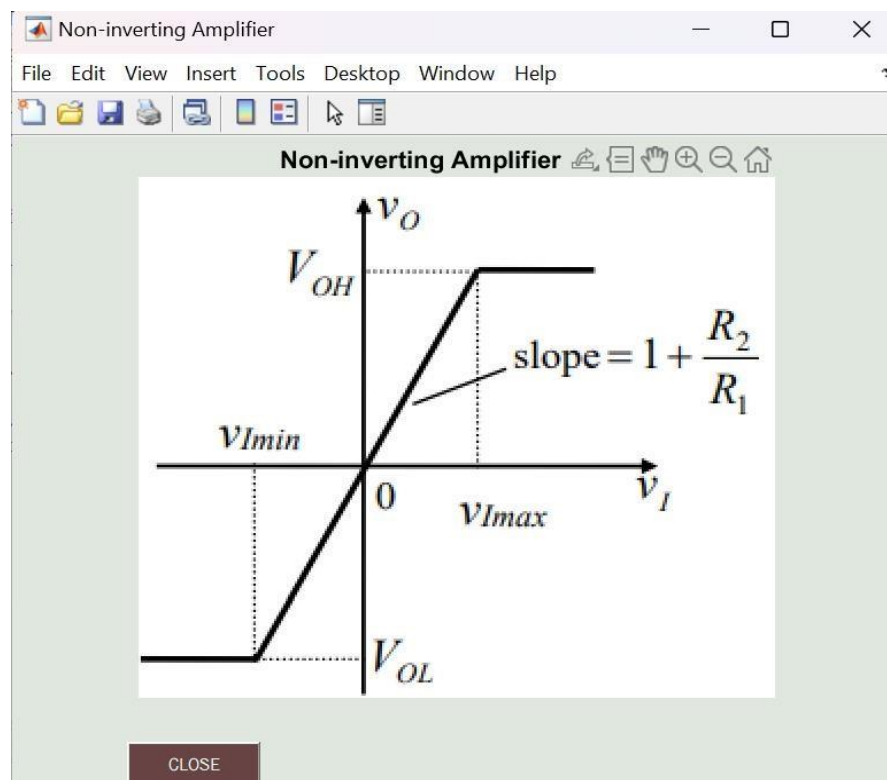
Cluj-Napoca, 2024

Student
 Anca-Valentina RADU

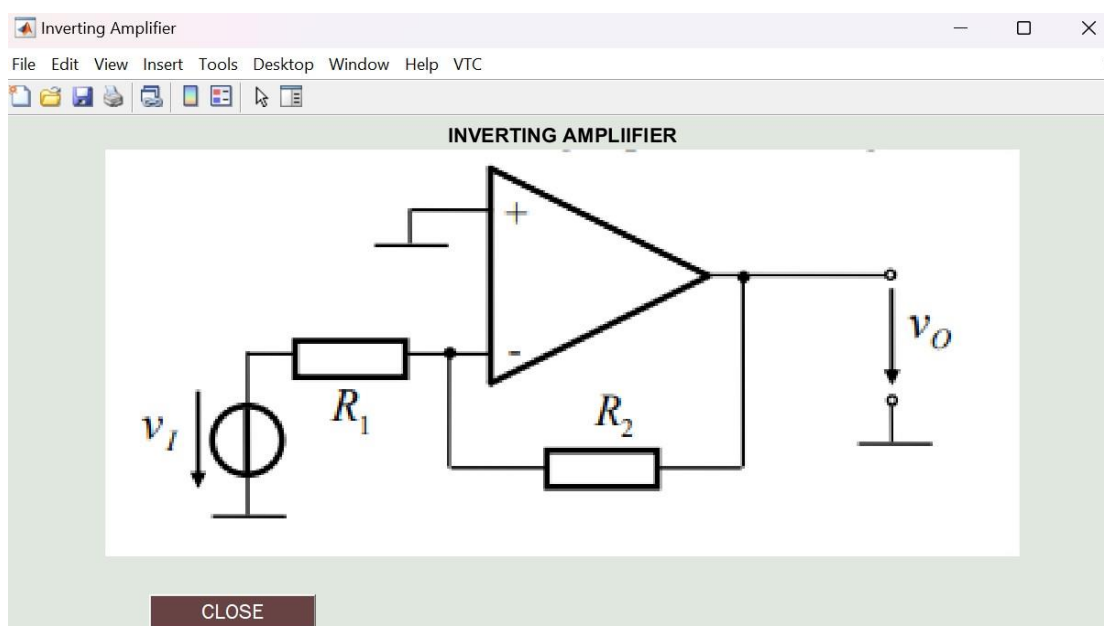
The "Non-inverting Amplifier" submenu takes you to a figure showing a picture of the corresponding circuit.



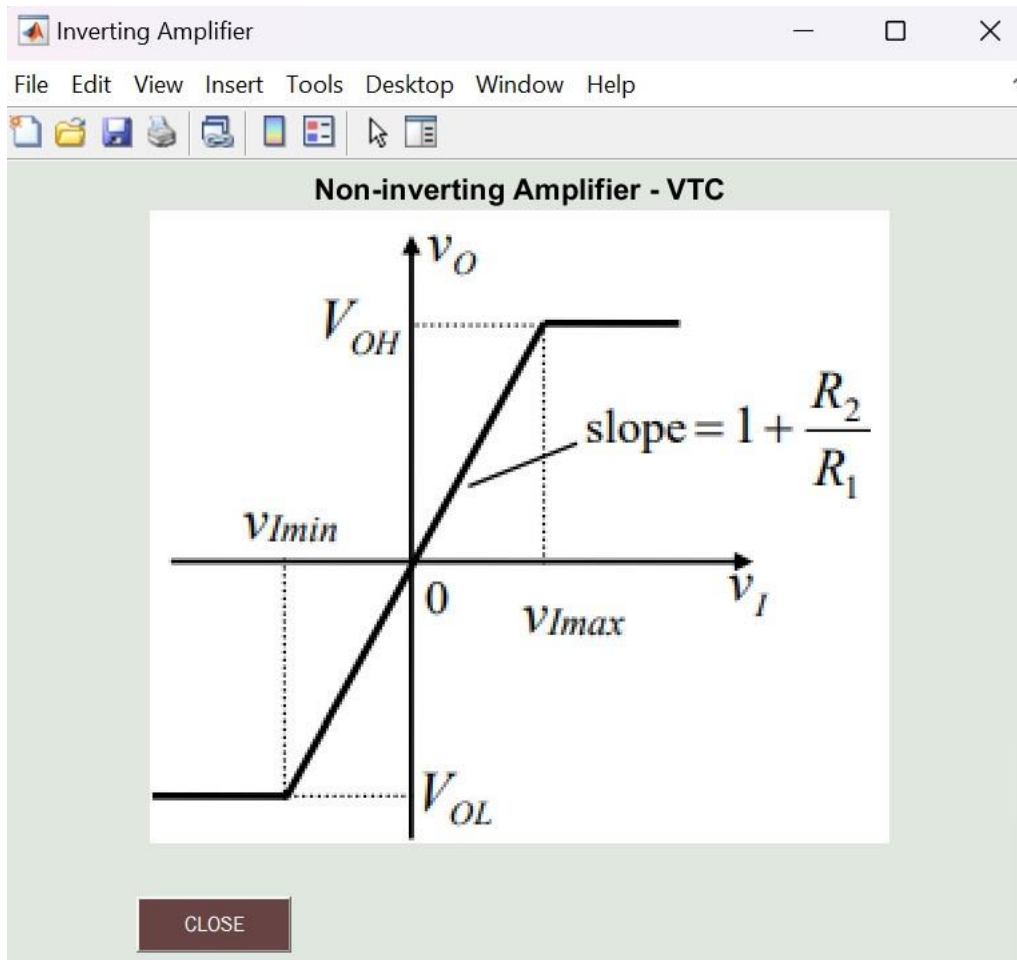
The "VTC" menu takes you to a figure showing a picture of the corresponding circuit' VTC.



