

Master Bender 2.3

Computer Aided Bending

and

Electrical Calculator and Tables

for

Palm, Windows Mobile & Windows Desktop

Master Bender PRO Edition and Master Bender EEC Edition

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www.paweng.com

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in collaboration with Electrician Journeyman Lewis Hinkle

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END OF LICENSE

Introduction

Master Bender is a program for aiding you in bending conduit raceways and helping you perform electrical computations. It takes the math out of bending and allows you to concentrate on the task at hand.

Master Bender uses a more precise conduit bending algorithm than commonly used in the industry. Most people use the cosecant method that has been around for years. For certain angles, the cosecant method is easy to remember: Multiply by 2 for 30 degree bends and multiply by 1.4 for 45 degree bends. However, using the cosecant method for conduit angles larger than 30 degrees and conduit sizes larger than 1 inch will cause large errors. Even for smaller conduit sizes long neck couplers are recommended to compensate for the inaccuracy.

Master Bender's algorithms automatically compensate for shrink for any angle, and Master Bender takes the characteristics of the bender into account. The results are far more precise than is possible using the cosecant method.

Bending conduit using Master Bender is easy: Select the bender tool and the type of bend, enter the angle, the distance to the object and the object height, and Master Bender instantly gives you the results in feet, inches and fractions of inches to the nearest 1/16th of an inch.

Using Master Bender, you can compute accurate values for the following types of bends:

- Offset bends
- Three point saddle bends
- Four point saddle bends
- Compound 90 degree bends
- Parallel bends
- Concentric bends
- Segment bends
- A series of 90 degree bends

Besides calculating bends of conduit raceways, Master Bender also contains electrical calculators and tables:

- Calculator for doing feet/inches calculations.
- Scientific calculator for doing both simple and advanced math.
- Conversion between units in 19 categories.
- Master Bender will assist you in doing DC and AC calculations like Ohm's Law, locked rotor current, parallel and series computations, and reactance computations.
- There are power formulas for computing horsepower, kilowatts, and volt-amps.
- Master Bender has tables of the sizes of the common conduits, drills and taps, and log torques.

It is our aim to provide you with a program that is useful in the field. Master Bender's large buttons and lack of menus enable you to use your fingers instead of a stylus. We use a high contrast color scheme to make Master Bender easier to use in low-light situations, and we group screen elements using color to help you quickly navigate the program.

Master Bender is available in three editions:

- Master Bender TRIAL Edition is for evaluation purposes only and many features are disabled.
- Master Bender PRO Edition contains the full functionality of the program.
- Master Bender EEC Edition contains everything but the bending worksheets.
 - EEC stands for Electrician's Electrical Calculator.

We hope that you will find Master Bender useful.

16 Reasons to Use Master Bender

Although every bend can be done with Master Bender, usually most supervisors or foremen prefer you do not do every bend with the aid of a computer. However many times:

1. An odd bend is required with an angle other than the standard 10, 22.5, 30, 45, 60 or 90 degrees.
2. The sidewinder tables are unreadable and/or no manual is available.
3. A precision bend is required.
4. Segment or concentric bends are required.
5. Precut and threading is required.
6. Fast bends are required.
7. You have not done conduit bending in a while.
8. Double check is necessary on an expensive large conduit or PVC Rigid or stainless steel to avoid waste.
9. Multiple bends are required on one piece of conduit.
10. Parallel bends are required.
11. A long neck coupler is not used.
12. Pipe larger than 1 inch is used and bent at steep angles larger than 45 degrees.
13. An unknown angle must be computed by trig calculation.
14. Cosecant reference values are needed.
15. Take-up reference values are needed.
16. You may forget cosecant and/or shrink values.

These are some of the situations where Master Bender will be of value to you.

Hardware Requirements

Master Bender runs on Palm, Windows Mobile, and Windows Desktop. Given the plethora of devices available, we cannot possibly test Master Bender on each and every one of them. However, we can give you some general guidelines:

- For Palm devices, you need Palm OS version 3.3 or higher.
- For Windows Mobile devices, you need:
 - Windows CE 3.0 or higher, Pocket PC 2002 or higher, or Windows Mobile Edition.
 - A device with a touchscreen.
 - An ARM, an SH3, or a MIPS microprocessor. (Most Windows PDAs use the ARM processor.)
- To use the Windows Desktop version of Master Bender, you will need a PC running Microsoft Windows version XP or Vista.
 - Master Bender may work with other versions of Microsoft Windows, but they have not been tested.
- We recommend you use a Palm or Windows Mobile device with a color display.

While we aim to support as many of the available devices as possible, we suggest you install the trial version of Master Bender before you buy to see if it will work for you.

Installation

Before installing Master Bender, please visit our website at <http://www.paweng.com> to ensure you have the latest version.

Windows PC users should download the Master Bender installation program for either Palm or Windows Mobile. Run the installation program on your Windows PC to install both Desktop version of Master Bender and either the Palm or Windows Mobile version.

Over-the-air delivery: You can install Master Bender directly from your Palm or Windows Mobile device: Simply visit <http://www.paweng.com> on your device, navigate to the Master Bender page, and follow the instructions for over-the-air delivery.

TRIAL Mode, EEC Mode, and PRO Mode

Once installed, Master Bender will be in TRIAL Mode. This means that certain features are disabled. TRIAL Mode is intended for you to evaluate Master Bender before you decide to buy it.

- **TRIAL Mode** allows you to use the fractional Calculator. You can sample some of the other features, but only in a restricted way.
 - Offset bends, but you are limited to 60 degree angles.
 - Only the formulas $E^2 = P \cdot R$ and $E^2 = AP \cdot Z$ in the DC and AC Ohm's Law worksheets.
 - Only the Horsepower formula in the HP / Power worksheet.
- **PRO Mode** allows you to utilize all features of Master Bender.
- **EEC Mode** is like PRO Mode except you do not have access to the bending worksheets.

