MathCAD Tutorial

By Colorado State University Student:

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Power Electronic III

The first time I heard about the MathCAD software is in my analog circuit design class. Dr. Gary Robison suggested that I should apply a new tool such as MathCAD or MatLab to solve the design problem faster and cleaner. I decided to take his advice by trying to learn a new tool that may help me to solve any design and homework problem faster. But the semester was over before I have a chance to learn and understand the MathCAD software. This semester I have a chance to learn, understand and apply the MathCAD Tool to solve homework problem. I realized that the MathCAD tool does help me to solve the homework faster and cleaner. Therefore, in this paper, I will try my very best to explain to you the concept of the MathCAD tool. Here is the outline of the MathCAD tool that I will cover in this paper.

1. What is the MathCAD tool/program?
2. How to getting started Math cad
3. What version of MathCAD should you use?
4. How to open MathCAD file?
   a. How to set the equal sign or numeric operators
      - Perform summations, products, derivatives, integrals and Boolean operations
   b. Write a equation
   c. Plot the graph, name and find point on the graph
   d. Variables and units
      - Handle real, imaginary, and complex numbers with or without associated units.
   e. Set the matrices and vectors
      - Manipulate arrays and perform various linear algebra operations, such as finding eigenvalues and eigenvectors, and looking up values in arrays.
   f. Do the differential equation solvers
      - Support ordinary differential equations; systems of differential equations, and boundary value problems both at the command line and in solve blocks that use natural notation to specify the DiffEQs and constraints.
   g. Do Statistics and data analysis
      - Generate random numbers or histograms, fit data to built-in and general functions, interpolate data, and build probability distribution models.
5. Uses some home works solution to show how to used MathCAD.
6. Compare the MathCAD result to Pspice and MatLab results.

7. What Arithmetic toolbar?

8. How to find Arithmetic toolbar?

9. What is containing in Arithmetic tool bar?

10. What is calculus toolbar?

11. How to find calculus toolbar?

12. What is containing in the calculus tool bar?

13. What is automatic calculation?

14. How to solving equation

15. To evaluate power multiplication

16. Substitution

17. What is matrix toolbar?

18. How to find the matrix toolbar?

19. What the matrix toolbar contain?

20. Simple keyboard practice

21. Entering simple equation onto MathCAD page

22. Range variable

    a. The range

    b. The array

23. Graphics

24. Multiple line graph

25. How to evaluating mathematical expressions

26. How to do integrals

27. How to an equation with 2 variables

28. Explain some preliminary remarks on matrices

29. How to inserting images

30. Operating key

31. What is meaning of various equation

32. Define a math region

33. Define a text region

34. Order of calculation

35. Common problem encountered in MathCAD

Learning to use MathCAD is much like learning a foreign language. As such, you will become a master by using the software on a regular basis and little will be gained by simple reading the MathCAD user manual. When I was first introduced to MathCAD, I was told, "that a few moments with an experienced user are more beneficial than the several pages of explanation found in a tutorial." In hindsight, I totally agree with this statement.

MathCAD is a computer software program that allows you to enter and manipulate mathematical equations, perform calculations, analyze data, and plot data. This combination

makes MathCAD an invaluable tool to physical chemists, engineer and who combine physical science with mathematics to describe chemical phenomena. MathCAD can present both equation and numerical values in easy to read fashion. Math CAD uses a unique method to manipulate formulas, numbers, test and graph. MathCAD is a unique powerful way to work with equations, number, text and graph.

The version of MathCAD you use is depends on the type of computer you have and what you have available. However, Higher version may have some differences in how higher-powered features are performed. Check your manual for individual version different. At Colorado State University is provided a MathCAD 2001i professional version to all Engineering students. This version is install in the ENS server. Therefore, on this paper I only focus on the MathCAD 2001i professional version.

Here are two simple and easy ways to start MathCAD program:

1. Load the MathCAD software

   a.   s:\Application\MathCAD2001i\program files\MathSoft\\MathCAD2001i Professional.

   b.   Double click on mathcad.exe

   c.   Copy the MathCAD file by using a right mouse button drag and drop the MathCAD file and drop it into you u drive

2. Start the MathCAD software by clicking on the *engineering application* group in window and clicking on the *MathCAD 2001i professional* icon. After a few moments a blank worksheet should appear. The figure below is a blank worksheet.
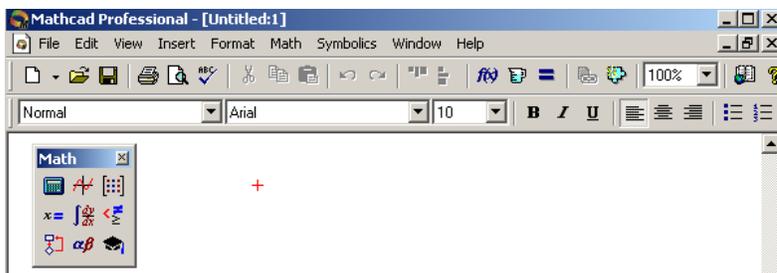

On your blank MathCAD worksheet, you will see a MathCAD toolbars or Math Palette. This Math palette contains all the subs toolbars or Math palette such as calculator or arithmetic,

Graph, Vector and matrix, Calculus, Evaluation palette, Boolean Palette, Programming Palette Greek Symbol Palette and Symbolic Keyword Palette. These toolbars are very helpful in the MathCAD calculation.   If you don't see these toolbars on your bank worksheet, then on your menu select view and then select toolbar. Figure below is shown all the toolbars on the MathCAD blank worksheet.

The MathCAD workspace is considerably different from most "spreadsheet style" data analysis program (like excel). Equations, data tables, graphs and descriptive text can all be combined in one MathCAD document, making this software particularly handy for application

development. The MathCAD software will help you analyze the results of experiments, work homework problem.

When you want to set the variable range or do some simply calculation of your homework or design, click on the calculator or arithmetic ![calculator button] button or from the menu select view then toolbar and then calculator, this window will appear.
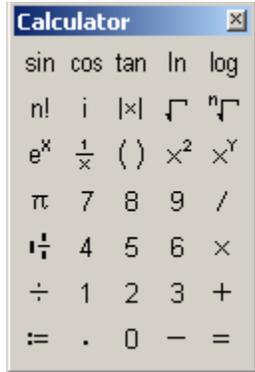
You want to plot a graph, click on graph ![graph button] button or select view then select toolbar and then select graph from the menu. A graph window will open.
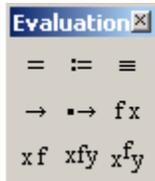

If you click on Matrix ![matrix button] button or select view then toolbar and then matrix from the menu, this window will open.

When you click on calculus ![calculus button] button or select view then toolbar and then calculus from the menu, this window will open.
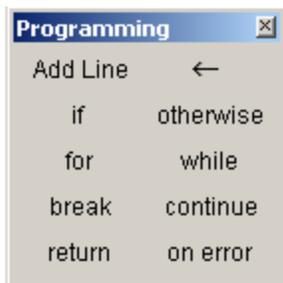
When you click on the Evaluation palette $x=$ button or select view then toolbar and then evaluation from the menu, this window will open.

When you click on the Boolean Palette button or select view then toolbar and then Boolean from the menu, this window will open.

When you click on programming palette button or select view then toolbar and then programming from the menu, this window will open.

When you click on the Greek Symbol Palette button or select view then toolbar and then Greek from the menu, this window will open.

When you click on the Symbolic Keyword Palette button or select view then toolbar and then symbolic from the menu, this window will open.
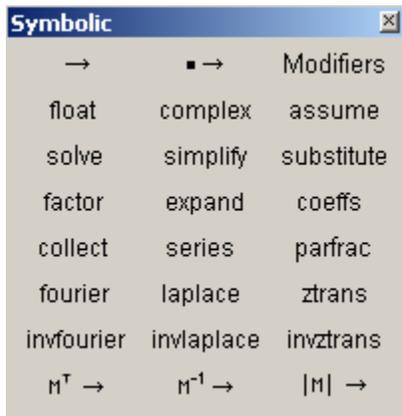
If you don't like to use the mouse to click every button on the MathCAD worksheet. Here are some useful commands that you can apply:

From your key board and toolbar:

Definition: shift + semi colon,   :=

n Factorial: n+shift +1,   n!

Mixed number: Ctrl +shift ++,

Pi: ctrl+shift+p

Inline divided: ctrl+/

Raise power: shift +6

Absolute value: shift + \

Square root: \

Nth root: ctrl+\

Derivative: shift +/

Nth derivative: ctrl+shift +/

Infinity: ctrl+shift + z

Definite integral: shift+7

Summation: ctrl+shift+4

Iterated product: ctrl+shift+3

Indefinite integral: ctrl +I

Range variable summation: shift+4

Range variable iterated product: shift+3

Two-side limit: ctrl +L

Limit from above: ctrl + shift +A

Limit from below: ctrl +shift + B

X-Y plot: shift +2

Polar plot: ctrl+7

Surface plot: ctrl+2

Contour plot, 3 D bar plot, 3D scatter: ctrl+5

Equal to: ctrl+=

Less than or equal to: ctrl+9

Greater than or equal to: ctrl+0

Not equal to: ctrl+3

Not: ctrl + shift +1

And: ctrl+shift+7

Or: ctrl+shift+6

Exclusive or (XOR): ctrl+shift+5

A MathCAD worksheet can rapidly run into a confusing jumble of mathematical gibberish, especially after several sequential expressions have been entered. For this reason, it is wise to annotate your worksheet with descriptive text. Entering text in a document is easy. Simply click on a blank region of the worksheet and start typing a sentence. For example, click and type " this is buck converter" As soon as you push the space bar after the word "this", MathCAD shift into text mode. If you wish to edit text that has already been entered, simply

click and highlight the text, go to the appropriate pull-down menu along the top of the MathCAD window and you can adjust the front type, size, color and so on. The figure below is example of entering text document into MathCAD.
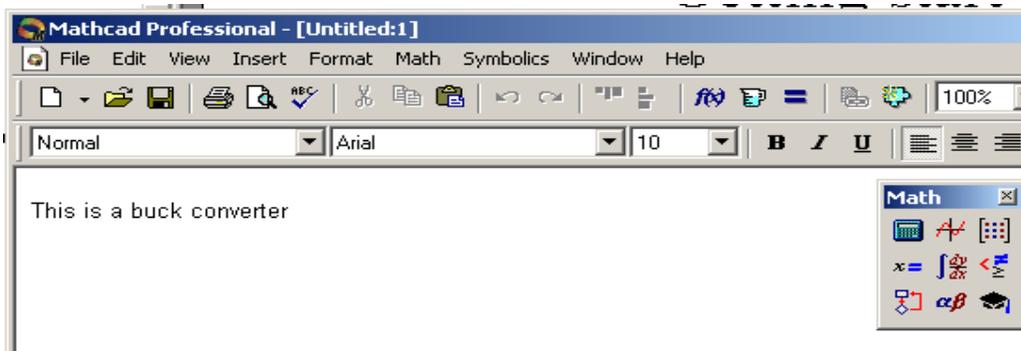
Text may be moved around in a worksheet in the following way. Move the mouse cursor near where you typed your sentences. Click and hold the left mouse and drag the mouse cursor towards your sentences; a dotted box will surround the text. Release the left mouse button. Move the mouse cursor along the right edge of the dotted box, the cursor turns into a small hand. When the cursor appears as a hand, click the left mouse button, hold it down, and drag the text block to its new location. From the menu, you can position the mouse cursor over the text and right click the mouse to activate the cut, copy and pate, ect. You can superscript/subscript text in this way.

