TI-86 COMPLEX NUMBERS

(1-1)

1. Choosing the Correct Format

Before entering complex numbers into the TI-86 for calculations or conversions, you must tell it the format you are going to use to enter information and the format you want it to use to display results back to you.

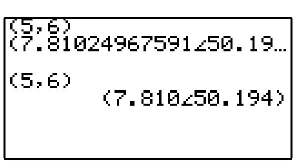
<2nd> <More> for the "Mode" screen (1-1).
When you first enter this screen, there will be a blinking cursor, some text in normal video and some text in reverse video. The items in reverse video are the current settings for the TI-86. To choose different settings, use the cursor keys to place the blinking cursor on the desired value and push <Enter>. When you move the cursor, you will see that your selection is now in reverse video.
For complex numbers, you will have to choose between radians and degrees and rectangular and polar formats.
<Down> to Radian/Degree and choose the desired format. This will affect how the TI-86 interprets angles you give it and how it displays angles back to you. In Radian mode, there are 2π, or about 6.28, radians to a circle. In Degree mode, there are 360° to a circle. It does not matter which format you use as long as you enter the data correctly for that format.
<Down> to RectC/PolarC and choose the desired format. In Rectangular mode, the TI-86 will return a complex number A+jB as (A,B). In the Polar mode, the TI-86 will return a complex number R<θ as (R<θ). θ can be in radians or degrees as set on the Radian/Degree line.
<Exit> back to the main screen.

Note: this handout will use "<" to indicate the symbol the TI-86 uses for angles using the <2nd><,> keys; it does not represent "less than."

Note: for the TI-86, complex numbers MUST be entered with parentheses as shown in the examples. To show that an operation was done with a complex number, the TI-86 will display the result with parentheses.

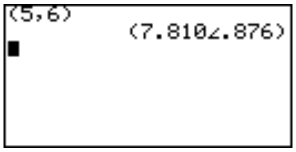
2. Converting Rectangular to Polar by Mode

Choose PolarC as described in Step 1. For this example, results will be shown for degrees and then for radians, so choose whichever angle format you want.
You may also want to fix the number of decimal places the TI-86 will display on the screen. This is done on the second line of the "Mode" screen. "Float" tells the TI-86 to display however many decimal points are necessary, "0" fixes the number to 0 decimal points, etc. Fixing the number of decimal points does not affect the accuracy of the calculations, but some numbers may be rounded on the displayed results (1-1).
<Exit> back to the main screen.



(2-1a)
(2-1b)

Converting 5+j6 to its polar equivalent is shown at left (2-1).
If you have not fixed your number of decimal places, the display would be as in (2-1a). (2-1b) shows the same answer fixed to three decimal places. The "50.19..." indicates that the total length of the number exceeds the amount of space the TI-86 has to display the number. You can use the

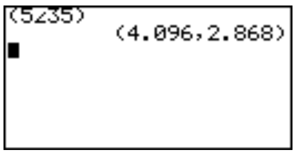


(2-2)

<Right> cursor key to view the rest of the number which is 50.1944289077.

If you had been in the radian mode, you answer would have been (7.81024967591<.8760...)

or to however many decimal points you have chosen (2-2).
Notice that the option of radians or degrees does not affect the R portion of the answer, only the θ, or angular, portion of the answer.
Also, notice that the TI-86 does not directly tell you if you are working in Radians or Degrees. It is your responsibility to choose and remember the correct format of angles for a given problem.

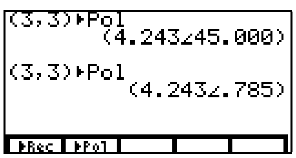


(3-1)

<u>3. Converting Polar to Rectangular by Mode</u>
Note: Answers will be shown from this point on fixed to 3 decimal places.

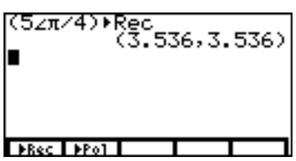
Choose RectC and Degree as described in Step 1.
<Exit> back to the main screen.
Converting 5<35° to its rectangular equivalent is shown at left (3-1).

Remember, for polar to rectangular conversions, the TI-86 will use whatever angle format you tell it. If your answer does not match the one above, verify that you were using degrees, not radians. One general clue to keep in mind is that radian values will not be greater than 6.28, whereas degree values can be up to 360.
If your given angle had been in radians, you would have selected RectC and Radian.



