

# Maltlab Software Application to Monitor and Analyze Linear Kirhoff Circuit in Harmonic Setting Mode

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**ABSTRACT:** Maltlab software is a software from the Mathwork, Inc, with a high-level programming language is used to solve scientific computing problems and engineering problems. Maltlab provides mathematical tools, integrates calculations, displays results, allows programming, easy to use interface for users. Today, Maltlab software is used commonly in Universities to support teaching and students to study and research, especially in numerical analysis, calculus courses, scientific computing... Beside, The analysis and investigation of linear kirhoff circuits in steady state is an important skill in the module "Circuit theory 1" for lecturers and students majoring in electrical engereering. Applying the utilities, mathematical tools and interfaces of Maltlab software to analyze and survey the operation of linear Kirhoff circuits in steady state mode help us to save time, effort, easily show the results of the problems, carry the characteristics of state variable such as current, voltage, power...

**Keywords:** Matlab software, linear Kirhoff circuits, analyze, survey, steady state mode

## I. QUESTION

The survey and analysis of Kirhoff linear circuitry in established mode is the most important part of the study and study process of the section "Theory of Circuit 1", as well as the first step in learning about the operation of the Kirhoffs Linear Circuit by students specializing in Electrical Engineering. Besides, this content needs to build mathematical models for the finite mathematics equations of state variables of time, build state equations systems, solve problems... requiring faculty and students with math knowledge, solid relative computing skills and rational calculation methods. Applying tools and libraries in MathWorks, Inc's Maltlab software to survey and analyze Kirhoff's linear circuitry helps teachers and students reduce time, computing effort and enhance

their ability to learn, explore, and study the advantages of software. So, the authors presented their self-study "Maltlab software application to survey and analyze Kirhoff linear circuitry in set mode" for reference by faculty and students.

## II. OVERVIEW OF MALTLAB SOFTWARE

### 2.1. Concept

Matlab is an advanced programming language used to solve technical problems. Matlab integrates computing, shows results, enables programming, the interface is very user-friendly. Data along with a pre-programmed library allows users to obtain the following applications: Using the functions available in the library, conventional mathematical calculations, programming to create new applications, simulating models, analyzing, surveying and displaying data and developing, interacting with some other software such as: C++, Fortran...

### 2.2. Data Structures and Applications of MATLAB

#### 2.2.1. Data

MATLAB data is presented as a matrix (or general array), with the following data types listed: Single, double, sparse, int8, uint8, int16..., char, cell, structure.

#### 2.2.2. Ứng dụng

Applications in mathematics and scientific computation courses, help engineers and scientific researchers solve technical problems, simulate systems... and calculate, research to create the best products in manufacturing.

#### 2.2.3. Toolbox

This tool provided by MATLAB allows the application of techniques to analyze, design, and

simulate models: Neural Networks, Fuzzy Logic, Simulink

### 2.3. MATLAB system

- Development Environment: Desktop, Command Window, Command History, Browsers for viewing help
- Math library and functions: Includes structures such as sum, sin, cos, atan, atan2 etc., simple calculations to complex calculations such as isolation matrix, self-rule, Fourier converter, Laplace, symbolic library...
- MATLAB languages: These are high matrix and array languages, with command lines, functions, data structures in, that can program object orientation.
- Graphics in MATLAB: Includes graphical expression commands in 2D and 3D environments, creates moving images, provides interactive user-computer interfaces.
- Communicate with other languages: MATLAB interacts with languages such as C/C++, Fortran...

### 2.4 Starting MATLAB

Starting MATLAB you double-click (or single-clicking) and the MATLAB.exe file icon, on the screen appears a window. That window contains the toolbars (human and machine interface) needed for managing files, variables, command windows, which can be considered desktop panels consisting of cells, regions, management and effects of each small window managed by the Desktop.

### 2.5. Working with MATLAB windows managed by desktop

#### 2.5.1. Command window

Matlab's main communication window is where you enter the values of variables, display values, calculate expressions, execute functions available in the library (command forms), or user-programmed functions in M-Files. Commands are entered after the '>>' prompt, and if there is an error while typing the command, press the Enter key until the prompt is received.

#### 2.5.2. Command History

Command lines entered in the Command window (these lines can be import lines, or they can be commands performing a function) are retained in Command History and this window allows us to reuse them by double-clicking on those commands or variables, if you want to re-use those variables. Twin the mouse to the fold or turn it for reuse.