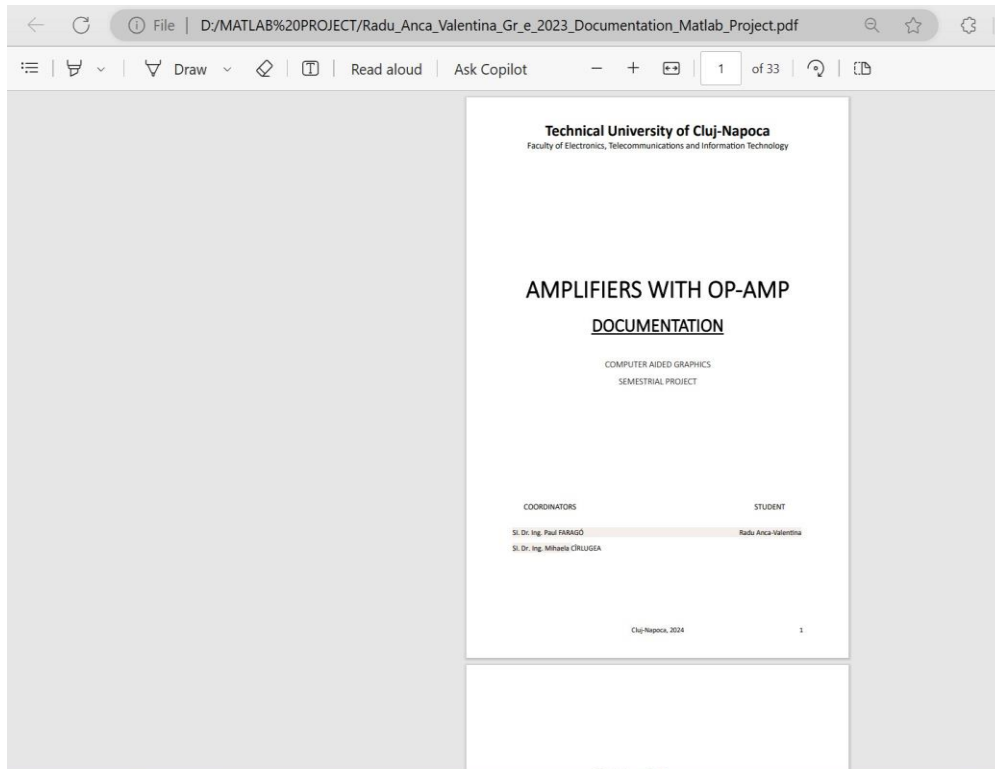
Just like the previous submenu, the "Inverting Amplifier" submenu takes you to a figure showing a picture of the corresponding circuit.



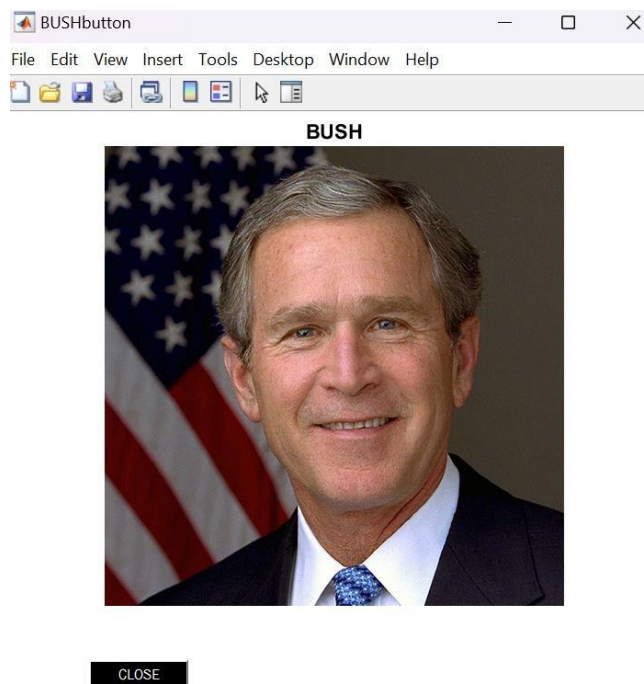
The Inverting Amplifier also has a VTC menu that opens up a figure of the VTC.



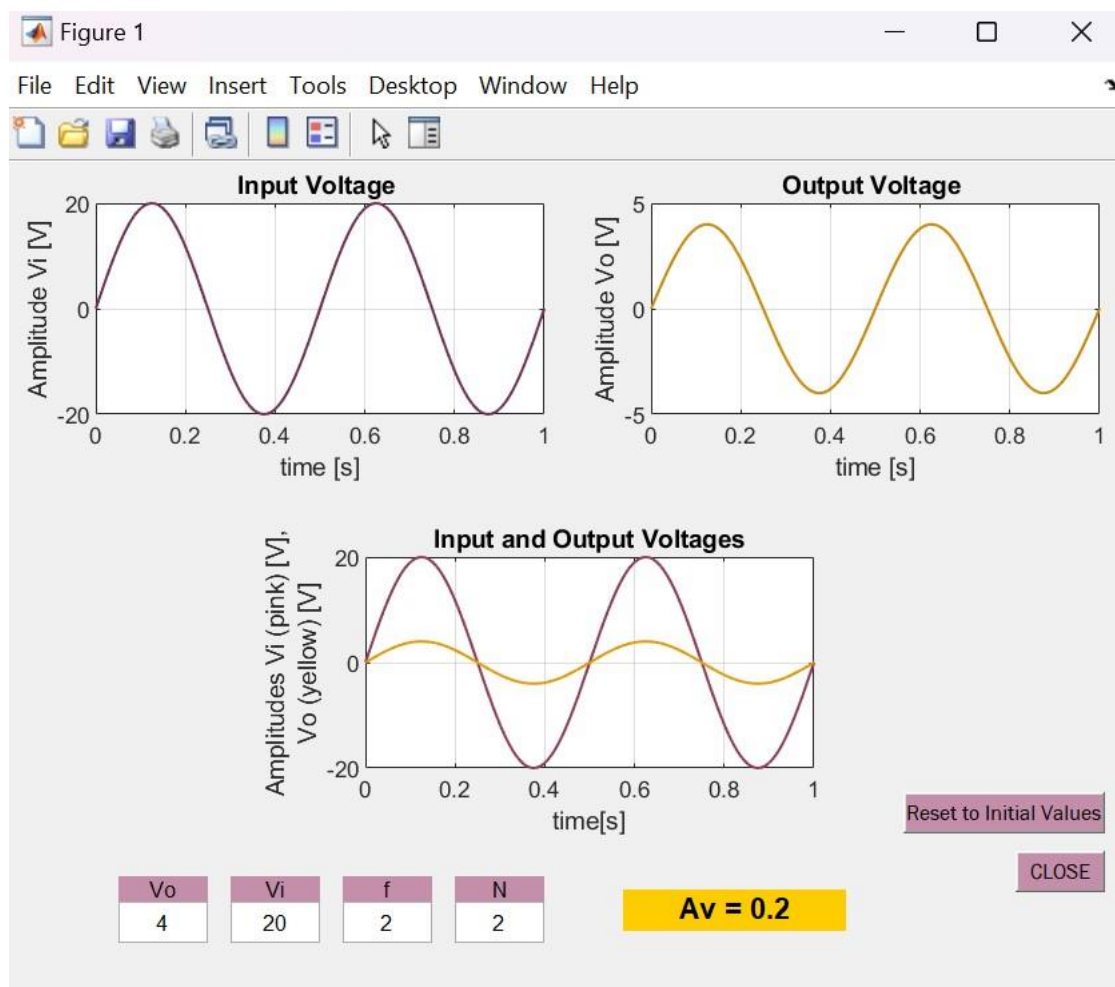
The "Documentation" submenu opens up the pdf of the project's documentation.

