

**EE210 – Circuits**  
**Complex Numbers and Your Calculator**  
Tony Richardson

*This is a work in progress. If you have a different calculator or software package you would like to see included, let me know. Thanks!!!*

*Note: I did not have access to a TI85/86 when this was written. If you have one of these calculators please test the accuracy of the statements here and let me know the results.*

Let's explore evaluating the following complex number expression on a variety of calculators:

$$\frac{(240 \angle 75^\circ + 160 \angle -30^\circ)(60 - j80)}{(67 + j84)(20 \angle 32^\circ)}$$

**Texas Instruments – TI83/84**

In the MODE menu set the default angle unit to Degree and the default complex format to  $re^{i\theta}$  (exponential) mode. These calculators allow you to directly enter the imaginary unit  $i$ . (This is NOT the same as the alphabetic  $i$  key that is also available). They do not allow you to enter complex numbers in polar form. You must use exponential mode instead. Angles in exponential mode can only be entered in radians. So to enter a number that is expressed in polar form (where the angle is in degrees) into the calculator you must convert the angle to radians. An easy way to do this is to multiply the angle by  $\pi/180$ . So to enter, for example, the polar form number  $(240 \angle 75)$  into the calculator you must enter  $240 e^{(i 75 \pi/180)}$ . With the calculator in DEGREE mode this will then display  $240 e^{(i 75)}$  corresponding to the polar form number  $(240 \angle 75)$ . These calculators will display complex numbers in exponential form with the angle in degrees, but will not allow you to enter the angle in degrees.

You can use the following trick to allow you to enter angles directly in degrees. Store the expression  $i \pi/180$  as variable  $I$  (that is a capital alphabetic  $i$ ), you can then enter  $(240 \angle 75)$  as  $240 e^{(I*75)}$  and the calculator will then display  $240 e^{(i 75)}$ .

With this trick, you can enter the expression above as:

$$((240 e^{(I*75)} + 160 e^{(I*-30)}) (60 - i80)) / ((67 + i84) 20 e^{(I*32)})$$

The calculator then displays:

$$11.709888 e^{(i*-99.444742)}$$

The ► Rect operator can be used to convert complex numbers to rectangular form, applying this operator to the previous result gives:

$$-1.9215496 - 11.551152 i$$

## Texas Instruments – TI85/TI86

In the MODE menu set the default Angle unit to DEGREE and the default Complex Format to POLAR. You must enclose complex numbers expressed in polar form in parentheses. A number in rectangular form is entered as (R, I) where R and I are the real and imaginary parts of the number. To enter a complex number representing  $i$ , enter (0,1) or (1  $\angle$  90).

When entered in the calculator the expression above looks like this:

$$(((240 \angle 75)+(160 \angle -30)) (60,-80))/((67,84) (20 \angle 32))$$

The calculator then displays:

$$(11.709888 \angle -99.444742)$$

The  $\blacktriangleright$ Rect operator can be used to convert complex numbers to rectangular form, applying this operator to the previous result gives:

$$-1.9215496 - 11.551152 i$$

## Texas Instruments – TI89/TI92/Voyage 200

In the MODE menu set the default Angle unit to DEGREE and the default Complex Format to POLAR. You must enclose complex numbers expressed in polar form in parentheses. These calculators allow you to directly enter the imaginary unit  $i$ . (This is NOT the same as the alphabetic  $i$  key that is also available).

When entered in the calculator the expression above looks like this:

$$(((240 \angle 75)+(160 \angle -30)) (60 - i80))/((67 + i84) (20 \angle 32))$$

The calculator then displays:

$$(11.7098879325 \angle -99.44474228)$$

The  $\blacktriangleright$ Rect operator can be used to convert complex numbers to rectangular form, applying this operator to the previous result gives:

$$-1.92154959538 - 11.5511524336 i$$

## Matlab/Octave

By default, these software packages only allow complex numbers to be entered in rectangular form. In Matlab and Octave use  $i$  to represent the imaginary unit  $i$ . You can, of course, enter complex numbers in exponential form, but it is convenient to define functions `to_rd()` and `to_pd()`. `to_rd()` allows you to easily enter numbers in polar form and converts numbers to rectangular form. `to_pd()` converts complex numbers to polar form.

To enter the expression in both Matlab and Octave use:

$$((\text{to\_rd}(240,75)+\text{to\_rd}(160,-30))*(60-i*80))/((67+i*84)*\text{to\_rd}(20,32))$$

The follow result is returned:

$$\text{ans} = - 1.9215 - 11.5512i$$

To display the result in polar form enter:

$$[\text{to\_pd}(a,1) \quad \text{to\_pd}(a,2) ]$$

and the software will display:

$$11.710 \quad -99.445$$

so in polar form the number is:

$$(11.710 \angle -99.445)$$

## Derive

The imaginary unit  $i$  can be entered by either typing  $\#i$  or by clicking on the icon that looks something like  $\hat{i}$ . Derive does not support direct entry of complex numbers in polar form. You can use a trick similar to that used for the TI83 calculator to simplify entry of complex numbers in polar form. Define  $I$  as  $i \pi/180$  by entering:

$$I := \hat{i} \cdot \pi/180$$

You can then enter our test expression as:

$$((240 \hat{e}^{(I*75)}+160 \hat{e}^{(I*-30)}) (60-\hat{i}80))/((67+\hat{i}84) 20 \hat{e}^{(I*32)})$$

Clicking on the Approximate icon yields:

$$\#2: \quad -1.921549595 - 11.55115243 \cdot \hat{i}$$

(The  $\#2$  is the tag assigned to the result.) We can display the components of the corresponding polar form number by entering:

$$[\text{abs}(\#2), \text{phase}(\#2)*180/\pi]$$

and clicking on the Approximate icon. Derive responds with:

$$\#3: \quad [11.70988793, -99.44474227]$$