The Effect of Controller Parameters on Closed-loop System Identification of Multiple-Input Multiple-Output (MIMO) Systems

by

Olivia Mah Yien Yien

13708

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

_____

(Dr. Lemma Dendena Tufa)

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May 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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OLIVIA MAH YIEN YIEN

ABSTRACT

In the industries today, less attention has been put on the effect of the controller parameters on closed loop system identification of a Multiple-Input Multiple-Output (MIMO) system. This paper studies the effect of Proportional controller and Proportional-Integral controller on a MIMO system using ARX model. The paper focuses on the effect of the controller parameters of a MIMO system on closed loop system identification when both loops are closed and one loop is open. It is observed that different parameters give different effects on the closed loop system identification. Generally, it is better to keep the gain lower if only Proportional controller is used. For a distillation column, a MIMO system in this project, neither too high or too low gain give a better model accuracy for both closed loop and one loop open when Proportional-Integral controller is used.

ACKNOWLEDGEMENTS

This report is done through the help and support from everyone, including my parents, supervisors, and my friend. Here, please allow me to dedicate my acknowledgement of gratitude towards them:

First and foremost, I would like to thank Dr. Lemma for his most support and encouragement. Under his advises, I have gained a lot of knowledge as an undergraduate student. Besides that, he always forgives me even when I made mistakes in the work given to me. He always hopes that I can improve myself.

Next, sincere thanks to my parents and my friends who never fail to support me. They will always be by my side whenever I am unhappy or feeling stress. I appreciate their time. Without them, I will not be able to complete the report will full courage.

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Abbreviations and Nomenclatures

ARMAX	Autoregressive Moving Average Model
ARX	Autoregressive Model
FPE	Final Prediction Error
MIMO	Multiple-Input Multiple-Output
PID	Proportional-Integral-Derivative
SISO	Single-Input Single-Output

CHAPTER 1

BACKGROUND OF STUDY

System identification is a way of developing a mathematical model using experimental data. It has widely been applied in aerospace engineering, mechanical engineering and structural engineering. It has been used to control, validate and update a model, assess different conditions, monitor health and detect the damage. These techniques can utilize both input and output data or can only include the output data. [1]

The construction of system identification involves three basic entities, which are set of data, model structure, and rule where the data can be used to assess the models. A set of data can be collected through those designed identification experiment. The user can decide which and when the signals to be measured, together with the input signals too. A designed experiment is carried out as the user can choose the data that is the most informative subjected to some specific constraints. [2]

The user is going to choose those suitable models collection and gather the models together. This model choosing is the critical part of system identification. During the stage, the user must equip with basic knowledge, engineering intuition and insight. Sometimes, a model set is obtained after careful modeling. Then, undeveloped physical laws and other entrenched relationships are built to know the physical parameters in a model. Meanwhile, a black box can be obtained when standard linear models are in use without referring to the physical background. [2]

With the guidance from the data, the user can choose the best model from the set. This method is known as identification. The quality of the model is assessed based on the model performance when the models attempt to regenerate the measured data. After

settling, the one that describes the data according to the chosen criterion best will be chosen as the particular model. Such test is known as model validation. Model validation comprises a number of procedures to access the relationship between the model and the observed data, to prior knowledge, and to its intended use. On the other hand, a model will be rejected if number of procedures fail to obtain the best model, the criterion is not carefully chosen, inappropriate model set, and non-informative data set. [2]

Model structures can be split into linear and nonlinear. A system is linear if it can be described by a model in a form of

$$y(t) = G(q^{-1})u(t) + H(q^{-1})e(t) \quad \text{Eq.(1)}$$

There are a few linear model structures which are Autoregressive (ARX) model structure, Autoregressive Moving Average (ARMAX) model structure, Box-Jenkins (BJ) model structure, FIR model structure, and State-Space model structure.

ARX model is the most non-complex model that merging the stimulus signals. Solving the linear regression equations in the analytic form makes the approximation of the ARX model is the most resourceful of the polynomial estimations. Unfortunately, system dynamics contains disturbances. The coupling between the deterministic and stochastic dynamics can bias the estimation of the ARX model when the disturbances of the systems are not white noise. [3] The parameters of the ARX model structure can be represented by

$$y(t) + ay(t-1) = B_1u(t-1) + B_2u(t-2) + e(t) \quad \text{Eq.(2)}$$

Least-squares method is used. [4]

ARMAX model structure is the ordinary tool that used in control and econometrics to describe the system or control the design. However, this model includes disturbance dynamics. It lacks of suitable choice when describing the properties of the disturbance term. ARMAX models are useful when there are governing disturbances that flow in early in the process, for example, input. This model contains more suppleness in

handling the disturbance modelling compared to ARX model. ARMAX model can be represented by [2, 3]

$$A(q)y(t) = B(q)u(t) + C(q)e(t) \quad \text{Eq.(3)}$$

Box-Jenkins model structure is a model that modifies the properties of the output error by using the output error. This structure provides a full model including the disturbance properties that are detached from the system dynamics. This model is advantageous when there are disturbances that flow in late into the progression. It can be represented by [2, 3]

$$y(t) = \frac{B(q)}{F(q)}u(t) + \frac{B(q)}{D(q)}e(t) \quad \text{Eq.(4)}$$

FIR model structure has two important advantages, where it is a linear regression and it is an output error model. Been a linear regression makes the model a special case of ARX while been an output error model makes the model a different case of OR. This model can be estimated efficiently which is robust against the noise. However, many parameters are needed when using this model. This model can be represented by

$$G(q,\theta) = \sum_{k=1}^{n} b_k q^{-k} \quad \text{Eq.(5)}$$

A State-Space model structure forms the connection between the input, noise, and output signals. This relationship is written in a first-order differential system or difference equations using an auxiliary state vector *x*(t). This model works well in many cases. Certain parameters can be fixed to known values and the remaining parameters can be estimated. But, for high order complex systems, the model can suffer from several problems such as experiencing local minima in the performance function which causes the absence of merging to global minima. This model can be described as [2, 3, 5]

$$x(n+1) = Ax(n) + Bu(n) + Ke(n) \quad \text{Eq.(6)}$$

$$y(n) = Cx(n) + Du(n) + e(n) \quad \text{Eq.(7)}$$

System identification can be divided into closed loop and open loop system identification. An open loop system identification is a way of developing a mathematical model with the presence of a controller that is set in manual mode. On the other hand, a

closed loop system identification is a way of developing a mathematical model with the presence of a controller that is set in automatic mode. In closed loop system identification, the input signal $u(t)$ is correlated with $e(t)$ while it is uncorrelated for open loop system identification. This project will only focus on closed loop system identification. [6]

A Single-Input Single-Output (SISO) system is a simple control system equipped with one input and one output. A Multiple-Input Multiple-Output (MIMO) system is a complex control system consists of multiple inputs and outputs. MIMO system is the hardest system to be designed as the process interactions occur between controlled and manipulated variables.

