

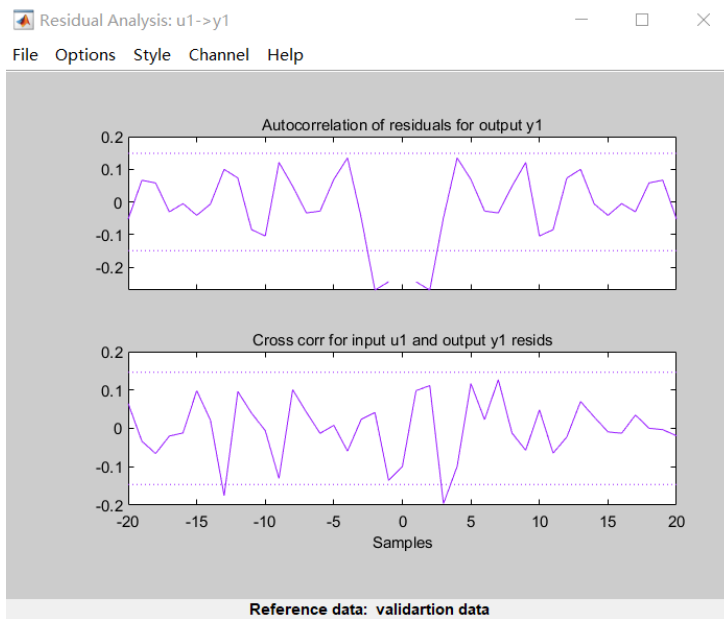
## System1:

```
Model Properties
>> data1 = iddata(y1,u1,1);
nk1 = delayest(data1);
>> nk1

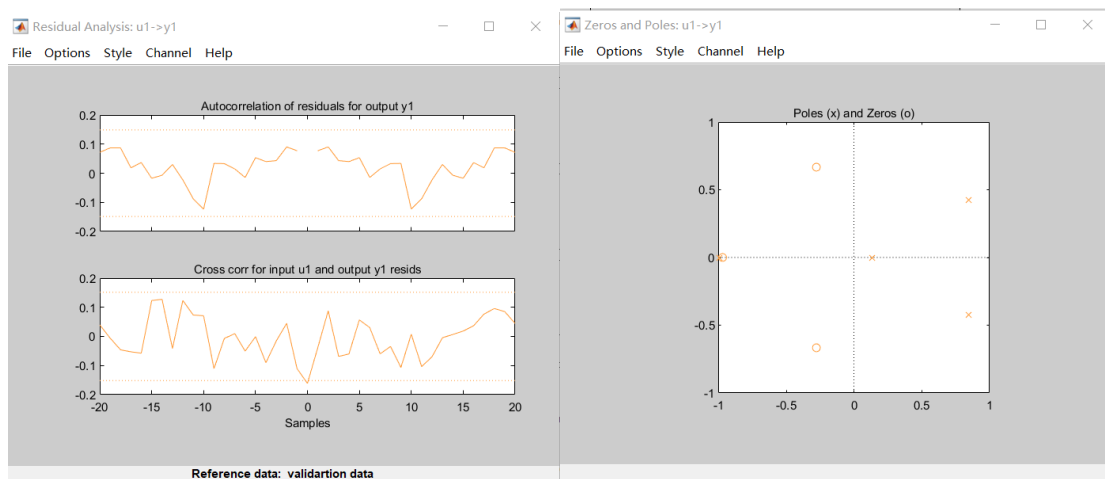
nk1 =

    3
```

Begin with ARX443



Residual analysis is bad ,so test BJ with 4<sup>th</sup> orders: [4 2 2 4 3]



```

bj42243 =
Discrete-time BJ model: y(t) = [B(z)/F(z)]u(t) + [C(z)/D(z)]e(t)
  B(z) = 1.243 (+/- 0.03683) z^-3 + 1.895 (+/- 0.04528) z^-4 + 1.317 (+/- 0.1188) z^-5 + 0.629 (+/- 0.1085) z^-6

  C(z) = 1 - 1.801 (+/- 0.2195) z^-1 + 0.8276 (+/- 0.2033) z^-2

  D(z) = 1 - 1.799 (+/- 0.2339) z^-1 + 0.8178 (+/- 0.2234) z^-2

  F(z) = 1 - 0.8409 (+/- 0.04637) z^-1 - 0.6926 (+/- 0.03891) z^-2 + 0.9994 (+/- 0.0356) z^-3 - 0.1207 (+/- 0.03905) z^-4

名称: bj42243
采样时间: 1 seconds

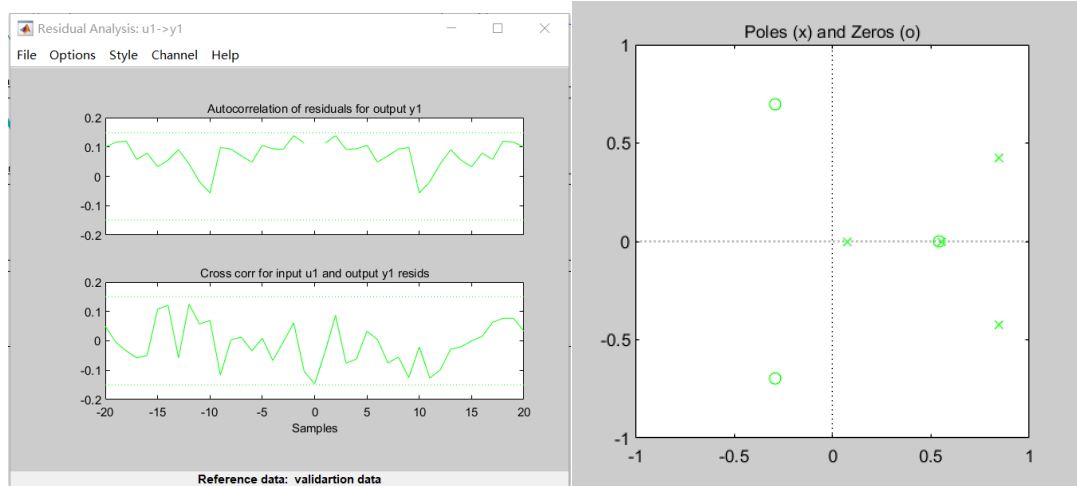
Parameterization:
  Polynomial orders:  nb=4  nc=2  nd=2  nf=4  nk=3
  Number of free coefficients: 12
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 15, Number of function evaluations: 56

Estimated using PEM on time domain data "identification data".
Fit to estimation data: 93.15% (prediction focus)
FPE: 0.9489, MSE: 0.917
More information in model's "Report" property.