### 2.5.3. Workspace

The Workspace window is a window that displays the names of the variables used along with the size of the memory area (byte number), the data type (layer), the variable that is released after each shutdown of the program. Double-click the variable to view the data (or change the value). In addition, it allows you to change the value, as well as the size of the variable by double-clicking on the variables. Or click on the left button next to the save button. The title is variable b, the data format in the cell is called: Numeric format, the default is short, The size is 1 by 3 (i.e. a row and 3 columns) we can change this size by changing the number in the size box. Using this window to save the variables below the data of variable b, we can change them by changing the values in those cells.

## III. MATLAB SOFTWARE APPLICATION IN LINEAR KIRCHOFF CIRCUIT ANALYSIS IN HARMONIC SETUP MODE.

### 3.1. Draw properties

Example 1: Draw properties

$$i_A(t) = 5\sqrt{2}\sin(100\pi t + 30^\circ) \text{ (A)} ; i_B(t) = 10\sqrt{2}\sin(100 - \text{tr}30^\circ) \text{ (A)} ; i_C(t) = 8\sqrt{2}\sin(120\pi t - 45^\circ) \text{ (A)} \text{ v\grave{a}} U_1(t) = 220\sqrt{2}\cos(100\pi t) \text{ (V)} ; U_2(t) = 110\sqrt{2}\cos(120\pi t) \text{ (V)}?$$

Writing programs on Matlab software

```
>>t=linspace(0,2*pi,100);
tsgoc1=100*pi*t;tsgoc2=120*pi*t;
>>Ia=5*sqrt(2)*sin(tsgoc1+pi/6);
>>Ib=10*sqrt(2)*sin(tsgoc1-pi/6);
>>Ic=8*sqrt(2)*sin(tsgoc2-pi/4);
>>U1=220*sqrt(2)*cos(tsgoc1);
>>U2=110*sqrt(2)*cos(tsgoc2);
>>figure
>>plot(tsgoc1,Ia,'r',tsgoc1,Ib,'b',tsgoc2,Ic);
>>grid
>>hold on
>>figure
>>plot(tsgoc1,U1,'r',tsgoc1,U2,'b');
>>grid
>>hold on
```

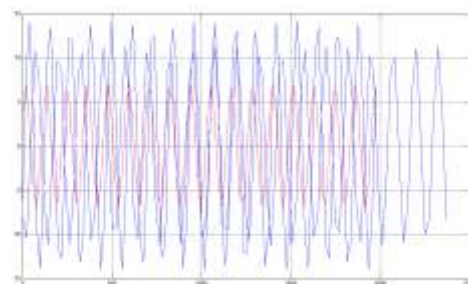


Figure 1-Characteristics of electrical currents

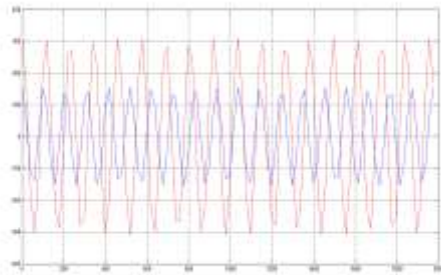
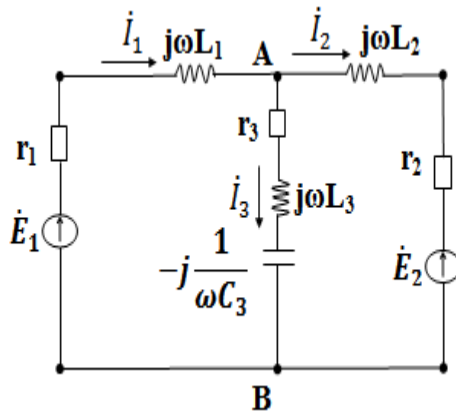


Figure 2-Specifications of the voltage

### 3.2. Analysis of determined processes in Kirchoff linear circuitry

#### 3.2.1. Branch Current Method

Example 2: Give the circuit as a diagram



Determine the current  $i_1(t)$ ;  $i_2(t)$ ; and  $i_3(t)$  in a circuit known to be stimulated by two voltage sources.