Variables are easily defined in MathCAD. If you want to set x equal to 10, then type "$x{:}10$". When you type the colon symbol "$:$", you will actually see "$:=$" on the screen. Or uses $:=$ button on the calculator. MathCAD interprets this symbol as " set the variable to the left equal to the quantity on the right." Here is the example of x=10.

$$x := 10$$

Now type "$y{:}x{\wedge}2{\#}{-}7$" (remember that the # symbol actually means to push the spacebar). This expression defines another variable (y) in terms of our original variable (x). Then type "$y{=}$" to see the numerical value of y (when $x{=}\ 10$).

Click on the previously type expressions *"x:10"* and edit it so that *x* equal to 20. After pressing enter, you should observe that MathCAD automatically re-evaluates the value of y. MathCAD evaluates expressions from top to bottom and from left to right on the automatically re-evaluate the rest of the worksheet. This is an extraordinarily powerful ability of MathCAD that you will soon appreciate.

A range is special type of assignment equation. Instead of assigning a single value to x, we are assigning a whole set f values.

Keyboard: typing a semicolon ";"

$$x := 0, .5 .. 2$$

Create these tables: just type x=, f (x)=

x =

0
0.5
1
1.5
2

To evaluate a numerical answer for a definite integral, open the calculus toolbar and click on the definite integral symbol. Clicking this produces an integral sign with placeholders for the upper and lower limits, the function, and the integration variable. Fill in these placeholders so that you evaluate the following integral:

$$\int_0^2 e^{-x^2} dx = 0.882$$

To defining an array of numbers (range variables), assign a range of values to a variable is straightforward in MathCAD. For example, to create a variable x that runs from 0 to 5
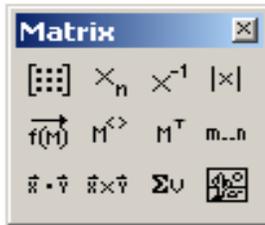
1.   Click to position the red crosshair in some free space

2.   Type x: 0; 5

3.   After clicking away, you will see

$$x := 0..5$$

When you type the semicolon character ';' it display on the screen as 2 dots (..) followed by a placeholder. This is MathCAD's range variable operator.

Another way to put the range variable operator in your worksheet is with the Range variable button.

1.   Matrix palette

2.   Click on   m..n

Use a range variable as you would any other variable. Create a output table, by type x=

x =

0
1
2
3
4
5

Suppose you wanted to calculate the value of the function y=2x at several different value of x. enter the following expression into your worksheet:

Step 1:   type "i:0; 9"   produces: $i := 0..9$

Step 2:   type "x [i#: 2*i"   Produces: $x_i := 2*i$

Step 3:   type "y [i#: 2*x [i#^2"   Produces: $y_i : 2*(x_i)^2$

Here are the steps how to set range variable in MathCAD

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Step 1: sets *i* equal to a range of integers (from 0 to 9). Notice how giving the original number, pressing the semicolon and then giving the final number define the range. If you instead wanted a range such as 0, 2,4 6,8,10, you would Type "i:0, 2; 10" where the 2 tells MathCAD to change the value of i by steps of 2. The expression typed in step 1 de3fines what is sometimes called a *Range Variable* of *Step Variable.* Step variable are often defined to contain a sequence of integers so that it can be used to index the elements of other arrays, like the one defined in step 2.

Step 2: define an array of numbers equal to times the index number (i.e. xo=0, x1=2, x3=4,…). Notice how the left bracket '[' allow you to generate subscripts and pushing the spacebar returns you to a regular script.

Step 3: works similar to step2 and defines a range of y values in terms of the range of x values. To see the range variables i, x, and y in their entirely, simply type "i=" an 'y=', respectively.

A matrix is a collection of mathematical elements, arranged in rows in columns. The elements of a matrix can be simple numbers, or mathematical expressions. If you have ever taken linear algebra, then you know that matrices are powerful tools. The elements of matrix can be simple numbers or mathematical expressions.

Here are three examples of matrices:

$$A := \begin{bmatrix} 1.1 \\ 3.7 \\ 8.2 \\ 11.4 \end{bmatrix} \qquad B := \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \qquad C := \begin{bmatrix} \cos(x) & 0 & 1 \\ 0 & \sin(x) & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

The first matrix, **A**, is a 4×1 matrix (contains 4 rows and 1 column of elements). Matrices **B** and **C** have dimensions of 2×2 and 3×3, respectively. Matrices that only contain one column (like **A**) are often called *vectors* (or you may call them *arrays*).

Here are the steps how to enter the matrix

Click on 3 by 3 matrix icon in the vector and matrix palette

Menu: insert/matrix

Keyboard: CTRL+M

Choose the number of rows and columns

Fill in the placeholders

To find the determinant:

Keyboard: shift+ vertical bar "|" or

Use the button on the vector and matrix palette.

$$A := \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 7 \\ 9 & 10 & 12 \end{pmatrix}$$

$$B := \begin{pmatrix} 0 & 1 & 4 \\ 4 & 5 & 2 \\ 0 & 1 & 0 \end{pmatrix}$$

$$A + B = \begin{pmatrix} 1 & 3 & 7 \\ 8 & 10 & 9 \\ 9 & 11 & 12 \end{pmatrix}$$

To access a particular element of a vector:

Use the subscript operator, typing a left square bracket "["

$$i := 0 .. 1$$

$$x_i := i$$

$$x_i =$$

0
1

We will often use vectors and matrices to hold and manipulate experimental data. Suppose you perform an experiment, measuring the pressure of one mole of nitrogen gas at four temperatures, obtaining 1.2, 2.5, 3.6, and 4.7 atm at 50, 100, 150, and 200 Kelvin, respectively. Enter these data in a fresh MathCAD worksheet as follows; the *Vector and Matrix Toolbar* will assist you.

$$\text{pressure} := \begin{bmatrix} 1.2 \\ 2.5 \\ 3.6 \\ 4.7 \end{bmatrix} \qquad \text{temperature} := \begin{bmatrix} 50 \\ 100 \\ 150 \\ 200 \end{bmatrix}$$

$$N := \text{rows}(\text{pressure})$$

$$i := 0 .. N - 1$$

$$\text{volume}_i := \frac{1 \cdot 0.0821 \cdot \text{temperature}_i}{\text{pressure}_i} \qquad \text{volume} = \begin{bmatrix} 3.421 \\ 3.284 \\ 3.421 \\ 3.494 \end{bmatrix}$$

The first two expressions define vectors containing the pressure and temperature data. The next statement uses the MathCAD function *rows ()* in order to determine the number of rows in vector *pressure*, which is set equal to *N*. The value of *N-1* defines the upper limit of a range variable *i*, which is used to index the elements of the *pressure* and *temperature* vectors in the last statement. The last statement calculates the volume (in liters) according to the ideal gas law ($V=nRT/P$), where $n = 1$ mol and $R = 0.0821$ atm L mol^{-1} K^{-1}. This example from reference [2].

Occasions will arise when an x-y data set will already exist, stored as a text document on the hard-drive of your computer. How does one import this data into MathCAD for analysis? For example, the last CY351 experiment scheduled for this fall involves using a computer apparatus to measure the conductivity of a solution as a function of time. The raw data is stored as a file on the computer (the file consists of two columns of numbers; column one contains the time data and column two the conductivity data). Let us suppose that the filename is called *sampledata.txt*. The following MathCAD expressions allow you to import this data file, and then define vectors containing the *x* and *y* data:

$$\text{DATA} := \text{READPRN}(\text{"sampledata.txt"})$$

Imports the file "sampledata.txt" and sets it equal to the two column matrix DATA.

$$x := \text{DATA}^{(0)}$$

$$y := \text{DATA}^{(1)}$$

The first column of the matrix DATA (containing the x values) is set equal to an array x. Similarly, an array containing the y values is defined from the second column of matrix DATA.

Data can also be exported from MathCAD by using the *WRITEPRN ("filename")* command. This feature can be useful for exporting numerical data to other data analysis programs like Excel. This example is from reference [3].

Equations can be typed into document, just as they would appear in your textbook. These equations can be manipulated (rearranged, differentiated, integrated) with the click of the mouse and ultimately solved to yield a numerical answer. If you desire, you can plot the equation as a function of one or more independent variables.

Suppose you want to write an equation of current of a circuit on your blank worksheet. Click any where on blank worksheet and typing I:V/R, you will see on the MathCAD worksheet

$$ I := \frac{V}{R} $$

MathCAD is capable of generating several different types of plots (*x-y* plots, bar graphs, 3D plots, surface plots, ...). We will concentrate here on simple *x-y* line plots.

How do you do the plot *y vs. x*?

Click on a blank place in the worksheet (below the expressions for x and y), then click on the *Graph Toolbar* icon and select XY Plot or form the menu select insert and select X-Y plot. Figure below is shown how to plot a graph in MathCAD software.

A blank graph should appear in the worksheet.
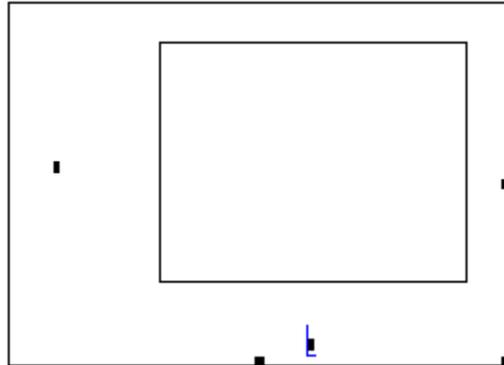
Small black boxes should be located near the center of the left vertical axis and the lower horizontal axis. Click on the vertical axis box and type "y". Click on the horizontal axis box and type "x". After pushing enters, a plot of *y* vs. *x* should appear. Plots are easily edited by clicking on the appropriate part of the graph. For example, clicking on the axis, clicking on the upper limit value, and changing it can alter the upper limit on the vertical axis. Double clicking on the center of the plot brings up a window that allows you to adjust numerous parameters.