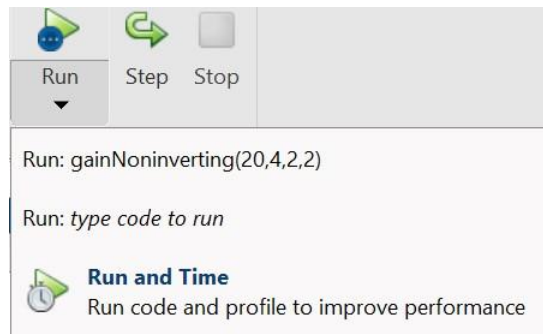


The "BUSH button" brings to life a candid shot of George Bush.



As a consequence to an error caused by the computation of T in the "gainNoninverting" and "gainInverting" functions, they have to be run from the MATLAB code, as the callback does not work. Prior to running them, the values can be changed. These 2 functions compute the gain A_v , and they display it on the figure.

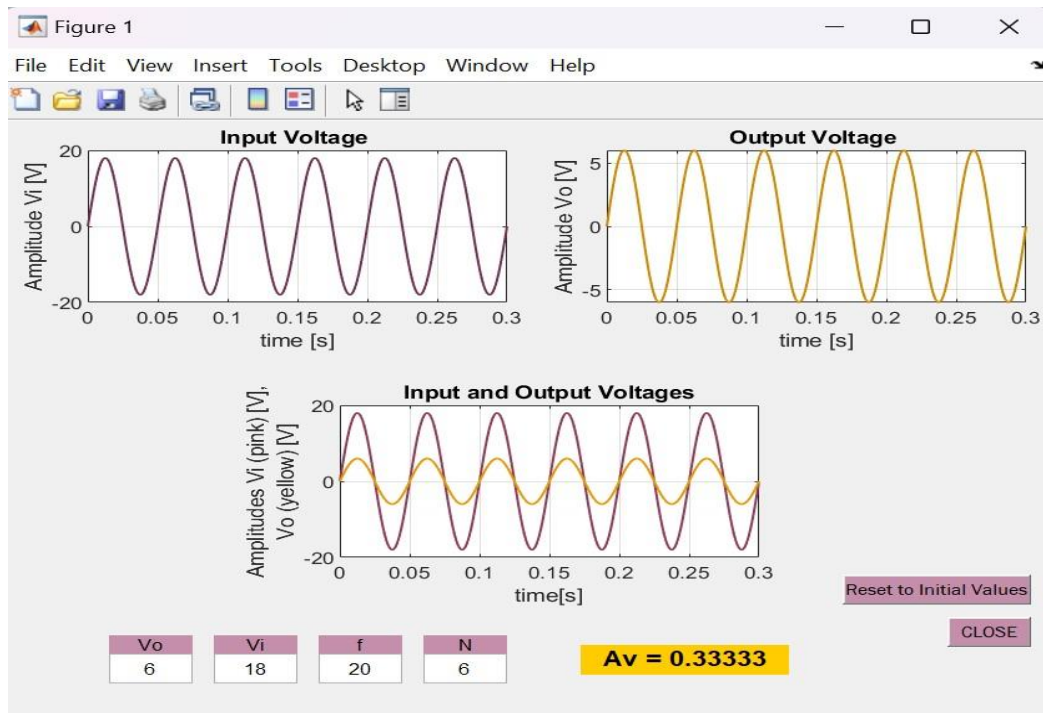




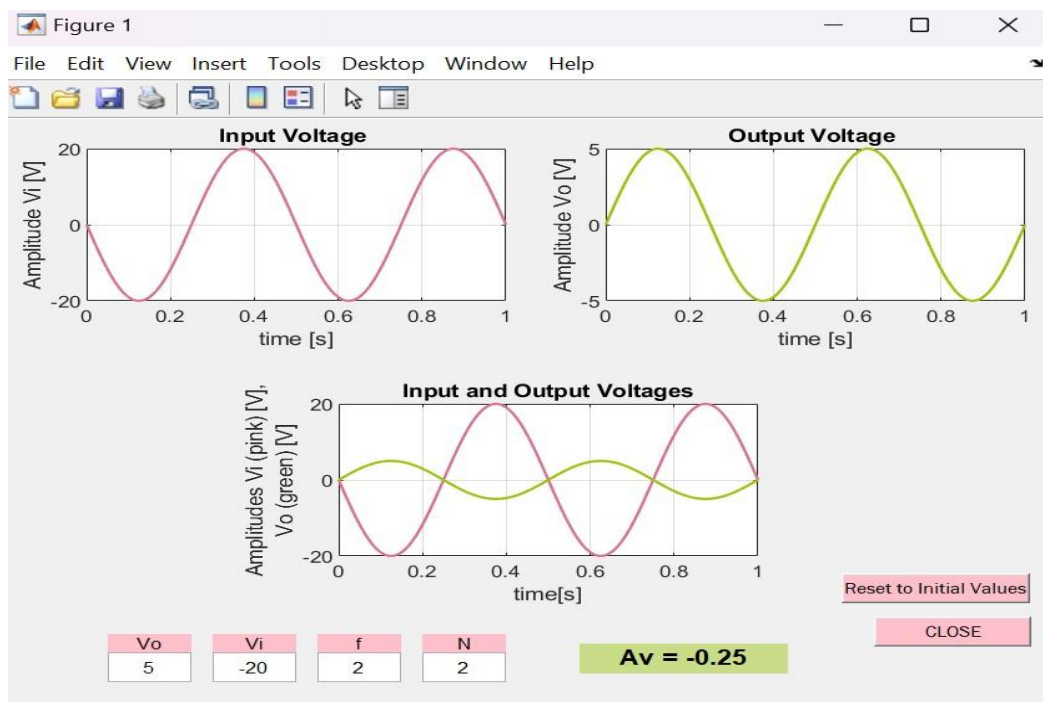
The "Reset to Initial Values" button resets the values and plots to the ones set in the code: 2,10,3,3 (V_o and V_i are reversed).

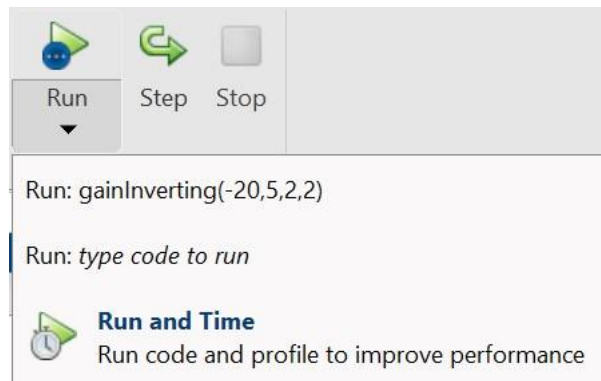


The values are modifiable from the edit boxes.