$e_1(t) = 20\sqrt{2}\sin(\omega t + 30^\circ)(V)$  and  $e_2(t) = 10\sqrt{2}\sin(\omega t)(V)$ ;  $f = 50\text{Hz}$ ;  $r_1 = 1(\Omega)$ ;  $r_2 = 2(\Omega)$ ;  $r_3 = 2,5(\Omega)$ ;  $L_1 = L_2 = 30\text{mH}$ ;  $L_3 = 20\text{mH}$ ;  $C = 250\mu\text{F}$ .

Branch current method: Choose  $i_1, i_2, i_3$  are the current that runs in the branches and is as dimensional as the drawing and applying Kirchoff's laws we have:

$$\begin{cases} i_1 - i_2 - i_3 = 0 \\ (r_1 + j\omega L_1)i_1 + \left(r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right)\right)i_3 = E_1 \\ (r_2 + j\omega L_2)i_2 - \left(r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right)\right)i_3 = -E_2 \end{cases} \rightarrow \begin{cases} i_1 - i_2 - i_3 = 0 \\ Z_1 i_1 + Z_3 i_3 = E_1 \\ Z_2 i_2 - Z_3 i_3 = E_2 \end{cases} \rightarrow [Z] \cdot [I] = [E]$$

$$\text{With } [Z] = \begin{bmatrix} 1 & -1 & -1 \\ Z_1 & 0 & Z_3 \\ 0 & Z_2 & -Z_3 \end{bmatrix}; [I] = \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix}; [E] =$$

$$\begin{bmatrix} 0 \\ E_1 \\ -E_2 \end{bmatrix}$$

$$f = 50\text{Hz} \rightarrow \omega = 2\pi f = 100\pi \left(\frac{\text{rad}}{\text{s}}\right); E_1 = 20 \cdot e^{j30^\circ} (V); E_2 = 10 \cdot e^{j0^\circ} (V)$$

$$Z_1 = r_1 + j\omega L_1 = 1 + j100\pi \cdot 30 \cdot 10^{-3} (\Omega)$$

$$Z_2 = r_2 + j\omega L_2 = 2 + j100\pi \cdot 30 \cdot 10^{-3} (\Omega)$$

$$Z_3 = r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right) = 2,5 + j\left(100\pi \cdot 20 \cdot 10^{-3} - \frac{1}{100\pi \cdot 250 \cdot 10^{-6}}\right) (\Omega)$$

Writing programs on Matlab software

```
>> z1=1+100*pi*30*10^(-3)*i;
>> z2=1+100*pi*30*10^(-3)*i;
>> z3=2.5+(100*pi*20*10^(-3)-
1/100*pi*250*10^(-6))*i;
>> Z=[1 -1 -1;z1 0 z3;0 z2 -z3]
Z =
    1.0000    -1.0000    -1.0000
    1.0000 + 9.4248i     0     2.5000 + 6.2832i
         0     1.0000 + 9.4248i    -2.5000 - 6.2832i
>> E1=20*exp(pi/6*i);
>> E2=10;
>> E=[0 E1 -E2]'
E =
    0
    17.3205 -10.0000i
   -10.0000
[I]=[Z]\E
>> I=Z\E//
I =
   -0.5377 - 1.0756i
   -0.4300 + 0.1962i
   -0.1078 - 1.2717i
>> Imax=abs(I)*sqrt(2)
Imax =
    1.7006
    0.6684
    1.8050
>> Igoc=angle(I)*180/pi
Igoc =
   -116.5629
    155.4769
   -94.8429
>> t=linspace(0,2*pi);tsgoc=100*pi*t;
>> i1=Imax(1)*sin(tsgoc+Igoc(1));
>> i2=Imax(2)*sin(tsgoc+Igoc(2));
>> i3=Imax(3)*sin(tsgoc+Igoc(3));
>> figure
```

```
>>plot(tsgoc,i1,'r',tsgoc,i2,'g',tsgoc,i3);
>>grid
```