Suppose you have a RLC circuit as shown below, you want to calculate and plot the transfer function of this circuit by suing MathCAD software. First, you must set all variable given values such as Vg, L, C, and R. Second, you must given the transfer function of RLC circuit to the MathCAD software. Unlike Pspice program, MathCAD can't simulation your circuit and give you a plot of the transfer function of your RLC circuit. Because MathCAD only a tool that help you to calculate and plot transfer function which you provided the values and equation of your circuit to the program.
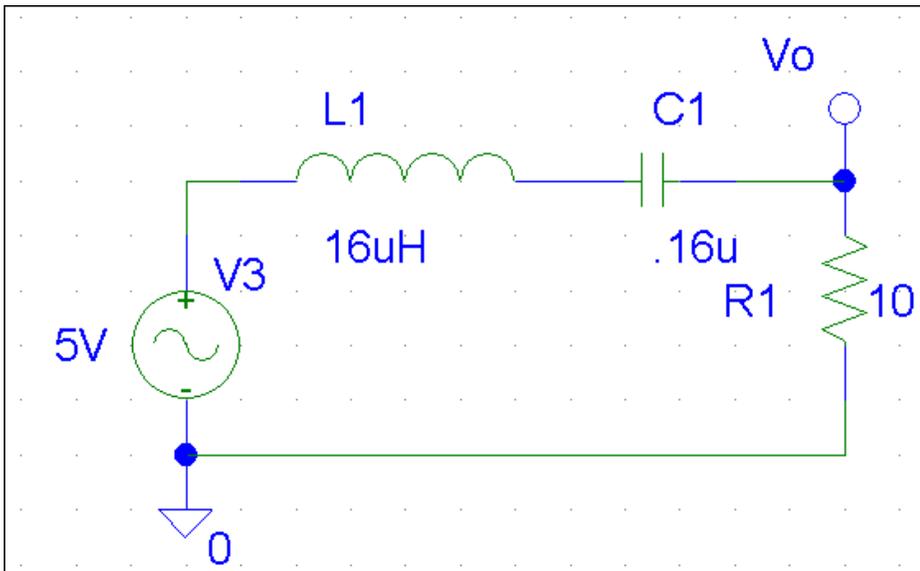
To Plots the transfer function of this circuit in MathCAD software, here is how you do it

Set all variable that given in the circuit:

Type Vg:5*V, on your mathcad worksheet you will see

$Vg := 5 \cdot V$

Type fs:100*kHz, on your MathCAD worksheet you will see

$fs := 100 \cdot kHz$

Type C:0.16* then click on th unit icon, then select the 'Capacitance' Then select microfarad. On your worksheet you will see.

$C := 0.16 \cdot \mu F$

$L := 16 \cdot \mu H$

$Rnominal := 10$

$Z := 10 \qquad j := \sqrt{-1}$

$R := \dfrac{8}{\pi^2} \cdot Rnominal$

Calculate the radian frequency of the RLC circuit
To get the omega symbol, click on the greek icon and click on omega symbol
type ω_0 : 1+/+\ and then L*C

$$\omega 0 := \dfrac{1}{\sqrt{L \cdot C}} \qquad\qquad \omega 0 = 6.25 \times 10^5 \, s^{-1}$$

Calculate the ouput resistor of the RLC circuit.
Type Ro : \ and then L/C

$$Ro := \sqrt{\dfrac{L}{C}}$$

Set the range of the omega that where it start, next and end value, click on the greek icon and click on omega symbol

type ω:100, 1000 ; 10*10^7, on your mathcad worksheet you will see

$$\omega := 100, 1000 .. 10 \cdot 10^7$$

Type the equation of your transfer function, this function will give you a plot which depend on omega, so you must put the omega sa a function of the transfer function

$$H(\omega) := \dfrac{R}{R + j \cdot \omega \cdot L + \dfrac{1}{j \cdot \omega \cdot C}}$$

Below your transfer function, click on the graph icon and select X-Y plot. At the placeholder on x-axis type omega and y-axis type the transfer function of your circuit. Because the transfer function has imaginary value, so you must take the absolute value of the function otherwise you don't see any graph on your plot. Here is the graph of your transfer function.

transfer function for series resonant
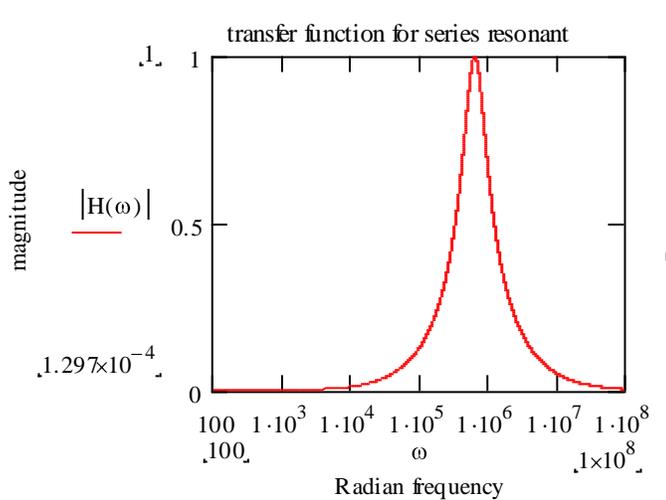
To checks or compare your calculation/estimate solution of RLC series resonant inverter circuit. You can use the Pspice software tool to run simulation of your circuit. This can done by simply design a RLC series resonant inverter circuit on the Pspice schematic, save and run simulation of the circuit. The Pspice will give you a graph of the transfer function of your circuit. Figure below is the Pspice result of RLC series resonant inverter circuit.
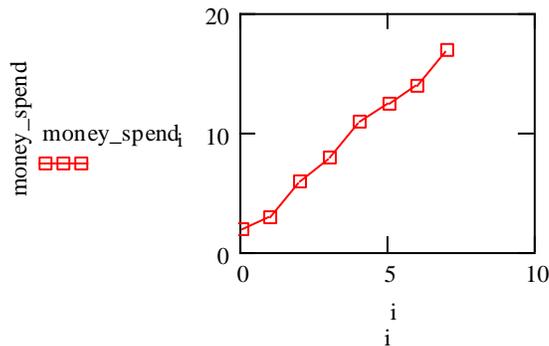

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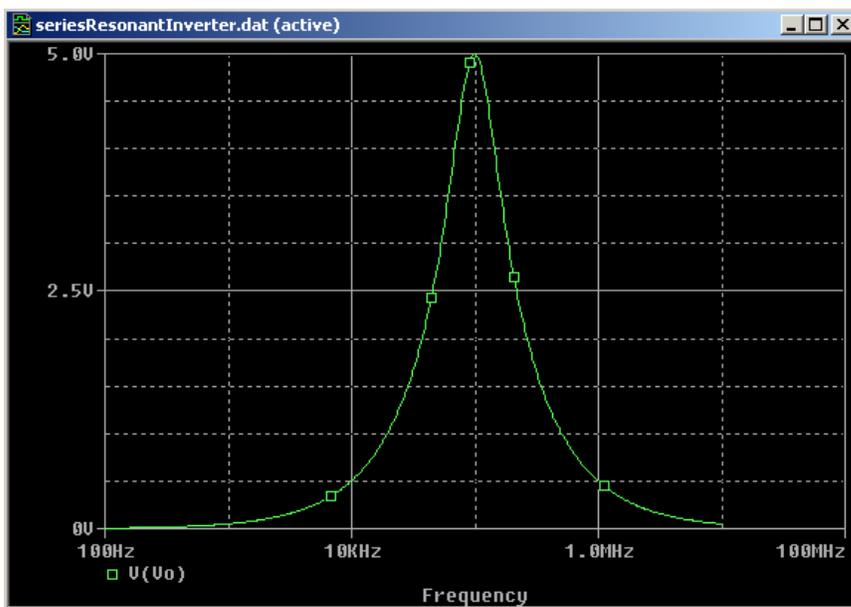
To plot the data point, on the horizontal axis must be an index variable into variable function or another vector with the same number of element. For Example:

$$\text{money\_spend} := \begin{pmatrix} 2 \\ 3 \\ 6 \\ 8 \\ 11 \\ 12.5 \\ 14 \\ 17 \end{pmatrix}$$

$$i := 0..7$$

$\text{money\_spend}_i =$

2
3
6
8
11
12.5
14
17

MathCAD can also be used to prepare multiple lines graph. Type the expression you want to plot in the middle placeholders on the x and y-axis. Type expressions on the y-axis only and MathCAD will choose a default range for you automatically on x-axis. Enter several expression separated by a comma (,) in theses axes placeholders to see multiple traces

The Placeholders is a small black box in a math region is a 'placeholder.' The placeholder indicates that the mathematical expression or plot is incomplete. To complete it, you need to put something appropriate in the placeholder. To fill the placeholder, click on it and begin typing.

$$a + (b + \blacksquare)^c$$

placeholder
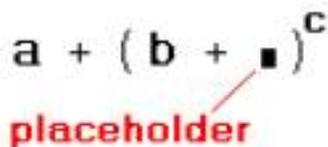
To Label and trace the graph. Double click on plot box, a window with several tabs will appear
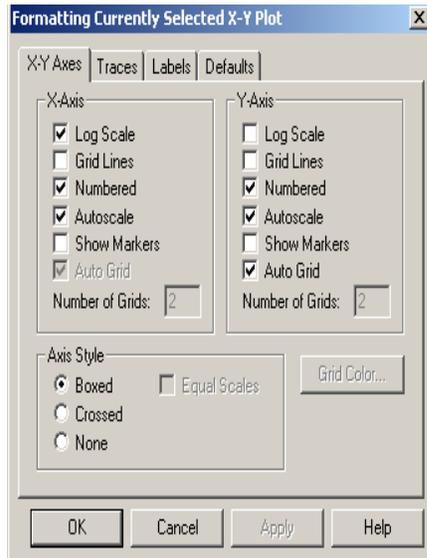
Select **TRACES**. You will see a list of several traces

     Click on the **trace 1** which will be the first function of your plot

     Click on the **arrow** beside the colors on the bottom of the window and select one. Now

     click **OK**
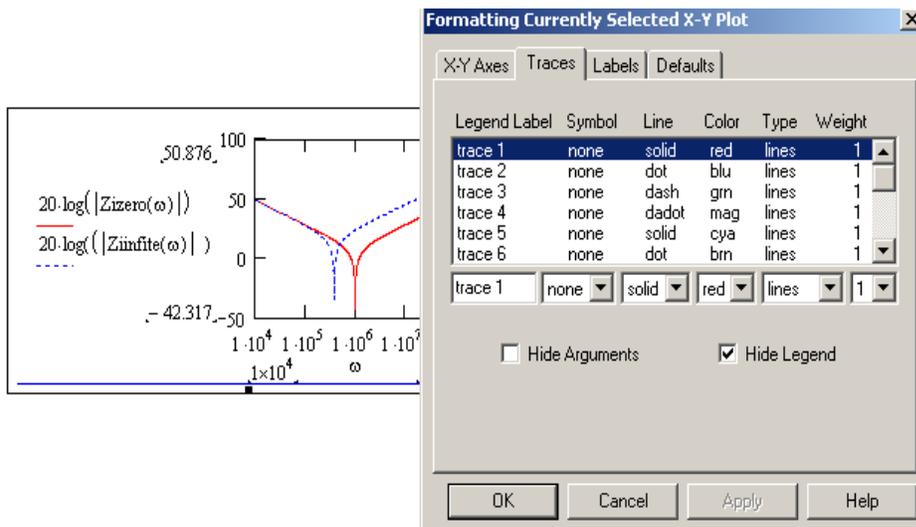
Select label, you will see the window with title and Axis Labels.   To see the title of your plot, on the title window, type the title of your plot and select show title. On your X-Axis typing the variable of the function of your graph and y-axis labels the function of your graph.