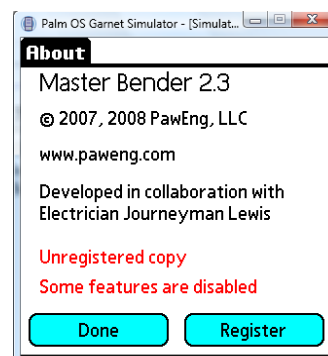
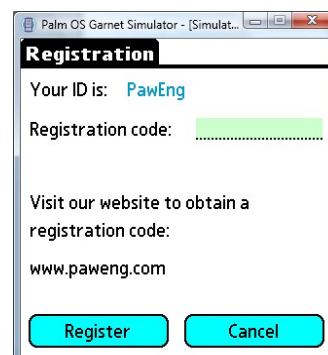
To enable EEC Mode or PRO Mode, you must purchase a Registration Code. Please visit our website at <http://www.paweng.com> for up-to-date instructions.

You will need to supply the ID of your device which is the HotSync name for Palm and the owner name for Pocket PC devices. You will find the ID at the top of on the registration screen of Master Bender.

In the Windows Desktop version of Master Bender, use the **same** ID as on your Palm or Windows Mobile version of Master Bender. If you are installing **only** the Windows Desktop version, use your **email** address as ID.

If Master Bender does not show an ID, you will need to HotSync your Palm to establish an ID, or enter an owner name into your Pocket PC. You may want to refer to the manual of your Palm or Pocket PC.

Once you receive your Registration Code, enter it at the prompt and tap the “Register” button to return to the “About” screen. If your Registration Code was accepted, you will see the text “MB PRO Licensed to <name>” for PRO Mode registration, and “MB EEC Licensed to <name>” for EEC Mode registration.. Press “Cancel” to return to the “About” screen without changing your registration status.



Master Bender and LectriCalc

LectriCalc by Arkansoft (<http://www.arkansoft.com>) is a great companion to Master Bender. LectriCalc provides a number of very useful tools for electricians.

Master Bender will automatically detect if you have LectriCalc installed. If found, you will be able to easily switch to LectriCalc from within Master Bender.

Visit the Arkansoft web page (<http://www.arkansoft.com>) for more information on LectriCalc. You may be able to qualify for a bundle discount if you buy both Master Bender and LectriCalc.

LectriCalc is developed by Arkansoft and *not* by PawEng, LLC. We make no guarantees as to the quality of LectriCalc. We provide this information about LectriCalc simply as a convenience for you. If you have questions about LectriCalc, please contact Arkansoft directly.

Working with Numbers

Many places in Master Bender require you to enter a value. You generally press a button next to the value field to bring up a numeric keyboard. Master Bender distinguishes between values expressed in feet and inches (like a height or a width) and other values (like an angle or a voltage).

A distance consists of four values: a number of feet, a number of inches, and the numerator and denominator of a fraction of inches. In Master Bender, there are buttons for those four values. Click any of those four buttons to select and clear it. Use the numeric keyboard to enter the value you want.

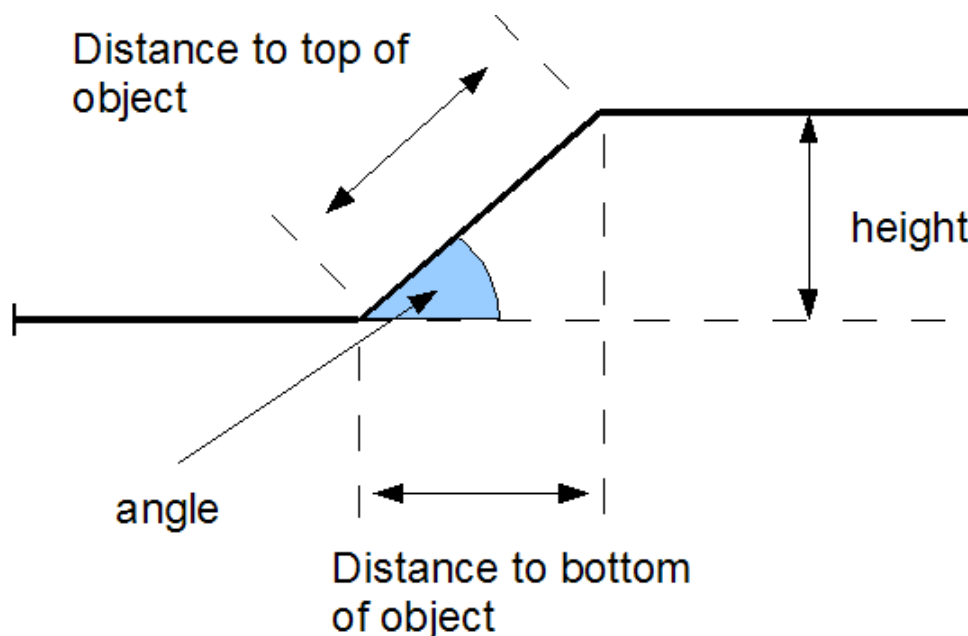
It is possible to enter a negative number using the “Negative” check box at the top of the screen. Master Bender will represent negative numbers using parentheses; for example, negative 5 feet would be written “(5 ft)”.

The “Inches” button will convert from feet and inches to just inches, and it will change the button name to be “Feet”. The “Feet” button will convert back to feet and inches.

The “Store” and “Recall” buttons allow you to store the current value or recall a previously stored value. This is convenient if you have computed a value using the Fractional Calculator worksheet and you want to use it in one of the bending worksheets.

The “C” button clears all fields on the screen.

The “?” button brings up a help page.



When entering angles, you have the option of directly entering the angle by selecting the “Angle” button, or by computing the angle from measurements. To compute the angle, first enter a height and a distance. The “Up” and “Down” buttons will then compute the angle – the “Up” button assumes the distance you measured is to the top of the obstacle, while the “Down” button assumes the distance you measured is to the bottom of the obstacle.

Overview of Master Bender

Master Bender's main screen has three portions, and you switch between them using the blue buttons at the top of the screen. The buttons are labeled “B” for Bending, “C” for Computations, and “T” for Tables.

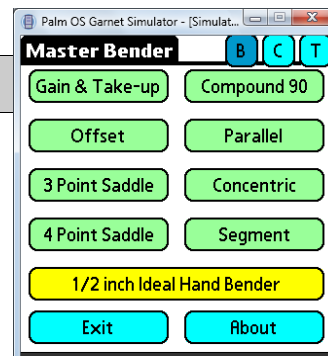
Press the blue “Exit” button to exit Master Bender. If you have LectriCalc installed, Master Bender will add a “LectriCalc” button, which will start the LectriCalc program for you.