```

It's clear that C and D are similar, so switch to OE without reducing order. OE [4 4 3]



```

oe443 =
Discrete-time OE model: y(t) = [B(z)/F(z)]u(t) + e(t)
  B(z) = 1.241 (+/- 0.03716) z^-3 + 0.04758 (+/- 1.578) z^-4 + 0.3153 (+/- 0.868) z^-5 - 0.3844 (+/- 0.8054) z^-6

  F(z) = 1 - 2.327 (+/- 1.277) z^-1 + 2.008 (+/- 2.349) z^-2 - 0.6346 (+/- 1.454) z^-3 + 0.03684 (+/- 0.1653) z^-4

名称: oe443
采样时间: 1 seconds

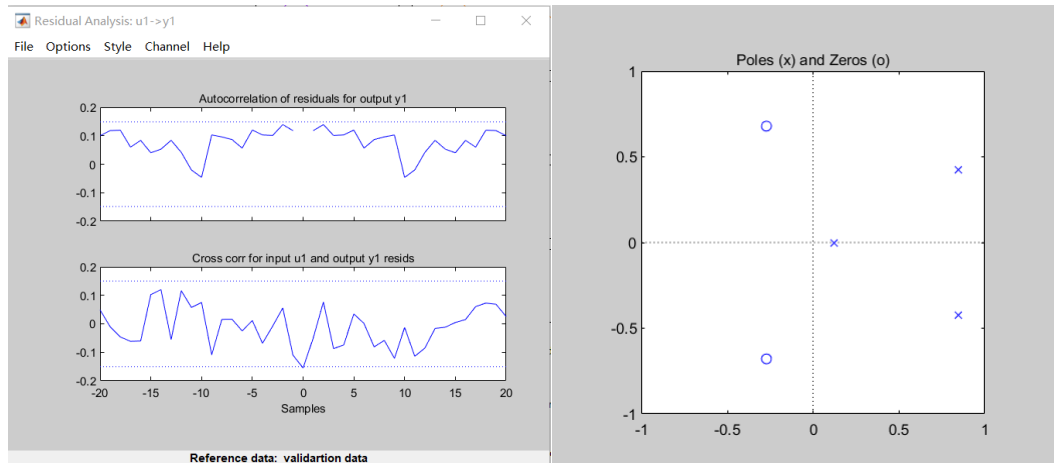
Parameterization:
  Polynomial orders:  nb=4  nf=4  nk=3
  Number of free coefficients: 8
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 10, Number of function evaluations: 33

Estimated using PEM on time domain data "identification data".
Fit to estimation data: 93.11%
FPE: 0.9484, MSE: 0.927
More information in model's "Report" property.

```

The variance is too big in F, so OE order should be reduced. OE



```
oe333 =
Discrete-time OE model: y(t) = [B(z)/F(z)]u(t) + e(t)
  B(z) = 1.242 (+/- 0.03699) z^-3 + 0.6751 (+/- 0.06888) z^-4 + 0.6646 (+/- 0.1051) z^-5
  F(z) = 1 - 1.822 (+/- 0.04361) z^-1 + 1.109 (+/- 0.07422) z^-2 - 0.111 (+/- 0.03923) z^-3
```

