Scilab in System and Control

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Introduction

- A powerful tool to the numerical study of:
  - Input-Output dynamic systems
  - Input-State-Output dynamic system
  - Feedback analysis
  - Feedback control design

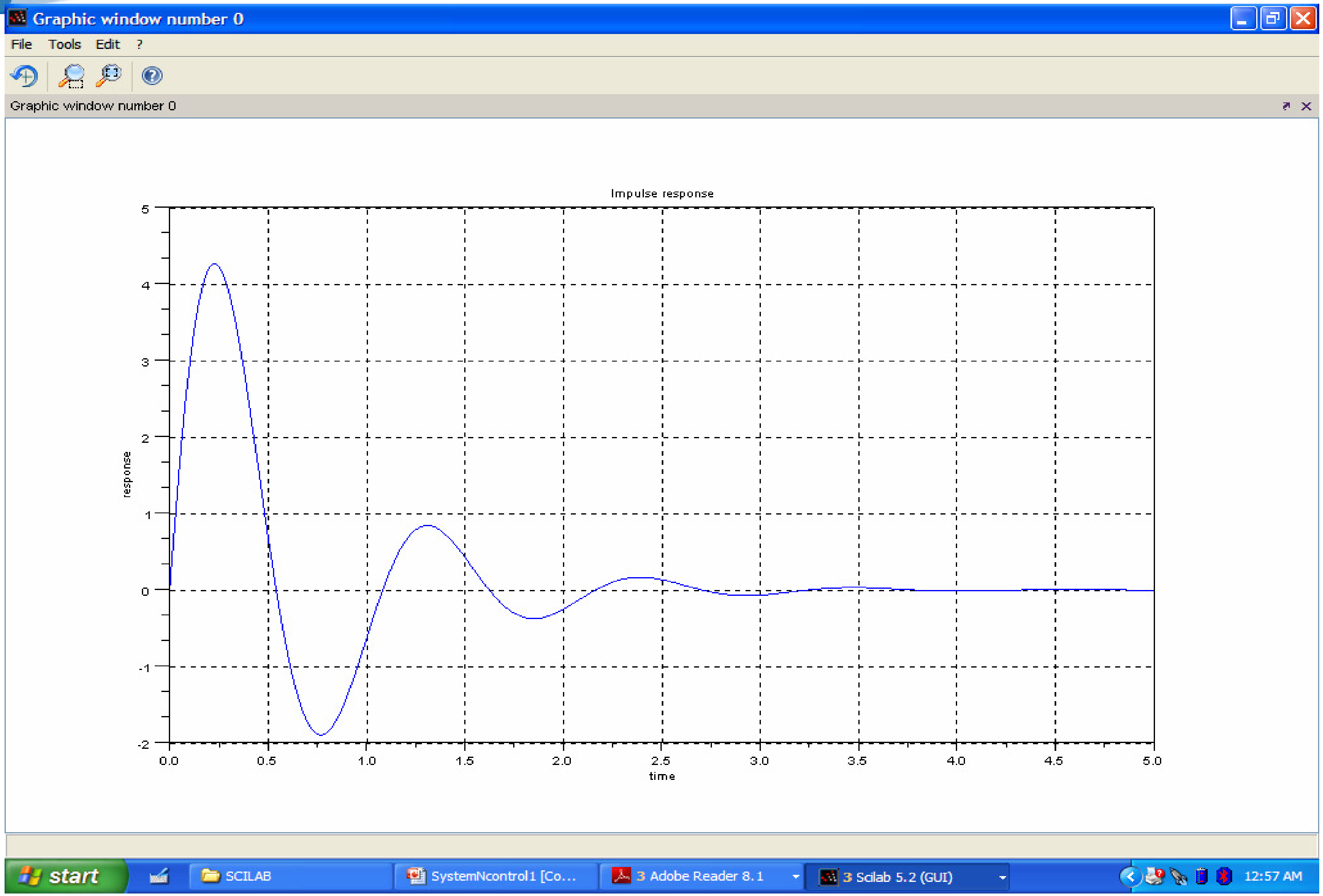
Transfer Function

```
-->s=%s;        // first create a variable
-->num=36;den=36+3*s+s^2;
-->//create a scilab continuous system LTI object
-->TF=syslin('c',num,den)
TF =
36
--------------
36 + 3s + s²
-->typeof(TF)
ans =
rational
```