The blue “About” button will take you to an informational screen, which will tell you the version of Master Bender you are running and your current license status. From the “About” screen, you can reach the “Registration” screen.

Bending Conduit Raceways

The “B” portion of the main screen gives you access to the tools for bending conduit raceways. The eight green buttons will take you to different bending worksheets.

The yellow button tells you which bender you have currently selected. For example, the screen shot shows the “1/2 inch Ideal Hand Bender” as the



currently selected bender.

We will now describe each of the worksheets for bending conduit race ways.

Selecting a Bender

The “Select Bender” button is the big yellow button on the “B” main screen. It shows you the currently selected bender. If you press the button, you can chose another bender from a list of 90 different benders. Select the bender you want, and Master Bender will use that bender's characteristics when calculating bends.

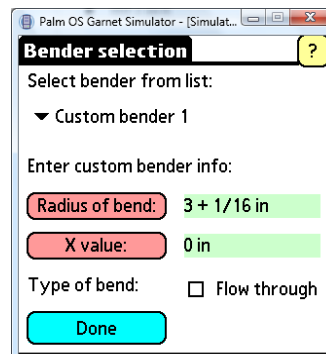
- 1/2 inch Ideal Hand Bender
- 3/4 inch Ideal Hand Bender
- 1 inch Ideal Hand Bender
- 1 1/4 inch Ideal Hand Bender
- 1/2 inch Gardner 930H Bender
- 3/4 inch Gardner 931H Bender
- 1 inch Gardner 932H Bender
- 1 1/4 inch Gardner 933H Bender
- 1/2 inch Site-Rite II Hand Bender
- 3/4 inch Site-Rite II Hand Bender
- 1 inch Site-Rite II Hand Bender
- 1 1/4 inch Site-Rite II Hand Bender
- 1/2 inch Site-Rite Hand Bender
- 3/4 inch Site-Rite Hand Bender
- 1 inch Site-Rite Hand Bender
- 1 1/4 inch Site-Rite Hand Bender
- 1/2 inch Site-Rite II Hand Bender
- 3/4 inch Site-Rite II Hand Bender
- 1 inch Site-Rite II Hand Bender
- 1 1/4 inch Site-Rite II Hand Bender
- 555 EMT 1/2 inch
- 555 EMT 3/4 inch
- 555 EMT 1 inch
- 555 EMT 1 1/4 inch
- 555 EMT 1 1/2 inch
- 555 EMT 2 inch
- 555 IMC 1/2 inch
- 555 IMC 3/4 inch
- 555 IMC 1 inch
- 555 IMC 1 1/4 inch
- 555 IMC 1 1/2 inch
- 555 IMC 2 inch
- 555 Rigid 1/2 inch
- 555 Rigid 3/4 inch
- 555 Rigid 1 inch
- 555 Rigid 1 1/4 inch
- 555 Rigid 1 1/2 inch
- 555 Rigid 2 inch
- 854 / 855 EMT 1/2 inch
- 854 / 855 EMT 3/4 inch
- 854 / 855 EMT 1 inch
- 854 / 855 EMT 1 1/4 inch
- 854 / 855 EMT 1 1/2 inch
- 854 / 855 EMT 2 inch
- 854 / 855 IMC/Rigid 1/2 inch
- 854 / 855 IMC/Rigid 3/4 inch
- 854 / 855 IMC/Rigid 1 inch
- 854 / 855 IMC/Rigid 1 1/4 inch
- 854 / 855 IMC/Rigid 1 1/2 inch
- 854 / 855 IMC/Rigid 2 inch
- 880 1/2 inch
- 880 3/4 inch
- 880 1 inch
- 880 1 1/4 inch
- 880 1 1/2 inch
- 880 2 inch
- 882 EMT 1 1/4 inch
- 882 EMT 1 1/2 inch
- 882 EMT 2 inch
- 882 IMC / Rigid 1 1/4 inch
- 882 IMC / Rigid 1 1/2 inch
- 882 IMC / Rigid 2 inch
- 1800 / 1801 IMC/Rigid 1/2 inch
- 1800 / 1801 IMC/Rigid 3/4 inch
- 1800 / 1801 IMC/Rigid 1 inch
- 1800 / 1801 / 855 IMC/Rigid 1 1/4 inch
- 1800 / 1801 IMC/Rigid 1 1/2 inch
- 777 1 1/4 inch
- 777 1 1/2 inch
- 777 2 inch
- 777 2 1/2 inch
- 777 3 inch
- 777 3 1/2 inch
- 777 4 inch
- 881 EMT 2 1/2 inch
- 881 EMT 3 inch
- 881 EMT 3 1/2 inch
- 881 EMT 4 inch
- 881 IMC / Rigid 2 1/2 inch
- 881 IMC / Rigid 3 inch

- 881 IMC / Rigid 3 1/2 inch
- 881 IMC / Rigid 4 inch
- 884 / 885 1 1/4 inch
- 884 / 885 1 1/2 inch
- 884 / 885 2 inch
- 884 / 885 2 1/2 inch
- 884 / 885 3 inch
- 884 / 885 3 1/2 inch
- 884 / 885 4 inch
- 884 / 885 5 inch

Besides selecting a specific bender, you can also select the cosecant method. This is an approximate method of calculating bends that does not take the characteristics of the actual bender tool into account. Using cosecant method results in less precise results than if you select the actual bender you are using.

If you do not see your bender in the list of available benders, you can select one of the “Custom bender” options. Master Bender will ask you for information about the bender:

- Radius of bend – this is the radius of the circle you would make if you bent a conduit 360 degrees. You will want to measure the radius in inches to the center of the conduit.
- X value – this is the distance in inches that the bender's marking is shifted from where the actual bending starts on the conduit. Most hand benders have an X value of zero.
- Flow through – check this box if your bender performs all the bends in the same direction. Often, large non-hand-operated benders use the flow through method of bending. Sometimes, “flow through” is called “push through”.

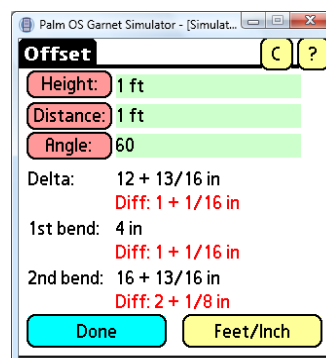


When you select a bender, Master Bender will display that bender's characteristics. You will only be able to modify the numbers if you have selected one of the “Custom bender” options.