名称: oe333  
采样时间: 1 seconds

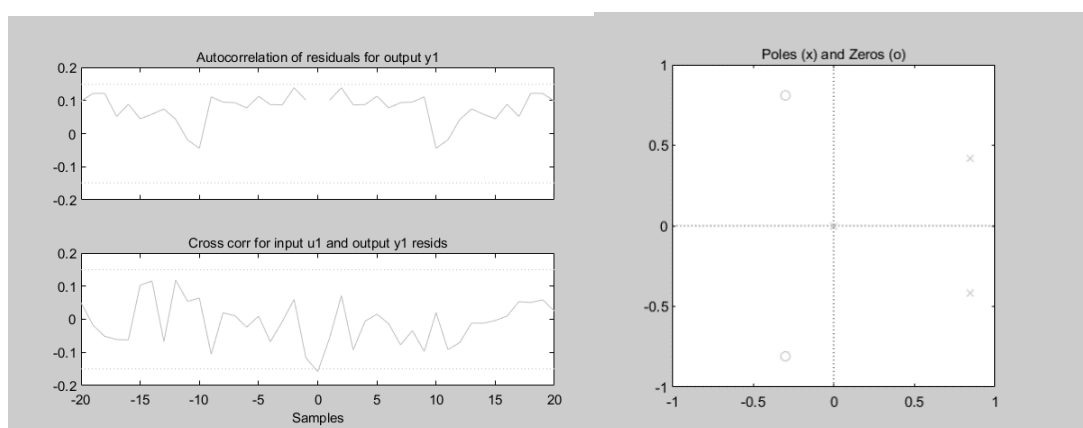
Parameterization:  
Polynomial orders: nb=3 nf=3 nk=3  
Number of free coefficients: 6  
Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:  
Termination condition: Near (local) minimum, (norm(g) < tol)..  
Number of iterations: 3, Number of function evaluations: 7

Estimated using PEM on time domain data "identification data".  
Fit to estimation data: 93.11%  
FPE: 0.9435, MSE: 0.9275  
More information in model's "Report" property.

Looks like when nf=3 the parameter test is not good enough.

So change to OE model [3 2 3]



```

oe323 =
Discrete-time OE model: y(t) = [B(z)/F(z)]u(t) + e(t)
  B(z) = 1.245 (+/- 0.03729) z^-3 + 0.7452 (+/- 0.06619) z^-4 + 0.9271 (+/- 0.04155) z^-5

  F(z) = 1 - 1.699 (+/- 0.0006195) z^-1 + 0.8988 (+/- 0.0005587) z^-2

名称: oe323
采样时间: 1 seconds

Parameterization:
  Polynomial orders:  nb=3  nf=2  nk=3
  Number of free coefficients: 5
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 3, Number of function evaluations: 7

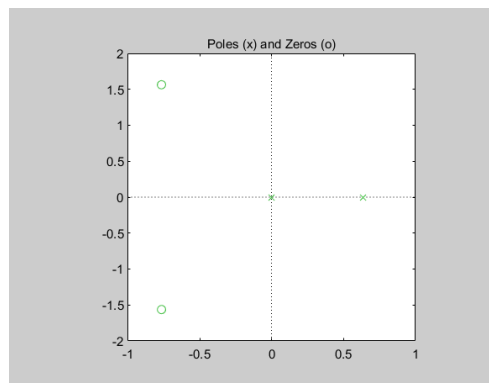
Estimated using PEM on time domain data "mydatadde".
Fit to estimation data: 93.07%
FPE: 0.9513, MSE: 0.9378
More information in model's "Report" property.

```

So the system1 choose OE model with nb =3 , nf =2, nk =3 at final.

## Alternative system:

OE 313



```

oe313 =
Discrete-time OE model: y(t) = [B(z)/F(z)]u(t) + e(t)
  B(z) = 1.479 (+/- 0.468) z^-3 + 2.265 (+/- 0.2818) z^-4 + 4.483 (+/- 0.477) z^-5

  F(z) = 1 - 0.6375 (+/- 0.04807) z^-1

名称: oe313
采样时间: 1 seconds

Parameterization:
  Polynomial orders:  nb=3  nf=1  nk=3
  Number of free coefficients: 4
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 6, Number of function evaluations: 18

Estimated using PEM on time domain data "mydatadde".
Fit to estimation data: 24%
FPE: 114.2, MSE: 112.9
More information in model's "Report" property.