(4-1a)
(4-1b)

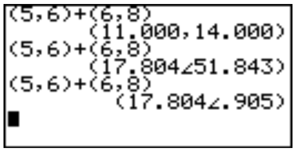
<u>4. Complex Menu Conversions</u>
The alternative way of converting complex numbers as described in Steps 2 and 3 is to use the TI-86's "Complex Menu." This menu may be used to convert complex numbers regardless of the RectC/PolarC setting in the "Mode" screen. **Angles entered and received are still governed by the Radian/Degree setting**.
<2nd><9> for the "Cplx" menu
<More> for the conversion functions
Enter the number you wish to convert followed by <F1> or <F2> as appropriate.
Converting 3+j3 to polar is shown in (4-1). (4-1a) is degrees, (4-1b) is radians.



(4-2)

Converting 5 < π/4 radians is shown in (4-2).

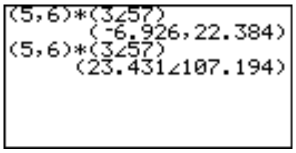
If you didn't get the correct answer, verify that you are in the Radian mode.



(5-1a)
(5-1b)
(5-1c)

5. Basic Operations

One of the nice things about the TI-86 calculator is that you can mix the format of complex numbers for math operations without having to do any conversions first. The calculator does not care if you add two rectangular numbers, two polar numbers, or any combination of polar and rectangular numbers or complex and real numbers.
To add 5+j6 and 6+j8 is shown at left in (5-1). (5-1a) is rectangular, (5-1b) is polar degrees, and (5-1c) is polar radians.

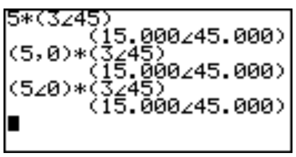


(5-2a)
(5-2b)

When entering numbers in the polar format, you must be using the format your TI-86 is expecting, either Radian or Degree. Entering an angle in degrees when your calculator is in the Radian mode and vice-versa will produce wrong answers.

To multiply 5+j6 and 3<57° is shown at left in (5-2). (5-2a) is rectangular mode, (5-2b) is in polar mode.

For this calculation, it is necessary to be in the Degree mode since your given angle is in degrees (57). Since you are in the Degree mode, the polar answer you receive will also be in degrees. Converting 107.194 degrees to radians is best done as a separate operation where 1radian = 57.296°.
Performing operations between a real number and a complex number is also an easy task.



(5-3)

The TI-86 interprets any number not in the format of (A,B) or (R<θ) to be a real number. Example (5-3) results in the same answer for three different entries.

As with the last example, since one entry contained an angle in degrees, you must be in Degree mode and the answer in Polar mode will be in degrees.

Note: The TI-86 does allow you to mix degrees and radians in an equation. However, doing so can easily lead to mistakes. If you wish to experiment, push <2nd><x> for the “Math” menu and then <F3> for the “Angle” functions.

6. Series Example

Note: from this point on, all answers will be shown in the Polar Degree mode.

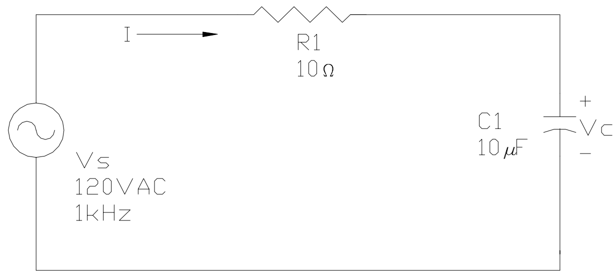
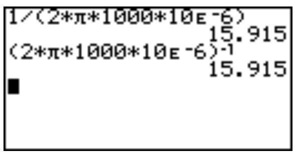


Figure 1



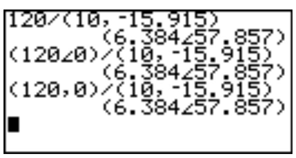
(6-1)

For the circuit in Figure 1, find I and then Vc using both Ohm's Law and voltage division.

The first item that must be found is Xc = -j / (2πfC). On your TI-86, you could enter this in either form on (6-1).

This makes Xc = -j15.915Ω.

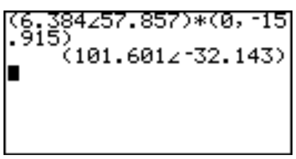
Since this is a series circuit, the entire impedance Z = R + jX is Z = 10 - j15.915Ω.



