```
> restart;
> with(plots):
```

Calculate Signal Transfer Function

```
> first := Y1 = (U*b1 - a1*Y3) * (c1 / (z-1));
```

$$first := Y1 = \frac{(U\,b1 - a1\,Y3)\,c1}{z-1} \tag{1}$$

```
> second := Y2 = (Y1 + U*b2 - a2*Y3) * (c2*z / (z-1)); # (c2 /(z-1)
  ); #
```

$$second := Y2 = \frac{(Y1 + U\,b2 - a2\,Y3)\,c2\,z}{z-1} \tag{2}$$

```
> third := Y3 = (Y2 + U*b3 - a3*Y3) * (c3 / (z-1));
```

$$third := Y3 = \frac{(Y2 + U\,b3 - a3\,Y3)\,c3}{z-1} \tag{3}$$

```
> first := solve(first, Y1);
```

$$first := \frac{(U\,b1 - a1\,Y3)\,c1}{z-1} \tag{4}$$

```
> second := subs(Y1=first, second);
```

$$second := Y2 = \frac{\left(\frac{(U\,b1 - a1\,Y3)\,c1}{z-1} + U\,b2 - a2\,Y3\right)c2\,z}{z-1} \tag{5}$$

```
> second := solve(second, Y2);
```

$$second := \frac{(c1\,U\,b1 - c1\,a1\,Y3 + U\,b2\,z - U\,b2 - a2\,Y3\,z + a2\,Y3)\,c2\,z}{(z-1)^2} \tag{6}$$

```
> ue_f := subs(Y2=second, third);
```

$$ue\_f := Y3 = \frac{\left(\frac{(c1\,U\,b1 - c1\,a1\,Y3 + U\,b2\,z - U\,b2 - a2\,Y3\,z + a2\,Y3)\,c2\,z}{(z-1)^2} + U\,b3 - a3\,Y3\right)c3}{z-1} \tag{7}$$

```
> ue_f := solve(ue_f, Y3);
```

$$ue\_f := \left(U\left(c2\,z\,c1\,b1 + c2\,z^2\,b2 - c2\,z\,b2 + b3\,z^2 - 2\,b3\,z + b3\right)c3\right) \Big/ \left(c3\,c2\,z\,c1\,a1 + c3\,c2\,z^2\,a2 - c3\,c2\,z\,a2 + c3\,a3\,z^2 - 2\,c3\,a3\,z + c3\,a3 + z^3 - 3\,z^2 + 3\,z - 1\right) \tag{8}$$

```
> ue_f := ue_f / U;
```

$$ue\_f := \left(\left(c2\,z\,c1\,b1 + c2\,z^2\,b2 - c2\,z\,b2 + b3\,z^2 - 2\,b3\,z + b3\right)c3\right) \Big/ \left(c3\,c2\,z\,c1\,a1 + c3\,c2\,z^2\,a2 - c3\,c2\,z\,a2 + c3\,a3\,z^2 - 2\,c3\,a3\,z + c3\,a3 + z^3 - 3\,z^2 + 3\,z - 1\right) \tag{9}$$

```
> nenner := denom(ue_f);
```

$$nenner := c3\,c2\,z\,c1\,a1 + c3\,c2\,z^2\,a2 - c3\,c2\,z\,a2 + c3\,a3\,z^2 - 2\,c3\,a3\,z + c3\,a3 + z^3 - 3\,z^2 + 3\,z - 1 \tag{10}$$

```
> pole := solve(nenner, z):
> numerator := numer(ue_f);
```

$$numerator := \left(c2\,z\,c1\,b1 + c2\,z^2\,b2 - c2\,z\,b2 + b3\,z^2 - 2\,b3\,z + b3\right)c3 \tag{11}$$

```
> nullst := solve(numerator, z);
```

$$nullst := \frac{1}{2}\,\frac{1}{b3 + c2\,b2}\left(-c2\,c1\,b1 + c2\,b2 + 2\,b3 + \sqrt{c2^2\,c1^2\,b1^2 - 2\,c2^2\,c1\,b1\,b2 - 4\,c2\,c1\,b1\,b3 + c2^2\,b2^2}\right), -\frac{1}{2}\,\frac{c2\,c1\,b1 - c2\,b2 - 2\,b3 + \sqrt{c2^2\,c1^2\,b1^2 - 2\,c2^2\,c1\,b1\,b2 - 4\,c2\,c1\,b1\,b3 + c2^2\,b2^2}}{b3 + c2\,b2} \tag{12}$$