```

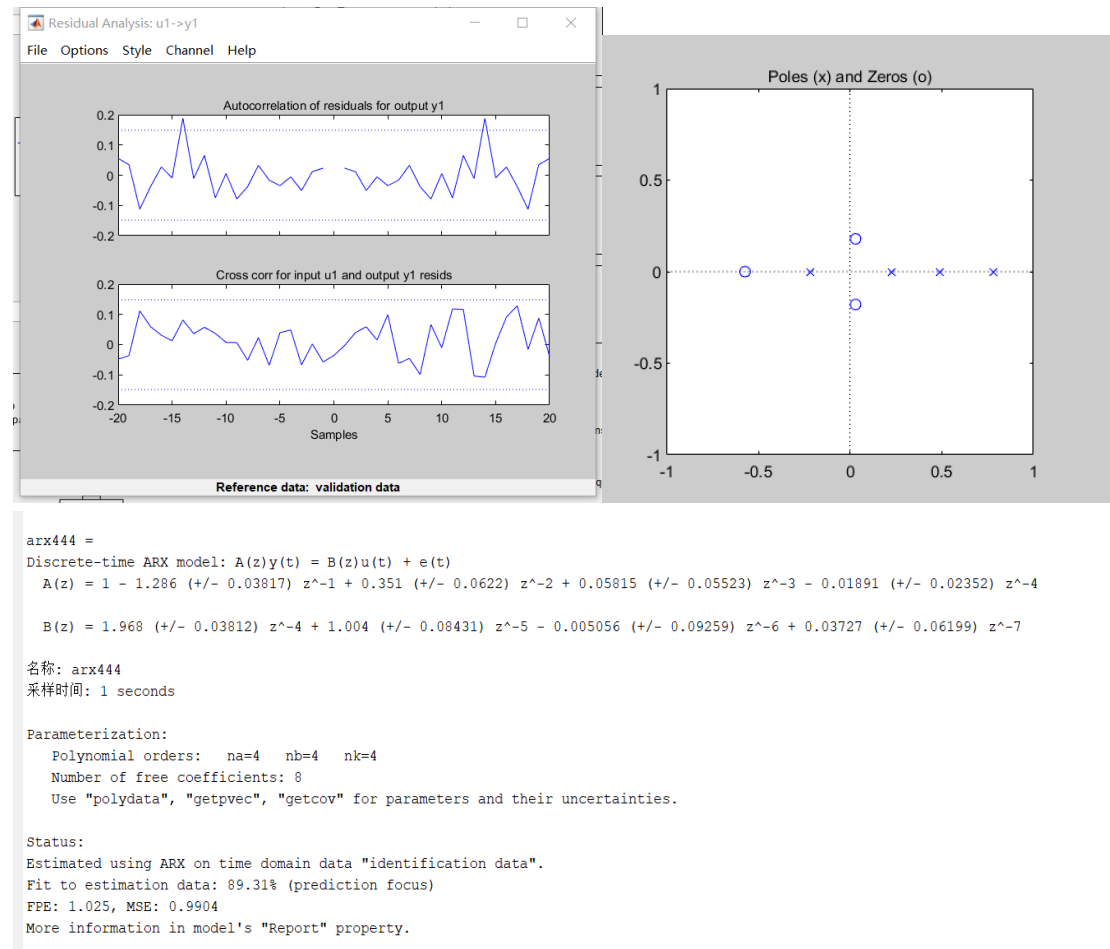
## System 2:

```
>> nk2
```

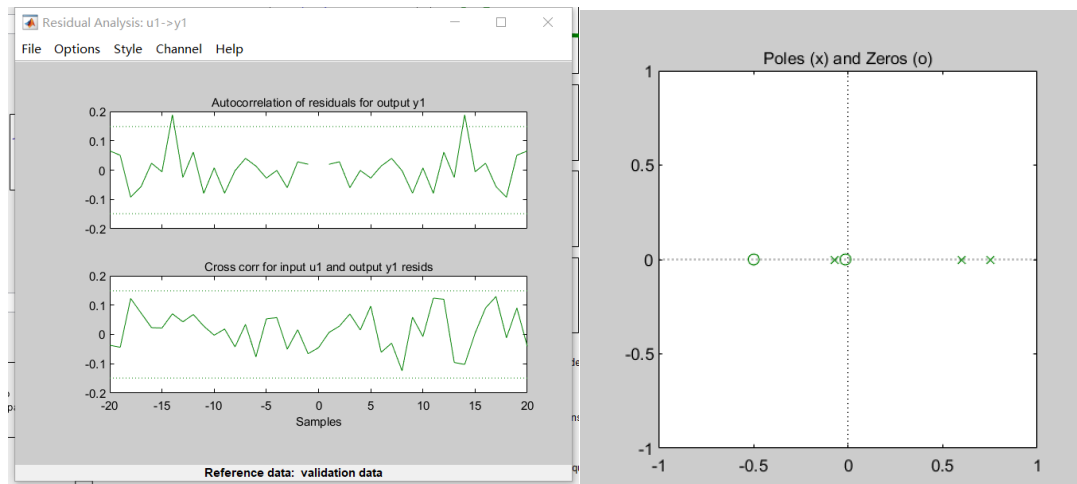
```
nk2 =
```

```
4
```

First we try compute 4<sup>th</sup> order ARX



The variance is too big in B(z) Reduce the ARX order set to [3 3 4]



```

arx334 =
Discrete-time ARX model: A(z)y(t) = B(z)u(t) + e(t)
  A(z) = 1 - 1.285 (+/- 0.03807) z^-1 + 0.3575 (+/- 0.0534) z^-2 + 0.03207 (+/- 0.02346) z^-3

  B(z) = 1.967 (+/- 0.03806) z^-4 + 1.006 (+/- 0.08415) z^-5 + 0.01277 (+/- 0.06188) z^-6

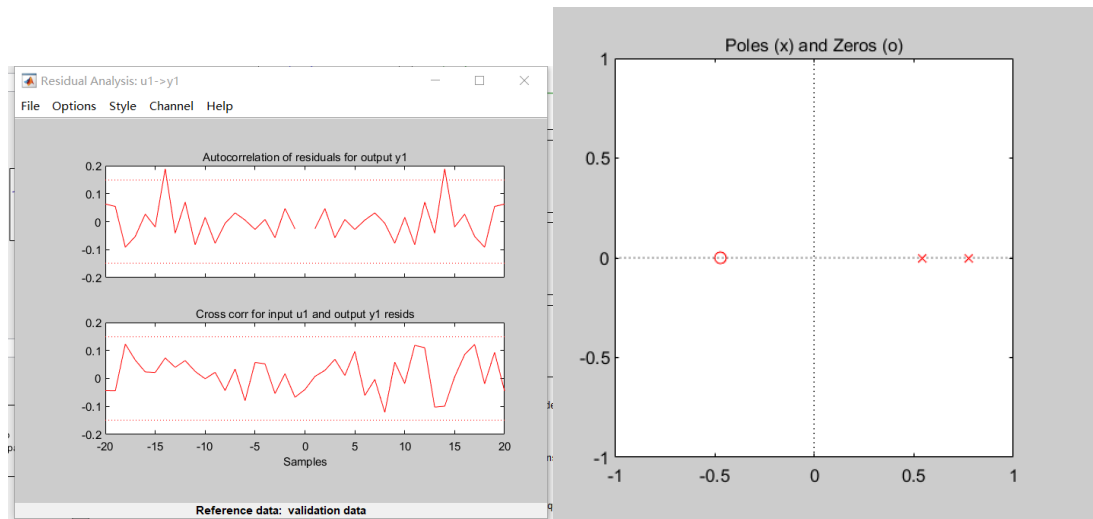
名称: arx334
采样时间: 1 seconds

Parameterization:
  Polynomial orders:  na=3  nb=3  nk=4
  Number of free coefficients: 6
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Estimated using ARX on time domain data "identification data".
Fit to estimation data: 89.3% (prediction focus)
FPE: 1.018, MSE: 0.9921
More information in model's "Report" property.

```

Still wrong, need to lower the order to [2 2 4]



```

arx224 =
Discrete-time ARX model:  $A(z)y(t) = B(z)u(t) + e(t)$ 
 $A(z) = 1 - 1.325 (+/- 0.01738) z^{-1} + 0.4253 (+/- 0.0169) z^{-2}$ 

