A RPN Calculator for real and complex numbers

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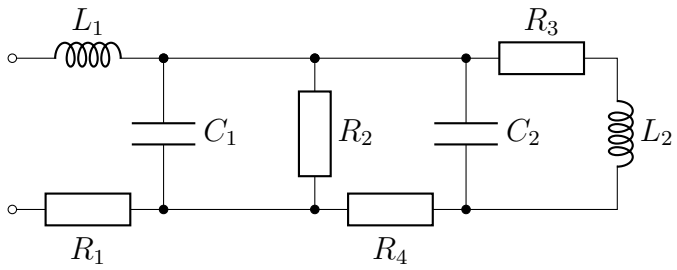
Calculation of AC-Circuits and more!



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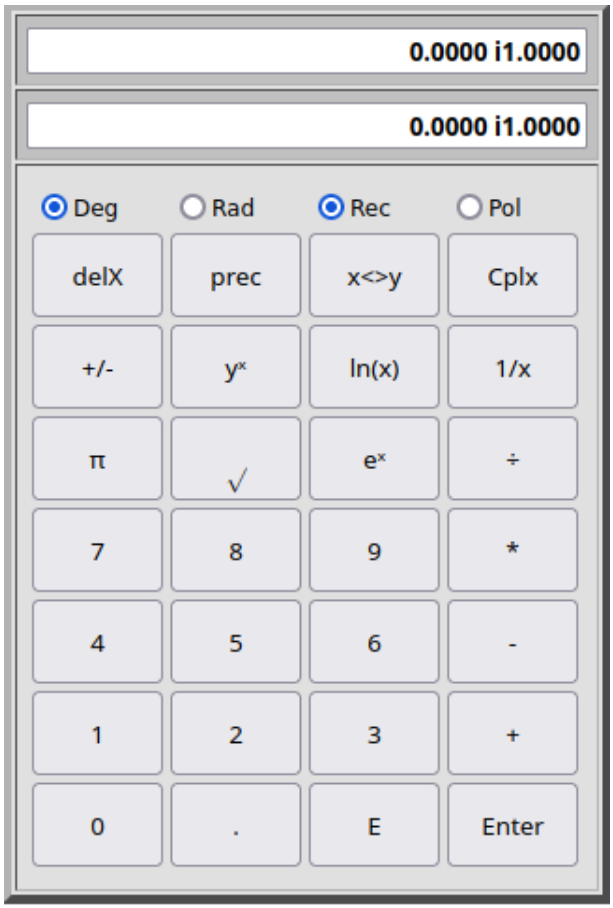
1 The calculator



How to get the Values in the display like in the picture above:

1 [Enter] 30 [cplx] [Enter] 1 [e^x]

1.1 Reverse Polish Notation (RPN)

First the numbers, then the operator (+, ∗ ...). Example: 35 [Enter] 14.7 [+].

Field	Stack	
T	0.0000	not visible
U	0.0000	not visible
Y	0.0000	visible
X	0.0000	visible

Calculate $^{(35+14.7)*7}/_{(22.7-3.14)}$

T	0.0000		0.0000		0.0000		0.0000		0.0000		
U	0.0000		0.0000		0.0000		0.0000		0.0000		
Y	0.0000		0.0000		35.0000		35.0000		0.0000		
X	0.0000	**35**	35	Enter	35.0000	**14.7**	14.7	+	49.7000	**7**	

T	0.0000		0.0000		0.0000		0.0000		
U	0.0000		0.0000		0.0000		347.9000		
Y	49.7000		0.0000		347.9000		22.7000		
X	7	*	347.9000	**22.7**	22.7	Enter	22.7000	**3.14**	

T	0.0000		0.0000		0.0000				
U	347.9000		0.0000		0.0000				
Y	22.7000		347.9000		0.0000				
X	3.14	−	19.56	/	17.7863				

2 Complex numbers

Complex numbers are two-dimensional numbers, with a real- and imaginary part. Calculation is similar to binomial theorem.

$$(a+b)^2 = a^2 + 2ab + b^2 \qquad \text{binomial theorem}$$
$$(a+ib)^2 = a^2 + i2ab - b^2 = a^2 - b^2 + i2ab \qquad \text{Complex number}$$

Get $-b^2$ because of $i^2 = -1$.