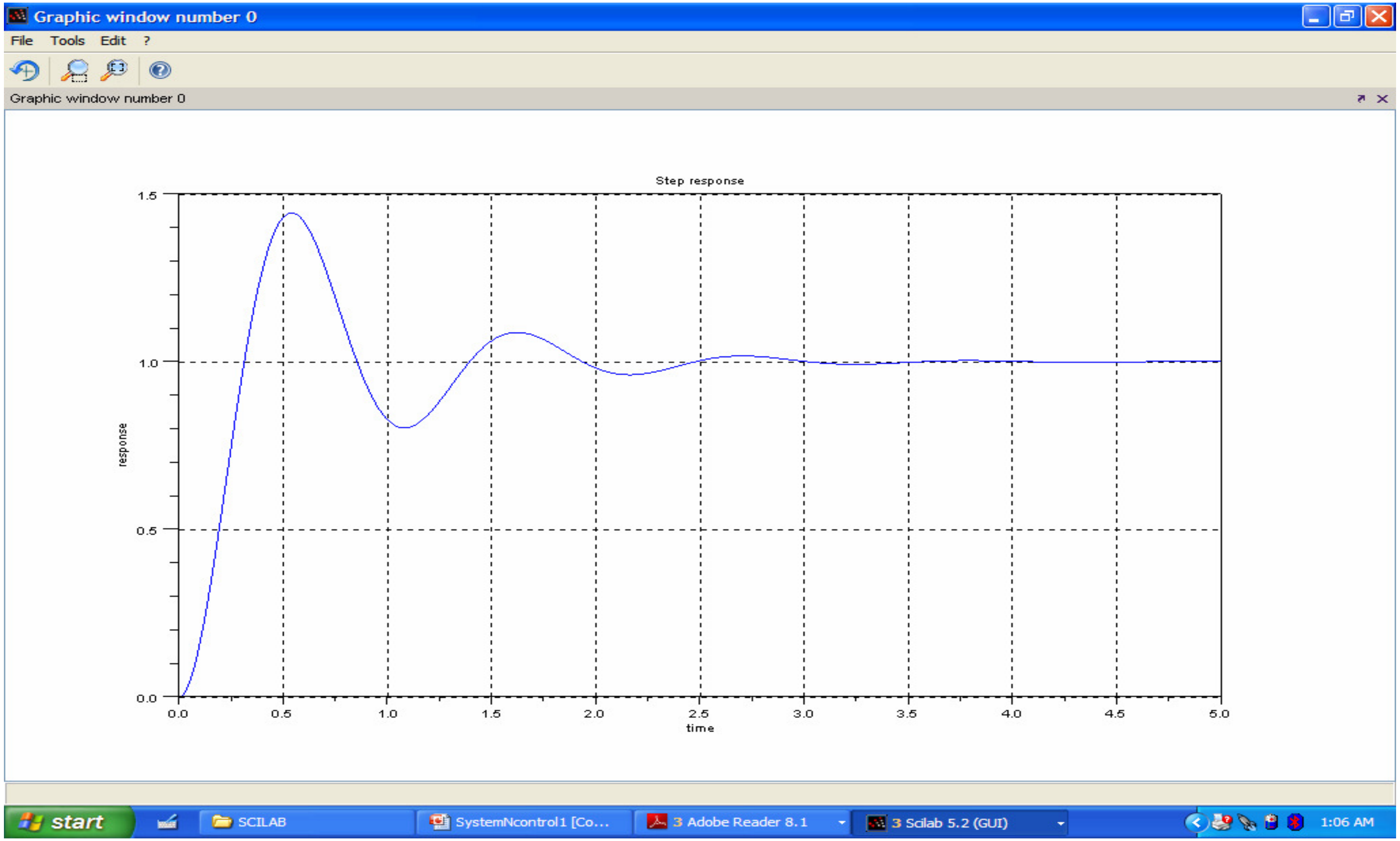
Impulse, Step, and Ramp Response

```
-->t=linspace(0,5,500);
-->imp_res=csim('imp',t,TF);
-->plot(t,imp_res),xgrid(),xtitle('Impulse
   response','time','response');

-->step_res=csim('step',t,TF);
-->plot(t,step_res),xgrid(),xtitle('Step
   response','time','response');

-->ramp_res=csim(t,t,TF);
-->plot(t,ramp_res),xgrid(),xtitle('Ramp
   response','time','response');
```