Comparing with the Cosecant Method

Many of the Master Bender worksheets have a “Compare” button. Pressing it, Master Bender will compare the precise results with the results of the cosecant method. Master Bender shows the differences in red lines starting with the word “Diff”. For example, the screen shot here shows the difference between an offset bend using the 1 1/4 inch Ideal Hand Bender and the cosecant method. The difference is more than two inches for the second bend.

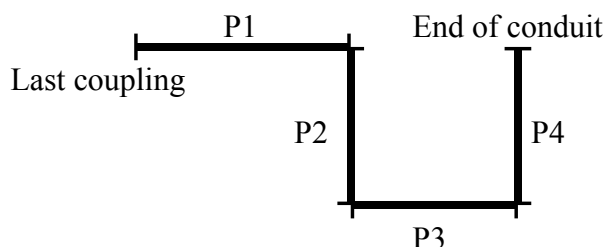
Using the cosecant method for conduit angles larger than 30 degrees and conduit sizes larger than 1 inch will cause large errors, and even for smaller conduit sizes long neck couplers are recommended to compensate for the inaccuracy.



Gain & Take-up

The “Gain & Take-up” button takes you to the Gain and Take-up worksheet. This worksheet computes

a series of one, two, or three 90 degree bends.



The illustration shows three consecutive 90 degree bends. P1 is the length of the first segment, and P2, P3, and P4 are the lengths of the second, third, and fourth segments, respectively.

Enter the P1, P2, P3, and P4 values into the worksheet. If you are doing two 90 degree bends, leave P4 as zero. If you are doing one 90 degree bends, leave P3 and P4 as zero.

Select the size of the conduit at the top of the screen, or select one of the “Custom values” options to enter your own gain and take-up values.

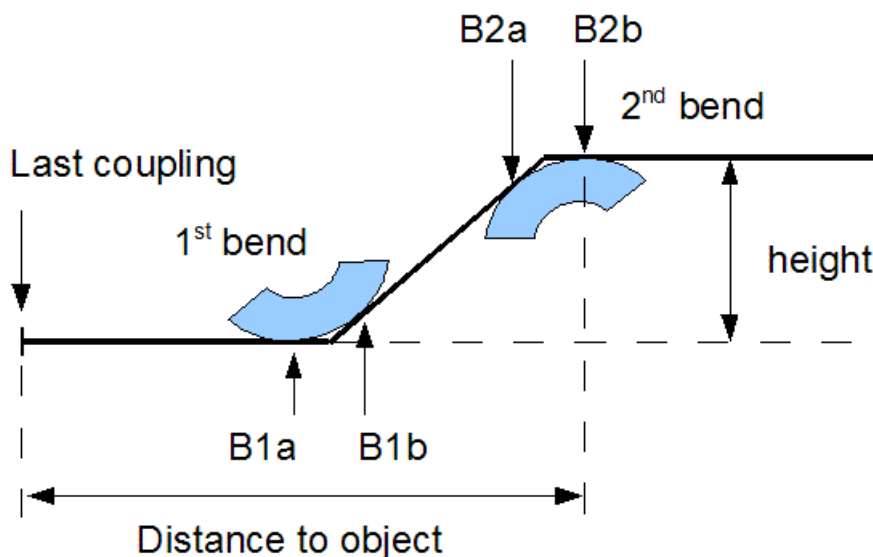
The “Precut” / “Arrows” button toggles between the first and the last three result lines: Precut, Take-up, Sum, or Arrow 1, 2, and 3.

Gain & Take-up	
Size:	EMT 1/2" (Gain 2+1/2")
P1:	1 ft 3 in
P2:	2 ft 6 in
P3:	1 ft 3 in
P4:	1 ft
Arrow 1:	10 in
Arrow 2:	3 ft 1 + 1/2 in
Arrow 3:	4 ft 2 in
<input type="button" value="Done"/> <input type="button" value="Precut"/> <input type="button" value="Inches"/>	

- Precut: The length of the conduit needed for the bend.
 - Since bending the conduit with a bender will not produce sharp corners like the ones shown in the illustration, the actual length of conduit needed is less than the sum; you “gain” conduit length. Master Bender displays the total length of the conduit as the “Precut”.
- Take-up: The take-up value for the bender.
- Sum: The sum of P1, P2, P3, and P4. You can use this as a convenient way to quickly add numbers.
- Arrow 1, 2, and 3: The location of the arrow mark for the three bends.

Offset Bends

The “Offset” button takes you to the Offset Bend worksheet. An offset bend is used to move a conduit from one plane to another. For example, you can use it to move the conduit around an obstruction. An offset bend consists of two bends of the same angle.



The arrows indicate the arrow marks on the bender. For "flow through" benders, use marks B1a and B2a. For other benders, use marks B1b and B2b.

On the illustration, the arrow marks match the beginning of a bend: The place where the conduit starts to bend. On some benders, the arrow marks are offset from the start of the bend by an amount known as the X value. While not shown on the illustration, Master Bender does take the X value into account.

To compute an offset bend, you need to provide:

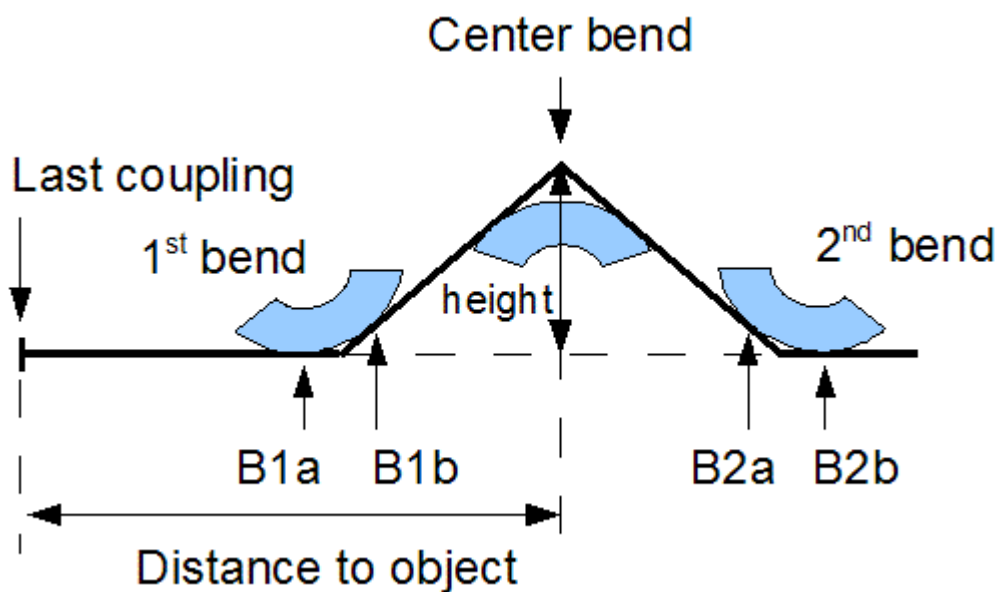
- The height of the obstacle.
- The distance from the last coupling to the front of the obstacle.
- The angle of the bends.