Formatting Currently Selected X-Y Plot

X-Y Axes | Traces | **Labels** | Defaults

Title
bode plots
◉ Above ○ Below ☑ Show Title

Axis Labels
X-Axis: ☑ radianfrequency
Y-Axis: ☑ magnitude (dB)

OK Cancel Apply Help
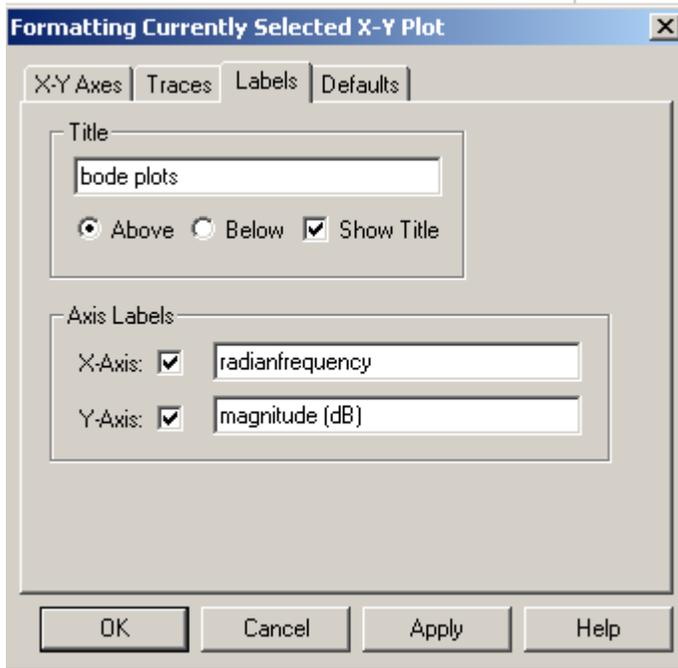
To find the point on your graph, on your plot box select show markers. Once you select *show markers* on either x or axis then your graph will appear 2 placeholders. Now click on the placeholder and type the point you wish to find on the graph.

Suppose you want to plot impedance output of the LLC inverter circuit as show below. Again define all given variable values of the LLC inverter circuit. Also define the range of the variable of your function that you want to plot your graph. The most important is type the impedance output equation of LLC circuit. The Steps below are shown how to plot the LLC inverter circuit and also shown how the multiple lines graph.

$$\text{fs} := 100 \cdot 10^3$$

$$C := 0.4 \cdot 10^{-6}$$

$$\text{Ls} := 2.5 \cdot 10^{-6}$$

$$\text{Lp} := 15 \cdot 10^{-6}$$

$$n := 3$$

$$\text{Vg} := 12$$
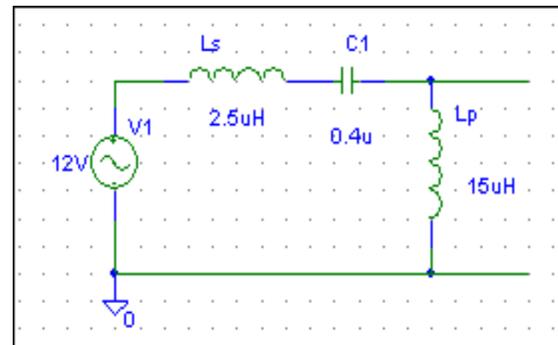
$$\omega := 1 \cdot 10^4, 1 \cdot 10^{4.2} .. 2 \cdot 10^7$$

$$\text{Zizero}\left(\omega\right) := \frac{1}{j \cdot \omega \cdot C} + j \cdot \omega \cdot \text{Ls}$$

$$\text{Ziinfite}\left(\omega\right) := \frac{1}{j \cdot \omega \cdot C} + j \cdot \omega \cdot (\text{Ls} + \text{Lp})$$

$$\text{atan}\left(\text{Zi0}\right) = -90 - 25.323i\text{deg}$$

$$\text{atan}\left(\text{Ziinf}\right) = 90 + 8.222i\text{deg}$$

bode diagram
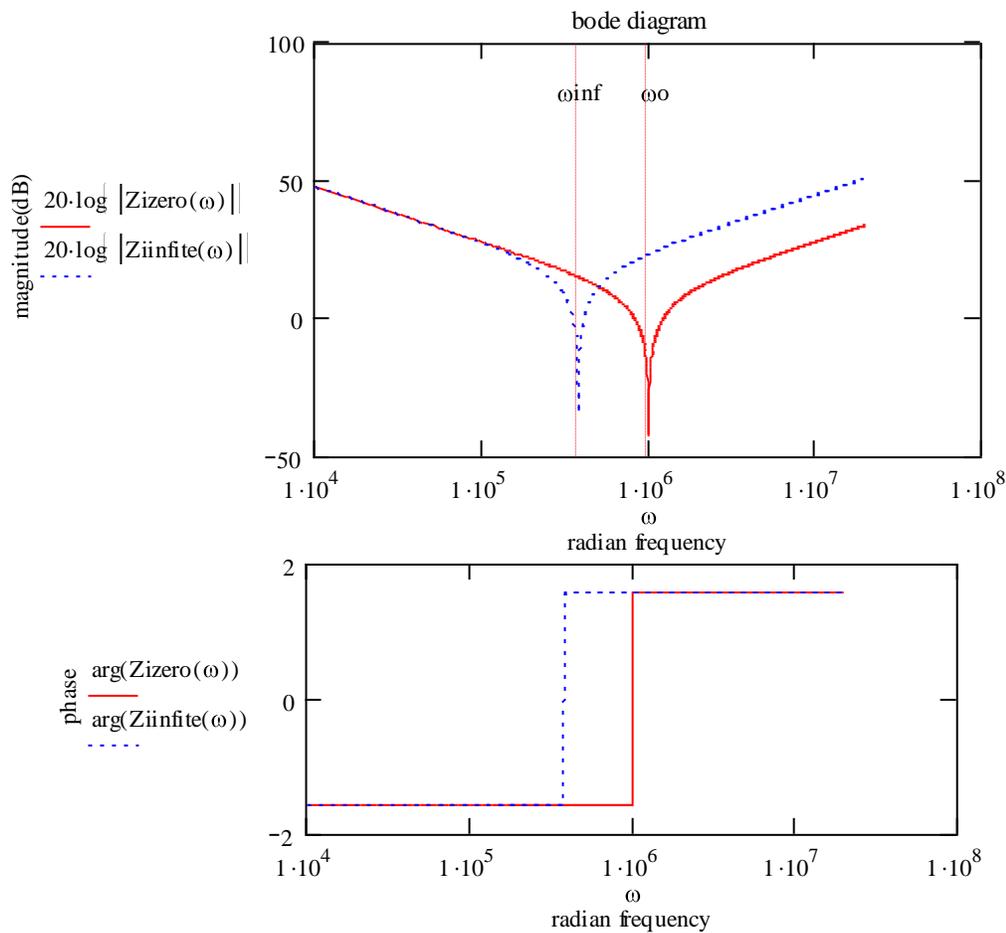
There is small problem with MathCAD software, which it might not able to plot the graph in the degree. MathCAD can give calculation answer in degree but it only can plot from Pi to –Pi or radian value. This is one of the disadvantages of the MathCAD software over the MATLAB program. MATLAB can plot graph in the degree value. Figure below is result of the MATLAB plot. As you can see the curve and results of both MathCAD and MATLAB solution are the same, however, the MATLAB show that the graph can go from –90 degree to 90 degree and MathCAD show the graph in the radian values.
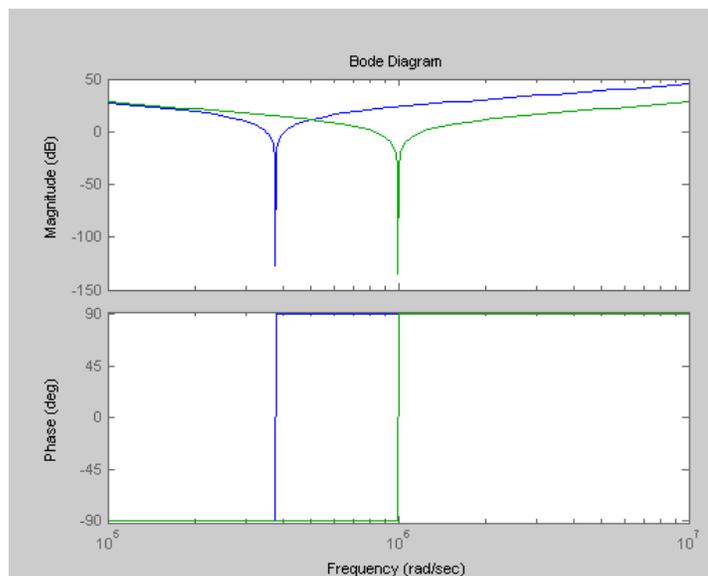
MathCAD recognizes most of the common scientific units (i.e. units for energy, time, distance, volume, so forth...). While we can sometimes carry out MathCAD calculations without including the units, it will often be necessary (and useful) to include the units in your calculations. To accomplish this, you must be careful how you define the units when typing an expression in a worksheet (MathCAD will only recognize the unit if you spell it correctly, or use the appropriate abbreviation). To see the correct spelling and abbreviation of the unit names, you can go to the pull-down *Insert* menu and select *Unit* or from your toolbar click 🖹 icon.

This opens a window in which the current system of units is identified and you can scroll through a menu to find the proper spelling/abbreviation.
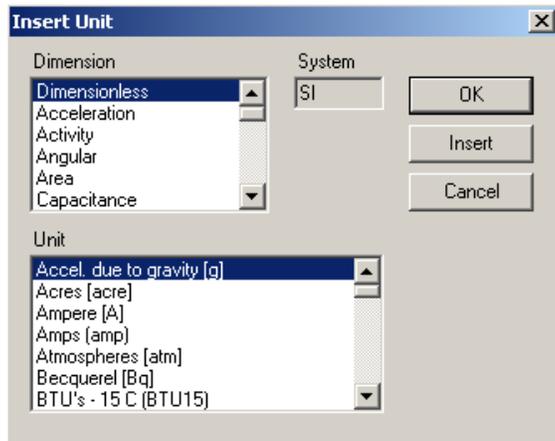
Before you begin, you must select a unit system (i.e. SI, mks, cgs, ...). The default unit system is the SI system (this can be changed by going to the *Math/Options* menu). Recall that the SI system (and the mks system) utilizes the fundamental units meter (*m*), kilogram (*kg*), second (*s*), Kelvin (*K*), mole (*mole*), and so forth. All other units are defined in terms of these fundamental units. For example, volume is defined in cubic meters (m^3), energy (*joule*) is defined in terms of kilograms, meters, and seconds, and pressure (*Pa*) is also related to some combination of kilograms, meters, and seconds.

To use the mks system, go to the *Math/Options* menu and change the unit system to mks. As a result, MathCAD will perform calculations and report answers in the following units

Fundamental Quantity	*mks unit (proper syntax to use in MathCAD)*
time	seconds (sec)
mass	kilogram (kg)
length	meter (m)
temperature	Kelvin (K)
mole	mole (mole)
charge	coulomb (coul)

	Derived Quantity	mks unit (proper syntax to use in MathCAD)

energy   Joule (joule)

volume   cubic meter (m^3)

pressure   Pascal (Pa)

After selecting the mks unit system, MathCAD will also recognize a number of other common chemical and physic units. However, MathCAD will not report answers in these units unless you ask.