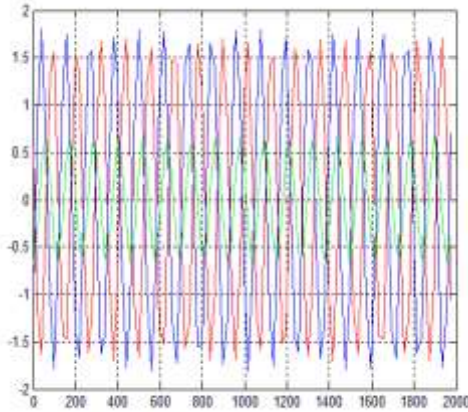
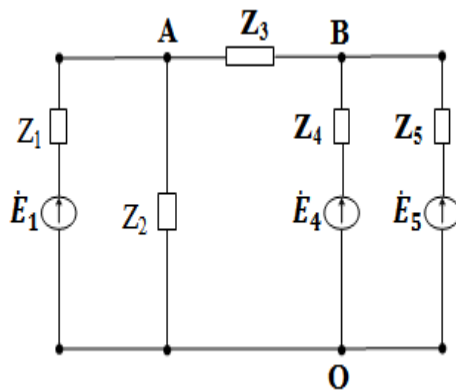


Figure 3- Characteristics of Currents

### 3.2.2. Top power method.

Example 3: Let's calculate the current flowing in the branches of the circuitry as shown in the figure. Knowing that the circuitry is stimulated by three sources:

$$\dot{E}_1 = 160e^{j30^0}(v); \dot{E}_4 = 100e^{j0^0}(v) \quad ; \quad \dot{E}_5 = 220e^{j0^0}(v) \text{ v\grave{a}} \quad Z_1=20(\Omega); \quad Z_2=j40(\Omega); \quad Z_3=-j20(\Omega); \\ Z_4=10+j20(\Omega); \quad Z_5=16(\Omega), f=50(\text{Hz}).$$



Select  $\phi_o = 0(v)$  as the electromagnetic root and the variable is the electrophysics at the peaks of A, B:  $\phi_A, \phi_B$ .

$$\text{Private lead total: } Y_A = Y_1 + Y_2 + Y_3 = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$Y_B = Y_3 + Y_4 + Y_5 = \frac{1}{Z_3} + \frac{1}{Z_4} + \frac{1}{Z_5}$$

$$\text{Mutual Conduct Total: } Y_{AB} = Y_{BA} = Y_3 = \frac{1}{Z_3}$$

Top impact streams A and B:

$$J_A = \dot{E}_1 Y_1; \quad J_B = \dot{E}_4 Y_4 + \dot{E}_5 Y_5$$

Applying Kirhoff's laws we have.

$$\begin{cases} Y_A \phi_A - Y_{AB} \phi_B = J_A \\ -Y_{BA} \phi_A + Y_B \phi_B = J_B \end{cases} \rightarrow [Y] * [\phi] = [J] \\ [J] \text{ With } [Y] = \begin{bmatrix} Y_A & -Y_{AB} \\ -Y_{BA} & Y_B \end{bmatrix}; [\phi] = \begin{bmatrix} \phi_A \\ \phi_B \end{bmatrix}; [J] = \begin{bmatrix} J_A \\ J_B \end{bmatrix} \\ \dot{I}_1 = \frac{\dot{E}_1 - \phi_A}{Z_1}; \dot{I}_2 = \frac{\phi_A}{Z_2}; \dot{I}_3 = \frac{\phi_A - \phi_B}{Z_3}; \dot{I}_4 = \frac{\dot{E}_4 - \phi_B}{Z_4}; \dot{I}_5 = \frac{\dot{E}_5 - \phi_B}{Z_5}$$