Assume you have selected the 1/2 inch Ideal Hand Bender. With a height of 6 inches, a distance of 2 feet, and an angle of 45 degrees, Master Bender computes the offset bend:

- The 1st bend is 1 foot 5+13/16 inches from the last coupling.
- The 2nd bend is 2 feet 2+1/8 inches from the last coupling.
- The two bends are 8+5/16 inches apart.

Three Point Saddle Bends

The "3 Point Saddle" button takes you to the Three Point Saddle worksheet. A three point saddle bend is used to move a conduit around a small obstacle. For example, you can use it to move the conduit around another conduit. A three point saddle bend consists of three bends: A center bend and two bends on either side. The angle of the center bend is twice that of the two side bends.



The arrows indicate the arrow marks on the bender for bend 1 and 2. For "flow through" benders, use marks B1a and B2a. For other benders, use marks B1b and B2a – the first and second bends are in the opposite direction of each other. The mark for the center bend is in the center of the bend – use the rim notch on your bender and not the normal arrow mark.

To compute a three point saddle bend, you need to provide:

- The height of the obstacle.
- The distance from the last coupling to the center of the obstacle.
- The angle of the **center** bend.

The two side bends are half the angle of the center bend.

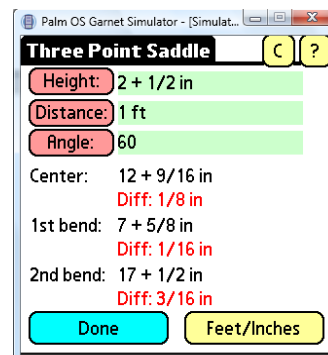
Assume you have selected the 1/2 inch Ideal Hand Bender. With a height of 2 1/2 inches, a distance of 1 foot, and a top angle of 60 degrees, Master Bender computes the three point saddle bend:

- The center bend is 12+9/16 inches from the last coupling.
- The 1st bend is 7+5/8 inches from the last coupling.
- The 2nd bend is 17+1/2 inches from the last coupling.

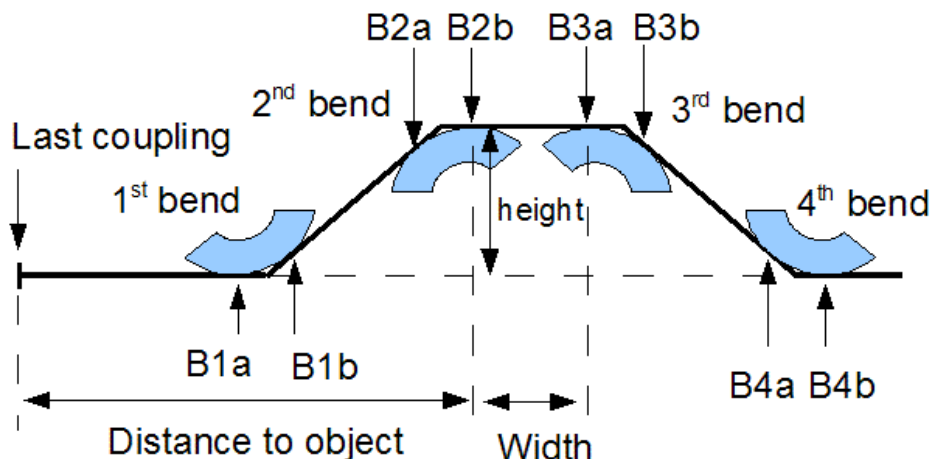
The top bend is 60 degrees. The two side bends are 30 degrees each.

Master Bender compares the result to the cosecant method. The red "Diff" lines show how much the cosecant method differs from the computed results.

Press the yellow button "Feet/Inches" to display distances in feet and inches. The yellow button will change to "Compare." If you press "Compare," Master Bender will show the "Diff" lines again.



Four Point Saddle Bends



The “4 Point Saddle” button takes you to the Four Point Saddle worksheet. A four point saddle bend is used to move a conduit around a larger obstacle. For example, you can use it to move the conduit around a duct. A four point saddle bend consists of four bends in the form of two consecutive offset bends. The first pair of bends moves the conduit from one plane to another. The second pair of bends moves the conduit back to the original plane.

The illustration shows a four point saddle bend. The arrows indicate the arrow marks on the bender. For “flow through” benders, use marks B1a, B2a, B3a, and B4a. For other benders, use marks B1b, B2b, B3a, and B4a – the last two bends are in the opposite direction of the first two bends.

The screenshot shows the “Four Point Saddle” worksheet in the Palm OS Garnet Simulator. The worksheet has a title bar “Palm OS Garnet Simulator - [Simulat...].” Below the title bar is a header “Four Point Saddle” with a “C” button and a “?” button. The worksheet contains four input fields: “Height: 8 in”, “Distance: 5 ft”, “Width: 9 in”, and “Angle: 60”. At the bottom of the worksheet are two buttons: “Done” and “Calculate”.

To compute a four point saddle bend, you need to provide:

- The height of the obstacle.
- The distance from the last coupling to the front of the obstacle.
- The width of the obstacle.
- The angle of the bends.

Assume you have selected the 1/2 inch Ideal Hand Bender. Chose a height of 8 inches, a distance of 5 feet, a width of 9 inches, and an angle of 60 degrees. Press the “Calculate” button to compute the bend. Master Bender computes the four point saddle bend as shown on the screen shot.

You can use the “Inches” button to switch from feet/inches to just inches. If you do, the button will change name to “Feet / Inches” to indicate that you can switch back again.