 $B(z) = 1.969 (+/- 0.038) z^{-4} + 0.9272 (+/- 0.05077) z^{-5}$ 

名称: arx224
采样时间: 1 seconds

Parameterization:
Polynomial orders:  na=2  nb=2  nk=4
Number of free coefficients: 4
Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

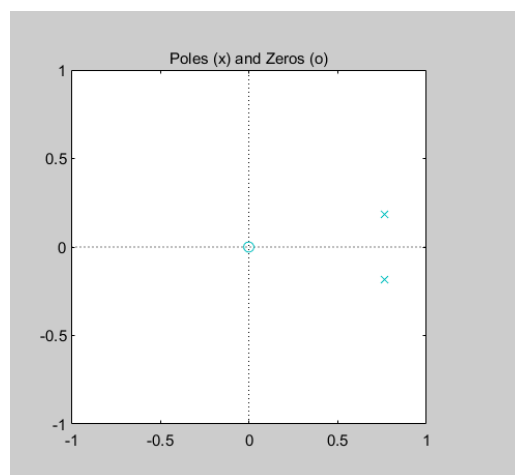
Status:
Estimated using ARX on time domain data "identification data".
Fit to estimation data: 89.29% (prediction focus)
FPE: 1.012, MSE: 0.9949
More information in model's "Report" property.

```

So the model for system 2 is ARX [2 2 4]    na = 2, nb =2 nk = 4

## Alternative model:

ARX [2 1 4]



```

arx214 =
Discrete-time ARX model:  $A(z)y(t) = B(z)u(t) + e(t)$ 
 $A(z) = 1 - 1.535 (+/- 0.01582) z^{-1} + 0.6222 (+/- 0.01582) z^{-2}$ 

 $B(z) = 1.972 (+/- 0.04619) z^{-4}$ 

名称: arx214
采样时间: 1 seconds

Parameterization:
Polynomial orders:  na=2  nb=1  nk=4
Number of free coefficients: 3
Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Estimated using ARX on time domain data "identification data".
Fit to estimation data: 86.97% (prediction focus)
FPE: 1.493, MSE: 1.472
More information in model's "Report" property.

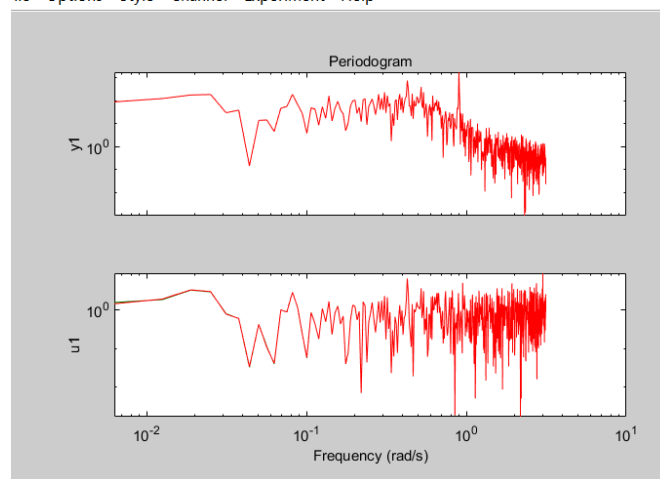
```