	Additional units	mks unit (proper syntax to use in MathCAD)

pressure   atmosphere (atm)

                                  Torr (torr)

volume   Liter (liter)

                                  milliliters (mL)

energy   Ergs (erg)

                                  International Calorie (cal)

                                  Kilocalorie (kcal)

Suppose you want to area of the circle with the radius of 10000 meter. Then type radius equal to 10 *km and type the equation to calculate the area of the circle. MathCAD calculated the area of the circuit and give the answer with the unit in meter squares as show below.

$$r := 10 \cdot km$$

$$A(r) := \pi \cdot r^2$$

$$A(r) = 3.142 \times 10^8 \, m^2$$

If you want to calculate a circuit with carry out the electrical unit, then type a define variable as normal but at the end of the value type multiply the unit of that suitable to the given variable in the circuit.   For example: current has unit of ampere (A).   Here is an example of how to include units when calculating the circuit. Enter the following expressions in a fresh MathCAD worksheet; only define quantities in terms of fundamental SI units:

$$\mathbf{I} := 1\mathbf{A}$$

$$\mathbf{R} := 10\Omega$$

$$\mathbf{V(R)} := \mathbf{I} \cdot \mathbf{R}$$

$$\mathbf{V(R)} = 10\,\mathbf{V}$$

Notice how the units are attached to the numerical value of each variable by using the multiplication symbol (*). The resultant voltage shown above is reported in units of Volts

One of MathCAD's best features is the easy way in which it handles Symbolic calculation. MathCAD can add two functions and display the results. Symbolic equation can solve equation one variable in MathCAD program. *MathCAD* that you want to perform a symbolic calculation, use the "live symbolic" operator -- which you can think of as the "symbolic equals" sign.   Use the arrow on the **Symbolic** tool bar or hold down the control key and press the period key.

To do the symbolic equation, following these steps

  –Ctrl+=, see a bold equal sign

  –Menu: Symbolic/Variable/Solve

  –Menu: symbolic/simplify/ expand or factors
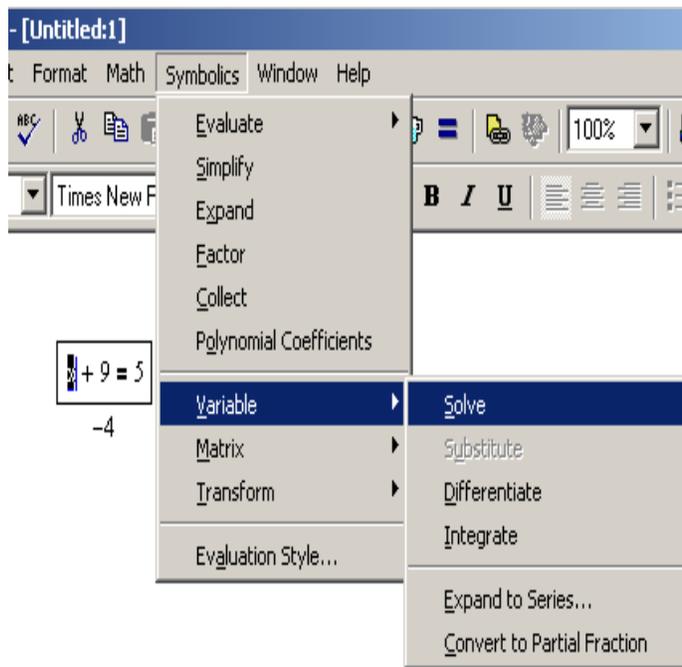
–Example:

$$f(x) := 3x^2 - 5x + 1$$

$$g(x) := x^2 + 2 \cdot x$$

⎯⎯Type f (x)+g (x) ctrl+., you will see

$$f(x) + g(x) \to 4 \cdot x^2 - 3 \cdot x + 1$$

If you want to do factors and displays the answer.   You must use the symbolic key word **factor** along with the symbolic equals sign.

$$x^2 - 9$$

Example:

$$x^2 - 9$$

Type   ctrl +. +Factor

You will see

$$x^2 - 9 \to x^2 - 9$$

$$(x - 3) \cdot (x + 3)$$

The syntax used to define a function in MathCAD is the same way as you see in textbooks.

−Type f (x) Shift+':'x^2 see on screen

$$f(x) := x^2$$

−Can include any of MathCAD's built in function

   •Menu: insert/function

   •Keyboard: Ctrl +E

   •Toolbar:
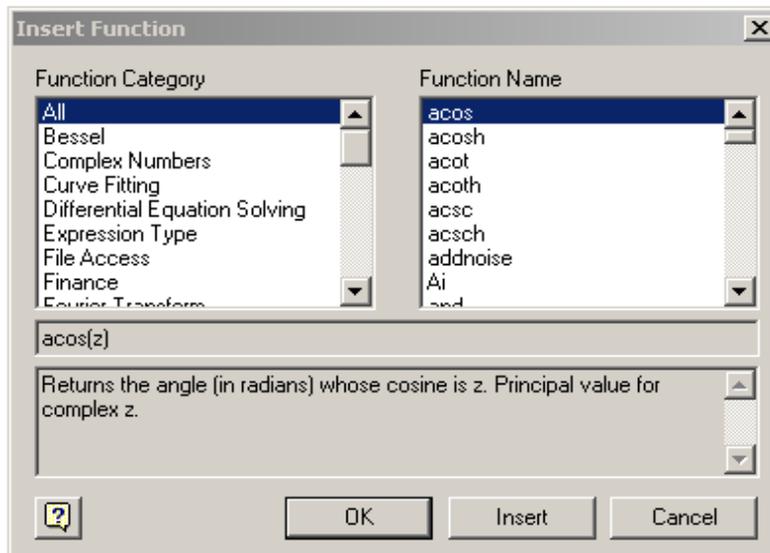
Example:

$$z := 2$$

$$acos\ (z) = 1.317i$$

Programs make it easy to do tasks that may be impossible or very inconvenient to do in any other way. This is because a program has many attributes associated with programming languages including conditional branching, looping constructs, local scoping of variables, error

handling, and the ability to call itself recursively. A program is simply an expression made up of more than one statement (available in Mathad Professional only). If you click on the examples below, you'll see how they look when written as a program rather than as a single expression.

$$f(x, w) := \log\left(\frac{x}{w}\right)$$

Despite the equivalence between programs and simple expressions, programs offer two distinct advantages:

1. When you use control structures like loops and conditional branches, a program can become far more flexible than a simple expression could ever be.
2. A program made of several simple steps is often much easier to create than an equivalent, but far more complicated expression draped with parentheses.

Defining a program (MathCAD Professional only)

To following steps illustrate how to define a the program

1. Type the left side of a function definition followed by the assignment operator ":".
2. Click on the Math toolbar to open the Programming toolbar containing the programming operators.

Programming	☒
Add Line	←
if	otherwise
for	while
break	continue
return	on error
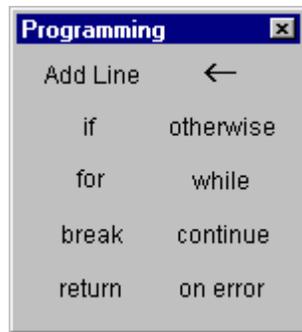
3. Click the "*Add Line*" button or press "]". This create a vertical bar

$$f(x, w) := \Big|\ \blacksquare$$

With a place holder for an additional program statement (a program can have any number of the statements.)

4. Click on the top placeholder, type 'z' and click on the *local assignment button*. ←

(Be aware that the definition of z is local to the program. It is undefined outside the program and has no effect anywhere but inside the program. You cannot use the MathCAD's usual assignment operator ":=", inside a program. You must use the local assignment operator represented by "<-".)

5. Complete the local assignment by typing "*x/w*" in the placeholder to the arrow's right. The last placeholder should always contain the value returned by the program. Type "*log (z)*" into this placeholder.

You can now use this function just as would any other function or evaluate it symbolically.

$$f(x, w) := \left| \begin{array}{l} z \leftarrow \dfrac{x}{w} \\ \log(z) \end{array} \right.$$

$$f(10, 2) = 0.699$$

Conditional statements (MathCAD Professional only)

Use a conditional statement whenever you want a program statement to execute only upon the occurrence of some condition as in the following program

To insert a conditional statement:

1. Click on the placeholder into which you want to place the condition statement
2. Click on the Math toolbar to open the programming toolbar containing the programming operators
3. Click the "*if*" button or press shift+]. Do not just type the word "if".
4. In the right placeholder, type a *Boolean* expression.
5. Click the *Add Line* button to insert placeholder for additional statements if necessary.
6. Click in the remaining placeholder and click the "*otherwise*" button. Do not just type the word "otherwise".

7. In the remaining placeholder type the value you want the program to return if the condition is false.

8. Example:

$$f(x) := \begin{cases} 0 & \text{if } |x| > 1 \\ \sqrt{1 - x^2} & \text{otherwise} \end{cases}$$

Test the value of x, x=2 which is bigger than 1 the answer will be 0

$$f(2) = 0$$

test value of x, x=.5 which is smaller than 1 the answer will be $\sqrt{1 - x^2}$

$$f\left(\frac{1}{2}\right) = 0.866$$

Note: If you use more than one "if" statement before an "otherwise" statement, the "otherwise" statement is executed only when all the conditions are false.

Program loops

A loop is a program statement that causes one or more statements (the body of the loop) to execute repeatedly until a particular condition occurs. There are two kinds of loops:

- "For" loops are useful when you know exactly how many times the body of the loop should execute.
- "While" loops are useful when you want to stop execution upon the occurrence of a condition but you don't know exactly when that condition will occur.

When using loops, you may need to break out of them or control particular iterations.

"FOR" LOOPS

Use a "for" loop when you know exactly how many times you want the body of the loop to execute.

To insert a "for" loop

1. Click in the placeholder into which you want to place the *"for"* loop.
2. Click on the *Math toolbar* to open the programming toolbar containing the programming operator
3. Click on the "*for*" button or press Ctrl +. Do not just type word for.

4. In the placeholder to the left of the *"e"* enter the iteration variable.

5. In the placeholder to the right of the *"e"*, enter the range of values to be taken by the iteration variable (although you will most often use a range variable here, you can also use a vector, a list of scalars and vectors separated by comma).

6. Click the *Add Line* button to insert placeholders for additional statements if necessary. If you want the body of the loop to execute until the occurrence of the condition but you don't know exactly how many times this will take, use a while loop instead.

7.

Example of for loop

$$\text{sum}(n) := \begin{array}{|l} s \leftarrow 0 \\ \text{for} \quad x \in 1..n \\ \quad s \leftarrow s + 1 \end{array}$$

$$\text{sum}(1) = 1$$

"WHILE" LOOPS

Use a "while" loops whenever you want a set of statements to keep executing until a condition is met. Make sure you have a statement somewhere that makes the condition false. Otherwise the loop will execute indefinitely and you will need to stop it by pressing **Esc**.

To insert a "while" loop:

1. Click in the Placeholder into which you want to place the "while" loop.

2. Click on the Math tool bar to open the programming toolbar containing the programming operators.

3. Click on the while button or press ctrl +]. Do not type word "while"

4. In the placeholder to the right of the "while" type a Boolean expression. Click the Add Line button on the programming toolbar to insert placeholders for additional statement if necessary.