The “Compare” button will compare the results against the cosecant method. In the example above, the 4th bend will be 1+3/8 inches off if you had used

The screenshot shows the “Four Point Saddle” worksheet in the Palm OS Garnet Simulator, displaying the results of the calculation. The worksheet has a title bar “Palm OS Garnet Simulator - [Simulat...].” Below the title bar is a header “Four Point Saddle” with a “?” button. The worksheet contains the following calculated results: “Delta: 8 + 3/4 in”, “1st bend: 4 ft 6 + 15/16 in”, “2nd bend: 5 ft 3 + 11/16 in”, “3rd bend: 6 ft 11/16 in”, “4th bend: 6 ft 9 + 7/16 in”, and “Center: 5 ft 8 + 3/16 in”. At the bottom of the worksheet are three buttons: “Done”, “Inches”, and “Compare”.

the cosecant method.

Compound 90 Degrees Bends

The “Compound 90” button takes you to the Compound 90 Degree worksheet. A compound 90 degree bend is used to bend a conduit 90 degrees but avoiding an obstacle in the 90 degree corner. Instead of one 90 degree bend, two 45 degree bends are used.

To compute a compound 90 degree bend, you need to provide:

- The shape of the obstacle: Round, square 45, square 90, or rectangular.
 - “Square 90” indicates that the sides of the object are parallel to the walls in the corner. In other words, the object fits all the way into the corner leaving no gap behind it.
 - “Square 45” indicates that the object is turned 45 degrees. It will leave a triangular empty space between it and the 90 degree corner of the wall.
- The distance from the last coupling to the corner.
- The diameter of the object (if round), the length of the side of the object (if square), or the lengths of the two sides (if rectangular).

Master Bender computes the distance from the last coupling to the two bends, and the distance between the bends.

Parallel Bends

The “Parallel” button takes you to the Parallel bend worksheet. Parallel bending is a method of bending multiple conduits and still maintain a constant distance between the them.

To compute a parallel bend, you need to provide:

- The distance between the conduits.
- The angle of the bend.

Once you enter the data, Master Bender will compute the distance you need to offset the second, third, and fourth conduit to maintain a constant distance between them.

For example, we want to maintain a constant distance of two inches between conduits. After we have bent each of them 15 degrees, we need to offset the second conduit by $\frac{1}{4}$ inch, the third conduit by $\frac{1}{2}$ inch, and the fourth conduit by $\frac{3}{4}$ inch.

Palm OS Garnet Simulator - [Simulat...]

Compound 90 [C] [?]

Distance: 2 ft

Side 1: 4 in

Side 2: 3 in

Distance: $9 + \frac{7}{8}$ in

1st bend: 17 in
1 ft 5 in

2nd bend: $26 + \frac{7}{8}$ in
2 ft $2 + \frac{7}{8}$ in

Done ▼ Rectangle

Palm OS Garnet Simulator - [Simulat...]

Parallel [C] [?]

Distance: 2 in

Angle: 15

2nd dist: $\frac{1}{4}$ in

3rd dist: $\frac{1}{2}$ in

4th dist: $\frac{3}{4}$ in

Done

Concentric Bends

The “Concentric” button takes you to the Concentric bends worksheet. A series of concentric segment bends allow parallel conduit runs to be placed with even spacing between the conduits.

When computing concentric bends, start with the innermost conduit; that is, the conduit with the smallest bending radius. The Concentric bends worksheet computes the bending radius of the next conduit; that is, the conduit with the second smallest bending radius. To compute the radius of third conduit, use the radius of the second conduit, and so on and so forth.

To compute a Concentric bend, you need to provide:

- The radius of the inner segment bend measured to the center of the conduit.
- The outside diameter (OD) of the inner conduit
- The distance between the inner and the outer conduits.
- The outside diameter (OD) of the outer conduit.

Master Bender will now compute the radius of the bend for the outer conduit. This is the radius measured to the center of the outer conduit, and it is the value you can use directly in the Segment bend worksheet.

Use the Concentric bends worksheet to work from the innermost to the outermost conduit. Once you have computed the radius for one conduit, you can use the “Next” button to populate the worksheet with values for the next bend: The values of the radius and outside diameter of the outer conduit will be moved to the radius and outside diameter for the inner conduit.

Concentric [C] [?]

Radius: 2 ft 6 in

OD(in): 2 + 3/8 in

Distance: 3 + 1/2 in

OD(out): 2 + 7/8 in

Radius: 36 + 1/8 in
3 ft 1/8 in

Done Next

Segment Bends

The “Segment” button takes you to the Segment bend worksheet. Segment bending is a method of bending conduit by making several small bends to produce one larger bend.

As an example, you may produce a 90 degree bend as six 15 degree bends.

To compute a segment bend, you need to provide:

- The angle of the combined bend.
- The number of segments you want. This is the number of small bends.
- The radius of the combined bend as measured to the center of the conduit.

Once you enter the data, Master Bender will compute the bend:

- The angle of each segment.
- The distance on the conduit between each of the small bends.
- The combined length of the conduit.

Segment [C] [?]

Angle: 90

Number: 6

Radius: 2 ft

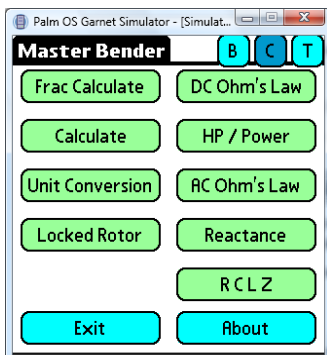
Angle: 15

Distance: 6 + 5/16 in

Length: 37 + 11/16 in
3 ft 1 + 11/16 in

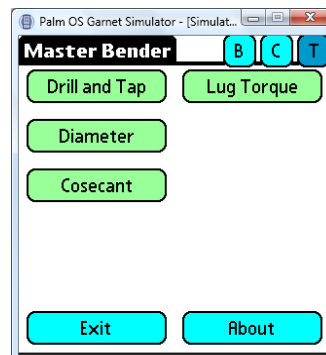
Done

Electrical Formulas, Tables and Calculators



The “C” portion of the Master Bender's main screen gives you access to electrical formulas and calculators. The “T” portion of the main screen gives you access to tables.