Find pole and null

```
> fs := 1500000;
```

$$fs := 1500000 \tag{13}$$

```
> f_nutz := 20000;
```

$$f\_nutz := 20000 \tag{14}$$

```
> redim := Pi / fs;
```

$$redim := \frac{1}{1500000}\,\pi \tag{15}$$

```
> f_nutz_norm := f_nutz * redim;
```

$$f\_nutz\_norm := \frac{1}{75}\,\pi \tag{16}$$

```
> pol_r := 0.7:
> nul_r := 0:
> nul_phi := 0*Pi:
> pol_def := [pol_r*exp(f_nutz_norm*I), pol_r*exp(-f_nutz_norm*I)];
```

$$pol\_def := \left[0.7\,e^{\frac{1}{75}\,I\pi}, 0.7\,e^{-\frac{1}{75}\,I\pi}\right] \tag{17}$$

```
> null_def := [nul_r*exp(nul_phi*I), nul_r*exp(-nul_phi*I)];
```

$$null\_def := [0, 0] \tag{18}$$

```
> eq1 := null_def[1] = nullst;
```

$$eq1 := 0 = \left(\frac{1}{2}\,\frac{1}{b3 + c2\,b2}\left(-c2\,c1\,b1 + c2\,b2 + 2\,b3 + \sqrt{c2^2\,c1^2\,b1^2 - 2\,c2^2\,c1\,b1\,b2 - 4\,c2\,c1\,b1\,b3 + c2^2\,b2^2}\right), -\frac{1}{2}\,\frac{1}{b3 + c2\,b2}\left(c2\,c1\,b1 - c2\,b2 - 2\,b3 + \sqrt{c2^2\,c1^2\,b1^2 - 2\,c2^2\,c1\,b1\,b2 - 4\,c2\,c1\,b1\,b3 + c2^2\,b2^2}\right)\right) \tag{19}$$

```
> eq1_simpl := null_def[1] = numer(nullst);
Error, invalid input: numer expects 1 argument, but received 2
> eq2 := pol_def[1] = pole[1];
```

$$eq2 := 0.7\,e^{\frac{1}{75}\,I\pi} = \frac{1}{6}\left(36\,c3^2\,c2\,c1\,a1\,a3 - 108\,c3\,c2\,c1\,a1 + 36\,c3^2\,c2^2\,c1\,a1\,a2 + 36\,c3^2\,a3\,c2\,a2 + 36\,c3^2\,c2^2\,a2^2 - 8\,c3^3\,a3^3 - 24\,c3^3\,a3^2\,c2\,a2 - 24\,c3^3\,a3\,c2^2\,a2^2 - 8\,c3^3\,c2^3\,a2^3\right) \tag{20}$$

$$+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.$$
$$+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3$$
$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$
$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$
$$\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2\right)^{1/2}\Bigg)^{1/3}$$
$$-\left(6\left(\frac{1}{3}\,c3\,c2\,c1\,a1+\frac{1}{3}\,c3\,c2\,a2-\frac{1}{9}\,c3^2\,a3^2-\frac{2}{9}\,c3^2\,a3\,c2\,a2\right.\right.$$
$$\left.\left.-\frac{1}{9}\,c3^2\,c2^2\,a2^2\right)\right)\Big/\left(36\,c3^2\,c2\,c1\,a1\,a3-108\,c3\,c2\,c1\,a1+36\,c3^2\,c2^2\,c1\,a1\,a2\right.$$
$$+36\,c3^2\,a3\,c2\,a2+36\,c3^2\,c2^2\,a2^2-8\,c3^3\,a3^3-24\,c3^3\,a3^2\,c2\,a2-24\,c3^3\,a3\,c2^2\,a2^2$$
$$-8\,c3^3\,c2^3\,a2^3$$
$$+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.$$
$$+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3$$
$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$
$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$
$$\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2\right)^{1/2}\Bigg)^{1/3}$$
$$-\frac{1}{3}\,c3\,a3+1-\frac{1}{3}\,c3\,c2\,a2$$

```
> pol_1_re := Re(pol_def[1]) = (1/2)*c3*c2*a1 - (1/2)*c3*c2*a2 + 1
  - (1/2)*c3*a3;
```