## System3:

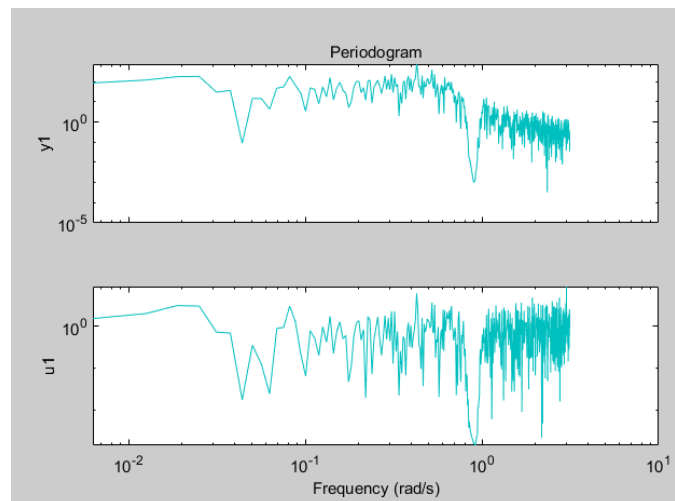
```
>> nk3
```

```
nk3 =
```

```
2
```

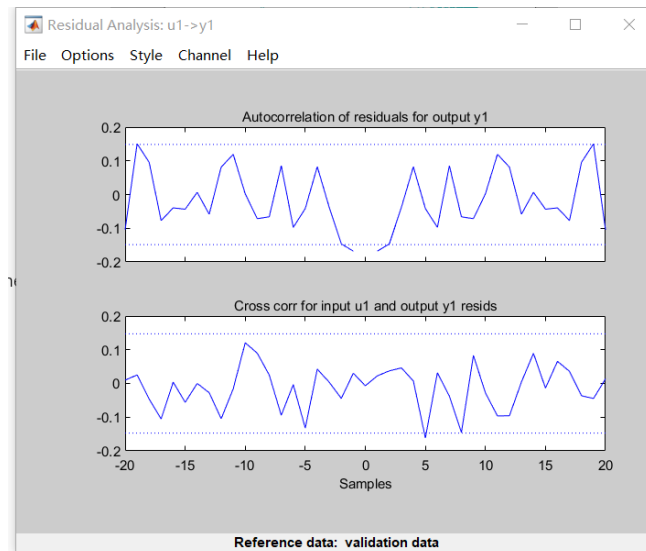


We should filter the data first,  
After the filter

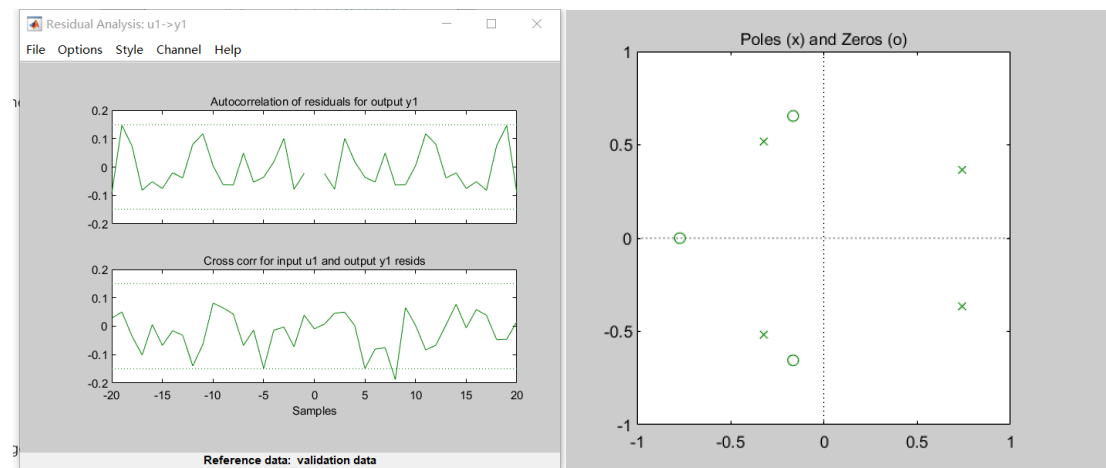


Use the ARX model [4 4 2] first, the residual analysis :