There are two ways to represent complex numbers:

- Rectangular coordinates (a + ib) (Rect)
- Polar coordinates $|r| * e^{i\varphi}$ mit $|r| = \sqrt{a^2 + b^2}$ (Pol)

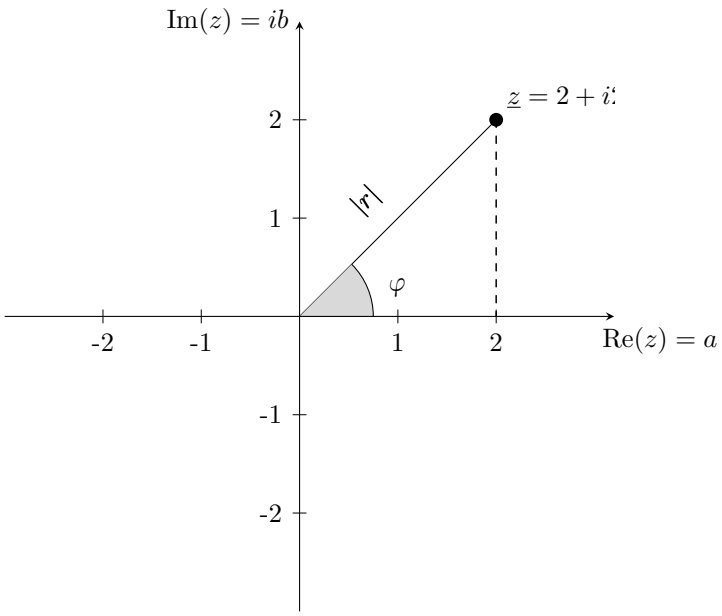


Figure 1: complex number plane

3 Operating instructions

The complex number 3 + i5 in rectangular coordinates (Rect):

3 [Enter] 5 [cplx]

The real part 3 in the Y-Field and the imaginary part 5 in the X-Field.

3.1 Trigonometric Functions

Take a look at the complex plane, you see a right triangle with these relation with the radius $r = 1$ of a circle.

$$\cos^2 a + \sin^2 b = 1$$

'Formular of Euler':

$$e^{i \cdot \varphi^\circ} = \cos(\varphi^\circ) + i \sin(\varphi^\circ))$$

Calculation of sine, cosine and tangent of $\varphi = 30^\circ$ (Pol and Deg):

1 [Enter] 30 [cplx] to Rect

because of the "Formular of Euler".
The input (Pol and Deg):

Input	X-Field	Y-Field
1	1	0.0000
Enter	1.0000	1.0000
30	30	1.0000
cplx	1.0000 ∠30.0000	0.0000
Rect	0.8660 i0.5000	0.0000
cplx	0.5000	0.8660
x⇔y	0.8660	0.5000
/	0.5774	0.0000

The $\sin(30^\circ) = 0.5$, the $\cos(30^\circ) = 0.866$. The last value in the table is $\tan(30^\circ) = 0.5774$. and backwards the atan (Rect and Deg):

Input	X-Field	Y-Field
1	1	0.5774
x⇔y	0.5774	1.0000
cplx	1.0000 i0.5774	0.0000
Pol	1.1547 ∠30.0000	0.0000

3.2 Homers last theorem

Calculation with big numbers. The Simpsons and Fermat's last theorem!

$$3987^{12} + 4365^{12} = 4472^{12}$$

One of the author of the of the TV-series wrote a C-Programm to find this equation.

Input	X-Field	Y-Field	U-Register
3987	3987	0.0000	
Enter	3987.0000	3987.0000	
12	12	3987.0000	
y^x	1.6134e+43	0.0000	
4365	4365	1.6134e+43	
Enter	4365.0000	4365.0000	1.6134e+43
12	12	4365.0000	1.6134e+43
y^x	4.7842e+43	1.6134e+43	
+	6.3977e+43	0.0000	
4472	4472	6.3977e+43	
Enter	4472.0000	4472.0000	6.3977e+43
12	12	4472.0000	6.3977e+43
y^x	6.3977e+43	6.3977e+43	

The left and the right side of the equation are equal!. But the [prec] toggle-button shows, that Fermat's last theorem was not disproved.

4 Calculation of AC-Circuits

4.1 Simple Resistor-Circuit

Calculation of R_{total}

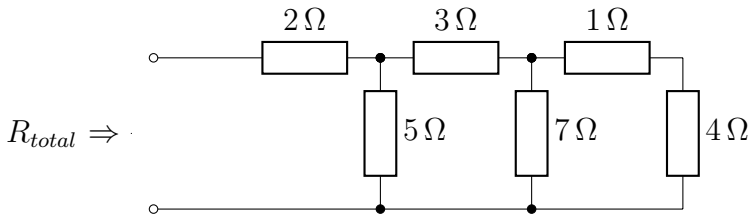


Figure 2: Resistor-Network

$$R_{total} = 2\Omega + \cfrac{1}{\cfrac{1}{5\Omega} + \cfrac{1}{3\Omega + \cfrac{1}{\cfrac{1}{7\Omega} + \cfrac{1}{1\Omega + 4\Omega}}}}$$