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism that has been widely used in the industry. A PID controller estimates an error value as the difference between a measured process variable and a desired set point. The controller tends to diminish the error by regulating the process through the use of a manipulated variable. The PID controller algorithm consists of three parameters, which are the proportional P, the integral I and the derivative D values. The response of the controller can be described in terms of the responsiveness of the controller to an error.

Conclusion

It is crucial to study the effect of the controller parameters on the closed loop identification of a MIMO system. In this research paper, proportional controller and proportional-integral controller will be studied. The model that will be used to develop the mathematical model is ARX model. ARX model structure is chosen because this model works better for a closed loop system compared with other models.

PROBLEM STATEMENT, OBJECTIVES & SCOPE OF STUDY

Problem Statement

MIMO system is been used in the industries today. Due to its complex designed system, the effect of controller parameters on closed loop identification is not well understood.

Objectives

The objectives of research paper are

a. To study the effect of controller parameters (gain and integral time constant) on the closed loop system identification for MIMO system when both loops are closed.
b. To study the effect of controller parameters (gain and integral time constant) on the closed loop system identification for MIMO system when one loop is open.

Scope of Study

The scopes of study for this paper are:

a. Closed loop system
   Open loop system will not be examined in this paper.
b. Linear System
   Non-linear system is excluded in this paper.
c. Multiple-Input and Multiple Output (MIMO) System
   Single-Input and Single-Output will not be considered in this paper.
d. Wood & Berry Distillation Column
   One type of MIMO system.
e. Autoregressive with Exogenous Input (ARX) Model
   ARX model will be used to develop the mathematical model.
f. Controller Parameters
   Only Proportional and Proportional-Integral control will be studied in this paper.

CHAPTER 2

LITERATURE REVIEW

A closed loop system identification needs a good noise modelling. Closed loop system identification of multivariable systems with colored noise. In order to produce a good noise modelling, many researchers tried to come out with some approaches. Some of the researchers combined the direct closed loop identification approach with the iterative least squares parameter estimation algorithm. This method had successfully produced highly accurate parameter estimations when a system faced with colored noise. Part of the team tried to balance the input-noise decorrelation against noise whitening. The correlation analysis was done on the signs of attention, analyzed asymptotic bias that caused by the feedback and noise model mismatching, same goes to the effect on the change of G at different occurrences. This approach has provided extra flexibility of the closed loop system identification. Another approach that had been done was proposing bias-eliminated closed loop subspace identification. [7-9]

Uncertain and large time delay leads to inaccurate models in closed loop system identification. In connection with this issue, some researchers have done researches to investigate the impacts of time sampling on the value of the model obtained and develop a model structure that can handle the closed loop system identification with uncertain time delay. The experiment uses Monte Carlo simulations and a heated tank set up was conducted to identify the impact of discrete time delay. The data was taken from the concept of closed loop system identification with unchanging operating data. The increasing of the sampling time of closed loop system identification was found leading to an incorrect model. On the other hand, an ARX-OBF model structure which was produced by substituting the numerator polynomial of the deterministic component of the ARX structure with conventional orthonormal basis filters (OBF) found to have a better performance than ARX model structure even with in certain time delays. [10, 11]

In closed loop system identification, model parameter and the structure cannot be estimated simultaneously. Based on this problem, some researchers had proposed an appropriate way to random input and output signals for the closed loop identification. This idea was to search the local optimization with NLJ algorithm at the iteration of PSO set which successfully obtained a better result at the best global location. Besides the idea, a generalized orthonormal basis filters (GOBFs)-ARX model was constructed. Those methods showed lesser number of parameters was needed to be estimated and the model structure could be estimated together with the structure. Moreover, the circumstances for closed loop system identifiability using operational operating data could be obtained by deriving the model structures. [12-14]

Sometimes, when identify a multivariable system that operates as a closed loop that contains a linear time-invariant controller, people wonder is it necessary to stimulate all reference signals. A research was done to determine the issue and found that that was not the case. User can always select the best controller with enough complexity that can turn the data into some information with respect to the structure of the model. People may also interest on the behavior of the closed loop and open loop system identification. A study to analyze the variance of estimated transfer functions was done on the issue using prediction error identification. It was found the changes of the predicted input-output model are smaller with closed loop than with open loop identification. [15, 16]

Every model structure has its disadvantages. Some might be time consuming while some might be having burn-through point that affects the quality and quantity of the sintering process. To reduce the time needed a novel approach wherein an information rich test signal was proposed. The approach was generated in closed loop system by maximizing the model predictive control objective, as opposed to minimization that is done in the standard controller. Multivariable systems that operate with closed loop as the identification method was proposed too. Both methods showed time reduction successfully. On the other hand, an ARX model was combined with BTP predictive control had effectively guarantee the steadiness of sintering process and dominate the fluctuation of BTP. [17-20]

The performance of the controller is always one of the most important factors in closed loop system identification. A new technology was proposed for the identification of the process to enable the assessment of the functioning of MIMO control systems. This method was based on subspace identification algorithms, which was used for the identification of the controller, process, and disturbance models from closed loop data. Another procedure was done to enable the originate of a controller that obtains the best robust performance. The complex interrelation between system identification and robust control is thoroughly studied and novel connections are created between control-relevant and coprime factor identification and model uncertainty size and the control criterion. Both approaches were found to achieve a better performance. [21, 22]

Conclusion

From the literature reviews analyzed, researchers tends to carry the researches on different aspects of a closed loop system such as noise modelling, time delay, sintering process, robust controller, the performance of a MIMO control system, and etc. It has been discovered that no study has been done on the effect of the controller parameters on closed-loop identification. Therefore, this project is carried out to achieve the purpose.

CHAPTER 3

METHODOLOGY

MATLAB is the main software used in this project. A representation of MIMO system, the Wood and Berry Distillation Column will be used in this project. The model for Wood and Berry Distillation Column is defined as

$$\begin{bmatrix} x_D(s) \\ x_B(s) \end{bmatrix} = \begin{bmatrix} \frac{12.8e^{-s}}{16.7s+1} & \frac{-18.9e^{-3s}}{21s+1} \\ \frac{6.6e^{-7s}}{10.9s+1} & \frac{-19.4e^{-3s}}{14.4s+1} \end{bmatrix} \begin{bmatrix} R(s) \\ S(s) \end{bmatrix}$$

The following steps are taken to accomplish the objectives:

1. Introduce excitation signal on the MIMO system
2. Vary the controller parameters
3. Collect the input-output data
4. Develop models
5. Validate by calculating Final Prediction Error (FPE)
6. Obtain the best fits, Y1 and Y2

FPE is defined as Akaikes Final Prediction Error = V*(1+2*d/N), where V is the loss function, d is the number of estimated parameters and N is the number of estimation data. Assume d << N.