$$pol\_1\_re := 0.7\cos\left(\frac{1}{75}\,\pi\right)=\frac{1}{2}\,c3\,c2\,a1-\frac{1}{2}\,c3\,c2\,a2+1-\frac{1}{2}\,c3\,a3 \tag{21}$$

```
> pol_1_im := Im(pol_def[1]) = 0.5*sqrt(c3^2*c2^2*a1^2 - 2*c3^2*
  c2^2*a1*a2 + 4*c3*c2*a1 - 2*c3^2*c2*a1*a3 + c3^2*c2^2*a2^2 - 4*
  c3*c2*a2 + 2*c3^2*c2*a2*a3 + c3^2*a3^2 - 4*c3*c2*a1*c1);
```

$$pol\_1\_im := 0.7\sin\left(\frac{1}{75}\,\pi\right) \tag{22}$$
$$=0.5\left(c3^2\,c2^2\,a1^2-2\,c3^2\,c2^2\,a1\,a2+4\,c3\,c2\,a1-2\,c3^2\,c2\,a1\,a3+c3^2\,c2^2\,a2^2\right.$$
$$\left.-4\,c3\,c2\,a2+2\,c3^2\,a3\,c2\,a2+c3^2\,a3^2-4\,c3\,c2\,c1\,a1\right)^{1/2}$$

```
> eq3 := pol_def[2] = pole[2];
```

$$eq3 := 0.7\,e^{-\frac{1}{75}\,I\pi}=-\frac{1}{12}\left(36\,c3^2\,c2\,c1\,a1\,a3-108\,c3\,c2\,c1\,a1+36\,c3^2\,c2^2\,c1\,a1\,a2\right. \tag{23}$$
$$+36\,c3^2\,a3\,c2\,a2+36\,c3^2\,c2^2\,a2^2-8\,c3^3\,a3^3-24\,c3^3\,a3^2\,c2\,a2-24\,c3^3\,a3\,c2^2\,a2^2$$
$$\left.-8\,c3^3\,c2^3\,a2^3\right)$$

$$+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.$$
$$+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3$$
$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$
$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$
$$\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2\right)^{1/2}\Big)^{1/3}$$
$$+\left(3\left(\frac{1}{3}\,c3\,c2\,c1\,a1+\frac{1}{3}\,c3\,c2\,a2-\frac{1}{9}\,c3^2\,a3^2-\frac{2}{9}\,c3^2\,a3\,c2\,a2\right.\right.$$
$$\left.\left.-\frac{1}{9}\,c3^2\,c2^2\,a2^2\right)\right)\Big/\left(36\,c3^2\,c2\,c1\,a1\,a3-108\,c3\,c2\,c1\,a1+36\,c3^2\,c2^2\,c1\,a1\,a2\right.$$
$$+36\,c3^2\,a3\,c2\,a2+36\,c3^2\,c2^2\,a2^2-8\,c3^3\,a3^3-24\,c3^3\,a3^2\,c2\,a2-24\,c3^3\,a3\,c2^2\,a2^2$$
$$-8\,c3^3\,c2^3\,a2^3$$
$$+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.$$
$$+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3$$
$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$
$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$
$$\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2\right)^{1/2}\Big)^{1/3}$$
$$-\frac{1}{3}\,c3\,a3+1-\frac{1}{3}\,c3\,c2\,a2+\frac{1}{2}\,\mathrm{I}\sqrt{3}\left(\frac{1}{6}\left(36\,c3^2\,c2\,c1\,a1\,a3-108\,c3\,c2\,c1\,a1\right.\right.$$
$$\left.\left.+36\,c3^2\,c2^2\,c1\,a1\,a2+36\,c3^2\,a3\,c2\,a2+36\,c3^2\,c2^2\,a2^2-8\,c3^3\,a3^3-24\,c3^3\,a3^2\,c2\,a2\right.\right.$$
$$\left.\left.-24\,c3^3\,a3\,c2^2\,a2^2-8\,c3^3\,c2^3\,a2^3\right.\right.$$
$$\left.\left.+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.\right.\right.$$
$$\left.\left.\left.+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3\right.\right.\right.$$
$$\left.\left.\left.-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2\right.\right.\right.$$
$$\left.\left.\left.-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2\right.\right.\right.$$
$$\left.\left.\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2\right)^{1/2}\right)^{1/3}\right.$$
$$\left.\left.-24\,c3^3\,a3\,c2^2\,a2^2-8\,c3^3\,c2^3\,a2^3\right.\right.$$
$$\left.\left.+12\left(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3\right.\right.\right.$$
$$\left.\left.\left.+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3\right.\right.\right.$$