5. In the placeholder below the "while", enter the statement you want to execute repeatedly. Use the Add Line button to insert placeholders for additional statement if necessary.

$$t(v,t) := \begin{vmatrix} j \leftarrow 0 \\ \text{while } v_j \leq t \\ \quad j \leftarrow j + 1 \\ j \end{vmatrix}$$

Note: "While" loops are useful when you want to stop execution upon occurrence of a condition and you don't know exactly when that condition will occur. If you know exactly how many iterations you want, use a "for" loop instead.

"BREAK" STATEMENT

Use a "break" statement in a loop whenever you want to halt execution in a loop.

To insert a "break" statement:

    a. Click in the placeholder in which you want to put the "break" statement.

    b. Click on the Math toolbar to open the program toolbar containing the programming operators.

    c. Click on the break button or press Ctrl+ {. Do not just type the word "break"

$$\begin{vmatrix} (\text{break}) & \text{if } x \leq 0 \\ y \end{vmatrix}$$

When MathCAD encounters a "break" statement in the body of a "for" or "while" loop:

    1. The loop ceases execution and return the most recent value computed.

    2. The program execution then continues with the next line of the program after the loop.

Controlling iterations in a loop

Program loops are designed to continue until a certain condition is met or after a certain number of iterations. However, you may want to halt a loop during certain iteration and continue with the next iteration. To do so, use a "continue" statement.

To insert a "continue" statement:

    a. Click on a placeholder into which you want to place the "continue" statement

    b. Click on the math toolbar to open the programming toolbar containing the programming operators

    c. Click on the continue button or press ctrl+[. Do not just type the word "continue"

    d. When the program encounters a "continue", it halt the iteration goes to the nearest outer loop and continues with the next iteration.

Example:

$$B := \begin{Vmatrix} \text{for } i \in 0..4 \\ \quad \begin{vmatrix} \text{for } j \in 0..3 \\ \quad \text{continue} \quad \text{if } \mod(j,2) = 0 \\ a_{i,j} \leftarrow 1 \end{vmatrix} \\ a \end{Vmatrix} \qquad B = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Returning a value from a program

By default, a program returns whatever is on the last line. However, you can return a value located elsewhere in the program by using a "return" statement.

To insert a "return" statement:

- Click on the placeholder into which you want to place the "return" statement.
- Click on the Math Toolbar to open the Programming Toolbar containing the Programming Operator.
- Click on the "return" button or press Ctrl+|. Do not just type the word "return".
- In the placeholder to the right of the "return", type whatever you would like to return.

"Return" statements are useful when you want to return a value from a particular loop.

Example:

$$x := 0$$

$$C := \begin{Vmatrix} 2 & \text{if } x = 0 \\ a \leftarrow 2 \\ \text{return } a \\ \text{for } i \in 0..x \\ \quad t \leftarrow x + t \\ t \end{Vmatrix}$$

$$C = 2$$

Trapping errors in a program

To return an alternative value when an error is encountered in an expression, use the "on error" programming operator:

   a. Click on the placeholder into which you want to place the "on error" statement

   b. Click on the Math toolbar to open the programming toolbar containing the programming operators.

   c. Click on the on error button or press Ctrl+. Do not just type the words " on error"

   d. In the placeholder to the right of the "on error", type whatever, you would like to return assuming it can be evaluated successfully.

   e. In the placeholder to the left of the "on error", type whatever you would like to return if the default return expression couldn't be evaluated. Use the add line button to insert placeholder for additional statement if necessary.

   f. The right-hand expression is evaluated and returned if no errors occur. If an error occurs, the left-hand argument is returned.

$$f(x) := \infty \quad \text{on error} \quad \frac{1}{2-x}$$

$$f(1) = 1$$

$$f(2) = 1 \times 10^{307}$$

Recursion

Recursion is a powerful programming language that involves defining a variable in terms of

Greatest common denominator:

$$gcd(x,y) := \begin{vmatrix} y & \text{if } x=0 \\ gcd(mod(y,x),x) & \text{otherwise} \end{vmatrix}$$

$$gcd(9,45) = 9$$

itself as shown in this example:

Recursive function definitions should always have at least two parts:

1. An initial condition to prevent the recursion from going forever, and
2. A definition of the function in terms of a previous value of the function.

The idea is similar to that underlying mathematical induction: if you can get $f(n+1)$ from $f(n)$, and you know $f(0)$, then you know all there is to know about f. Keep in mind however, that although recursive function definitions, despite their elegance and conciseness, are not always the most computationally efficient definitions. You may find that an equivalent definition using one o f the iterative loops will evaluate more quickly.

Evaluating a program symbolically

Once you've defined a program that you want to evaluate symbolically:

(1) Type the name of the function or variable name, which is defined in terms of a program.
2. (2) Press **Ctrl +Period** to insert the right arrow representing the symbolic equal sign.
1.

The following is an example of Step and natural response of series RLC, this example will apply the condition statement

Given

$$A1 + A2 = Vc0 - Vf$$
$$s1(R) \cdot A1 + s2(R) \cdot A2 = \frac{-iL0}{C}$$

$$\text{Find}(A1, A2) \rightarrow \begin{bmatrix} \dfrac{(-iL0 - Vc0 \cdot C \cdot s2(R) + Vf \cdot C \cdot s2(R))}{C \cdot (s1(R) - s2(R))} \\ \dfrac{(-s1(R) \cdot C \cdot Vc0 + s1(R) \cdot C \cdot Vf - iL0)}{C \cdot (-s1(R) + s2(R))} \end{bmatrix}$$

Some typical values are

$$R := 8 \qquad L := 5 \cdot 10^{-3} \qquad C := 200 \cdot 10^{-6}$$
$$iL0 := 2 \qquad Vc0 := -5 \qquad Vf := 0$$

$$\alpha(R) := \frac{R}{2 \cdot L} \qquad \alpha(R) = 800 \qquad\qquad \alpha1 := \frac{10}{2 \cdot L} \qquad \alpha1 = 1 \times 10^{3}$$

$$\omega0 := \frac{1}{\sqrt{L \cdot C}} \qquad \omega0 = 1 \times 10^{3}$$

39

$$s^{2} + 2 \cdot \alpha \cdot s + \omega0^{2} = 0$$

We can solve this with mathcad as follows:

1.Highlight any "s"
2. from symbolics menu select variable then 'solve' to get tthe roots of the equation

$$\left[\begin{array}{c} -\alpha + \left| \alpha^2 - \omega 0^2 \right|^{\frac{1}{2}} \\ \\ -\alpha - \left| \alpha^2 - \omega 0^2 \right|^{\frac{1}{2}} \end{array} \right]$$

with the specific values we find:

$$s1(R) := -\alpha(R) + \sqrt{\alpha(R)^2 - \omega 0^2} \qquad s1(R) = -800 + 600i$$

$$s2(R) := -\alpha(R) - \sqrt{\alpha(R)^2 - \omega 0^2} \qquad s2(R) = -800 - 600i$$

For overdamped response $\omega_{0>\alpha}$

$$A2(R) := \frac{1}{s2(R) - s1(R)} \cdot \left[\frac{iL0}{C} - s1(R) \cdot (Vc0 - Vf) \right] \qquad A2(R) = -2.5 + 5i$$

$$A1(R) := Vc0 - A2(R) - Vf \qquad\qquad A1(R) = -2.5 - 5i$$

$$tm := \frac{1}{|s1(R)|} + \frac{1}{|s2(R)|} + \frac{1}{\alpha(R)}$$

$$tm = 3.25 \times 10^{-3}$$

$$k := 2 \qquad t := 0.01 \cdot tm, 0.11 \cdot tm .. 5 \cdot tm$$

$$Vc1(t, R) := Vf + (A1(R) \cdot \exp(-s1(R) \cdot t) + A2(R) \cdot \exp(-s2(R) \cdot t))$$

For critical damped $\omega_{0=\alpha}$

$D2 := Vc0 - Vf$ $\qquad$ $D2 = -5$

$D1(R) := \dfrac{iL0}{C} + \alpha(R) \cdot D2$ $\qquad$ $D1(R) = 6 \times 10^3$

$Vc2(t,R) := Vf + \left[D1(R) \cdot t \cdot \exp\left[-\alpha(R) \cdot t \right] + D2 \cdot \exp\left[-\alpha(R) \cdot t \right] \right]$

For underdamp response $\omega_{0>\alpha}$

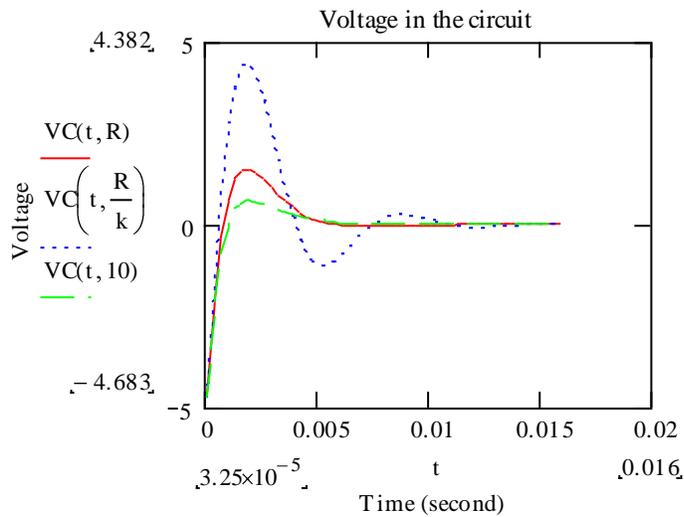$\omega d(R) := \sqrt{\omega 0^2 - \alpha(R)^2}$ $\qquad$ $\omega d(R) = 600$

$B1 := Vc0 - Vf$ $\qquad$ $B1 = -5$

$B2(R) := \dfrac{1}{\omega d(R)} \cdot \left(\dfrac{iL0}{C} + \alpha(R) \cdot B1 \right)$ $\qquad$ $B2(R) = 10$

$Vc3(t,R) := Vf + \exp\left[-\alpha(R) \cdot t \right] \cdot \left[B1 \cdot \cos\left[\omega d(R) \cdot t \right] + B2(R) \cdot \sin\left[\omega d(R) \cdot t \right] \right]$

$VC(t,R) := if\left[\alpha(R) > \omega 0, Vc1(t,R), if\left[\alpha(R) < \omega 0, Vc3(t,R), Vc2(t,R) \right] \right]$

$VC(0,R) = -5$ $\qquad$ $VC(100000,R) = 0$

Voltage in the circuit

4.382

VC(t, R)

$VC\left(t, \dfrac{R}{k}\right)$

VC(t, 10)

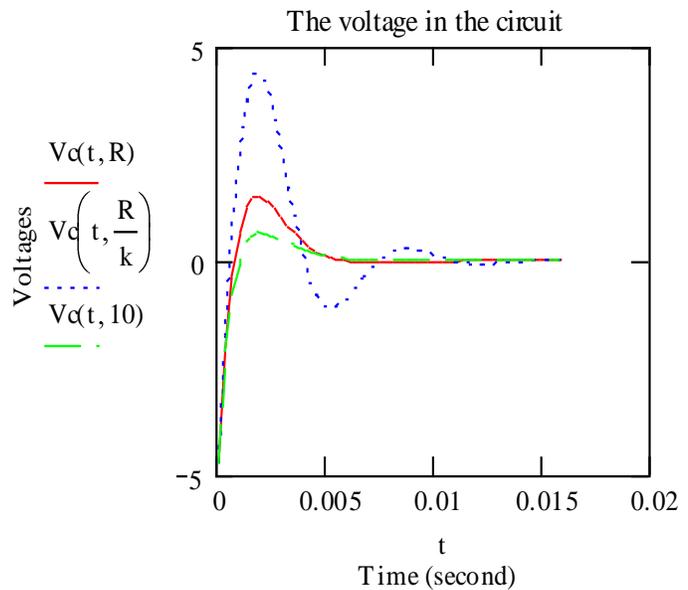− 4.683

3.25×10^{-5}

0.016

Voltage

t

Time (second)

For the plotting the three differnt cases for Vc
we make the following plot statements.
First we set Vc define as.
Then we type the right bracket ']' to create an if statement.
To get three conditions we also add a line through the programming menu.

$$Vc(t,R) := \begin{cases} Vc1(t,R) & \text{if } \alpha(R) > \omega 0 \\ Vc2(t,R) & \text{if } \alpha(R) = \omega 0 \\ Vc3(t,R) & \text{if } \alpha(R) < \omega 0 \end{cases}$$

The voltage in the circuit

Vc(t, R)

$Vc\left(t, \dfrac{R}{k}\right)$

Vc(t, 10)

Voltages

t

Time (second)

MathCAD has extensive help available. If you know the name of the command, you can get help from the index.