The model set up is shown in the following page.

Objective (a) - *To study the effect of controller parameter on the closed loop system identification for the MIMO system (distillation column) when both loops are closed.*
To accomplish this objective, Proportional and Integral controls are studied to understand their effects on the closed loop identification of MIMO system

The model set-up

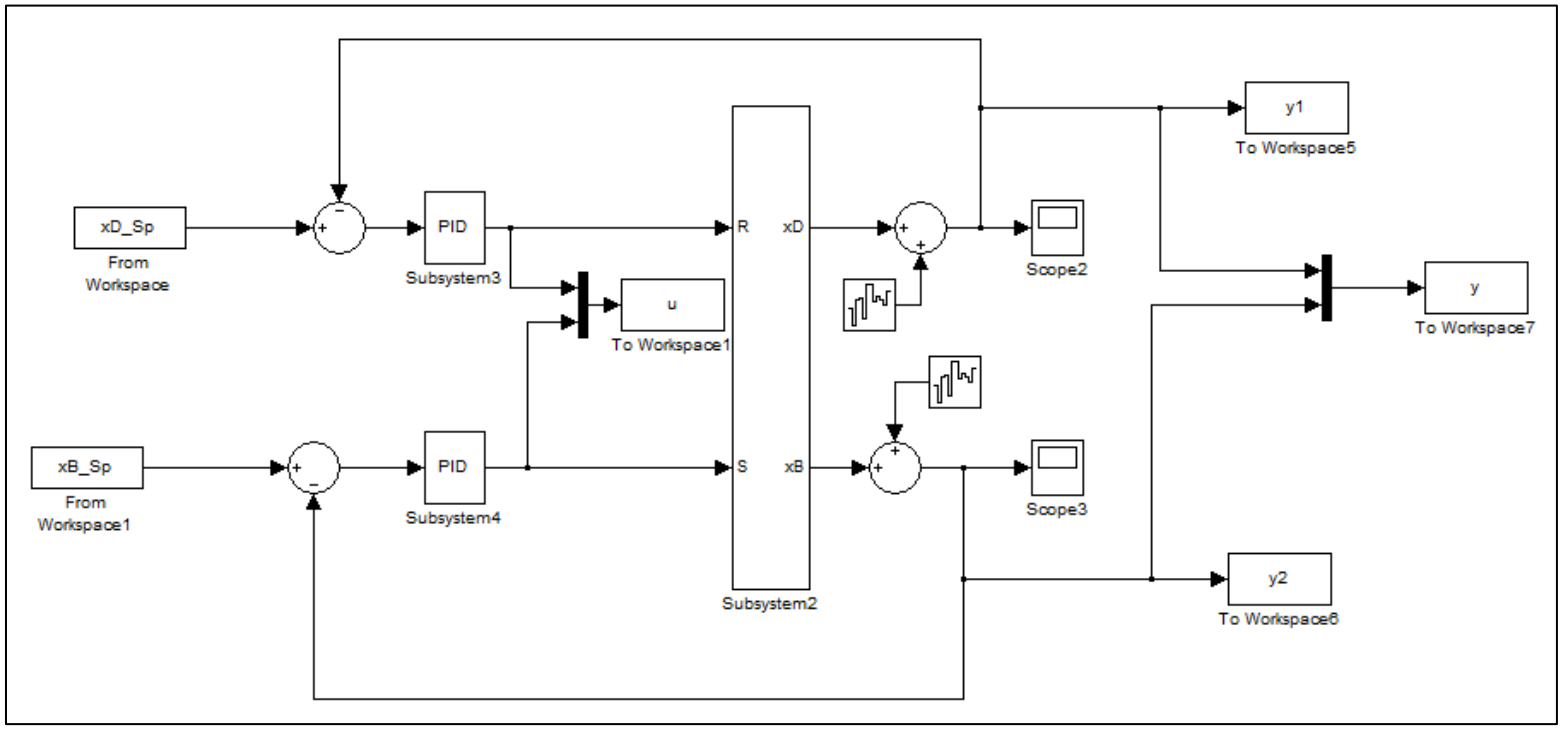

Figure 1: Model Set-up.

The model set-up of subsystem 2.

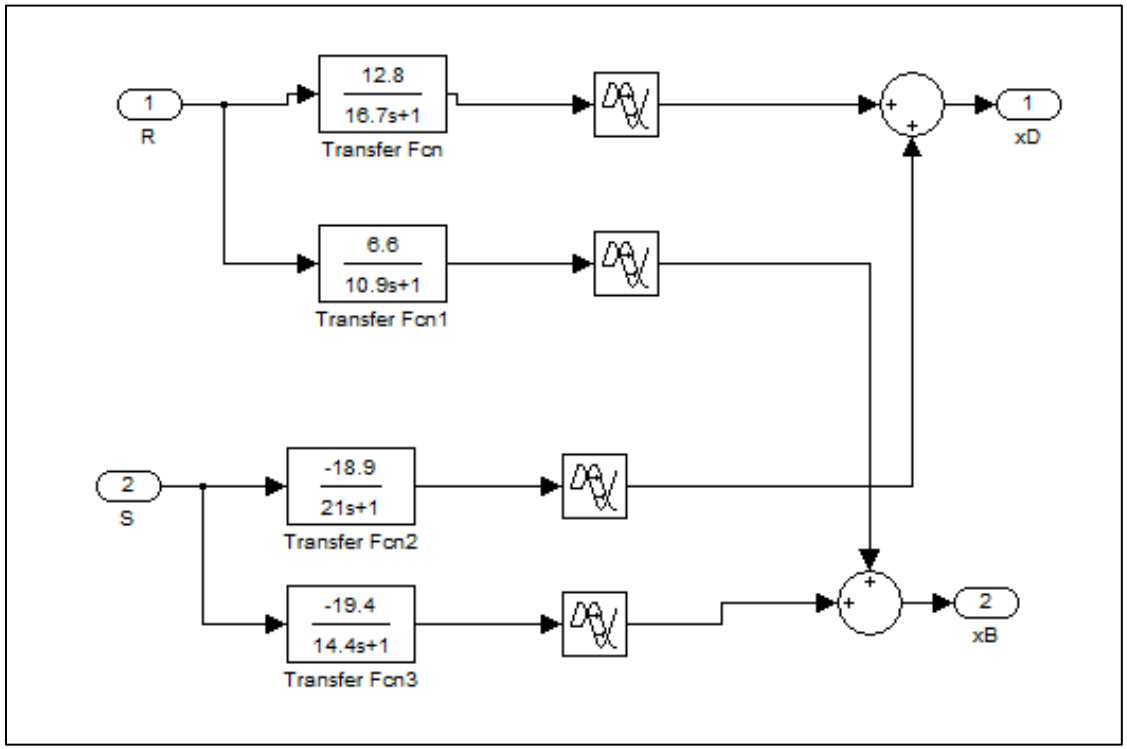

Figure 2: Subsystem 2 Model Set-up.