Writing programs on Maltlab software

```
>> z1=20;y1=1/z1;
>> z2=40*i;y2=1/z2;
>> z3=-20*i;y3=1/z3;
>> z4=10+20*i;y4=1/z4;
>> z5=16;y5=1/z5;
>> ya=y1+y2+y3
ya =
    0.0500 + 0.0250i
>> yb=y3+y4+y5
yb =
    0.0825 + 0.0100i
>> yab=y3
yab =
    0 + 0.0500i
>> Y=[ya -yab;-yab yb]
Y =
    0.0500 + 0.0250i    0 - 0.0500i
    0 - 0.0500i    0.0825 + 0.0100i
>> E1=160*exp(pi/6*i);
>> E4=100;E5=220;
>> Ja=E1*y1;Jb=E4*y4+E5*y5;
>> J=[Ja Jb]'
J =
    6.9282 - 4.0000i
    15.7500 + 4.0000i
>> dt=Y\J
dt =
    1.0e+02 *
    0.8418 + 0.4880i
    1.7088 + 0.7879i
>> dtA=dt(1)
dtA =
    84.1756 +48.7972i
>> dtB=dt(2)
dtB =
    1.7088e+02 + 7.8787e+01i
>> I1=(E1-dtA)*y1;I2=dtA*y2;I3=(dtA-
dtB)*y3;I4=(E4-dtB)*y4;I5=(E5-dtB)*y5;
>> figure;
>> t=linspace(0,2*pi);tsgoc=100*pi*t;
>> Imax1=abs(I1)*sqrt(2);Igc1=angle(I1)*180/pi;
>> Imax2=abs(I2)*sqrt(2);Igc2=angle(I2)*180/pi;
>> Imax3=abs(I3)*sqrt(2);Igc3=angle(I3)*180/pi;
>> Imax4=abs(I4)*sqrt(2);Igc4=angle(I4)*180/pi;
>> Imax5=abs(I5)*sqrt(2);Igc5=angle(I5)*180/pi;
```

```
>>i1=Imax1*sin(tsgoc+Igcoc1);
>>i2=Imax2*sin(tsgoc+Igcoc2);
>>i3=Imax3*sin(tsgoc+Igcoc3);
>>i4=Imax4*sin(tsgoc+Igcoc4);
>>i5=Imax5*sin(tsgoc+Igcoc5);
>>plot(tsgoc,i1,'r',tsgoc,i2,'g',tsgoc,i3,'k',tsgoc,i4,
'y',tsgoc,i5);
>>grid
```

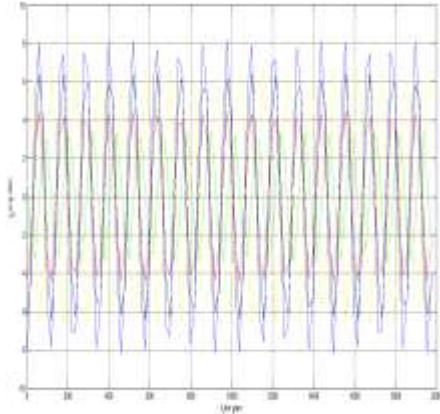
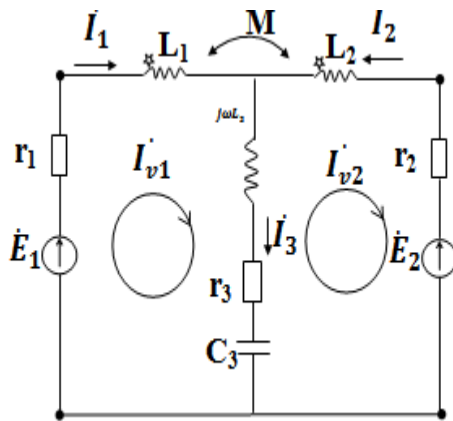


Figure 4- Characteristics of Currents

### 3.2.3. Circular Current Method

Example 4: Look for electric currents  $I_1, I_2, I_3 = ?$  in the following circuit:



Know the excitation voltage:  $\dot{E}_1 = 110e^{j0^0}(v)$ ;  $\dot{E}_2 = 220e^{j0^0}(v)$   
 $f=50(\text{Hz})$ ;  $r_1=200(\Omega)$ ;  $r_2=2.r_1$ ;  
 $r_3 = 100(\Omega)$ ;  $\omega L_1=10^3(\Omega)$ ;  $\omega L_2=4.10^3(\Omega)$ ;  
 $\omega L_3=200(\Omega)$ ;  $\omega M=2.10^3(\Omega)$ ;  $\frac{1}{\omega C_3} = 250(\Omega)$ .

Select currents flowing in two closed loops  $I_{v1}, I_{v2}$  there is dimension like the drawing  
 Applying Kirchoff's law 1 we have  $I_{v1} = I_1$ ;  $I_{v2} = I_2$ ;  
 $I_3 = I_{v1} - I_{v2}$   
 Applying Kirchoff's law 2 we have:

$$\begin{cases} (r_1 + j\omega L_1)I_{v1} + j\omega M I_{v2} + \left[ r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right) \right] \cdot (I_{v1} - I_{v2}) = \dot{E}_1 \\ +j\omega M I_{v1} + (r_2 + j\omega L_2)I_{v2} + \left[ r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right) \right] (I_{v2} - I_{v1}) = -\dot{E}_2 \end{cases}$$