For example, if you want help on the **solve** symbolic operator,

Click on **help** on the tool bar.

Then pick **MathCAD Help**.
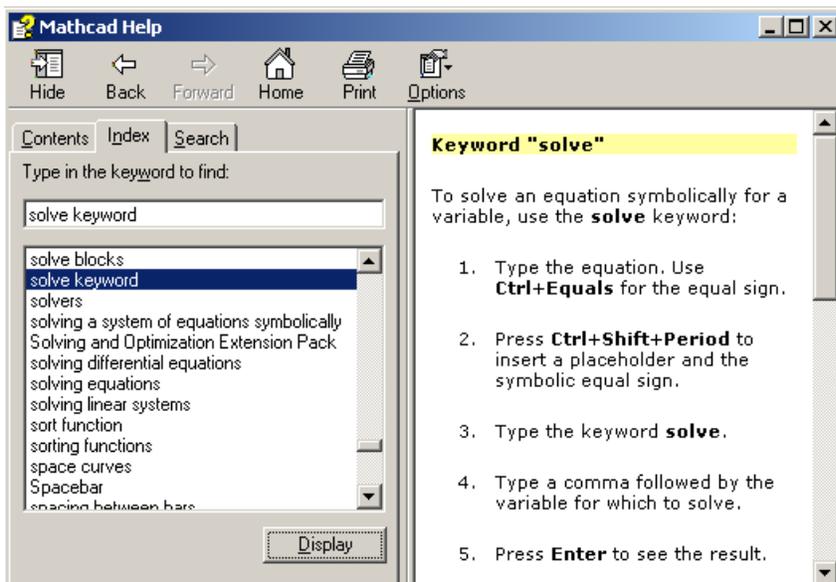
Menu: pressing the **F1** key.

In the index window, type **solve**

This will give you a list of options.

Choose **solve keyword**.

This will bring up a window

That explains how to use the **solve** command.

In addition to the index, the *MathCAD* help has a resource center that contains a more extensive tutorial. The reference center also contains "Quick sheets." These are *MathCAD* files that have been written to do specific tasks. Explore and learn!

Uses LCC inverter circuit as an example to show how to calculation and plot the transfer function on the dB. The circuit is given below:

It is desired to operate a resonant inverter at switching frequency fs =100kHz

An input voltage of Vg 160V

The converter should be capable of producing an open circuit peak output voltage Voc=400 V

Should also produce a nominal output of 150Vrms at 25 W. It is desired to select resonant tank elements that accomplish this.
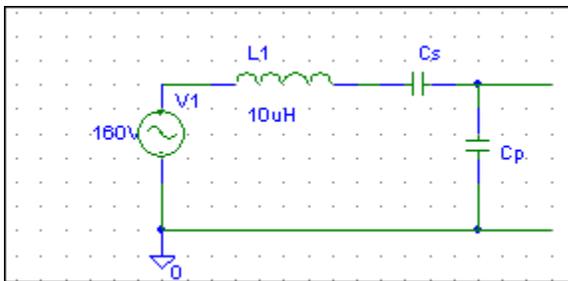
$\text{Vg} := 160 \cdot \text{V}$

$\text{fs} := 100 \cdot \text{kHz}$

$\text{Voc} := 400 \cdot \text{V}$

$\text{Vnominal} := 150 \cdot \text{V}$

$\text{Power} := 25 \cdot \text{W}$

The specifications imply that the converter should exhibit an open circuit transfer function of

$\text{Vs1} := \dfrac{4}{\pi} \cdot \text{Vg}$ $\qquad \text{Vs1} = 203.718\text{V}$

$\text{Hinifite} := \dfrac{\text{Voc}}{\text{Vs1}}$ $\quad \text{Hinifite} = 1.963$

The specification imply that the peak voltage and current at the nominal opearting point are:

$\text{V} := \text{Vnominal} \cdot \sqrt{2}$ $\qquad \text{V} = 212.132\text{V}$

$\text{I} := \dfrac{\text{Power}}{\text{Vnominal}} \cdot \sqrt{2}$ $\qquad \text{I} = 0.236\text{A}$

$\text{Rnominal} := \dfrac{\text{V}}{\text{I}}$ $\qquad \text{Rnominal} = 900\Omega$

The required short circuit current is

$\text{Isc} := \dfrac{\text{I}}{\sqrt{1 - \left(\dfrac{\text{V}}{\text{Voc}}\right)^2}}$ $\qquad \text{Isc} = 0.278\text{A}$

Therefore the match load occurs at the operating point

$\text{Vmat} := \dfrac{\text{Voc}}{\sqrt{2}}$ $\qquad \text{Vmat} = 282.843\text{V}$

$\text{Imat} := \dfrac{\text{Isc}}{\sqrt{2}}$ $\qquad \text{Imat} = 0.197\text{A}$

$\text{Zoutzero} := \dfrac{\text{Voc}}{\text{Isc}}$ $\qquad \text{Zoutzero} = 1.439 \times 10^3 \, \Omega$

The impedances of the series and parallel branches can be represented using the reactances Xp and Xs.

$\text{j} := \sqrt{-1}$

$\omega\text{s} := 2 \cdot \pi \cdot \text{fs}$ $\qquad \omega\text{s} = 6.283 \times 10^5 \, \text{Hz}$

$$jXs = j \cdot \omega s \cdot L + \frac{1}{j \cdot \omega s \cdot Cs} = j \cdot \left(\omega s \cdot L + \frac{1}{\omega s \cdot Cs} \right)$$

$$jXp = \frac{1}{j \cdot \omega s \cdot Cp} = j \cdot \left(\frac{-1}{\omega s \cdot Cp} \right)$$

The transfer function $H_\infty(j\omega s)$ is given by the voltage divider formula

$$Hinfite(\omega s) = \frac{jXp}{jXs + jXp}$$

The output impedance is given by the parallel combination

$$Zout(\omega s) = \frac{1}{\dfrac{1}{jXs} + \dfrac{1}{jXp}} \cdot \frac{-Xs \cdot Xp}{j \cdot (Xs + Xp)}$$

solve for Xp and Xs

$$jXp = \frac{Zout(\omega s)}{1 - Hinfite(\omega s)} \qquad Xs = Xp \cdot \frac{1 - Hinfite(\omega s)}{Hinfite(\omega s)}$$

The capacitor Cp should chose equal to

$$Xp := -Zoutzero \qquad Xp = -1.439 \times 10^3 \, \Omega$$

$$Cp := \frac{-1}{\omega s \cdot Xp} \qquad Cp = 1.106 \times 10^{-9} \, F$$

The reactance of the series branch should be choosen according to

$$Xs = Xp \cdot \frac{1 - Hinfite(\omega s)}{Hinfite(\omega s)} \qquad Xs := Xp \cdot \frac{1 - Hinifite}{Hinifite} \qquad Xs = 706 \, \Omega$$

Since Xs is comprised fo series combination of the inductor L and Cs, there is a degree of freedom in chooseing the values of L and Capacitor Cs to realize Xs.
if We choose Cs very large (tending to a short circuit) This effectively would result in a parallel resonant converter with

$$Lchoose := \frac{Xs}{\omega s} \qquad Lchoose = 1.124 \times 10^{-3} \, H$$

For nonzero Cs, L must be choose according to

$$L := \frac{1}{\omega s} \cdot \left(Xs + \frac{1}{\omega s \cdot Cs} \right)$$

$$Cs := 3 \cdot Cp \qquad Cs = 3.319 \times 10^{-9} \, F$$

$$L := \frac{1}{\omega s} \cdot \left(Xs + \frac{1}{\omega s \cdot Cs} \right)$$

$$L = 1.887 \times 10^{-3} \, H$$

$$fo := \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot Cs}} \qquad fo = 6.36 \times 10^{4} \, Hz$$

$$Zc := \frac{1}{\frac{1}{Cs} + \frac{1}{Cp}} \qquad Zc = 8.297 \times 10^{-10} \, F$$

$$finifite := \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot Zc}} \qquad finifite = 1.272 \times 10^{5} \, Hz$$

$$Zcm := \frac{1}{\frac{1}{Cs} + \frac{1}{2 \cdot Cp}} \qquad Zcm = 1.327 \times 10^{-9} \, F$$

$$fm := \frac{1}{2 \cdot \pi \cdot \sqrt{L \cdot Zcm}} \qquad fm = 1.006 \times 10^{5} \, Hz$$