The first section studies on the effect of the Proportional controller, Kc on the closed loop system identification when both loops are closed. In this case, both Integral controllers, I1 and I2 are set as infinity.

The second section studies on the effect of the Proportional-Integral controller on the closed loop system identification when both loops are closed. In this case, both Integral controllers, I1 and I2 are set at 16.37 and 14.46 respectively.

The third section studies on the effect of the Proportional-Integral controller on the closed loop system identification when both loops are closed. In this case, both proportional controllers, Kc1 and Kc2 are set at 0.604 and -0.127 respectively.

Objective (b) - *To identify the effect of controller parameter on the closed loop system identification for the MIMO system (distillation column) when one loop is open.*
In this section, the focus is on the effect of the Proportional-Integral controller on the closed loop identification of MIMO system when one loop is open.

The set up to achieve the objective is shown

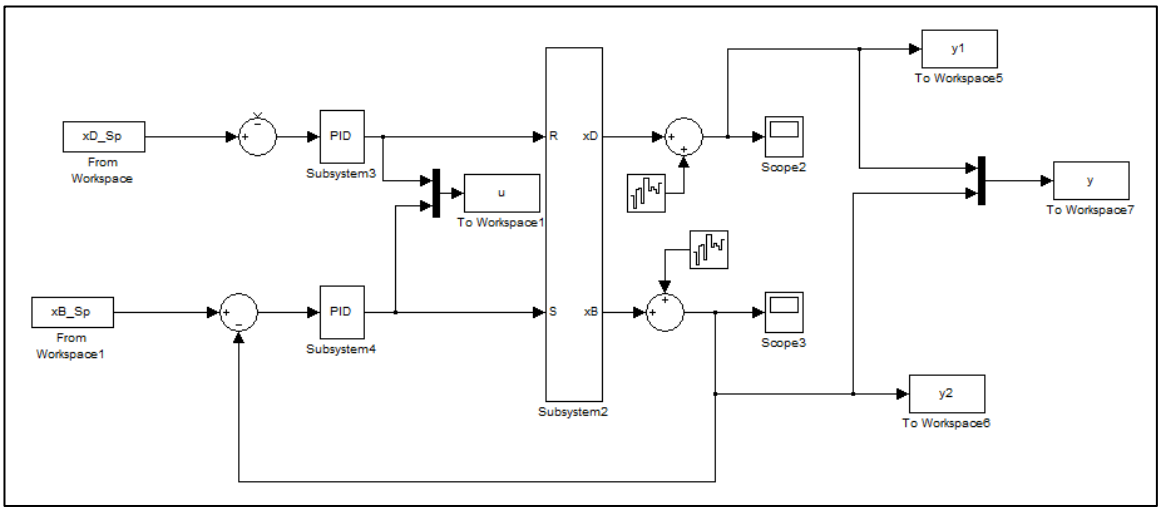

Figure 3: Model Set-up.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Model developed from MATLAB

The model developed from the MATLAB is recorded. The model can be represented by Eq.(2) in Chapter 1. Two ARX models are used, which are [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]] and [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]]. The first column of the model represents A(q), the second column represents B(q), while the last column represents the time delay.

4.1.1 Model [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]]

Model [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]] is used when only Proportional control is used to study the effect on the closed loop identification on MIMO system. Model [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]] is not suitable as it gives an error on the result.

The model as shown in the table is taken from the MATLAB when Kc1 is set at 0.4 and both Integral controllers are set at infinity.

Table 1: Best Fits and FPE.

Kc2	Y1	Y2	FPE
-0.03	86.10	82.39	9.21E-06
-0.05	86.48	83.97	1.01E-05
-0.07	86.72	84.98	1.19E-05
-0.09	87.12	85.82	1.43E-05
-0.127	87.07	86.55	2.07E-05
-0.14	87.15	86.83	2.36E-05
-0.16	87.28	87.27	2.87E-05

Table 2: Model Developed - Values of A(q).

A0	A1	A2	A3
1 0 0 1	-0.4082 0.1203 0.3 591 -0.6390	-0.1994 -0.0791 -0.0448 -0.2153	-0.1823 -0.1435 -0.2079 -0.1134
1 0 0 1	-0.4131 0.1198 0.3576 -0.6416	-0.1996 -0.0809 -0.0517 -0.2110	-0.1957 -0.1292 -0.2249 -0.0961
1 0 0 1	-0.4180 0.1186 0.3565 -0.6455	-0.2002 -0.0818 -0.0591 -0.2054	-0.2077 -0.1148 -0.2416 -0.0784
1 0 0 1	-0.4224 0.1164 0.3561 -0.6508	-0.2021 -0.0810 -0.0679 -0.1979	-0.2177 -0.1010 -0.2566 -0.0612
1 0 0 1	-0.4290 0.1091 0.3572 -0.6650	-0.2107 -0.0741 -0.0895 -0.1783	-0.2302 -0.0790 -0.2789 -0.0317
1 0 0 1	-0.4307 0.1056 0.3582 -0.6712	-0.2154 -0.0699 -0.0986 -0.1696	-0.2327 -0.0726 -0.2850 -0.0222
1 0 0 1	-0.4328 0.0991 0.3601 -0.6819	-0.2245 -0.0615 -0.1143 -0.1545	-0.2345 -0.0640 -0.2928 -0.0087

Table 3: Model Developed - Values of B(q).