$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$

$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$

$$+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2)^{1/2})^{1/3}$$

$$+\left(6\left(\frac{1}{3}\,c3\,c2\,c1\,a1+\frac{1}{3}\,c3\,c2\,a2-\frac{1}{9}\,c3^2\,a3^2-\frac{2}{9}\,c3^2\,a3\,c2\,a2\right.\right.$$

$$\left.\left.-\frac{1}{9}\,c3^2\,c2^2\,a2^2\right)\right)\Big/\left(36\,c3^2\,c2\,c1\,a1\,a3-108\,c3\,c2\,c1\,a1+36\,c3^2\,c2^2\,c1\,a1\,a2\right.$$

$$+36\,c3^2\,a3\,c2\,a2+36\,c3^2\,c2^2\,a2^2-8\,c3^3\,a3^3-24\,c3^3\,a3^2\,c2\,a2-24\,c3^3\,a3\,c2^2\,a2^2$$

$$-8\,c3^3\,c2^3\,a2^3$$

$$+12\,(81\,c3^2\,c2^2\,c1^2\,a1^2-3\,c3^4\,a3^2\,c2^2\,a2^2-6\,c3^4\,a3\,c2^3\,a2^3+12\,c3^3\,c2^3\,c1^3\,a1^3$$

$$+12\,c3^3\,c2^3\,a2^3-3\,c3^4\,c2^4\,a2^4-18\,c3^3\,c2^3\,c1\,a1\,a2^2+6\,c3^4\,c2^4\,c1\,a1\,a2^3$$

$$-18\,c3^3\,c2^3\,c1^2\,a1^2\,a2-3\,c3^4\,c2^2\,c1^2\,a1^2\,a3^2-3\,c3^4\,c2^4\,c1^2\,a1^2\,a2^2$$

$$-54\,c3^3\,c2^2\,c1^2\,a1^2\,a3+12\,c3^4\,c2\,c1\,a1\,a3^3-54\,c3^3\,c2^2\,c1\,a1\,a3\,a2$$

$$\left.+30\,c3^4\,c2^2\,c1\,a1\,a3^2\,a2+24\,c3^4\,c2^3\,c1\,a1\,a3\,a2^2-6\,c3^4\,c2^3\,c1^2\,a1^2\,a3\,a2)^{1/2})^{1/3}\right)$$

```
> pol_2_re := Re(pol_def[2]) = (1/2)*c3*c2*a1 - (1/2)*c3*c2*a2 + 1
  - (1/2)*c3*a3;
```

$$pol\_2\_re := 0.7\cos\left(\frac{1}{75}\,\pi\right)=\frac{1}{2}\,c3\,c2\,a1-\frac{1}{2}\,c3\,c2\,a2+1-\frac{1}{2}\,c3\,a3 \qquad \textbf{(24)}$$

```
> pol_2_im := Im(pol_def[2]) = -(1/2)*sqrt(c3^2*c2^2*a1^2 - 2*c3^2*
  c2^2*a1*a2 + 4*c3*c2*a1 - 2*c3^2*c2*a1*a3 + c3^2*c2^2*a2^2 - 4*
  c3*c2*a2 + 2*c3^2*c2*a2*a3 + c3^2*a3^2 - 4*c3*c2*a1*c1);
```