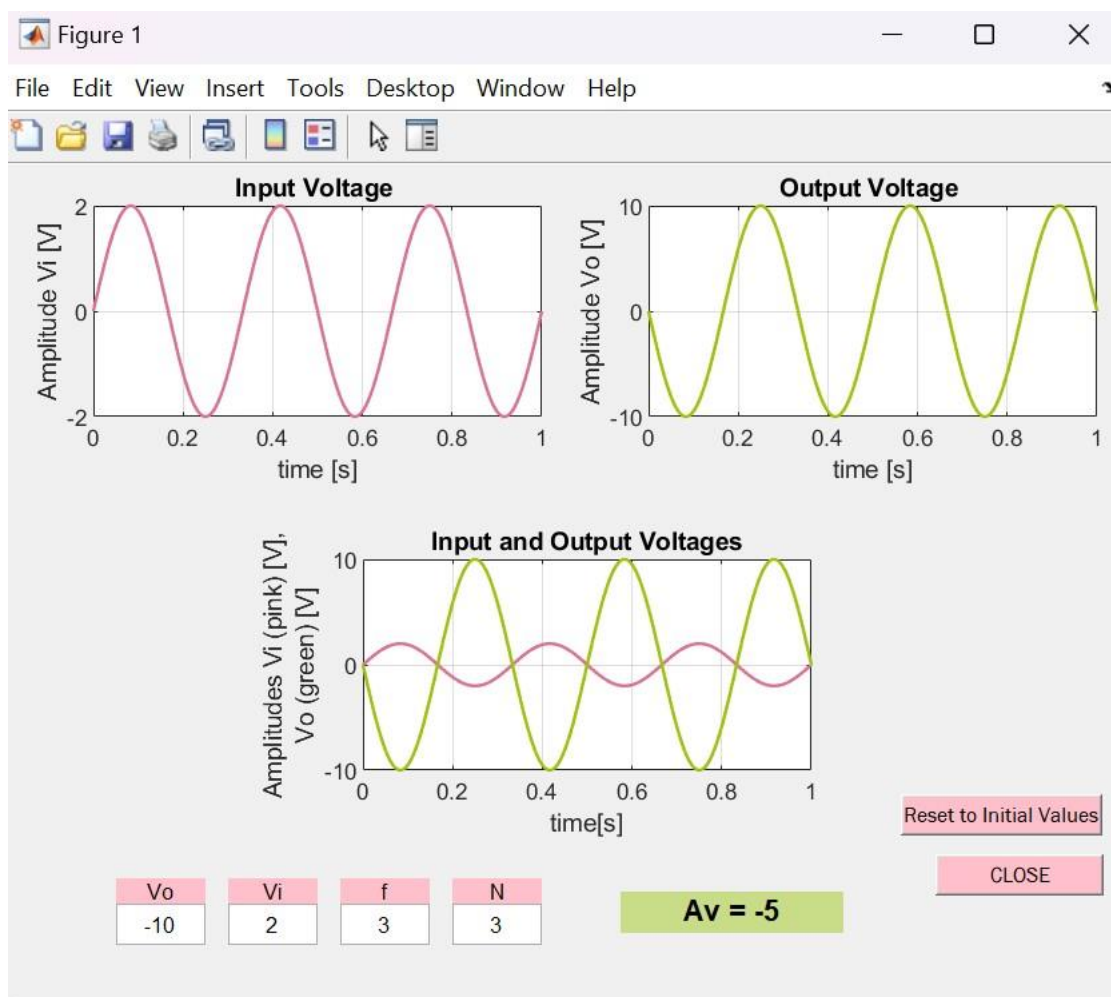


The "gainNoninverting" function works exactly the same. It computes the gain, the values can be changed prior to running the code,

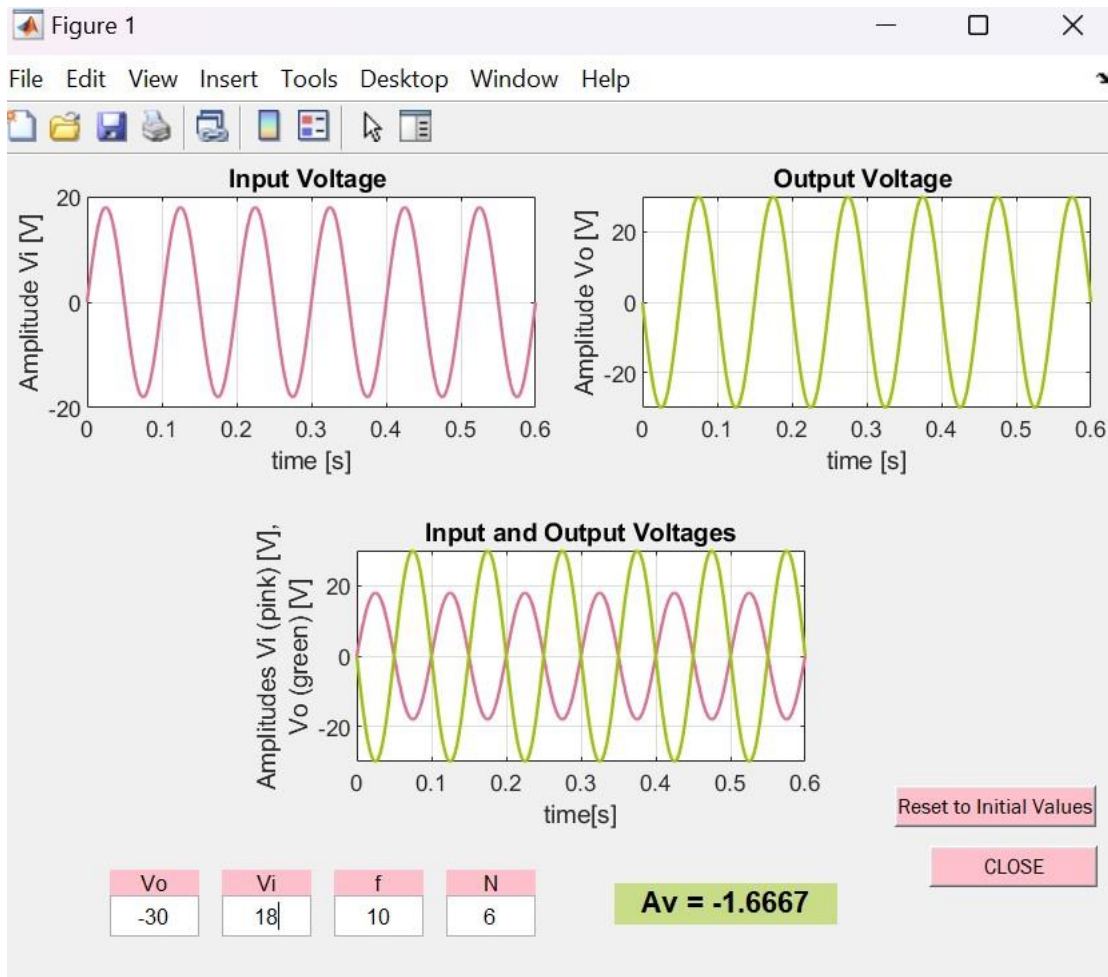




the "Reset to Initial Values" button resets the values to the ones set in the code, 2, -10, 3, 3



and the values are modifiable from the text boxes.