$$\begin{cases} Z_1 I_{v1} + Z_M I_{v2} + Z_3 \cdot (I_{v1} - I_{v2}) = \dot{E}_1 \\ Z_M I_{v1} + Z_2 I_{v2} + Z_3 (I_{v2} - I_{v1}) = -\dot{E}_2 \end{cases}$$

$$\rightarrow \begin{cases} (Z_1 + Z_3)I_{v1} + (Z_M - Z_3)I_{v2} = \dot{E}_1 \\ (Z_M - Z_3)I_{v1} + (Z_2 + Z_3)I_{v2} = -\dot{E}_2 \end{cases}$$

$$\rightarrow [Z] * [I] = [E]$$

with  $[Z] = \begin{bmatrix} Z_1 + Z_3 & Z_M - Z_3 \\ Z_M - Z_3 & Z_2 + Z_3 \end{bmatrix}$ ;  $[I] =$

$$\begin{bmatrix} I_{v1} \\ I_{v2} \end{bmatrix}; [E] = \begin{bmatrix} \dot{E}_1 \\ -\dot{E}_2 \end{bmatrix}$$

$Z_1 = r_1 + j\omega L_1 = 200 + j10^3(\Omega)$ ;  $f = 50\text{Hz}$   $\rightarrow$   
 $\omega = 2\pi f = 100\pi \left(\frac{\text{rad}}{\text{s}}\right)$ ;

$Z_2 = r_2 + j\omega L_2 = 400 + j4.10^3(\Omega)$ ;

$Z_3 = r_3 + j\left(\omega L_3 - \frac{1}{\omega C_3}\right) =$

$100 + j(-50)(\Omega)$ ;  $Z_M = +j\omega M = +j2.10^3(\Omega)$ ;

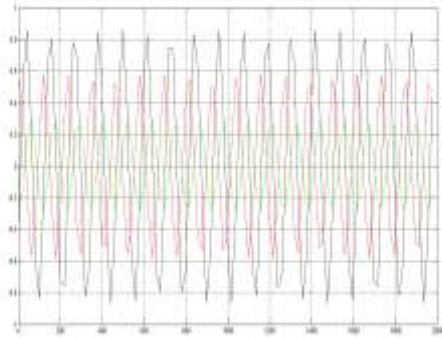
$\dot{E}_1 = 110e^{j0^0}(v)$ ;  $\dot{E}_2 = 220e^{j0^0}(v)$  ;

Writing programs on Maltlab software

```
>> z1=200+10^(3)*i;
>> z2=400+4*10^(3)*i;
>> z3=100-50*i;
>> zm=2*10^(3)*i;
>> Z=[z1+z3 zm-z3;zm-z3 z2+z3]
Z =
    1.0e+03 *
    0.3000 + 0.9500i -0.1000 + 2.0500i
    -0.1000 + 2.0500i  0.5000 + 3.9500i
>> E1=110;
>> E2=220;
>> E=[E1 -E2]'
E =
    110
   -220
>> Iv=Z\E//
Iv =
    0.3998 + 0.0980i
   -0.2011 - 0.0308i
>> I1=Iv(1)
I1 =
    0.3998 + 0.0980i
>> I2=Iv(2)
I2 =
   -0.2011 - 0.0308i
>> I3=Iv(1)-Iv(2)
I3 =
    0.6010 + 0.1288i
>> figure
>> t=linspace(0,2*pi);tsgoc=100*pi*t;
```



```
>>Imax1=abs(I1)*sqrt(2);Igc1=angle(I1)*180/pi;
>>Imax2=abs(I2)*sqrt(2);Igc2=angle(I2)*180/pi;
>>Imax3=abs(I3)*sqrt(2);Igc3=angle(I3)*180/pi;
>>i1=Imax1*sin(tsgoc+Igc1);
>>i2=Imax2*sin(tsgoc+Igc2);
>>i3=Imax3*sin(tsgoc+Igc3);
>>plot(tsgoc,i1,'r',tsgoc,i2,'g',tsgoc,i3,'k')
>>grid
```



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#### IV. CONCLUSION

The results of the application of the Matlab software to the survey and analysis of Kirchoff linear circuits in set mode have built mathematical models corresponding to the finite mathematics systems of state variables of time, built state equations, solved problems... and shortened time, computational effort and improved ability to self-learning, search, research the superiority of software. Besides, with the authors' self-studies and presentations in the above section, the applications of the Matlab software in solving specific technical issues are described for reference by faculty members and students.

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