$$pol\_2\_im := -0.7\sin\left(\frac{1}{75}\,\pi\right)= \qquad \textbf{(25)}$$

$$-\frac{1}{2}\,(c3^2\,c2^2\,a1^2-2\,c3^2\,c2^2\,a1\,a2+4\,c3\,c2\,a1-2\,c3^2\,c2\,a1\,a3+c3^2\,c2^2\,a2^2$$

$$-4\,c3\,c2\,a2+2\,c3^2\,a3\,c2\,a2+c3^2\,a3^2-4\,c3\,c2\,c1\,a1)^{1/2}$$

Define Coefficients

```
> #b1 := 1;
> #a1 := 1;
> #eq1_simpl;
> #pol_1_re;
```

```
> #pol_1_im;
> #pol_2_re;
> #pol_2_im;
> #c2 := solve(eq1_simpl,c2);
> #pol_1_re;
> #c1 := solve(pol_1_re, c1);
> #pol_1_im;
> #c3 := solve(pol_1_im, c3);
> #pol_2_re;

> #a3 := solve(pol_2_re, a3);

> #pol_2_im;
> params := [a1=0.53711, a2=0.60174, a3=1.06183, b1=1.93711, b2=
  0.72150, b3=9.12712, c1=1.27265, c2=1.05154, c3=1];
```

$$params := [a1 = 0.53711,\ a2 = 0.60174,\ a3 = 1.06183,\ b1 = 1.93711,\ b2 = 0.72150,\ b3 = 9.12712,\ c1 = 1.27265,\ c2 = 1.05154,\ c3 = 1] \quad (26)$$

Plotting of found coefficients

```
> nullst1:=eval(nullst, params);
```

$$nullst1 := 0.8305141345 + 0.4832197022\ \mathrm{I},\ 0.8305141345 - 0.4832197022\ \mathrm{I} \quad (27)$$