The green buttons take you to the individual worksheets. We will now describe each of the worksheets.



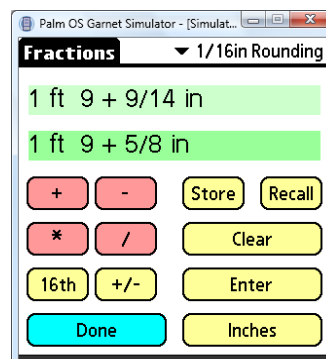
Fraction Calculator

The “Frac Calculate” button takes you to the Fraction Calculator worksheet. This worksheet is a basic calculator, but it calculates in feet and inches.

The calculator worksheet has two results lines:

- The first line shows the exact result.
- The second line shows either...
 - ...the result rounded to the nearest 1/16th of an inch
 - ...the result using decimals (instead of fractions), or
 - ...the result in meters (to the nearest millimeter).

Using the pull-down list at the top of the screen, you can chose the behavior of the second result line.



The buttons on the worksheet behaves as follows:

- +, -, *, / Add, subtract, multiply, or divide the current result with a new number, which Master Bender will ask you for.
- Store Save the current result.
- Recall Recall a previously stored result.
- Enter Enter a value.
- Inches or Feet/Inches Switch between feet and inches, and inches only mode.
- 16th Round the exact result off to the nearest 1/16th of an inch.
- +/- Change the sign of the result.

Example: Evenly space 5 outlet boxes on a 27' 3/4" wall.

1. Select [Enter] and type in 27 feet and 3/4 inches.
2. Divide by 6. The result is 4 feet and 6 + 1/8 inches.

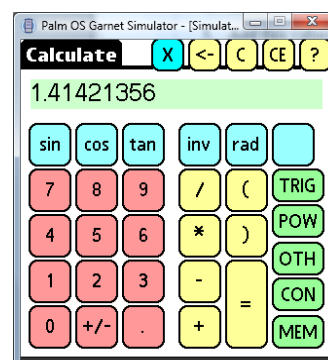
3. The first outlet box is centered 4 feet and $6 + 1/8$ inches from the end of the wall.
4. Save this value by selecting [Store].
5. Add this values to itself to get the subsequent locations. Use the sequence [+] [Recall] [Done] four times.
 - Location 1: 4 feet and $6 + 1/8$ inches
 - Location 2: 9 feet and $1/4$ inch
 - Location 3: 13 feet and $6 + 3/8$ inches
 - Location 4: 18 feet and $1/2$ inch
 - Location 5: 22 feet and $6 + 5/8$ inches

Scientific Calculator

The “Calculate” button takes you to the scientific calculator. The scientific calculator lets you perform both simple and advanced math.

Use the red buttons to enter values. Use the yellow buttons to perform simple computations. The green buttons selects which functions are available via the blue buttons.

The calculator follows standard operator precedence. This means that multiplication and division takes precedence over addition and subtraction. For example, “ $1+2*3$ ” computes to 7 because multiplication happens before addition. Use parentheses to force a different order of computation – for example, “ $(1+2)*3$ ” computes to 9 because parentheses are computed before multiplication.



At the top of the screen you will find a number of of buttons:

- X : Exit calculator
- <- : Remove last entered digit
- C : Clear number (but not current expression)
- CE: Clear number and current expression
- ? : Help

Use the green buttons for more functions. You may tap the green buttons more than onces. Here is a list of the available functions:

TRIG (Trigonometric Functions)

- Standard trig functions: sin, cos, tan
- Hyperbolic functions: sinh, cosh, tanh
- Use “inv” to compute the inverse of trig functions.

- Use “rad” to compute in radians instead of degrees.
- Use “r2d” and “d2r” to convert between radians and degrees.

POW (Power Functions)

- Square number: x^2
- Square root: sqrt
- General power function: x^y
- Inverse function: $1/x$
- Enter numbers in scientific notation: E+ and E-
 - Example: 2e3 for 2000, and 1e-3 for 0.001
- Exponential function: exp
- Base 10 power function: 10^x
- Natural logarithm: ln
- Base 10 logarithm: log

OTH (Other Functions)

- Integer part: int
- Fractional part: frac
- Round: rnd
- Percent: %
 - Example: $20 + 10\% = 22$
 - Example: $20 * 10\% = 2$

CON (Constants and Conversions)

- Constant pi: pi
- Constant e: e
- Square root of 2: sq2
- Square root of 3: sq3
- Convert between units: unit
 - Note: See the Unit Conversion section for more information on units
- Area of circle from radius: cirA
- Circumference of circle from radius: cirC

- Peak to effective value conversion: p2e
- Effective to peak value conversion: e2p

MEM (Memory Functions)

- Memory clear: MC
- Memory set: MS
- Memory read: MR
- Memory add: M+
- Memory subtract: M-

Unit Conversion

The “Unit Conversion” button takes you to the unit conversion worksheet. You may also access the worksheet from within the scientific calculator.

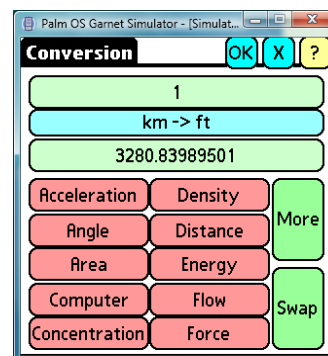
The worksheet converts the top value to the bottom value using the conversion in the blue field.

Click “OK” or “X” to leave the worksheet. If you accessed the worksheet from within the scientific calculator, pressing “OK” will copy the result of the conversion to the calculator.

Click on the top value to change it.

Use the red buttons to select the type of conversion. The “More” button will give you access to even more categories of units for a total for more than 250 units in 19 categories.

The “Swap” button swaps the direction of the conversion. For example, instead of converting from km to ft, you would be converting from ft to km.



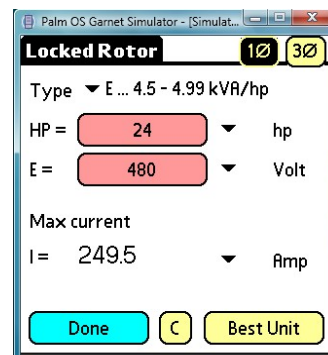
Locked Rotor

The “Locked Rotor” button takes you to the Locked Rotor Current worksheet.