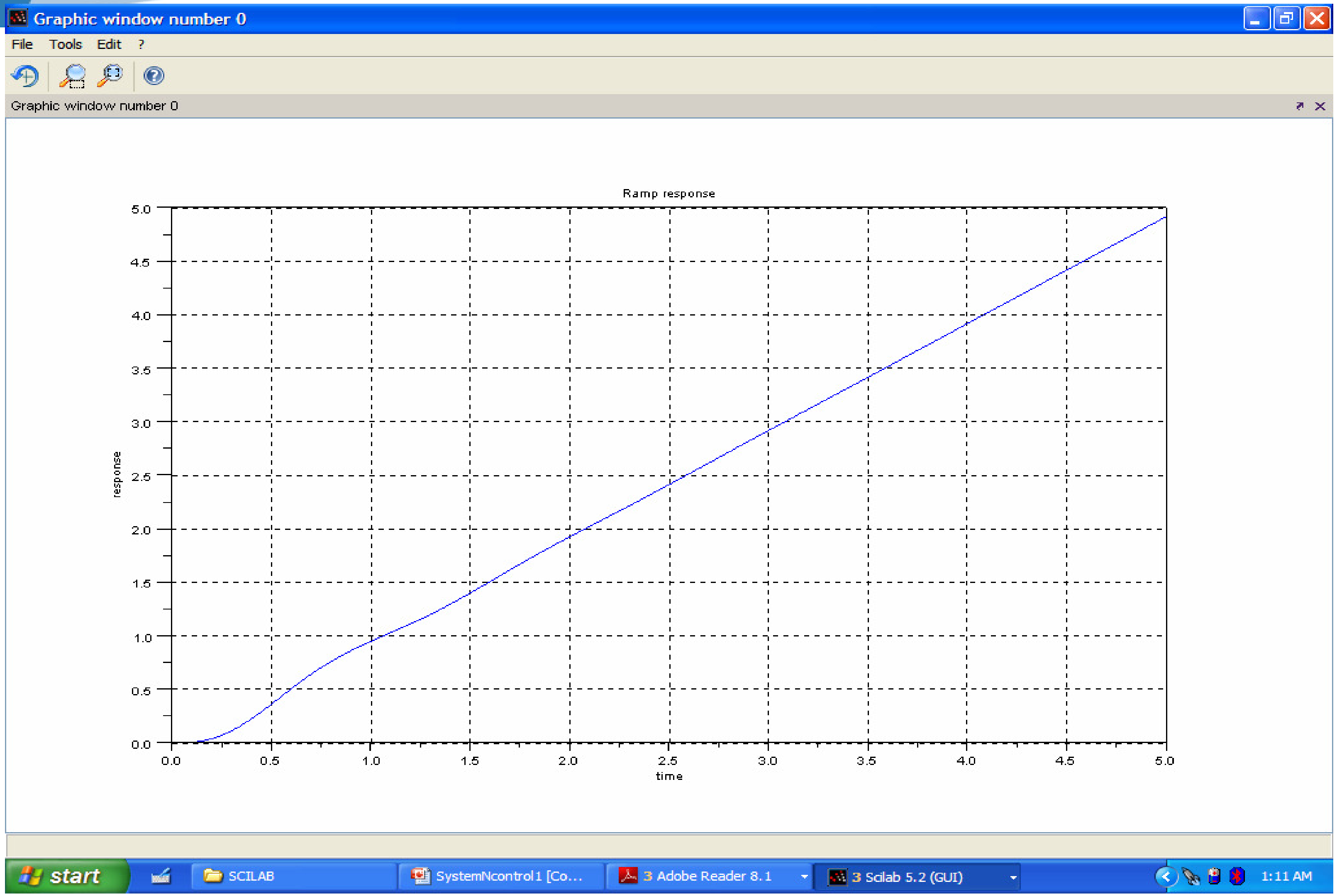
Impulse Response



Step Response



Ramp Response



TF to SS Conversion

```
-->SS1=tf2ss(TF)
 SS1  =
        SS1(1)   (state-space system:)
 !lss  A  B  C  D  X0  dt  !
 SS1(2) = A matrix =
    0.     8.
  - 4.5  - 3.
  SS1(3) = B matrix =
   0.
   6.
  SS1(4) = C matrix =
    0.75    0.
  SS1(5) = D matrix =
    0.
 SS1(6) = X0 (initial state) =
    0.
    0.
 SS1(7) = Time domain = c
```

SS to TF Conversion

```
-->TF1=ss2tf(SS1)
 TF1  =

          36
    ---------- -------
                     2
    36 + 3s + s

-->roots(den)
 ans  =
- 1.5 + 5.809475i
  - 1.5 - 5.809475i

-->c=companion(den)
 c  =
   - 3.  - 36.
     1.    0.
```

Transfer Function

```
-->s=%s;        // first create a variable
-->num=36;den=36+3*s+s^2;
-->//create a scilab continuous system LTI object
-->TF=syslin('c',num,den)
TF =
36
--------------
36 + 3s + s^2
-->typeof(TF)
ans =
rational
```

Transfer Function

```
-->z=%z;

-->Pd=syslin('d',1,z-0.5)
Pd =
              1
           -------
         - 0.5 + z

-->typeof(Pd)
ans =
rational
```

State Space Representation

```
-->A = [-5 -1

--> 6 0];

-->B = [-1; 1];

-->C = [-1 0];

-->D =0;

-->Sss = syslin('c',A,B,C,D)
```

State Space Representation

```
Sss =
    Sss(1) (state-space system:)
   ! lss  A  B  C  D  X0  dt  !

    Sss(2) = A matrix =
   - 5. - 1.
     6.   0.

    Sss(3) = B matrix =
   - 1.
     1.
```

State Space Representation

Sss(4) = C matrix =

- 1. 0.

Sss(5) = D matrix =

0.

Sss(6) = X0 (initial state) =

0.

0.

State Space Representation

Sss(7) = Time domain =
c

-->typeof(Sss)
ans =
state-space

Conversion ss<->tf

- Conversions are always possible

  tf2ss

  Ss2tf

- Conversions are subtles, refer to dynamic systems textbooks

- Affected by round-off errors

- See `minss`, `minreal`

Extract information from tf

- The tf is a rational and all the corresponding functions can be applied:

```
-->roots(TF.den)
 ans  =

  - 1.5 + 5.809475i
  - 1.5 - 5.809475i
```