Input	X-Field	Y-Field
1	1	0.0000
Enter	1.000	1.0000
4	4	1.0000
+	5.0000	0.0000
$^1/_x$	0.2000	0.0000
7	7.0000	0.2000
$^1/_x$	0.14286	0.2000
+	0.34286	0.0000
$^1/_x$	2.91667	0.0000
3	3	2.9167
+	5.9167	0.0000
$^1/_x$	0.1690	0.0000
5	5	0.1690
$^1/_x$	0.2000	0.1690
+	0.3690	0.0000
$^1/_x$	2.7099	0.0000
2	2	2.7099
+	4.7099	0.0000

4.2 Circuit with complex resistors

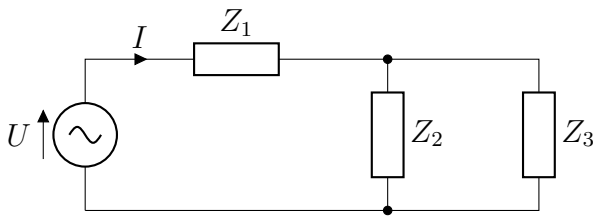
Calculate Z_{total} and the current I (Select Rect and Deg).

$U = 5\text{V}$

$Z_1 = 200\Omega + i100\Omega$

$Z_2 = 100\Omega - i50\Omega$

$Z_3 = 150\Omega + i150\Omega$



$$Z_{total} = Z_1 + \frac{1}{\frac{1}{Z_2} + \frac{1}{Z_3}} \text{ and } \quad I = \frac{U}{Z_{total}}$$

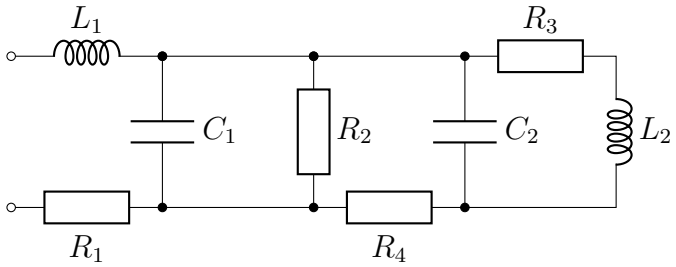
Input	X-Field	Y-Field	U-Register
100	100	0.0000	
Enter	100.0000	100.0000	
50	50	100.0000	
+/-	-50	100.0000	
cplx	100 i-50	0.0000	
1/x	0.0080 i0.0040	0.0000	
150	150	0.0080 i0.0040	
Enter	150.0000	150.0000	0.0080 i0.0040
cplx	150.0000 i150.0000	0.008 i0.004	
1/x	0.0033 i -0.0033	0.008 i0.004	
+	0.00113 i0.0007	0.0000	
1/x	87.9310 i -5.1724	0.0000	
200	200	87.9310 i -5.1724	
Enter	200.0000	200.0000	87.9310 i -5.1724
100	100	200.0000	87.9310 i -5.1724
cplx	200 i100	87.9310 i -5.1724	
+	287.9310 i94.8276	0.0000	
5	5	287.9310 i94.8276	
x⇔y	287.9310 i94.8276	5.0000	
/	0.0157 i -0.0052	0.0000	
Pol	0.0165 ∠-18.2288	0.0000	

$$Z_{total} = 287.9310\Omega + i94.8276\Omega \quad \text{and} \quad I = 16.5mA * e^{-18.2288}$$

4.3 Circuit with coils and capacitors

Calculate Z_{total} (Select Rect and Deg).

$\omega = 100Hz$
$L1 = 0.5H$, $L2 = 1H$
$C1 = 500\mu F$, $C2 = 100\mu F$
$R1 = 20\Omega$, $R2 = 50\Omega$, $R3 = 50\Omega$, $R4 = 30\Omega$



$Z_1 = X_{C_2}||(X_{L_2} + R_3) : 200\,i$ -100
$Z_2 = [(Z_1 + R_4)||R_2]||X_{C_1} : 7.3442\,i$ -16.0160
$Z_{total} = Z_2 + R_1 + X_{L_2} : 27.3442\,i33.9840$

The input in the calculator:

- 100 [Enter] 100E6 +/- * [cplx]
- 0 [Enter] 100 [cplx] 50 + 1/x + 1/x
- 30 + 1/x 50 1/x + 0 [Enter] 100 [Enter] 500E6 +/- * [cplx] + 1/x
- 20 + 0 [Enter] 100 [Enter] 0.5 * [cplx] +