Select the type of motor. The types are indicated by a letter and the range of kVA per hp for that type.

Enter the horsepower and voltage to compute the max current for the motor; or the minimum current in the case motor type V.

Use the buttons at the top to select between one and three phase motors.

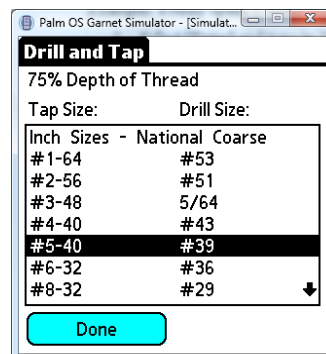


Drill and Tap

The “Drill and Tap” button takes you to the Drill and Tap worksheet.

This simple worksheet lists common tap sizes and labels for both U.S. and metric taps: National Coarse, National Fine, Taper Pipe Sizes (NPT), Straight Pipe Sizes (NPS), Metric Coarse, and Metric Fine. Use the arrows to scroll the table up or down.

All values assume 75% depth of thread.



Diameter Tables

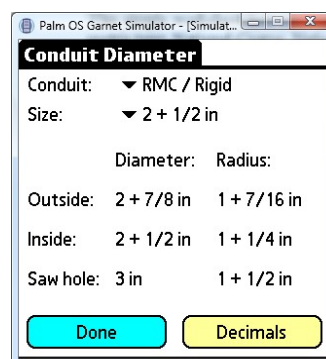
The “Diameter” button takes you to the Conduit Diameter worksheet.

Select the type of conduit you are using. You can choose between EMT, RMC / Rigid, IMC, Greenfield, L.T. Flex, OCAL-Blue, Copper K, Copper L, and Copper M.

Next, select the size of your conduit. Master Bender will let you choose between trade sizes from ½ inch to 6 inches. Not all conduits are available in all trade sizes.

Once you have made a selection, Master Bender shows you the outside diameter and the radius of the conduit, and the size of the saw hole you need to accommodate it.

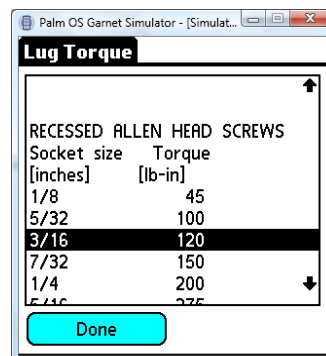
Master Bender shows the values both as a decimal number and rounded to the nearest 1/16th of an inch.



Lug Torque

The “Lug Torque” button takes you to the Lug Torque worksheet. The worksheet gives you a table of the torque for:

- Slotted heads larger than number 10
 - There are two columns in the table: One for width less than 3/64 inch and length less than 1/4 inch, and one for width larger than 3/64 inch and length larger than 1/4 inch.
- Hexagonal head
 - Two columns: Split-bolt connectors and other connectors.
- Slotted heads less than number 10



- Two columns: Width less than 3/4 inch, and width larger than or equal to 3/4 inch.
- Recessed Allen head
- Lug-bolting torques for connection of wire connectors to busbars

AC and DC Formulas

The “DC Ohm's Law” and “AC Ohm's Law” buttons take you to the two Ohm's Law worksheets.

Each worksheet will present you with 12 formulas. Select the button of a formula to enter the worksheet for that formula.

The formula worksheets allow you to enter values by pressing the red buttons. For example, on the worksheet to the left, pressing the red buttons allow you to enter values for E (Voltage) and R (Resistance). Use the pull-down lists to select a prefix for the units. Available prefixes are none, m (milli), k (kilo), μ (micro), and M (mega).

The “Best Unit” button selects the best prefix for the result. You can also use the unit prefix pull-down to change the prefix for the result.

Master Bender uses the following symbols:

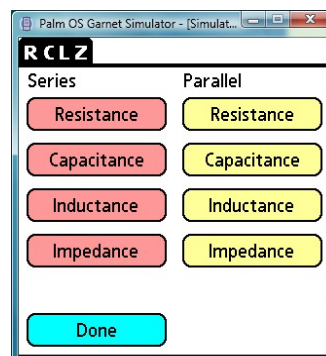
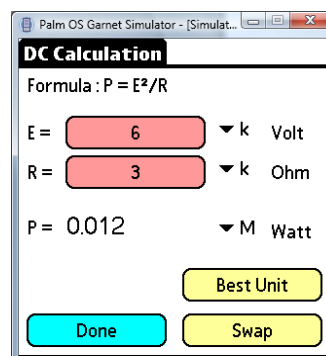
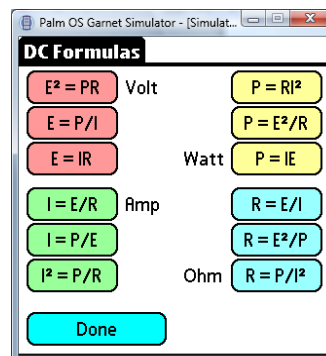
Symbol	Meaning
E	Voltage
I	Current
R	Resistance
Z	Impedance
P	DC Power
AP	AC Power

When using the AC formulas, make sure you use RMS (Root Mean Square) values.

Parallel and Series

The “R C L Z” button takes you to a worksheet for computing parallel and series combinations of resistance (R), capacitance (C), inductance (L), and impedance (Z).

Select the red buttons to do series combinations or the yellow buttons to do parallel combinations.



Reactance

The “Reactance” button takes you to the Reactance worksheet. You can choose between capacitive and inductive reactance.

Capacitive reactance is computed from a frequency in Hertz and a capacitance in Farad.

Inductive reactance is computed from a frequency in Hertz and an inductance in Henry.

HP / Power Formulas

The “HP / Power” button takes you to the Horsepower and Power worksheet. Here you will be able to compute power in horsepower, volt amps, and watts. You can compute the current if you know either the horsepower, the volt amps, or the watts. There are formulas for efficiency and power factor.

Press one of the buttons to access the formula worksheet.

All the formulas allow you to select between DC, 1 phase AC, 2 phase 4 wire AC, and 3 phase AC using the four buttons at the top of the screen.

Both efficiency and power factor are numbers between 0 and 1. If you enter a number larger than 1, Master Bender will assume you are entering the number in percent, and it will automatically adjust it. For example, if you enter an efficiency of 85, Master Bender will assume you mean 85% and adjust it to 0.85.