Extract information from ss

- Extract, e.g., the dynamic matrix

  Sss.A

- Extract all matrices

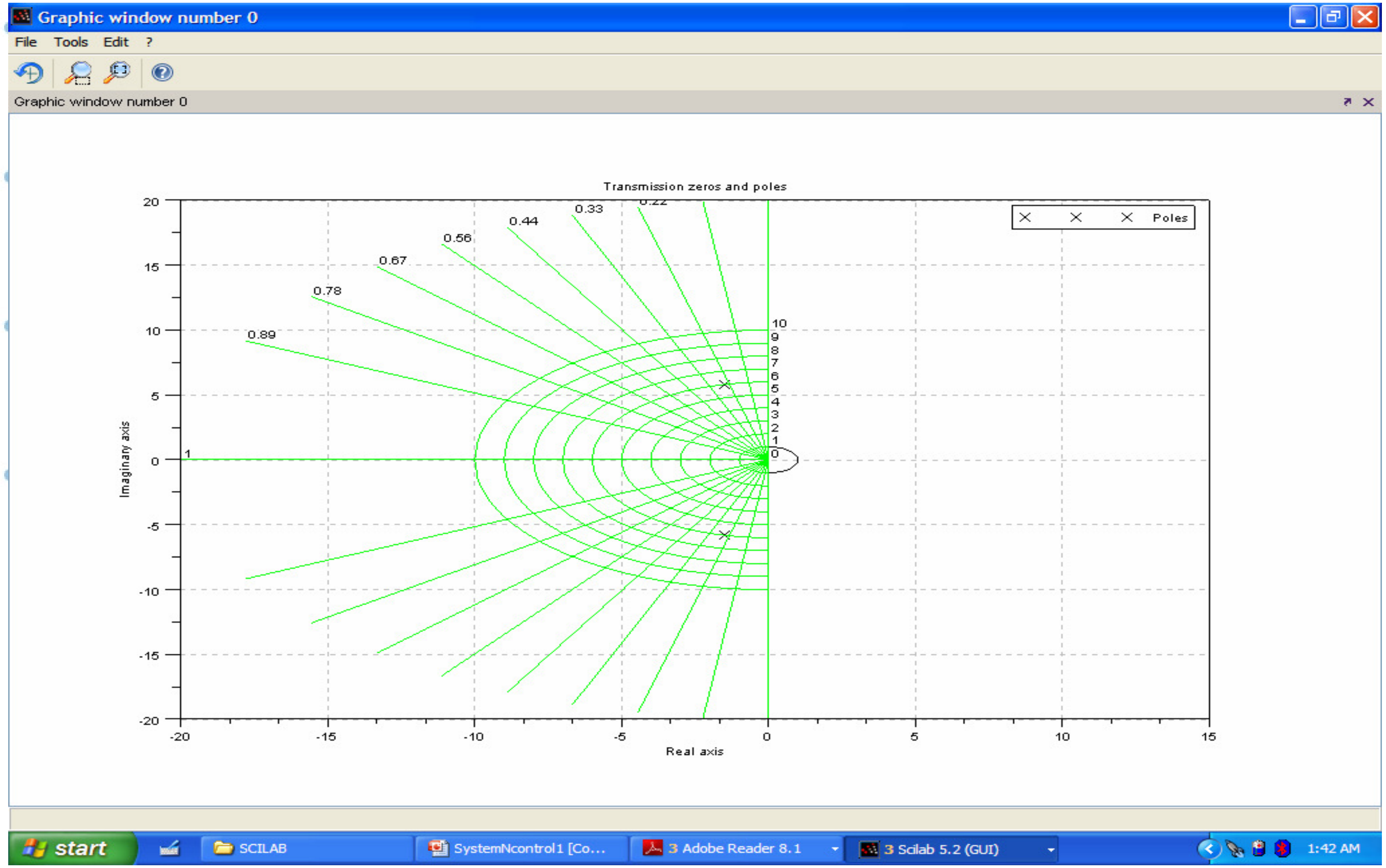
  [A,B,C,D]=abcd(Sss);

Smart View of ss Systems

```
-->ssprint(Sss)

.       |-5 -1 |      |-1 |

x =    | 6 0   |x +  | 1 |u

y =     |-1 0 |x
```