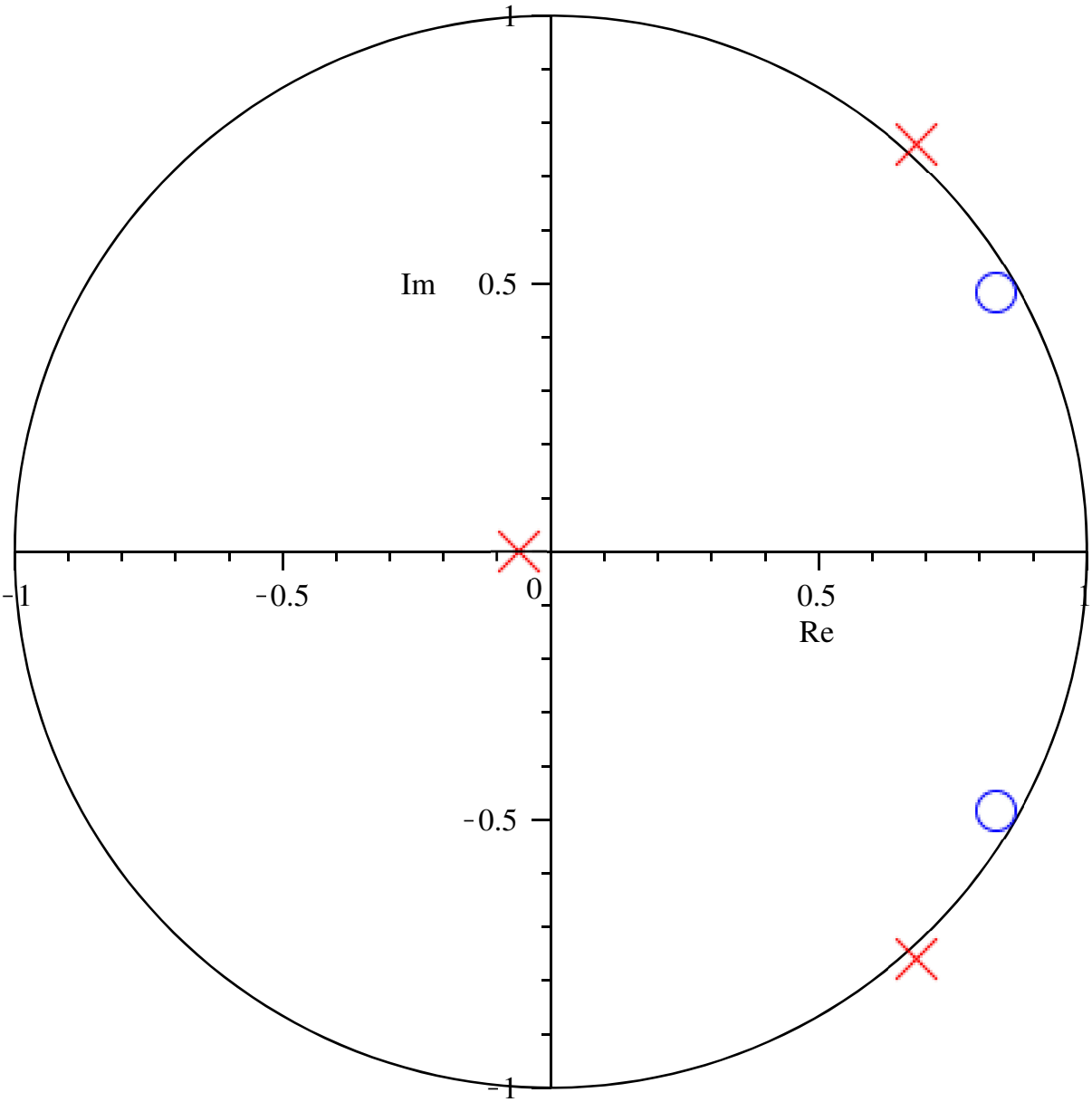
```
> pole1:=eval(pole, params);
```

$$pole1 := -0.0592667069,\ 0.6823415137 + 0.4388089992\ \mathrm{I}\sqrt{3},\ 0.6823415137 - 0.4388089992\ \mathrm{I}\sqrt{3} \quad (28)$$

```
> ue_f_num := subs(params, ue_f);
```

$$ue\_f\_num := \frac{-16.42060341\ z + 9.885806110\ z^2 + 9.12712}{0.9623696854\ z - 1.305416320\ z^2 + 0.06183 + z^3} \quad (29)$$

```
> #ue_f_num := unapply(ue_f_num, z);
> complexplot([pole1],style=point,
    color=red, labels = ["Re", "Im"],
    symbol="diagonalcross", symbolsize=20,thickness=10,
    scaling=constrained): #,view=[-2..1,-2..2]):
> complexplot([nullst1], style=point,
    color="blue", labels = ["Re", "Im"],
    symbol="circle", symbolsize=20,thickness=10,
    scaling=constrained): #,view=[-2..1,-2..2]):
> complexplot(cos+I*sin, -Pi .. Pi, labels = ["Re", "Im"], color=
  black, scaling=constrained):
> display(%,%%, %%%);
```