5. Conclusion

The project works the way I wanted it to, computing and displaying both the gain of inverting and non-inverting amplifiers, as well as the plots of the input and output signals and a plot with both of them, with no error.

The issues I encountered were with the callback to the gain computing functions, as stated above, and with setting limits to the output signal, V_{OH} and V_{OL} .

I tried using this function,

```
% ensure that Vo stays within the specified limits (Voh and Vol)
function limitedVo=limitAmplification(Vo, Voh, Vol)
    % Ensure Vo does not exceed positive voltage supply
    limitedVo = min(Vo, Voh);

    % Ensure Vo does not go below negative voltage supply
    limitedVo = max(limitedVo, Vol);
end
```

and calling it here

```
if isValid

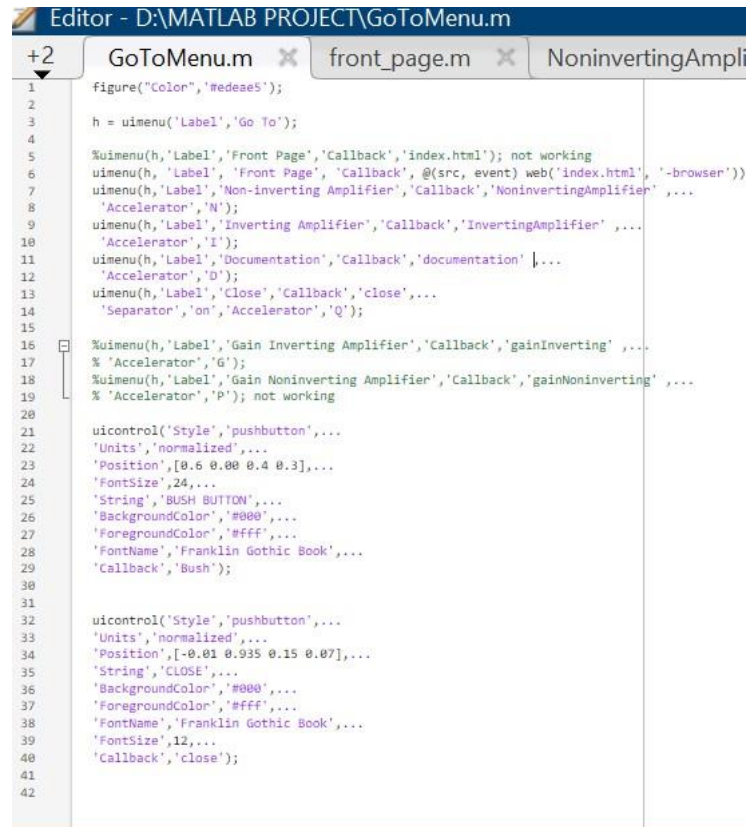
    % Limit amplification to specified Voh and Vol values
    Vo = limitAmplification(Vo, Voh, Vol);
```

but the limits only worked when running the code for the first time. After editing it from the button, V_o is not limited anymore.

6. References

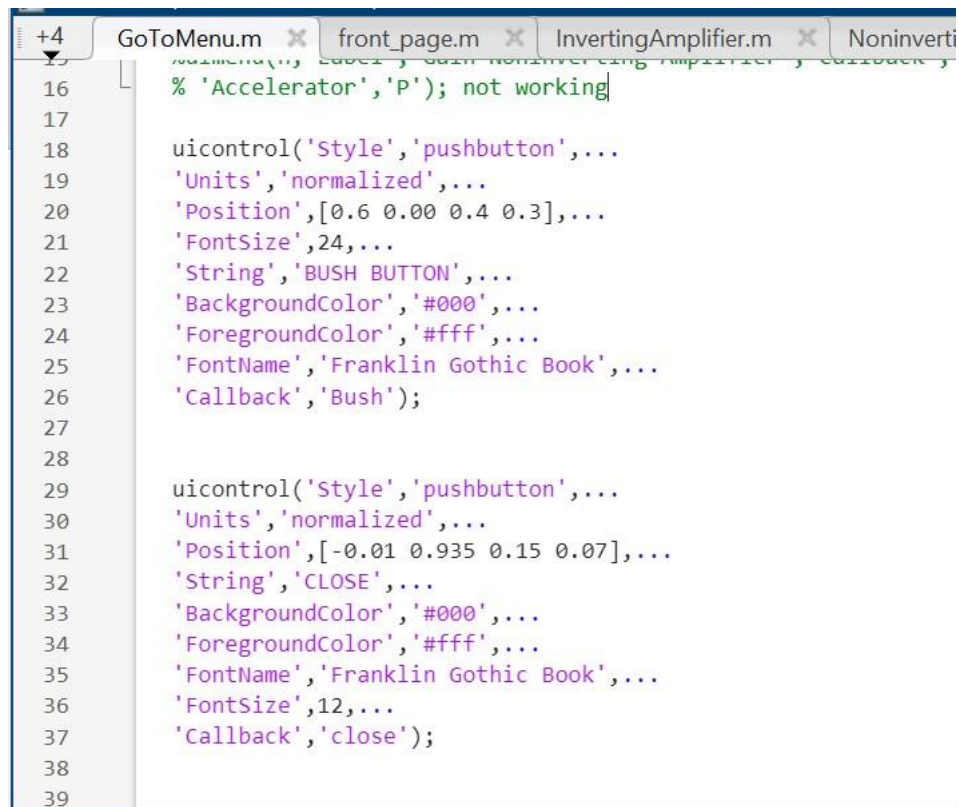
- <https://circuitglobe.com/difference-between-inverting-and-non-inverting-amplifier.html#chart> - Circuit Globe
- <https://www.javatpoint.com/matlab-introduction>
- <https://biblioteca.utcluj.ro/files/carti-online-cu-coperta/639-5.pdf>
- <https://html-color.codes/>
- <https://www.mathworks.com/>

7.Appendix



The image shows a MATLAB Editor window titled "Editor - D:\MATLAB PROJECT\GoToMenu.m". The window contains a script named "GoToMenu.m" with the following code:

```
1 figure('Color','redesse5');
2
3 h = uimenu('Label','Go To');
4
5 %uimenu(h,'Label','Front Page','Callback','index.html'); not working
6 uimenu(h,'Label','Front Page','Callback',@(src,event) web('index.html','-browser'))
7 uimenu(h,'Label','Non-inverting Amplifier','Callback','NoninvertingAmplifier',...
8 'Accelerator','N');
9 uimenu(h,'Label','Inverting Amplifier','Callback','InvertingAmplifier',...
10 'Accelerator','I');
11 uimenu(h,'Label','Documentation','Callback','documentation',...
12 'Accelerator','D');
13 uimenu(h,'Label','Close','Callback','close',...
14 'Separator','on','Accelerator','Q');
15
16 %uimenu(h,'Label','Gain Inverting Amplifier','Callback','gainInverting',...
17 % 'Accelerator','G');
18 %uimenu(h,'Label','Gain Noninverting Amplifier','Callback','gainNoninverting',...
19 % 'Accelerator','P'); not working
20
21 uicontrol('Style','pushbutton',...
22 'Units','normalized',...
23 'Position',[0.6 0.00 0.4 0.3],...
24 'FontSize',24,...
25 'String','BUSH BUTTON',...
26 'BackgroundColor','#000',...
27 'ForegroundColor','#fff',...
28 'FontName','Franklin Gothic Book',...
29 'Callback','Bush');
30
31
32 uicontrol('Style','pushbutton',...
33 'Units','normalized',...
34 'Position',[-0.01 0.935 0.15 0.07],...
35 'String','CLOSE',...
36 'BackgroundColor','#000',...
37 'ForegroundColor','#fff',...
38 'FontName','Franklin Gothic Book',...
39 'FontSize',12,...
40 'Callback','close');
```