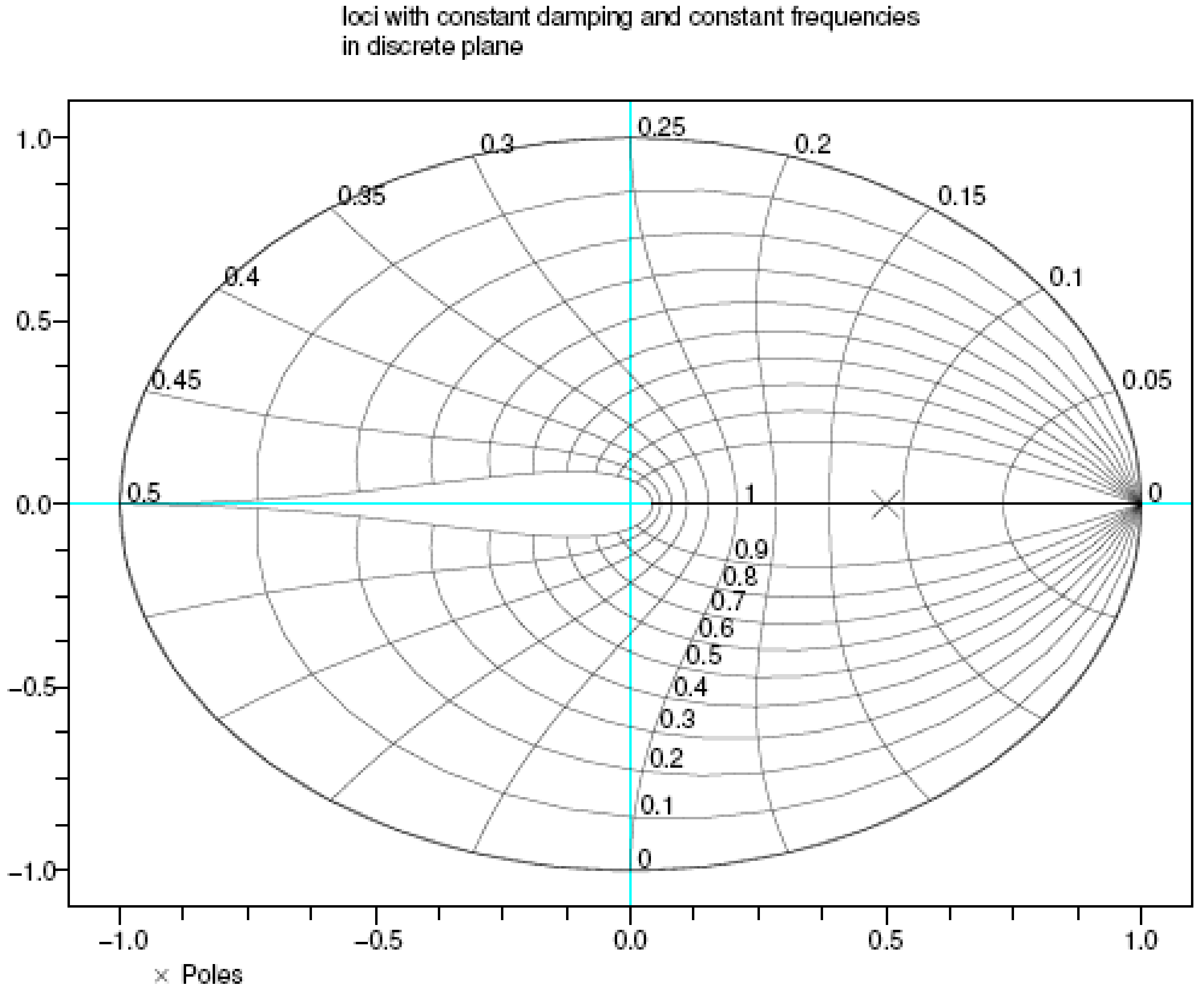
Pole-zero map - continuous time

- plzr(P);sgrid



Pole-zero map-discrete time

- plzr(P);zgrid

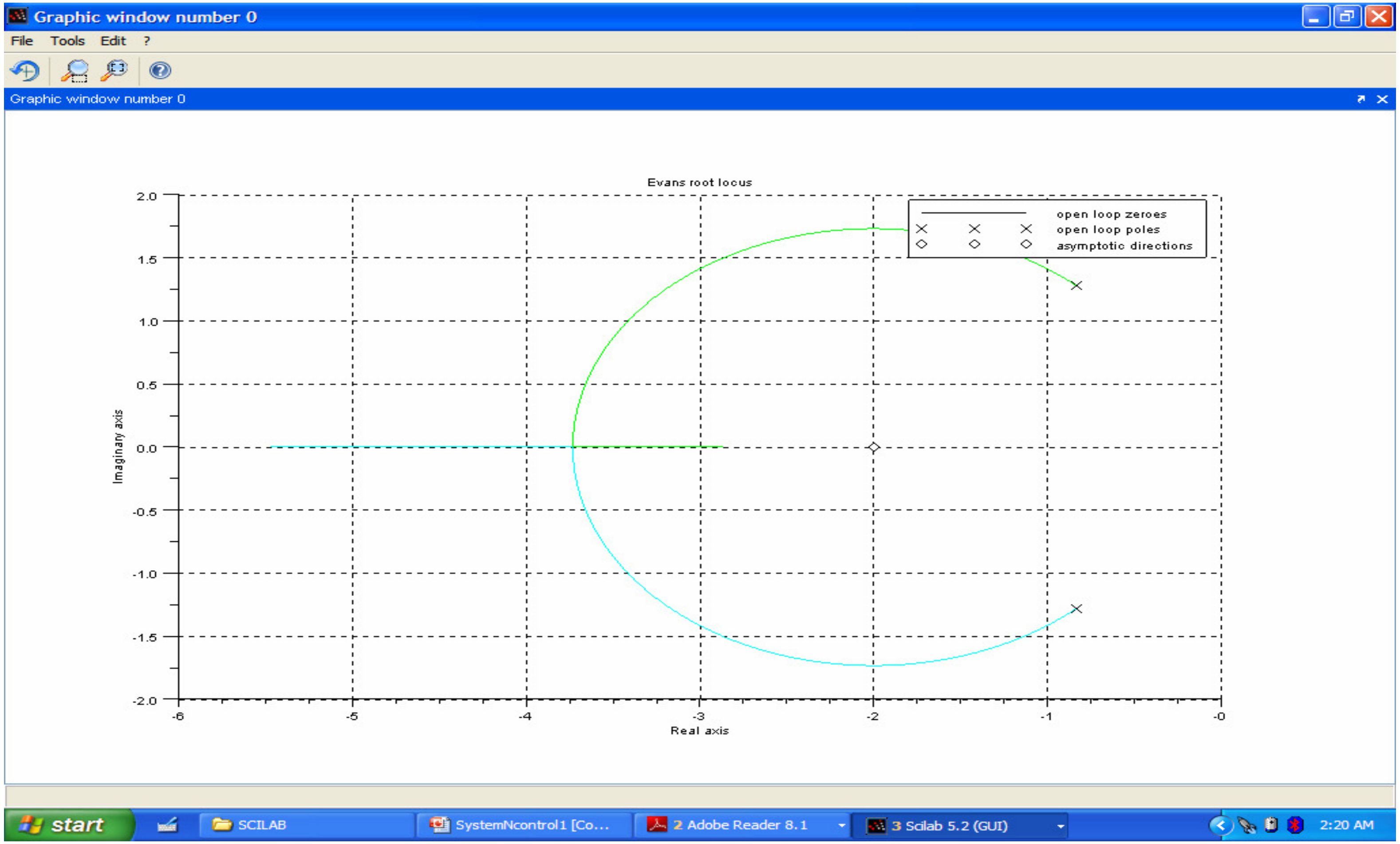


Root Locus

```
-->n=2+s;

-->d=7+5*s+3*s^2;

-->TF2=syslin('c',n,d)
 TF2  =

          2 + s
    ---------------
                   2
    7 + 5s + 3s

-->evans(TF2,20)
 -->xgrid
```

Root Locus

- Default points useless! use `evans(TF2,20)`



Root Locus

- The basic operation needed to design with the root locus tool is to calculate the value of k that corresponds to a certain point in the locus:

