# Waveform Generation Using Excel

An Online Continuing Education Course for Engineers

**Course Number: E-3100**

**Credit: 3 Hours / 3 PDH / 3 CPD**

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## 1. Introduction

While working on certain projects, it is sometimes very useful to be able to generate waveforms to help in analyzing a circuit or other problem. We could, of course, generate our own spreadsheet and go through the working and thinking to make a program that does what we think we need. This would probably lead to some blind alleys and a lot of time working out the details of our waveform generator. Or, we could find a prepackaged waveform generator with most of the details already worked out for us. With that in mind, I am presenting a waveform generator using the Microsoft software program Excel. Excel is not the only software that uses spreadsheets, but it is the most popular one. This course can also be helpful in learning to use Excel for other purposes. This course is only the beginning, and there is so much more that can be done with Excel.

## 2. How It Came About and How to Enter Data

This all started in about 2003 or 2004 when I was teaching a course in basic electronics. The original attempts were crude and elementary, but the concept of what electrical signals looked like, if we could see them, was the driving force. An oscilloscope helps with this, but actually generating Sin and Cos waveforms turned out to be very useful. Figure 2.1 shows 2 cycles of a Sin wave and a Cos wave with a peak value of 1 Volt.

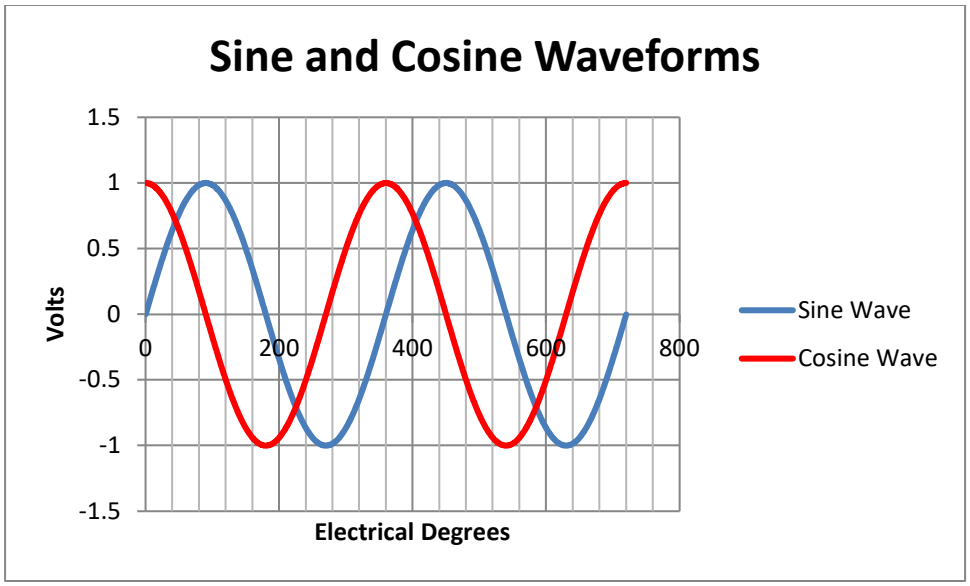


**Figure 2.1 Sine and Cosine Waveforms with a Peak Value of 1**

This Waveform was generated on sheet 8 of the Excel program that accompanies this course. As we look at this page, note that Column A is electrical degrees, Column B is the radian equivalent of the degrees in Column A. Column C is a Sin wave, and Column K is a Cos wave. I used 360 electrical degrees as one cycle, and this part of the program generates two cycles or 720 electrical degrees. Column B is the Radian equivalent of the degrees shown in Column A because Excel determines the magnitude of Sins and Cosines by using radians for the angles. This can be done by multiplying the number of degrees by Pi/180 or using the Radian function in the mathematical functions section. This would be a good time to become more familiar with the mathematical functions of Excel. There are over 300 functions, such as Sin, Cos, Pi, and Radian, in Excel; these functions are sub-divided into 11 categories. For our waveform making program, we will only be using Mathematical and Trigonometric functions. There are also the simpler and easier to use standard math functions such as plus (+), minus (-), multiply (*), and divide (/).

But first, let's look at a typical Excel spreadsheet so that we can determine how the software works and how we can use it to generate waveforms. Looking at Sheet 8 again, notice that Excel is set up as Rows and Columns of Cells. Each Cell has an address that we can refer to specifically. For instance, 0 degrees is in Column A and Row 10. One way to make Cell A10 equal to 0 is just to highlight that cell and type 0 in that cell, and enter it by using the Enter key

on your keyboard. That Cell now has a numerical value of Zero; its address is A10. We can use that address in calculations and for doing other things, such as making charts and graphs. A10 was chosen as 0 degrees because it is helpful to have some Cells above A10 in which to put some useful information for this application. Using Cell A10 also gives us an easy way to put 0 degrees in a cell that has the digit 0 as the last digit. The Cells can have useful information, data, or information. Notice that Cell A1 has the information "Degrees" in it. In this program, it is not used for anything else. As soon as an Excel worksheet is opened, the cells have a default size of 17 pixels high by 64 pixels wide. That is about ½ centimeter high by 2 centimeters wide. This size can be changed, but all of a row will have a certain height, and all of a column will have a certain width initially. We can put information or data into any Cell. For instance, we put the information "Degrees" in Cell A1. That is only there to help us know that Column A is Electrical Degrees.