The image shows a MATLAB Editor window titled "Editor - D:\MATLAB PROJECT\InvertingAmplifier.m". The window contains a script named "InvertingAmplifier.m" with the following code:

```
16 % 'Accelerator','P'); not working
17
18 uicontrol('Style','pushbutton',...
19 'Units','normalized',...
20 'Position',[0.6 0.00 0.4 0.3],...
21 'FontSize',24,...
22 'String','BUSH BUTTON',...
23 'BackgroundColor','#000',...
24 'ForegroundColor','#fff',...
25 'FontName','Franklin Gothic Book',...
26 'Callback','Bush');
27
28
29 uicontrol('Style','pushbutton',...
30 'Units','normalized',...
31 'Position',[-0.01 0.935 0.15 0.07],...
32 'String','CLOSE',...
33 'BackgroundColor','#000',...
34 'ForegroundColor','#fff',...
35 'FontName','Franklin Gothic Book',...
36 'FontSize',12,...
37 'Callback','close');
```

```
+4 GoToMenu.m x front_page.m
1 function front_page
2   open('index.html');
3
4   end
```

```
+4 GoToMenu.m x front_page.m x NoninvertingAmplifier.m x Noninv
1 function NoninvertingAmplifier
2
3   img=imread('NoninvAmplifier.png');
4
5   figure('Name','Non-inverting Amplifier','Numbertitle','off',...
6         'Color','#dfe7df');
7
8
9   imshow(img,'InitialMagnification',250)
10
11   title('NON-INVERTING AMPLIFIER');
12
13   uicontrol('Style','pushbutton',...
14             'Units','normalized',...
15             'Position',[0.13 0.025 0.15 0.07],...
16             'String','CLOSE',...
17             'BackgroundColor','#674443',...
18             'FontName','Franklin Gothic Book',...
19             'ForegroundColor','#fff',...
20             'FontSize',12,...
21             'Callback','close');
22
23
24   uimenu('Label','VTC','Callback','NoninvertingAmplifierVTC',...
25         'Accelerator','T');
26
27   end
```

```
+4 GoToMenu.m x front_page.m x NoninvertingAmplifier.m x NoninvertingAmplifierVTC.m x c
1 function NoninvertingAmplifierVTC
2
3   img=imread('NoninvAmplifierVTC.png');
4
5
6   imshow(img,'InitialMagnification',200)
7
8   title('Non-inverting Amplifier - VTC');
9
10
11   uicontrol('Style','pushbutton',...
12             'Units','normalized',...
13             'Position',[0.13 0.025 0.15 0.07],...
14             'String','CLOSE',...
15             'BackgroundColor','#674443',...
16             'FontName','Franklin Gothic Book',...
17             'ForegroundColor','#fff',...
18             'Callback','close');
```

```

+4  GoToMenu.m  front_page.m  NoninvertingAmplifier.m  NoninvertingAmplifierVTC.m  gainNoninverting.m
1  function gainNoninverting(Vi,V0,f,N)
2
3      T=1/f ;% period
4      t=0:T/100:N*T; % representation range in time
5
6      % the amplifier is noninverting, so both voltages must be positive,
7      % hence we only go through to code if the function is true
8      isValid = verifyPositivePositive(V0, Vi);
9
10     if isValid
11
12         x0=V0*sin(2*pi*f*t); % first function
13         x1=Vi*sin(2*pi*f*t); % second function
14
15     % Create or update the figure - to update plot when pressing the reset
16     % button
17     createOrUpdateFigure(t, x0, x1);
18
19
20     % pushbutton CLOSE
21     uicontrol('Style','pushbutton',...
22         'Units','normalized',...
23         'Position',[0.9 0.13 0.08 .05],...
24         'String','CLOSE',...
25         'BackgroundColor','#c58fac',...
26         'FontName','Franklin Gothic Book',...
27         'Callback','close');
28
29     % reset to initial parameters button

```

```

+4  GoToMenu.m  front_page.m  NoninvertingAmplifier.m  NoninvertingAmplifierVTC.m  gainNoninverting.m  Inverti
28
29     % reset to initial parameters button
30     uicontrol('Style','pushbutton',...
31         'Units','normalized',...
32         'Position',[0.8 0.2 0.18 .05],...
33         'String','Reset to Initial Values',...
34         'BackgroundColor','#c58fac',...
35         'FontName','Franklin Gothic Book',...
36         'Callback','gainNoninverting(2,10,3,3)'); %call with initial values
37     %'FontWeight','bold',...
38
39
40     % text button for variable Vi = cosine Amplitude
41     uicontrol('Style','text',...
42         'Units','normalized',...
43         'Position',[0.2 0.10 0.08 .05],...
44         'backgroundcolor','#c58fac',...
45         'string','Vi');
46
47     % edit button for Vi = the input voltage
48     uicontrol('Style','edit',...
49         'Units','normalized',...
50         'Position',[0.2 0.07 0.08 .05],...
51         'String',Vi,...
52         'Callback',['Vi=str2num(get(gcf,'String'));gainNoninverting(Vi,V0,f,N)']);
53
54
55     % text button for V0 = the output voltage
56     uicontrol('Style','text',...

```

```

+4  GoToMenu.m  front_page.m  NoninvertingAmplifier.m  NoninvertingAmplifierVTC.m  gainNoninverting.m
56     uicontrol('Style','text',...
57         'Units','normalized',...
58         'Position',[0.1 0.10 0.08 .05],...
59         'Backgroundcolor','#c58fac',...
60         'String','V0');
61
62     % edit button for V0
63     uicontrol('Style','edit',...
64         'Units','normalized',...
65         'Position',[0.1 0.07 0.08 .05],...
66         'String',V0,...
67         'Callback',['V0=str2num(get(gcf,'String'));gainNoninverting(Vi,V0,f,N)']);
68
69
70     %text button for f = frequency
71     uicontrol('Style','text',...
72         'Units','normalized',...
73         'Position',[0.3 0.1 0.08 .05],...
74         'Backgroundcolor','#c58fac',...
75         'String','f');
76
77     % edit button for f
78     uicontrol('Style','edit',...
79         'Units','normalized',...
80         'Position',[0.3 0.07 0.08 .05],...
81         'String',f,...
82         'Callback',['f=str2num(get(gcf,'String'));gainNoninverting(Vi,V0,f,N)']);
83
84

```



```

+4 GoToMenu.m front_page.m NoninvertingAmplifier.m NoninvertingAmplifierVTC.m gainNoninverting.m
82 'Callback',[f=str2num(get(gcf,'String'));gainNoninverting(Vi,Vo,f,N)];
83
84
85 % text Button for n = the no. of cycles to be displayed
86 uicontrol('Style','text',...
87 'Units','normalized',...
88 'Position',[0.4 0.10 0.08 .05],...
89 'BackgroundColor','#c58fac',...
90 'String','N');
91
92 % edit button for N
93 uicontrol('Style','edit',...
94 'Units','normalized',...
95 'Position',[0.4 0.07 0.08 .05],...
96 'String',N,...
97 'Callback',[N=str2num(get(gcf,'String'));gainNoninverting(Vi,Vo,f,N)];
98
99
100
101 Av=Vo/Vi;
102
103 %display Av
104 Av
105
106 uicontrol('Style','text',...
107 'Units','normalized',...
108 'Position',[0.55 0.0835 0.2 .05],...
109 'BackgroundColor','#ffcc00',...
110 'FontSize',11,...