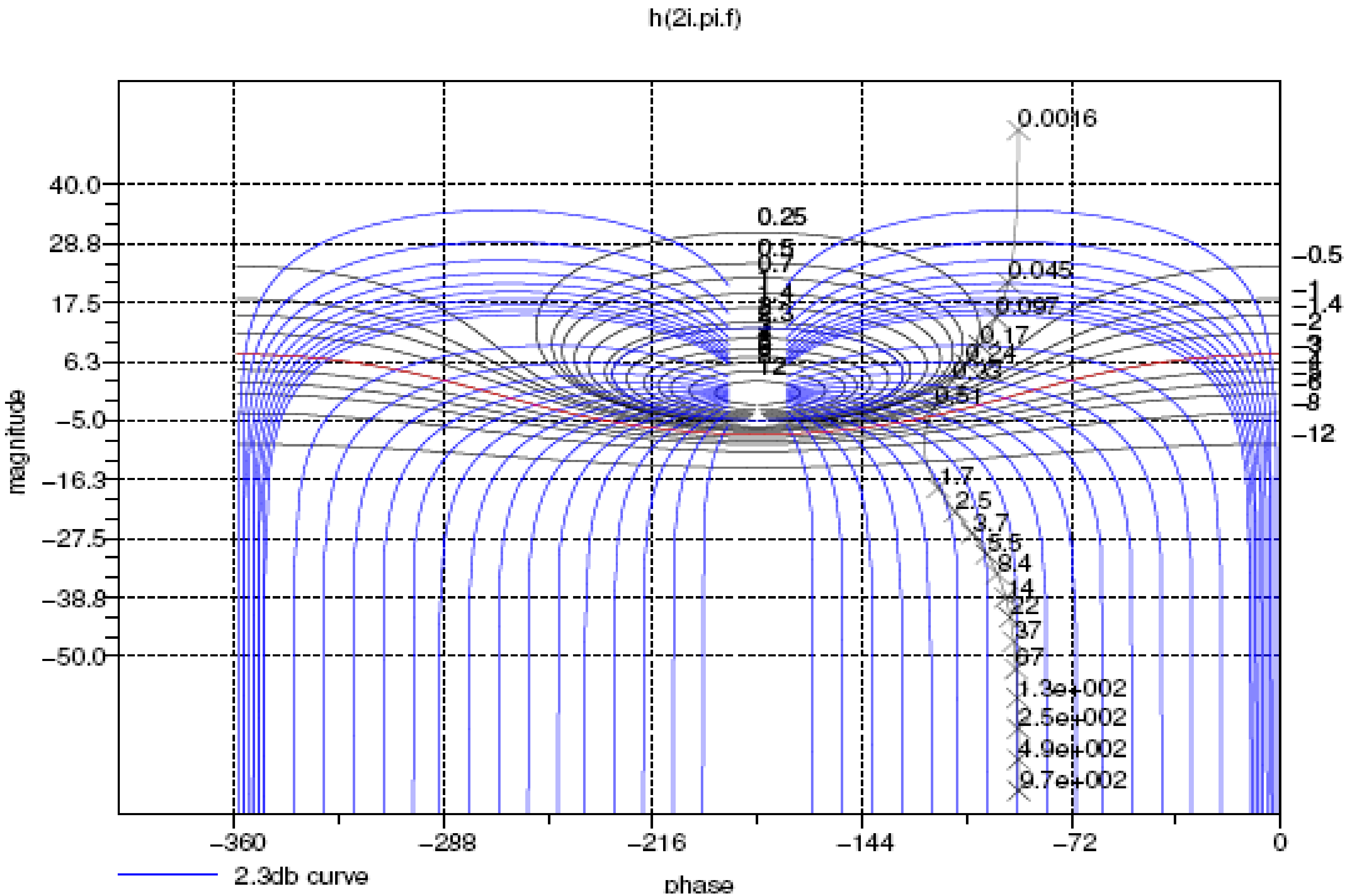
```
-->k=-1/real(horner(Stf,[1,%i]*locate(1)))
```

- `locate` returns the coordinates of a point in the graphic selected with the mouse

- `horner` computes a rational or polynomial in a given point

Nichols

- black(); chart()



Nichols

- The curve is parametrized according to a constant range(!)

  - Continuous time: $[10^{-3}, 10^{3}]$Hz
  - Discrete time: $[10^{-3}, 0.5]$

- Better to use the whole syntax assigning frequency range:

black(sl, [fmin,fmax] [,step] [,comments])

Bode

- bode(); gainplot()
- **Same considerations done for the Nichols diagram**
- **Better to use:**

bode(sl, [fmin,fmax] [,step] [,comments])

Nyquist

- nyquist(); m_circle()

- **Same considerations done for the Nichols diagram**

- **Better to use:**

  nyquist(sl, [fmin,fmax] [,step] [,comments])

Horner & Phasemag

- horner() evaluates a polynomial/rational in a point

- Evaluate F(jω) (in dB and deg) with ω = 5

```
-->F=syslin('c',1,%s+2);
 -->out=horner(F,5*%i)
out =
0.0689655 - 0.1724138i
-->[phi,db]=phasemag(out)
db =
- 14.62398
phi =
- 68.198591
```

A Final Bird's-Eye View

- Stability margins (`g margin, p margin`)
- Continuous-discrete time conversion (`cls2dls`)
- Simple numerical simulation of dynamics systems
- Numerical resolution of differential equations (`ode`)
- Observability, controllability, Kalman filter
- Controller design commands

Thank You !!!