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A USER GUIDE TO THE CONTROL SYSTEM IDENTIFICATION AND DESIGN PACKAGE-TRIP

by

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1. Introduction

TRIP is a control system identification and design package for single-input, single-output systems. It has similar facilities to the package SCADS but overcomes several deficiencies and bugs in SCADS and therefore TRIP should be used in preference to SCADS. THIS GUIDE ONLY SHOWS HOW TO USE A SMALL SAMPLE OF TRIP FACILITIES. THE MAIN TRIP MANUAL SHOULD BE READ ALSO.

2. Model Types

The following model types are available, each having its own two-letter mnemonic code.

SS - transfer function H(s)

ZZ - transfer function H(z)

WW - transfer function H(ω)

MA - matrix model (continuous)

MZ - matrix model (discrete)

FR - frequency domain model representation

TY - time domain model representation

3. Entry of a transfer function model H(s)

Consider a system with transfer function given by

$$H(s) = \frac{15560}{s(s+20)(s^2+10s+100)} = \frac{15560}{s(s+20)(s+5+8.66i)(s+5-8.66i)}$$

There are two ways to enter such a system. The first way is via the MR (model read) command. The second way is via a polynomial to transfer function (PORO) transformation.

a) Entry of System Model Via Model Read Command

Type:

MR CON SS EXPI This will read a model in transfer function (pole-zero) form from the user terminal (CON) and give the model a name EXPI

The package then asks for the following information to be entered in free format.

Order of numerator and denominator of transfer function	(0 4)
Real and imag. parts of first zero	
.	
.	
.	
Real and imag. parts of last zero	
Real and imag. parts of first pole	(-20 0)
.	(0 0)
.	(-5 -8.66)
.	
Real and imag. parts of last pole	(-5 8.66)
D.C. (steady-state) gain	(7.78)
Time delay	(0.0)

The first information requested is the order of the numerator and denominator of the transfer function. The real and imaginary parts of all zeros and poles are then requested in turn. The complex poles arising out of the term ($s^2 + 10s + 100$) have to be calculated separately, such as by using the NAG library routine CO2AEF. This is a very good reason with this example for using the alternative way of entering the system, (b) below.

When all poles and zeros have been entered, the package asks for a value of the d.c. gain to be entered. This is NOT the numerator coeff. (15560 in this example), it is the d.c. gain which is 7.78. The final item requested, the system time delay, is zero.

b) <u>Entry of System Model Via PORO Command</u> (see also p. 61-62 of TRIP manual)

The PORO command allows a system in transfer function representation, H(s), to be produced from a system described in polynomial form. The order and coefficients of the system polynomial are entered as the parameters of the PORO command.

Our system polynomial is given by

$$H(s) = \frac{15560}{s(s+20)(s^2 + 10s + 100)} = \frac{778}{100s + 15s^2 + 1.5s^3 + 0.05s^4}$$

The parameter update mode is entered and the parameters set by the following commands.

```
P    PORO
P1   0.0    (order of numerator)
P2   4.0    (order of denominator)
P3   778.0
P4   0.0
P5   100.0
P6   15.0
P7   1.5
P8   0.05
```

The transfer function model (SS) can now be produced by typing:

```
DO   PORO
```

4. Storing Models on Disc (see also p.6 of TRIP manual)

Models of all the types shown in section (2) can be saved on disc and subsequently restored at a later date.

a) Saving Models on Disc

MW SS USER ASM1

This will save a transfer function model in a file USER;ASM1.SSM

MW TY USER TIM1

This will save a time response model in a file USER: TIM1. SSM

This facility is most useful in allowing two or more time responses to be displayed on the same graph. It allows time responses from past simulations to be superimposed on the present one. See Section 7 on display facilities for how to make use of this.

b) Restoring Models From Disc

MR USER SS ASM1

This will restore the transfer function model from a previously saved file ASM1. SSM on disc.

5. Computing System Time Response

The time response is calculated by doing a transformation to the time domain model representation TY.

The command

DO SSTY

Will produce time response of a model in transfer function (SS) form, according to the parameters set up for the SSTY transformation.
NOTE that this does not display the time response, it only produces a time domain model. See Section 7 to see how the model is displayed as a graphical time response.
The current parameter settings for the SSTY transformation will be displayed by typing:

P SSTY

Parameter 1 defines the input signal (1 = step, 2 = ramp, 3 = impulse)
2 defines amplitude of input signal
3 defines maximum time of response (seconds)

Once parameters have been displayed by typing P SSTY, which also initiates the parameter update mode, parameters can be changed by typing for example

P3 5.0

which would change the value of parameter 3 to 5.0.

a) Open-Loop Step Response (see also p. 22-23 of TRIP manual)

Parameter 1 for the SSTY transformation must be set to 1 to obtain a step response. If parameter 2 is also 1, then a unity step response will be obtained.