The open circuit tank input impedance is

$$Ziinfite := j \cdot (Xs + Xp) \qquad Ziinfite = -732.749i \, \Omega$$

When the load is open circuit, the transistor peak current has magnitude

$$Is1 := \frac{Vs1}{Ziinfite} \qquad Is1 = 0.278i \, A$$

$$Is1 := \frac{Vs1}{|Ziinfite|} \qquad Is1 = 0.278 \, A$$

When the load is short circuit, the transistor peak current has magnitude

$$Is1 := \frac{Vs1}{|Xp|} \qquad Is1 = 0.142 \, A$$

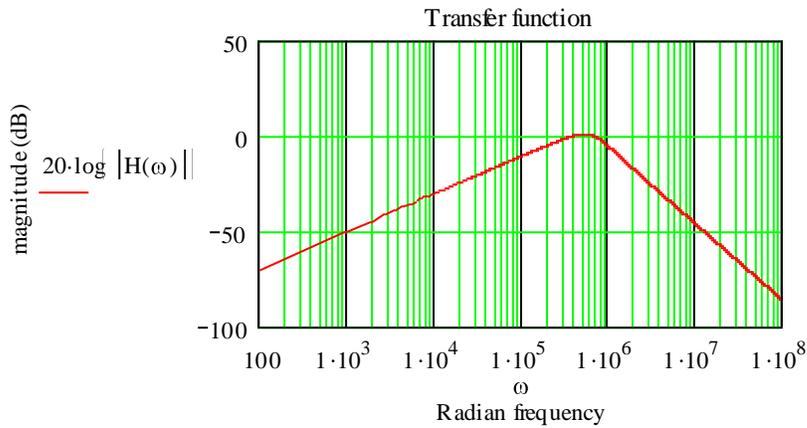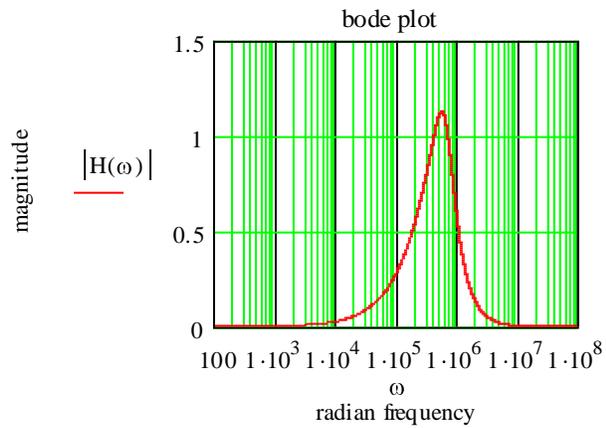$$\omega := 100, 1000 .. 10 \cdot 10^{7}$$

The input impedance of tank

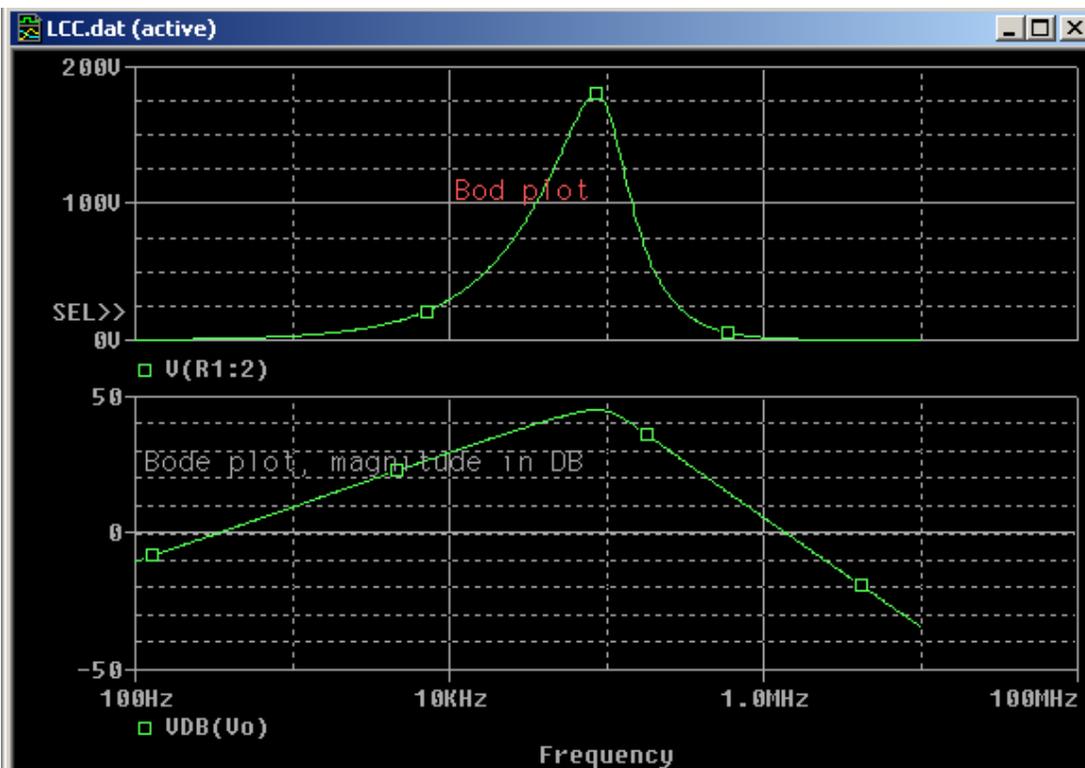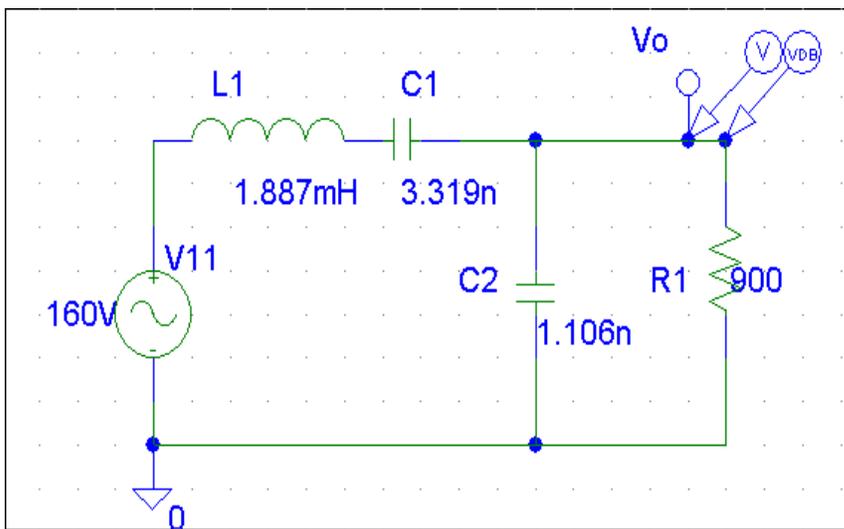$$\text{Zizero}(\omega) := \frac{1}{|j \cdot \omega \cdot Cs|} + j \cdot \omega \cdot L$$

$$\text{Ziinfite}(\omega) := j \cdot \omega \cdot L + \frac{1}{j \cdot \omega \cdot Zc}$$

The tank transfer function

$R := \text{Rnominal}$ $\qquad$ $R = 900\Omega$

$$H(\omega) := \frac{\dfrac{R}{1 + j \cdot \omega \cdot Cp \cdot R}}{\dfrac{R}{1 + j \cdot \omega \cdot Cp \cdot R} + j \cdot \omega \cdot L + \dfrac{1}{j \cdot \omega \cdot Cs}}$$

bode plot

magnitude

$|H(\omega)|$

ω
radian frequency

Transfer function

magnitude (dB)

$20 \cdot \log |H(\omega)|$

ω
Radian frequency

the input impedance of LCC inverter

input impedance

1.205×10^7

$|Zizero(\omega)|$

$|Ziinfite(\omega)|$

0.237

$1 \cdot 10^8$
$1 \cdot 10^7$
$1 \cdot 10^6$
$1 \cdot 10^5$
$1 \cdot 10^4$
$1 \cdot 10^3$
100
10
1
0.1

100 $1 \cdot 10^3$ $1 \cdot 10^4$ $1 \cdot 10^5$ $1 \cdot 10^6$ $1 \cdot 10^7$ $1 \cdot 10^8$

100 ω 1×10^8

radian frequecny

Vo

V VDB

L1   C1

1.887mH   3.319n

V11

160V

C2

1.106n

R1   900

0

LCC.dat (active)

200U

100U

SEL>>
0U
□ V(R1:2)

Bod plot

50

Bode plot, magnitude in DB

0

−50
100Hz   10KHz   1.0MHz   100MHz
□ VDB(Vo)

Frequency

49

Sometime you write the function instead give you the answer to the problem, MathCAD give you a red mark. That read mark is an error of your function. You wonder why MathCAD give you an error and you don't know what how to fit this problem. Here are some simple steps you can apply to solve this problem:

1.	Making sure you have definition variable

2.	Make sure you use the button in the programming tool or press the key. Do not type the word

3.	Make sure use the correct function

4.	Check the error message
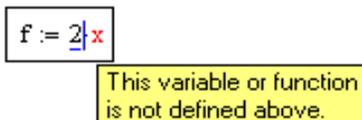
MathCAD is using 15 decimal places internally, but displaying 3. If you would like to display more decimal places

–D-click the equal sign or the answer.

–You will get this option window.
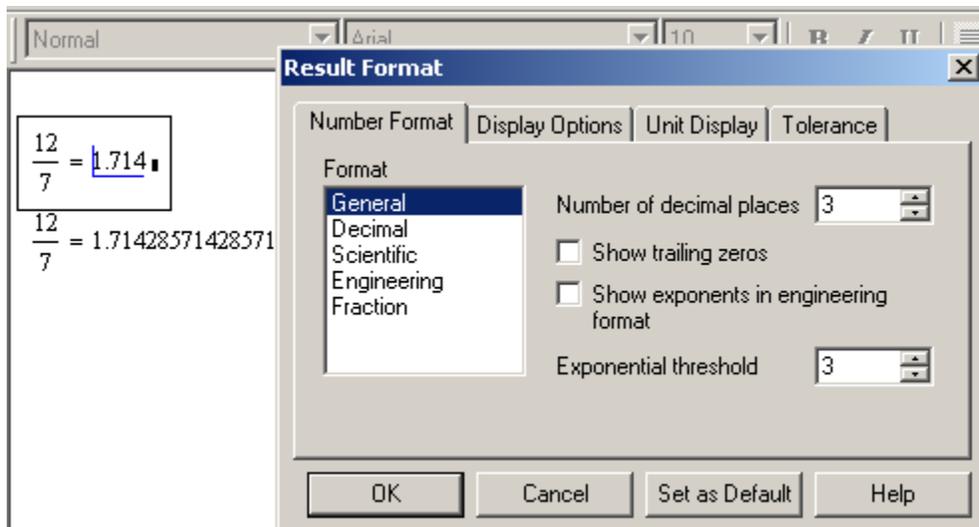
If you would like that to be default number of decimal places for all calculations in this work sheet. Click on the "Set as default" button. Remember this will apply to this worksheet only.

Because MathCAD is a unique, powerful way to work with equations, numbers, text, and graphs. Unlike any other math software, MathCAD does math the same way you do. That's because it looks and works like a scratchpad and pencil. MathCAD's on-screen interface is a blank worksheet on which you can enter equations, graph data or functions, and annotate with text -- anywhere on the page. And instead of forcing you to use a programming-like syntax, MathCAD lets you use the language of mathematics.

Today, I have explained to you what the MathCAD software is, and shows you step by do calculation, plot and programming. I also show you step by steps how to calculate the transfer and reasons why the MathCAD used in circuit design. I hope that my paper will help you understand more what the MathCAD software is. And when someone ask you what is the MathCAD software, you can answer him/her question easily. Especially, when you interview for a job.

Reference:

http://www.maelabs.ucsd.edu/mae_guides/analysis_guide/MathCAD_tutorial.htm

http://www.ric.edu/mrodrigues/mathcad/index2.htm

http://courses.albion.edu/math219/tutorial/tutorial.htm

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http://class.et.byu.edu/meen337/mathcadtutor.pdf

http://www.msu.edu/course/for/810/mathcad.htm

http://www.uh.edu/~djwells/INDE1331/MATHCADtutorial1.htm