(6-2)

a. Ohm's Law

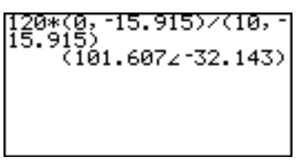
Find the current by I = V/Z. Referring back to Section 5, either of the entries in (6-2) could be correct.



(6-3)

Finding the voltage across the capacitor would now be Vc = I*Xc on your calculator as in (6-3).

Therefore, the total series current is 6.384<57.857° Amps and the voltage across the capacitor is 101.607<-32.143° Volts.



(6-4)

b. Voltage Division

Vc can also be found by voltage division using the formula
Vc = Vs * Xc / Z. On your calculator, this would appear as (6-4).
which matches the Ohm's Law method.

7. Parallel Example

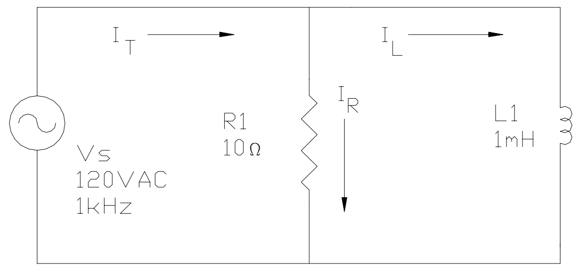
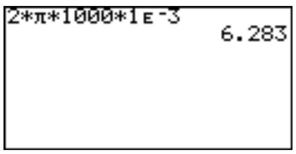


Figure 2

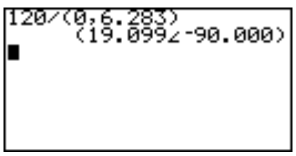


(7-1)

For the circuit in Figure 2, find all of the currents, first by Ohm's Law and KCL and then by using current division.
The first step is to find the reactance of the inductor. This is done using the formula $X_L = j2\pi f\ L$. On your calculator this would be as in (7-1).

This makes $X_L = j6.283\Omega$.

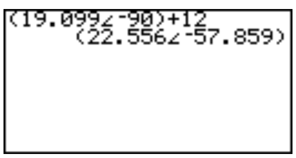
a. Ohm's Law
Find $I_L = Vs/X_L$ as in (7-2).



(7-2)

This makes I_L = 19.099<-90° Amps.

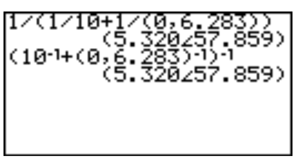
Also by Ohm's Law, $I_R = 120V/10\Omega$ = 12Amps or 12<0° Amps or 12+j0 Amps. Having solved for I_L and I_R, you can use KCL to find I_T: $I_T = I_L + I_R$. This is shown in (7-3).



(7-3)

Thus, I_T = 22.556<-57.859° Amps.

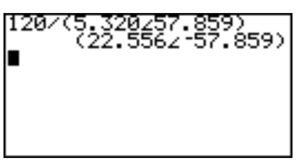
b. Current Division
In order to use current division, you must find I_T before finding the branch currents. To find I_T, you must have Z_T.
For a parallel circuit, recall that the total impedance is the inverse of the sum of the inverses of the individual impedances. So in this example, $Z_T = 1/\ (1/R + 1/X_L)$.
This would be entered in several ways as shown in (7-4).



(7-4)

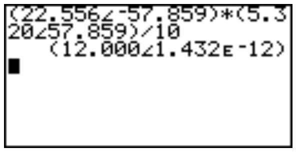
Thus, Z for Figure 2 is 5.320<57.859° Ω.

Then, using Ohm's Law, $I = V/Z_T$ on your calculator would be as in (7-5)

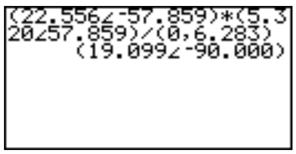


(7-5)

Thus, I_T = 22.556<-57.859° Amps which matches the KCL method.



(7-6)



(7-7)

For the individual branch currents, you can use current division which is formula $I_X = I_T * (Z_T / Z_X)$. For the resistor, $Z_X = R$; for the inductor, $Z_X = X_L$.

Thus, to find I_R on your TI-86, enter this equations as shown in (7-6). Notice that the angle for IR should be 0°. Due to internal precision, your calculator displays a very small number instead of 0. This can be assumed close enough to 0° to call $I_R=12<0°$ Amps.

Next, find I_L, as in (7-7).

Notice these last two answers match the Ohm’s Law method.