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0050 0 0 0	0.7634 0 0 0	0 -4.4952 0 -4.4036	0 -2.3231 0 -2.4999	0 0 0 0	0 0 0 0	0 0 -0.0431 0	0 0 0.5613 0
0 0 0 0	-0.0027 0 0 0	0.7635 0 0 0	0 -2.6698 0 -2.6446	0 -1.7811 0 -2.0341	0 0 0 0	0 0 0 0	0 0 -0.0450 0	0 0 0.5583 0
0 0 0 0	1.0e-003 *-0.4011 0 0 0	0.7635 0 0 0	0 -1.8855 0 -1.8902	0 -1.5488 0 -1.8358	0 0 0 0	0 0 0 0	0 0 -0.0477 0	0 0 0.5549 0
0 0 0 0	0.0017 0 0 0	0.7636 0 0 0	0 -1.4497 0 -1.4713	0 -1.4160 0 -1.7228	0 0 0 0	0 0 0 0	0 0 -0.0510 0	0 0 0.5512 0
0 0 0 0	0.0045 0 0 0	0.7634 0 0 0	0 -1.0073 0 -1.0450	0 -1.2693 0 -1.5977	0 0 0 0	0 0 0 0	0 0 -0.0587 0	0 0 0.5439 0
0 0 0 0	0.0051 0 0 0	0.7634 0 0 0	0 -0.9084 0 -0.9491	0 -1.2325 0 -1.5662	0 0 0 0	0 0 0 0	0 0 -0.0618 0	0 0 0.5412 0
0 0 0 0	0.0055 0 0 0	0.7634 0 0 0	0 -0.7888 0 -0.8324	0 -1.1843 0 -1.5249	0 0 0 0	0 0 0 0	0 0 -0.0673 0	0 0 0.5369 0

With the values obtained from MATLAB, the model can be represented by the following equation. (Take note: the example below shows the first row of the values obtained only, which is when Kc2 is set at -0.03.)

$$y(t) + ay(t-1) = B_1u(t-1) + B_2u(t-2) + e(t) \qquad \text{Eq.(2)}$$

When substitute the values above,

$$x_D(s) = \frac{-0.005q^{-1} + 0.7634q^{-2}}{1 - 0.4082q^{-1} - 0.1994q^{-2} - 0.1823q^{-3}} R(k)$$

$$x_B(s) = \frac{-4.4952q^{-3} - 2.3231q^{-4}}{0.1203q^{-1} - 0.0791q^{-2} - 0.1435q^{-3}} R(k)$$

$$x_D(s) = \frac{-0.0431q^{-7} + 0.5613q^{-8}}{0.3591q^{-1} - 0.0448q^{-2} - 0.2079q^{-3}} S(k)$$

$$x_B(s) = \frac{-4.4036q^{-3} - 2.4999q^{-4}}{1 - 0.6390q^{-1} - 0.2153q^{-2} - 0.1134q^{-3}} S(k)$$

4.1.2 Model [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]]

Model [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]] is used when Proportional and Integral controllers are used to study the effect on the closed loop identification on MIMO system. Two conditions will be studied, which are when both loop are closed and when one loop is open.

The model as shown in the table is taken from the MATLAB when Kc1 is set at 0.4 and I1 is set at 16.37 and I2 is set at 14.46 respectively.

Table 4: Best Fits and FPE.

Kc2	Y1	Y2	FPE
-0.03	NaN	NaN	1.03E-05
-0.05	NaN	NaN	1.61E-05
-0.07	88.81	88.35	2.34E-05
-0.09	88.84	89.02	3.07E-05
-0.127	88.91	89.66	4.07E-05
-0.14	88.97	89.94	4.26E-05
-0.16	89.12	90.44	4.39E-05

Table 5: Model Developed - Values of A(q).

A0	A1	A2
1 0 0 1	-0.2686 0.1005 -0.6230 0.4799	-0.0846 -0.0721 0.9573 -1.0869
1 0 0 1	-0.2721 0.0969 -0.5303 0.3822	-0.0931 -0.0708 0.8902 -1.0261
1 0 0 1	-0.2739 0.0912 -0.4362 0.2830	-0.1019 -0.0700 0.8198 -0.9625
1 0 0 1	-0.2744 0.0843 -0.3413 0.1830	-0.1103 -0.0699 0.7463 -0.8959
1 0 0 1	-0.2745 0.0729 -0.1764 0.0080	-0.1217 -0.0735 0.6136 -0.7767
1 0 0 1	-0.2750 0.0701 -0.1238 -0.0482	-0.1240 -0.0763 0.5701 -0.7380
1 0 0 1	-0.2765 0.0676 -0.0482 -0.1294	-0.1256 -0.0821 0.5066 -0.6820

Table 6: Model Developed - Values of A(q).

A3	A4	A5
-0.3968 0.2504 -0.2177 0.0741	-0.1190 -0.0952 -0.1222 -0.0808	-0.0327 -0.1288 -0.0145 -0.1429
-0.3659 0.2174 -0.2144 0.0695	-0.1379 -0.0777 -0.1416 -0.0642	-0.0232 -0.1282 0.0065 -0.1572
-0.3383 0.1875 -0.2142 0.0686	-0.1562 -0.0599 -0.1553 -0.0522	-0.0101 -0.1295 0.0242 -0.1678
-0.3125 0.1594 -0.2173 0.0714	-0.1730 -0.0426 -0.1633 -0.0453	0.0058 -0.1329 0.0374 -0.1741
-0.2680 0.1111 -0.2315 0.0860	-0.1976 -0.0154 -0.1658 -0.0437	0.0382 -0.1431 0.0521 -0.1769
-0.2540 0.0960 -0.2390 0.0936	-0.2040 -0.0079 -0.1635 -0.0459	0.0493 -0.1473 0.0550 -0.1758
-0.2353 0.0757 -0.2526 0.1075	-0.2116 0.0015 -0.1572 -0.0519	0.0652 -0.1539 0.0574 -0.1722

Table 7: Model Developed - Values of B(q).

B0	B1	B2	B3	B4
0 0 0 0	0.0064 0 0 0	0.7902 0 0 0	0.9097 7.5153 0 6.7079	0 -5.8993 0 -6.1035
0 0 0 0	0.0090 0 0 0	0.7901 0 0 0	0.8400 3.9714 0 3.4627	0 -3.8356 0 -4.2321
0 0 0 0	0.0114 0 0 0	0.7898 0 0 0	0.7758 2.4825 0 2.0702	0 -2.9552 0 -3.4206
0 0 0 0	0.0134 0 0 0	0.7893 0 0 0	0.7140 1.6538 0 1.2966	0 -2.4699 0 -2.9613
0 0 0 0	0.0146 0 0 0	0.7880 0 0 0	0.5887 0.7816 0 0.5362	0 -1.9834 0 -2.4829
0 0 0 0	0.0140 0 0 0	0.7876 0 0 0	0.5428 0.5806 0 0.3757	0 -1.8761 0 -2.3732
0 0 0 0	0.0120 0 0 0	0.7871 0 0 0	0.4731 0.3395 0 0.1885	0 -1.7476 0 -0.2383

Table 8: Model Developed - Values of B(q).