Change to the BJ model [4 2 2 4 2]:



```
bj42242 =
Discrete-time BJ model:  $y(t) = [B(z)/F(z)]u(t) + [C(z)/D(z)]e(t)$ 
  B(z) = 0.9889 (+/- 0.039) z^-2 + 1.088 (+/- 0.2558) z^-3 + 0.7004 (+/- 0.3039) z^-4 + 0.3476 (+/- 0.1106) z^-5

  C(z) = 1 - 1.053 (+/- 0.06749) z^-1 + 0.3065 (+/- 0.06378) z^-2

  D(z) = 1 - 1.518 (+/- 0.05088) z^-1 + 0.7323 (+/- 0.04464) z^-2

  F(z) = 1 - 0.8464 (+/- 0.2487) z^-1 + 0.1069 (+/- 0.3582) z^-2 - 0.1145 (+/- 0.3453) z^-3 + 0.2558 (+/- 0.1755) z^-4

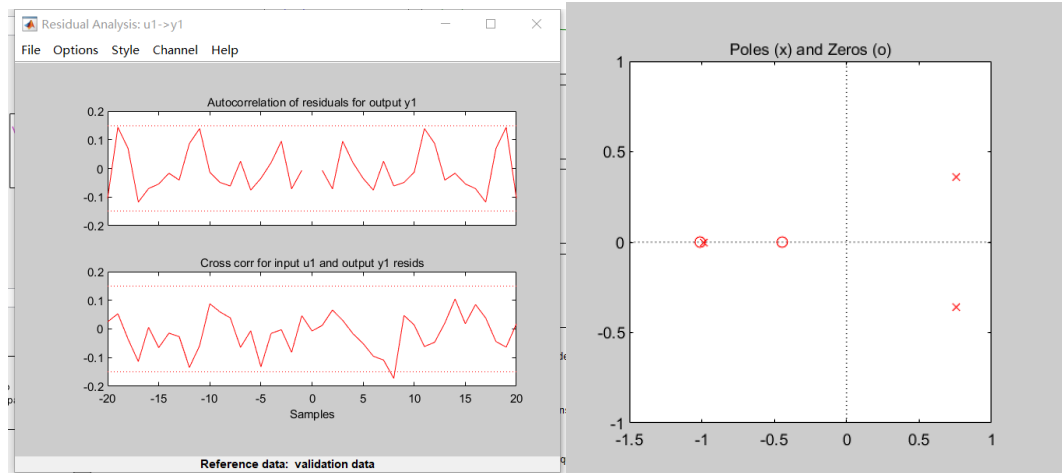
名称: bj42242
采样时间: 1 seconds

Parameterization:
  Polynomial orders: nb=4 nc=2 nd=2 nf=4 nk=2
  Number of free coefficients: 12
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 5, Number of function evaluations: 12

Estimated using PEM on time domain data "identification data".
Fit to estimation data: 77.33% (prediction focus)
FPE: 0.9609, MSE: 0.9285
More information in model's "Report" property.
```

Reduce the BJ order to [3 2 2 3 2]



```
bj32232 =
Discrete-time BJ model: y(t) = [B(z)/F(z)]u(t) + [C(z)/D(z)]e(t)
B(z) = 0.9891 (+/- 0.03885) z^-2 + 1.444 (+/- 0.04053) z^-3 + 0.4469 (+/- 0.05466) z^-4
C(z) = 1 - 1.05 (+/- 0.06811) z^-1 + 0.298 (+/- 0.06455) z^-2
D(z) = 1 - 1.513 (+/- 0.0516) z^-1 + 0.7254 (+/- 0.04553) z^-2
F(z) = 1 - 0.5229 (+/- 0.02314) z^-1 - 0.7924 (+/- 0.02863) z^-2 + 0.6915 (+/- 0.01642) z^-3
```

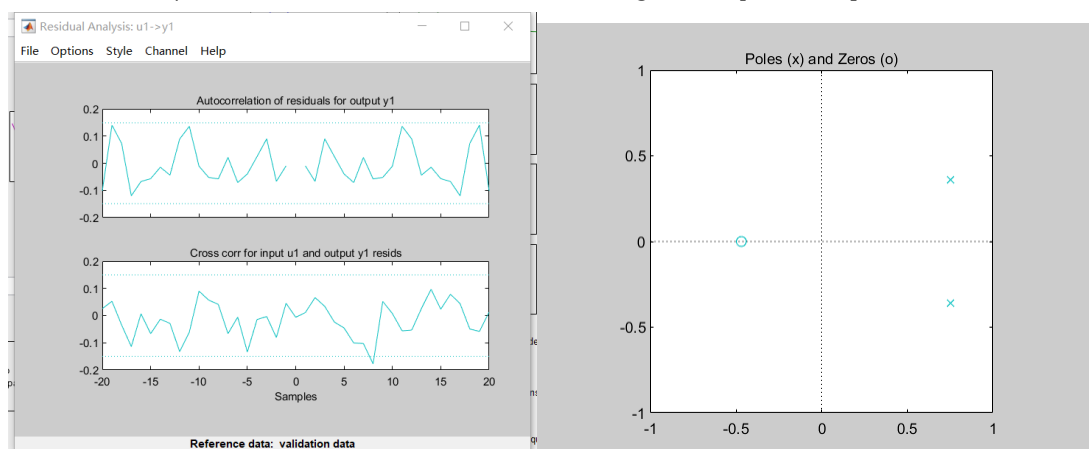
名称: bj32232  
采样时间: 1 seconds

Parameterization:  
Polynomial orders: nb=3 nc=2 nd=2 nf=3 nk=2  
Number of free coefficients: 10  
Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:  
Termination condition: Near (local) minimum, (norm(g) < tol)..  
Number of iterations: 9, Number of function evaluations: 22

Estimated using PEM on time domain data "identification data".  
Fit to estimation data: 77.16% (prediction focus)  
FPE: 0.9694, MSE: 0.9421  
More information in model's "Report" property.