Now we need to put a real number in Cell A10. We already did this in a certain manner, but here is another way that will become more and more useful as we go along. We do this by using the "=" sign. Put the cursor on Cell A10 and left click on that Cell. It will become highlighted. Then put in an "=" sign. The equal sign will appear in the formula bar above Columns E, F, and G. After that, you can get Excel to do any mathematical operation or function allowed by Excel. Follow the equal sign with a "0" and hit Enter. The value of 0 will be placed in Cell A10. Of course, it was already there, so nothing has changed.

As a further example, put the cursor on A8 and highlight it with a left click. It should show a dark border. Then do "= 2 + 3", and hit enter. The cell should then show 5, which is the result when you add 2+3. Since we don't need that 5, put the cursor on A8 again, highlight it with a left click, and then delete it. We now know how to do simple mathematical operations on any cell. We could also add Cell A12 + Cell A13. Go through the same process; instead of actual numbers, use Cell A8, and add Cells A12 and A13. When doing mathematical operations, always start with "=." When Cell A8 is highlighted, enter "=A12+A13" and hit Enter. We should get the same result, 5. Delete it also since it is not needed for Waveform Generation. We can also use any of the approximately 300 functions. For another example, use Cell A8 again and find the Sin of 30 degrees. Go to Cell A8, left click on it, and enter "=." A table of functions will appear

directly above Columns A, B, and C. Find the Sin function and click on it. If Sin is not in the short list of recently used functions, click on more functions, and pick it out of the list. A box will appear asking for the argument of the Sin function. 30 degrees is at A40, and the radians of 30 degrees is located in Cell B40. So just put B40 as the argument, hit OK, and the value of the Sin of 30 degrees, which is also the Sin of 0.523589 or $\pi/6$ radians, appears. It should be 0.5. This concept will be very useful as we use Excel to generate waveforms. Delete the contents of Cell A8 again. It will then contain no useful information.

Before we look at the uses of waveforms and waveform generators, let's do a few more useful Excel operations that are helpful in waveform generation. If we want to generate a list of numbers, say from 0 to 720, let's go to column "L" in Worksheet 10 and put 0 in cell L10. For this example, Worksheet 10 is being used because it is almost empty. Then in Cell L11, put in "=L10+1" and hit enter. Cell L11 should then have the value 1 in it. Now, and I don't know any better way to say this, first, highlight Cell L11 with a left-hand mouse click and grab the lower right corner of Cell A11 with the left-hand mouse clicker, and a bold black "+" will appear. Start dragging that bold "+" downward, and a series of numbers will appear. It should start counting from 0 to whatever Cell you stop. You can delete this series of numbers by clicking on Cell L10 again, and while holding the right-hand mouse switch down, just move as far down Column L as you want. The cells will be highlighted in a light blue color. Stop where you want, and hit delete. All the numbers that were highlighted will disappear. I counted from 0 to 9 in Column L of Worksheet 10 and left that data there. It can be erased as it is not being used except as an example. This operation will come in handy later when half of a Sin wave wants to be graphed. You just need to highlight any cells that you want to be empty and hit enter. **Notice that empty is different from zero**. If some calculations were done on the deleted Cells, an error message might appear in some Cells. Just delete them also. Zero is a real number that can exist in a cell, while an empty cell just contains nothing. This operation can also be done one cell at a time, but that would be somewhat tedious.

## 3. The Importance of Waveforms in Electrical Engineering

Much of electrical engineering is concerned with periodic functions. Despite the digital world that we are now thoroughly immersed in, many, if not most, electrical phenomena are analog in nature. Audio signals start out as analog signals (voice or musical instruments) and end up as analog signals (sound). Even digital signals are time-varying. An analog to digital converter turns an analog audio signal into a digital signal by an electronic circuit called an Analog to Digital Converter (ADC), which is then handled as a string of zeros and ones. This digital signal is then handled as a time-varying signal with nal can be stored or recorded as a strin show what that digital signa e could take the principles dev s then converted to an analog sign AC) that outputs an analog signa nstance, is an entirely analog e frequency range for human second. We really hear in ana is amplified, we could look at t hase shift of an amplifier outpu ot those signals.



We will do a simple igure 3.1 is a picture of a simple Low Pass Fi y of 1000 cycles per second. The value of R was chosen as an easy to use and common value. The value of C was chosen to have an impedance of 10,000 Ohms at 1000 cycles per second. The voltage gain and phase shift change with frequency, as shown in the equation in Figure 3.1.