B5	B6	B7	B8	B9
0 -4.5612 0 -4.9738	0 0 0 0	0 0 0.0129 0	0 0 0.5901 0	0 0 0.6914 0
0 -2.9560 0 -3.4480	0 0 0 0	0 0 0.0287 0	0 0 0.5964 0	0 0 0.6396 0
0 -2.2563 0 -2.7403	0 0 0 0	0 0 0.0410 0	0 0 0.6007 0	0 0 0.5852 0
0 -1.8564 0 -2.3044	0 0 0 0	0 0 0.0492 0	0 0 0.6029 0	0 0 0.5281 0
0 -1.4286 0 -1.7957	0 0 0 0	0 0 0.0561 0	0 0 0.6025 0	0 0 0.4245 0
0 -1.3277 0 -1.6667	0 0 0 0	0 0 0.0564 0	0 0 0.6014 0	0 0 0.3903 0
0 -1.2022 0 -1.4986	0 0 0 0	0 0 0.0550 0	0 0 0.5989 0	0 0 0.3402 0

(Take note: the example below shows the first row of the values obtained only, which is when Kc2 is set at -0.03.)

When substitute the values above,

$$x_D(s) = \frac{0.0064q^{-1} + 0.7902q^{-2} + 0.9097q^{-3}}{1 - 0.2686q^{-1} - 0.0846q^{-2} - 0.3968q^{-3} - 0.1190q^{-4} - 0.0327q^{-5}} R(k)$$

$$x_B(s) = \frac{7.5153q^{-3} - 5.8993q^{-4} - 4.5612q^{-5}}{0.1005q^{-1} - 0.0721q^{-2} + 0.2504q^{-3} - 0.0952q^{-4} - 0.1288q^{-5}} R(k)$$

$$x_D(s) = \frac{-0.0129q^{-7} + 0.5901q^{-8} + 0.6914q^{-9}}{-0.6230q^{-1} + 0.9573q^{-2} - 0.2177q^{-3} - 0.1222q^{-4} - 0.0145q^{-5}} S(k)$$

$$x_B(s) = \frac{6.7079q^{-3} - 6.1035q^{-4} - 4.9738q^{-5}}{1 + 0.4799q^{-1} - 1.0869q^{-2} + 0.0741q^{-3} - 0.0808q^{-4} - 0.1429q^{-5}} S(k)$$

The complete values of the model developed is attached in Appendix A.

4.2 Effect of the Proportional controller on the closed loop system identification when both loops are closed

To achieve the objective above, different values of Kc will be examined when the values of I are kept as infinity.

The model used is [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]]

4.2.1 First Section – Different constant of Kc1 with varying value of Kc2

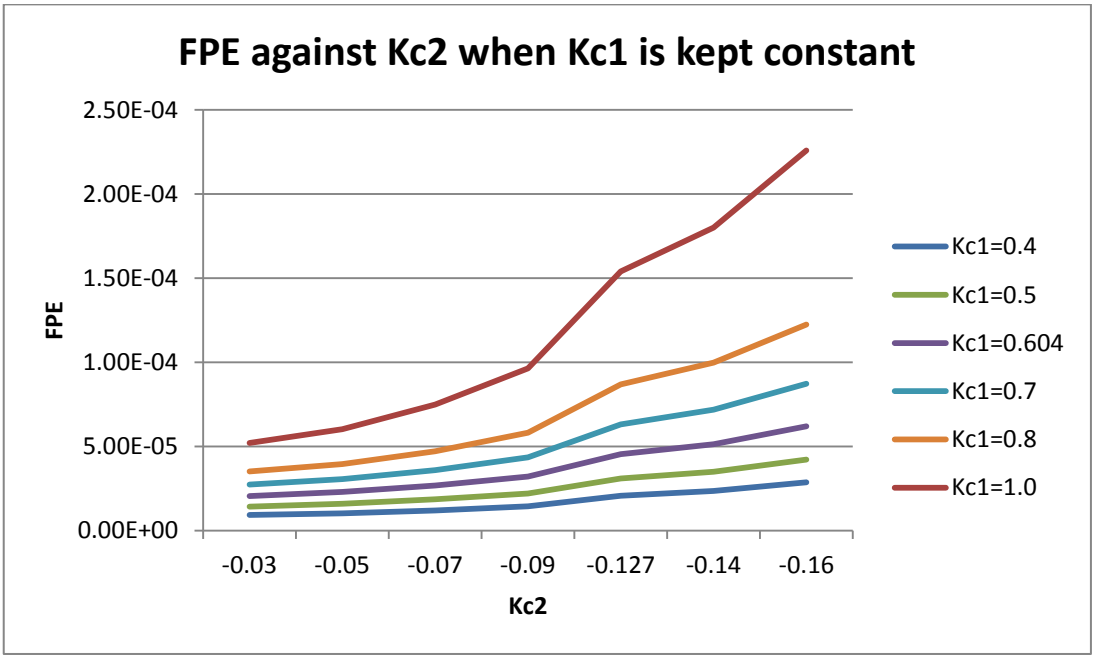

Figure 4: FPE against Kc2 with constant Kc1.

From the plot above, the FPE increases when the value of Kc2 increases. Different Kc1 values are showing the same pattern as the FPE increases when the absolute values of Kc2 are getting larger. However, the larger the value of Kc1, the larger the FPE when Kc2 is increasing. The FPE obtained when Kc2 = -0.03 with different value of Kc1 shows the least difference, which is in between 0 to 6e-05. The results for Kc1 =0.4 are tabulated as shown below. For Kc1 = 0.5, 0.604, 0.7, 0.8, and 1.0, the results can be found in Appendix B.

Table 9: Kc1 is fixed at 0.4, I1 and I2 are fixed at 999999999.