The zero and points are not correct so need to change to BJ [2 2 2 2 2]



```

bj22222 =
Discrete-time BJ model:  $y(t) = [B(z)/F(z)]u(t) + [C(z)/D(z)]e(t)$ 
 $B(z) = 0.9887 (+/- 0.03881) z^{-2} + 0.4633 (+/- 0.05176) z^{-3}$ 

 $C(z) = 1 - 1.052 (+/- 0.06805) z^{-1} + 0.2999 (+/- 0.06442) z^{-2}$ 

 $D(z) = 1 - 1.513 (+/- 0.05153) z^{-1} + 0.7258 (+/- 0.04548) z^{-2}$ 

 $F(z) = 1 - 1.51 (+/- 0.01221) z^{-1} + 0.6995 (+/- 0.01036) z^{-2}$ 

名称: bj22222
采样时间: 1 seconds

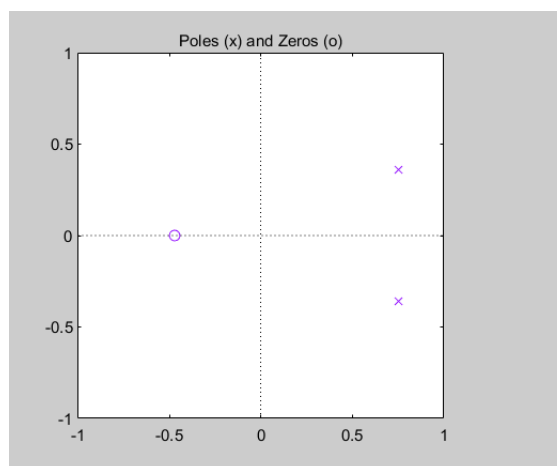
Parameterization:
  Polynomial orders:  nb=2  nc=2  nd=2  nf=2  nk=2
  Number of free coefficients: 8
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 4, Number of function evaluations: 9

Estimated using PEM on time domain data "identification data".
Fit to estimation data: 77.13% (prediction focus)
FPE: 0.9663, MSE: 0.9445
More information in model's "Report" property.

```

F and D are similar , so need to switch to ARMAX [2 2 2 2]



```

amx2222 =
Discrete-time ARMAX model:  $A(z)y(t) = B(z)u(t) + C(z)e(t)$ 
 $A(z) = 1 - 1.509 (+/- 0.01183) z^{-1} + 0.6988 (+/- 0.01005) z^{-2}$ 

 $B(z) = 0.9883 (+/- 0.03863) z^{-2} + 0.4653 (+/- 0.05135) z^{-3}$ 

 $C(z) = 1 - 1.038 (+/- 0.03921) z^{-1} + 0.2535 (+/- 0.0382) z^{-2}$ 

名称: amx2222
采样时间: 1 seconds

Parameterization:
  Polynomial orders:  na=2  nb=2  nc=2  nk=2
  Number of free coefficients: 6
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.

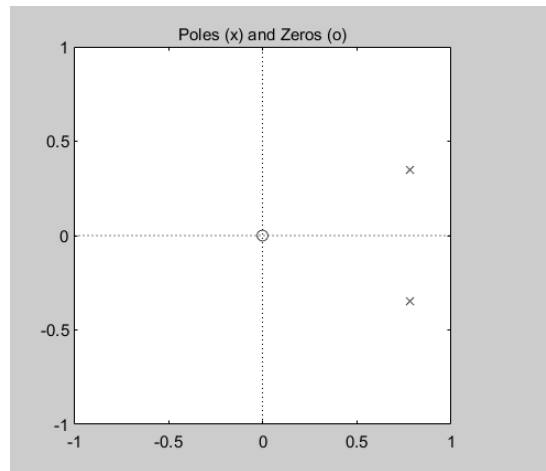
Status:
Termination condition: Near (local) minimum, (norm(g) < tol)..
Number of iterations: 3, Number of function evaluations: 7

Estimated using PEM on time domain data "identification data".
Fit to estimation data: 77.12% (prediction focus)
FPE: 0.9617, MSE: 0.9454
More information in model's "Report" property.

```

So the optimal model is ARMAX [2 2 2 2]

Alternative model is ARMAX [2 1 2 2]



```
amx2122 =  
Discrete-time ARMAX model: A(z)y(t) = B(z)u(t) + C(z)e(t)  
  A(z) = 1 - 1.567 (+/- 0.009728) z^-1 + 0.7359 (+/- 0.008918) z^-2  
  
  B(z) = 1.245 (+/- 0.02794) z^-2  
  
  C(z) = 1 - 1.098 (+/- 0.03813) z^-1 + 0.2753 (+/- 0.03778) z^-2  
  
名称: amx2122  
采样时间: 1 seconds  
  
Parameterization:  
  Polynomial orders:  na=2  nb=1  nc=2  nk=2  
  Number of free coefficients: 5  
  Use "polydata", "getpvec", "getcov" for parameters and their uncertainties.  
  
Status:  
Termination condition: Near (local) minimum, (norm(g) < tol)..  
Number of iterations: 6, Number of function evaluations: 14  
  
Estimated using PEM on time domain data "identification data".  
Fit to estimation data: 75.8% (prediction focus)  
FPE: 1.073, MSE: 1.058
```