```

```

+4 GoToMenu.m front_page.m NoninvertingAmplifier.m NoninvertingAmplifierVTC.m gainNoninverting.m Inverting.
110 'FontSize',11,...
111 'FontWeight','bold',...
112 'String',['Av = ', num2str(Av)];
113
114
115 %plot windows
116
117 %plot Vo
118 subplot('position',[0.575, 0.7, 0.4, 0.25]);
119 p=plot(t,xo);
120 p.Color="#cc8800";
121 p.LineWidth=1;
122 grid on;
123 title('Output Voltage ');
124 xlabel('time [s]');
125 ylabel('Amplitude Vo [V]');
126
127 %plot Vi
128 subplot('position',[0.08, 0.7, 0.4, 0.25]);
129 q=plot(t,xi);
130 q.Color="#6f3052";
131 q.LineWidth=1;
132 grid on;
133 title('Input Voltage ');
134 xlabel('time [s]');
135 ylabel('Amplitude Vi [V]');
136
137
138 %plot both

```

```

+4 GoToMenu.m front_page.m NoninvertingAmplifier.m NoninvertingAmplifierVTC.m gainNoninverting.m
138 %plot both
139
140 %custom colors
141 c1=[142,58,89]/255;
142 c2=[230, 153, 0]/255;
143 %MATLAB uses normalized RGB values in the range [0, 1], so you need to divide GB values by 255 to convert them
144
145 subplot('position',[0.32,0.28,0.4,0.25]);
146
147 plot(t, xi, 'Color', c1,LineWidth=1);
148 hold on; % allows multiple plots on the same axes
149 plot(t, xo, 'Color', c2,LineWidth=1);
150 hold off; % release the hold
151
152 grid on;
153 title('Input and Output Voltages');
154 xlabel('time[s]');
155 ylabel({'Amplitudes Vi (pink) [V]', 'Vo (yellow) [V]'});
156 %end plot both
157
158 %if the condition is not met
159 else
160     disp('No positive-positive/negative-negative pair found.')
161
162 end
163
164
165 function isValid = verifyPositivePositive(Vo, Vi)
166     isValid = false; % initialize the result

```

```

+4  GoToMenu.m  front_page.m  NoninvertingAmplifier.m  NoninvertingAmplifierVTC.m  gainNoninverting.m
165 function isValid = verifyPositivePositive(Vo, Vi)
166     isValid = false; % initialize the result
167
168     % check if one of Vo and Vi is negative and the other is positive
169     if (Vo > 0 && Vi > 0) || (Vo < 0 && Vi < 0)
170         isValid = true;
171
172     end
173
174 end
175
176
177 function createOrUpdateFigure(t, xo, xi)
178     % Plot windows
179     subplot('position', [0.58, 0.5, 0.4, 0.25]);
180     plot(t, xo);
181     grid on;
182     title('Output Voltage ');
183     xlabel('time [s]');
184     ylabel('Amplitude Vo [V]');
185
186     subplot('position', [0.08, 0.5, 0.4, 0.25]);
187     plot(t, xi);
188     grid on;
189     title('Input Voltage ');
190     xlabel('time [s]');
191     ylabel('Amplitude Vi [V]');
192 end
193 end

```

```

+4  GoToMenu.m  front_page.m  NoninvertingAmplifier.m  NoninvertingAmplifierVTC.m  gainNoninverting.m  InvertingAmplifier.m
1 function InvertingAmplifier
2 |
3 img=imread('InvAmplifier.png');
4
5 figure('Name','Inverting Amplifier','Numbertitle','off',...
6       'Color','#dfe7df');
7
8 imshow(img,'InitialMagnification',250)
9
10 title('INVERTING AMPLIFIER');
11
12 uicontrol('Style','pushbutton',...
13          'Units','normalized',...
14          'Position',[0.13 0.025 0.15 0.07],...
15          'String','CLOSE',...
16          'BackgroundColor','#674443',...
17          'FontName','Franklin Gothic Book',...
18          'FontSize',12,...
19          'ForegroundColor','#fff',...
20          'Callback','close');
21
22 uimenu('Label','VTC','Callback','NoninvertingAmplifierVTC',...
23       'Accelerator','T');
24
25 end

```

```

+4 GoToMenu.m front_page.m NoninvertingAmplifier.m NoninvertingAmplifierVTC.m gainNoninverting.m InvertingAmplifier.m InvertingAmplifierVTC.m
1 function InvertingAmplifierVTC
2
3 img=imread('NoninvAmplifierVTC.png');
4
5
6 imshow(img,'InitialMagnification',200)
7
8 title('Inverting Amplifier - VTC');
9
10 uicontrol('Style','pushbutton',...
11 'Units','normalized',...
12 'Position',[0.13 0.01 0.15 0.05],...
13 'String','CLOSE',...
14 'BackgroundColor','#674443',...
15 'FontName','Franklin Gothic Book',...
16 'Callback','close');
17

```

```

+4 gainInverting.m GoToMenu.m front_page.
1 function gainInverting(Vi,Vo,f,N)
2
3 T=1/f;
4 t=0:T/100:N*T; % representation range in time
5
6 % the amplifier is inverting, so one of the voltages has to be negative, one
7 % positive, so we only go through to code if the function is true
8 isValid = verifyPositiveNegative(Vo, Vi);
9
10 if isValid
11
12 xo=Vo*sin(2*pi*f*t); % first function
13 xi=Vi*sin(2*pi*f*t); % second function
14
15 % Create or update the figure - to update plot when pressing the reset
16 % button
17 createOrUpdateFigure(t, xo, xi);
18
19
20 % pushbutton CLOSE
21 uicontrol('Style','pushbutton',...
22 'Units','normalized',...
23 'Position',[0.831 0.128 0.15 0.05],...
24 'String','CLOSE',...
25 'BackgroundColor','#ffc0cb',...
26 'FontName','Franklin Gothic Book',...
27 'Callback','close');
28
29 % reset to initial parameters button
30 uicontrol('Style','pushbutton',...
31 'Units','normalized',...
32 'Position',[0.8 0.2 0.18 0.05],...
33 'String','Reset to Initial Values',...
34 'BackgroundColor','#ffc0cb',...
35 'FontName','Franklin Gothic Book',...
36 'Callback','gainInverting(2,-10,3,3)'); %call with initial values
37
38 % text button for Vo = the output voltage
39 uicontrol('Style','text',...
40 'Units','normalized',...
41 'Position',[0.1 0.10 0.08 0.05],...
42 'BackgroundColor','#ffc0cb',...
43 'String','Vo');
44