Kc2	Y1	Y2	FPE (1e-05)
-0.03	86.10	82.39	0.92
-0.05	86.48	83.97	1.01
-0.07	86.72	84.98	1.19
-0.09	87.12	85.82	1.43
-0.127	87.07	86.55	2.07
-0.14	87.15	86.83	2.36

4.2.2 Second Section - Kc2 will be held constant with different value of Kc1

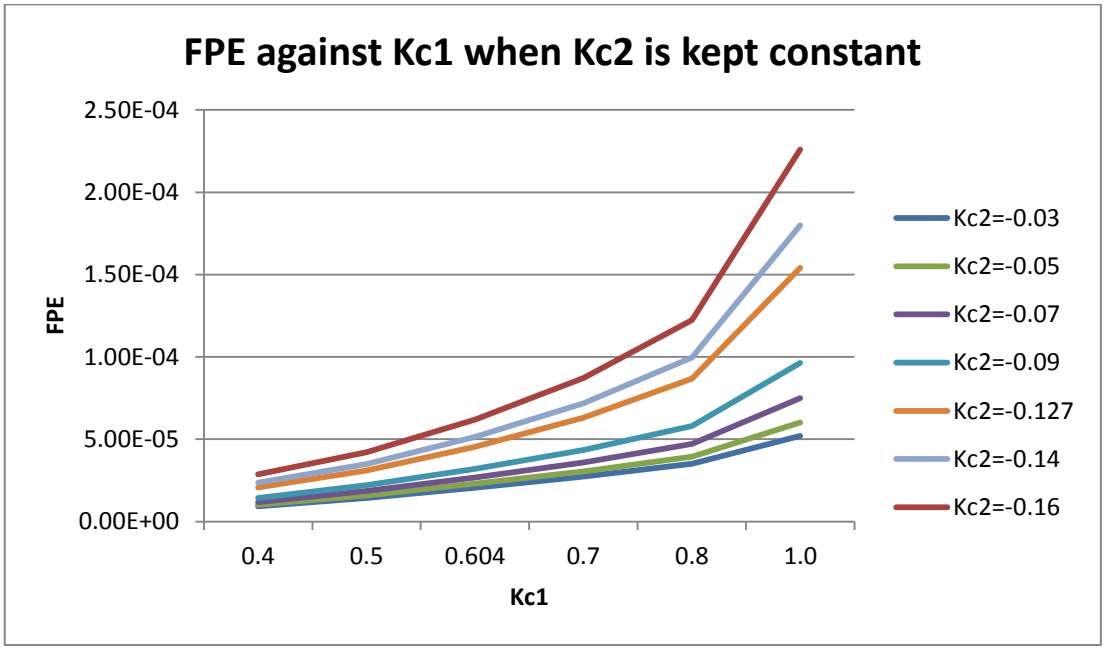

Figure 5: FPE against Kc1 with constant Kc2.

From the plot above, it can be seen that when Kc1 = 0.4, FPE is concentrated between 0 to 4e-05. The FPE of each Kc2 increases when the values of Kc1 increase. When the values of Kc1 increase, the value of FPE increases. This gives the same pattern of increment with different absolute values of Kc2 whereas the lower the absolute value of Kc2, the higher the value of FPE. The results for Kc2 = -0.03 is tabulated as shown below. For Kc1 = -0.05, -0.07, -0.09, -0.127, -0.14, and -0.16, the results can be found in Appendix B.

Table 10: Kc2 is fixed at -0.03, I1 and I2 are fixed at 999999999.

Kc1	Y1	Y2	FPE (1e-05)
0.4	86.10	82.39	9.21
0.5	86.64	83.00	1.43
0.604	87.03	83.46	2.05
0.7	87.52	84.07	2.72
0.8	87.49	83.96	3.50
1.0	87.73	84.07	5.21

4.3 Effect of the Proportional-Integral controller on the closed loop system identification when both loops are closed

To achieve the objective above, different values of Kc will be examined with I1 fixed at 16.37 and I2 is set at 14.46.

The model used is [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]]

4.3.1 First Section - Kc1 will be kept as a constant with different value of Kc2

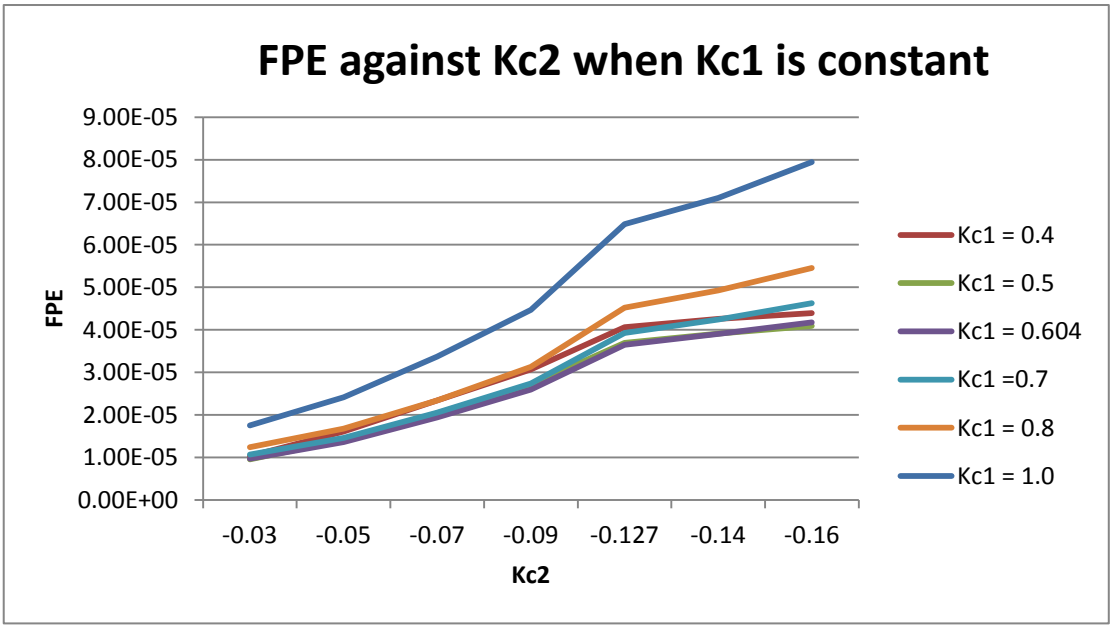

Figure 6: FPE against Kc2 with constant Kc1.

From the graph plotted, it can be known that when the absolute values of Kc2 increases, the FPE increases, which apply to all value of Kc1 as a constant. The FPE is the highest when Kc1 =1.0. Comparing the graph obtained in section 4.2.1, the MIMO system gives

a higher FPE when Proportional controller is used. The results for Kc1 =0.4 are tabulated as shown below. For Kc1 = 0.5, 0.604, 0.7, 0.8, and 1.0, the results can be found in the appendix.

Table 11: Kc1 is fixed at 0.4, I1 is fixed at 16.37 and I2 is fixed at 14.46.