1
Im
0.5
-1
-0.5
0
0.5
1
Re
-0.5
-1

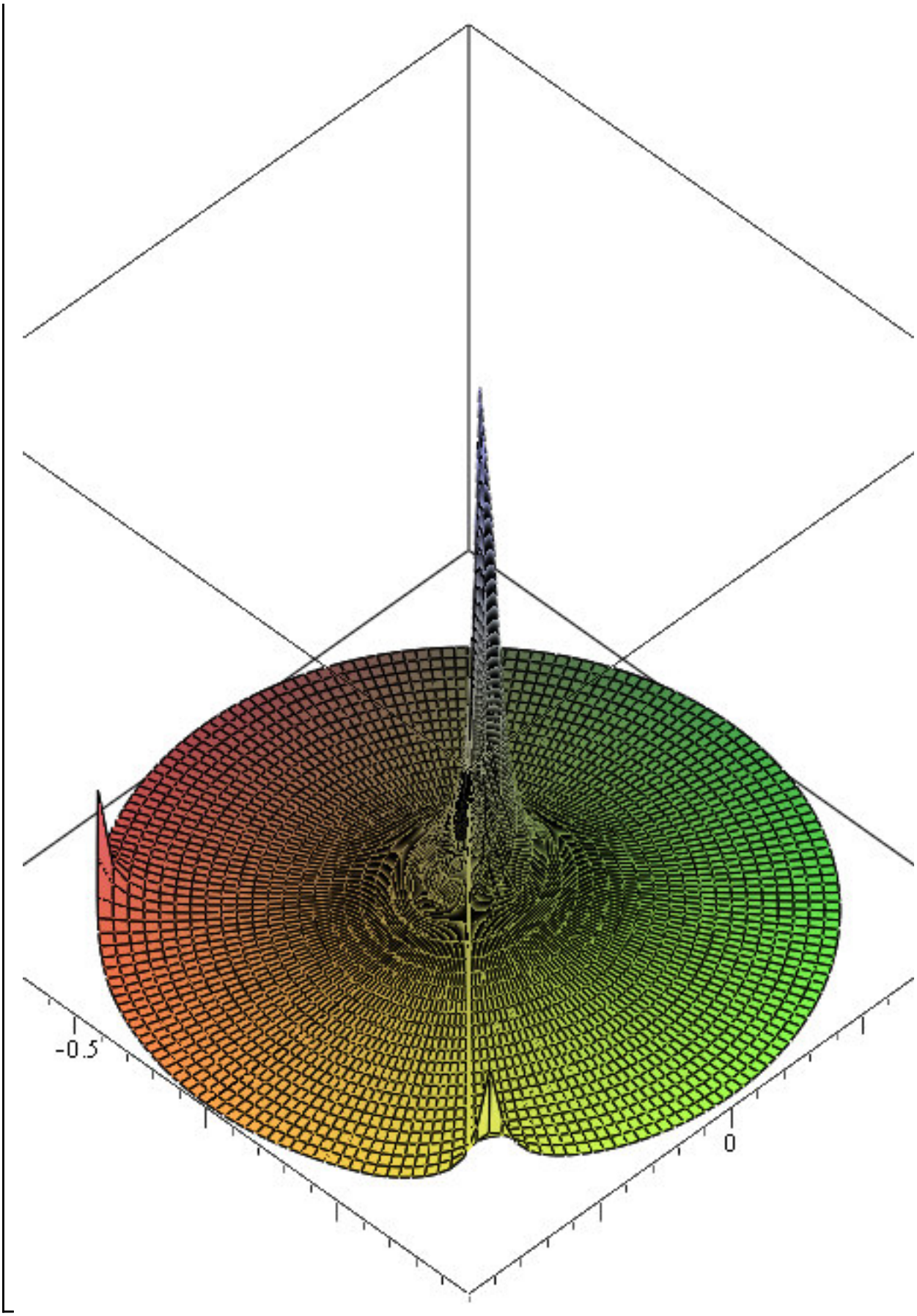
```
> #ue_f_abs := subs(params, ue_f_abs);
> #ue_f := subs(params, ue_f_abs);
> ue_f_num := subs(z=r*exp(I*phi),ue_f_num);
```

$$ue\_f\_num := \frac{-16.42060341\, r\, e^{I\phi} + 9.885806110\, r^2 \left(e^{I\phi}\right)^2 + 9.12712}{0.9623696854\, r\, e^{I\phi} - 1.305416320\, r^2 \left(e^{I\phi}\right)^2 + 0.06183 + r^3 \left(e^{I\phi}\right)^3} \quad \textbf{(30)}$$

```
> ue_f_abs := abs(ue_f_num);
```

$$ue\_f\_abs := \left| \frac{-16.42060341\, r\, e^{I\phi} + 9.885806110\, r^2 \left(e^{I\phi}\right)^2 + 9.12712}{0.9623696854\, r\, e^{I\phi} - 1.305416320\, r^2 \left(e^{I\phi}\right)^2 + 0.06183 + r^3 \left(e^{I\phi}\right)^3} \right| \quad \textbf{(31)}$$

```
> #ue_f_abs := unapply(ue_f_num, r, phi);
> changecoords(plot3d(ue_f_abs, r=0..1, phi=0..2*Pi, grid=[25,180],
  axes=boxed), polar);
```


-0.5
0

```
> plot(subs(r=1, ue_f_abs), phi=0..Pi);
```