```



```

+4 gainInverting.m x GoToMenu.m x front_p
42 'BackgroundColor','w',...
43 'String','Vo');
44
45 % edit button for Vo
46 uicontrol('Style','edit',...
47 'Units','normalized',...
48 'Position',[0.1 0.07 0.08 .05],...
49 'String','Vo',...
50 'Callback',['Vo=str2num(get(gcf,'String'));gainInverting(Vi,V0,f,N)']);
51
52
53 % text button for variable Vi = cosine Amplitude
54 uicontrol('Style','text',...
55 'Units','normalized',...
56 'Position',[0.2 0.10 0.08 .05],...
57 'BackgroundColor','w',...
58 'String','Vi');
59
60 % edit button for Vi = the input voltage
61 uicontrol('Style','edit',...
62 'Units','normalized',...
63 'Position',[0.2 0.07 0.08 .05],...
64 'String','Vi',...
65 'Callback',['Vi=str2num(get(gcf,'String'));gainInverting(Vi,V0,f,N)']);
66
67
68 %text button for f = frequency
69 uicontrol('Style','text',...
70 'Units','normalized',...
71 'Position',[0.3 0.1 0.08 .05],...
72 'BackgroundColor','w',...
73 'String','f');
74
75 % edit button for f
76 uicontrol('Style','edit',...
77 'Units','normalized',...
78 'Position',[0.3 0.07 0.08 .05],...
79 'String','f',...
80 'Callback',['f=str2num(get(gcf,'String'));gainInverting(Vi,V0,f,N)']);
81
82
83 % text Button for N = the no. of cycles to be displayed
84 uicontrol('Style','text',...
85 'Units','normalized',...

```

```

+4 gainInverting.m x GoToMenu.m x front_p
85 'Units','normalized',...
86 'Position',[0.4 0.10 0.08 .05],...
87 'BackgroundColor','w',...
88 'String','N');
89
90 % edit button for N
91 uicontrol('Style','edit',...
92 'Units','normalized',...
93 'Position',[0.4 0.07 0.08 .05],...
94 'String','N',...
95 'Callback',['N=str2num(get(gcf,'String'));gainInverting(Vi,V0,f,N)']);
96
97
98 Av=Vo/Vi;
99
100 uicontrol('Style','text',...
101 'Units','normalized',...
102 'Position',[0.55 0.0835 0.2 .05],...
103 'BackgroundColor','w',...
104 'FontSize',11,...
105 'FontWeight','bold',...
106 'String',['Av = ', num2str(Av)]);
107
108
109 %display Av
110 Av
111
112
113 %plot windows
114
115 %plot Vo
116 subplot('position',[0.575, 0.7, 0.4, 0.25]);
117 p=plot(t,x0);
118 p.Color="r";
119 p.LineWidth=1.2;
120 grid on;
121 title('Output Voltage ');
122 xlabel('time [s]');
123 ylabel('Amplitude Vo [V]');
124
125 %plot Vi
126 subplot('position',[0.08, 0.7, 0.4, 0.25]);
127 q=plot(t,x1);
128 q.Color="b";

```

```

+4 gainInverting.m x GoToMenu.m x front_page.m x Noninvertin
127 q=plot(t,x1);
128 q.Color='mdb7093';
129 q.LineWidth=1.2;
130 grid on;
131 title('Input Voltage ');
132 xlabel('time [s]');
133 ylabel('Amplitude Vi [V]');
134
135
136 %plot both
137 %custom colors
138
139 c1=[219,112,147]/255;
140 c2=[157,194,9]/255;
141 %MATLAB uses normalized RGB values in the range [0, 1], so you need to divide GB values by 255 to convert them
142
143 subplot('position',[0.32,0.28,0.4,0.25]);
144
145 plot(t, xi, 'Color', c1,LineWidth=1.2);
146 hold on; % allows multiple plots on the same axes
147 plot(t, xo, 'Color', c2,LineWidth=1.2);
148 hold off; % release the hold
149
150 grid on;
151 title('Input and Output Voltages');
152 xlabel('time[s]');
153 ylabel({'Amplitudes Vi (pink) [V]', 'Vo (green) [V]'});
154 %end plot both
155
156
157 %if the condition is not met
158 else
159 disp('No positive-negative pair found.')
160
161 end
162
163
164
165
166 function isValid = verifyPositiveNegative(Vo, Vi)
167 isValid = false; % initialize the result
168
169 % check if one of Vo and Vi is negative and the other is positive
170

```

```

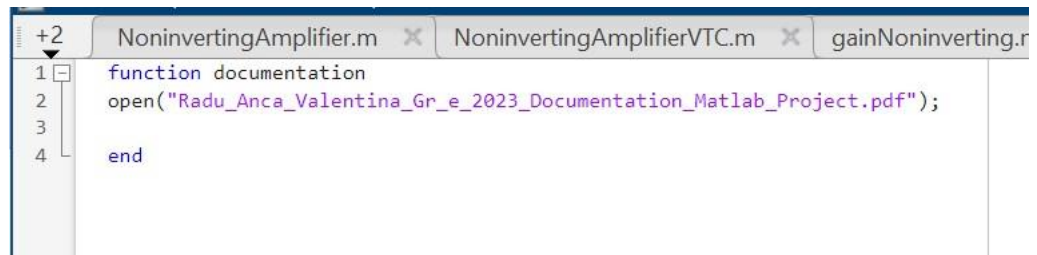
+4 gainInverting.m x GoToMenu.m x front
154 ylabel({'Amplitudes Vi (pink) [V]', 'Vo (green) [V]'});
155 %end plot both
156
157
158 %if the condition is not met
159 else
160 disp('No positive-negative pair found.')
161
162 end
163
164
165
166 function isValid = verifyPositiveNegative(Vo, Vi)
167 isValid = false; % initialize the result
168
169 % check if one of Vo and Vi is negative and the other is positive
170
171 if (Vo < 0 && Vi > 0) || (Vo > 0 && Vi < 0)
172 isValid = true;
173
174 end
175
176
177
178
179 function createOrUpdateFigure(t, xo, xi)
180 % Plot windows
181 subplot('position', [0.58, 0.5, 0.4, 0.25]);
182 plot(t, xo);
183 grid on;
184 title('Output Voltage ');
185 xlabel('time [s]');
186 ylabel('Amplitude Vo [V]');
187
188 subplot('position', [0.08, 0.5, 0.4, 0.25]);
189 plot(t, xi);
190 grid on;
191 title('Input Voltage ');
192 xlabel('time [s]');
193 ylabel('Amplitude Vi [V]');
194
195 end
196
197

```

```

+1 front_page.m x NoninvertingAmplifier.m x NoninvertingAmplifierVTC.m x gainNoninverting.m x InvertingAmplifier.m x InvertingAmplifierVTC.m x Bush.m x gainIn
1 Function Bush
2
3 img=imread('bush.jpg');
4
5 figure('Name','BushButton','Numbertitle','off',...
6 'Color','w');
7 imshow(img,'InitialMagnification','best');
8
9 title('BUSH');
10
11
12 uicontrol('style','pushbutton',...
13 'units','normalized',...
14 'position',[0.15 0.01 0.15 0.05],...
15 'string','CLOSE',...
16 'backgroundcolor','w',...
17 'foregroundcolor','r',...
18 'fontname','Franklin Gothic Book',...
19 'callback','close');
20

```



The image shows a MATLAB editor window with three tabs: 'NoninvertingAmplifier.m', 'NoninvertingAmplifierVTC.m', and 'gainNoninverting.r'. The active tab is 'NoninvertingAmplifier.m'. The code in the editor is as follows:

```
1 function documentation
2   open("Radu_Anca_Valentina_Gr_e_2023_Documentation_Matlab_Project.pdf");
3
4   end
```

THANK YOU!