If the system model entered is an open loop transfer function, then the command

DO SSTY

will compute the open loop step response.

b) Closed-Loop Step Response (see also p. 18-23 of TRIP manual)

To obtain the closed loop step response, the open loop transfer function must be first changed to closed loop using the SSSS transformation. Parameter 1 of the SSSS transformation defines feedback gain.

The following two successive commands would therefore give the closed loop time response.

DO SSSS

DO SSTY

6. Computing System Frequency Response (see also p. 21-22 of TRIP manual

The frequency response is calculated by doing a transformation to the frequency domain model representation FR.

The command

DO SSFR

will produce the frequency response of a model in transfer functions (SS) form, according to the parameters set up for the SSFR transformation. NOTE that this does not display the frequency response, it only produces a frequency domain model. See Section 7 to see how the model is displayed as a graphical frequency response.

The current parameter settings for the SSFR transformation will be displayed by typing:

P SSTY

Parameter 1 selects Bode/Nyquist (1 = Bode, 2 = Nyquist)

2 defines manual/automatic frequency bounds

(1 = frequency bounds defined by parameters 3 and 4

2 = automatic adjustment of frequency bounds)

3 defines lower frequency bound

4 defines upper frequency bound.

See Section 5 for how to change parameter settings.

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a) Nyquist Diagram

Suitable parameter values for the fourth order system example of Section 3 are

P1 = 2

P2 = 1

P3 = 1

P4 = 1E4 (10^4)

Having set the required parameters, typing

DO SSFR

will compute the frequency response.

b) Bode Diagram

Suitable parameter values for the fourth order system example of Section 3 are

P1 = 1

P2 = 1

P3 = 0.1

P4 = 10

Having set the required parameters, typing

DO SSFR

will compute the frequency response.

7. Display of Time and Frequency Response Models (see also p. 11 of TRIP manual)

Having computed time or frequency domain models by the SSTY or SSFR transformation, the time or frequency response can be displayed by typing

D TY

or D FR

More than one time or frequency domain model can be superimposed on one graph, if such models have previously been preserved on disc.

e.g. the time response model saved in Section 4 can be displayed with the latest time response model by typing

D TY + TIM1

8. Displaying Poles and Zeros of Transfer Function

The command

D SS

will display graphically the poles and zeros of the transfer function (SS) model.

9. . Root Locus Plot (see also pages 56-60 of TRIP manual)

A root locus plot is produced by the ROLO transformation. Typing

DO ROLO

causes the system to ask whether you require a continuous (SS) or discrete root locus plot. Either SS or ZZ should be entered, after which the root locus plot is computed and displayed. The algorithm seems temperamental, and injudicious choice of parameters can give either floating point underflow or other errors.

Parameters suitable for the fourth order system in chapter 3 are

P1 = 1

P2 = 0.5 (distance between points)

P3 = 0.7 (damping ratio)

P4 = -25 (x min of plot)

P5 = -10 (y min of plot)

P6 = 5 (x max of plot)

P7 = 10 (y max of plot)

10. Updating System Model (see also pages 12-15 of TRIP manual)

It is possible to change the values of poles, zeros, system time delay and d.c. gain with the update command. Once in the update mode, all commands are prefixed with the number of characters in the command.

To enter the update mode for a transfer function (SS) model, type:

U SS

This will then display the poles and zeros of the current model and encircle one pole or zero. Typing (CR) will cause a redisplay of system poles and zeros with another one encircled. The value of the encircled pole/zero can be changed by a secondary command of the form

11C - 4.0 7.22 (changes pole/zero value to -4,7.22)

Note that for complex poles, each half of the pair must be changed in value. Changing one does not automatically change the other.

The system d.c. gain and time delay values can be changed by the commands:

09C KD 3.89 (new d.c. gain = 3.89)

06C DT 0 (new time delay = 0)

New poles and zeros can be added by the append command within the update mode:

15A PO - 12.0 -1.0 (adds new pole at -12, -1)

13A ZE - 4.0 0.0 (adds new zero at -4).