Kc2	Y1	Y2	FPE (1e-05)
-0.03	NaN	NaN	1.03
-0.05	NaN	NaN	1.61
-0.07	88.81	88.35	2.34
-0.09	88.84	89.02	3.07
-0.127	88.91	89.66	4.07
-0.14	88.97	89.94	4.26
-0.16	89.12	90.44	4.39

4.3.2 Second Section - Kc2 will be held constant with different value of Kc1

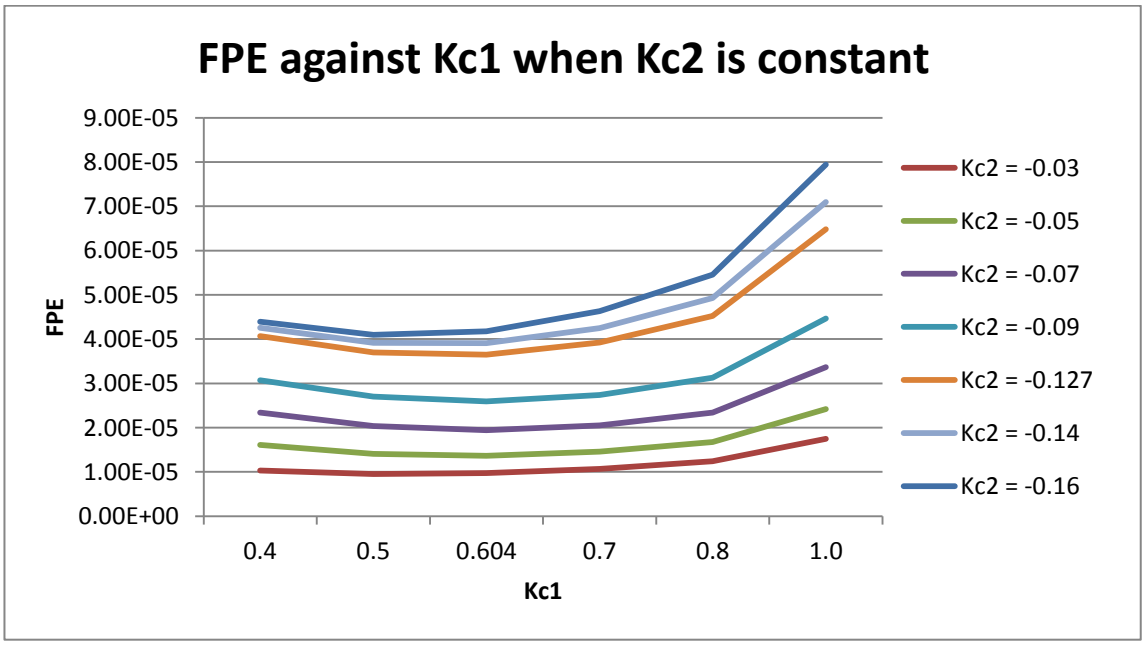

Figure 7: FPE against Kc1 with constant Kc2.

Comparing with the graph obtained in section 4.2.2, both graphs show FPE increment when Kc2 increases. However, the range of FPE (0 to 8e-05) is much larger when the Proportional-Integral controller is used compared to the range of FPE (0 to 2.4e-04) when Proportional controller is used. Other than that, it can be observed that the values

of FPE slightly decrease for all absolute values of Kc2 when Kc1 is increased from 0.4 to 0.5. The results for Kc2 = -0.03 is tabulated as shown below. For Kc1 = -0.05, -0.07, -0.09, -0.127, -0.14, and -0.16, the results can be found in Appendix B.

Table 12: Kc2 is fixed at -0.03, I1 is fixed at 16.37 and I2 is fixed at 14.46.

Kc1	Y1	Y2	FPE (1e-05)
0.4	NaN	NaN	1.03
0.5	NaN	NaN	0.95
0.604	88.79	86.51	0.97
0.7	88.87	87.65	1.07
0.8	88.93	86.76	1.24
1.0	89.06	86.97	1.75

4.4 Effect of the Proportional-Integral controller on the closed loop system identification when both loops are closed

The values of I is set at different values. In this case, Kc1 and Kc2 are set at 0.604 and -0.127 respectively.

The model used is [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]]

4.4.1 First Section - I2 will be kept as a constant with different value of I1

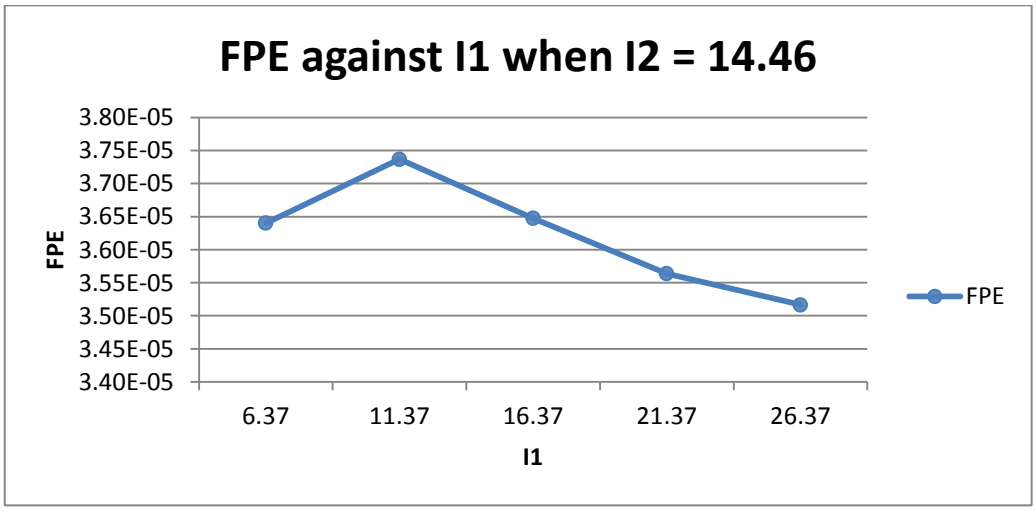

Figure 8: FPE against I1 with I2 as a constant.

From the graph plotted, the value of FPE shows the highest when I1 is set at 11.37, which is 3.74e-05 while the FPE is lowest when I1 is set at 26.37, which is 3.52e-05. However, the difference between the highest FPE and lowest FPE is just a mile, which is 0.22e-05. It can be concluded when Proportional-Integral controller is used with different values of I1, no much difference in term of FPE occur.

Table 13: Kc1 is fixed at 0.604, Kc2 is fixed at -0.127, and I2 is fixed at 14.46.

I1	Y1	Y2	FPE (1e-05)
6.37	89.90	90.89	3.64
11.37	89.41	90.42	3.74
16.37	88.90	90.09	3.65
21.37	88.65	89.95	3.56
26.37	88.49	89.87	3.52

4.4.2 Second Section - I1 will be held constant with different value of I2

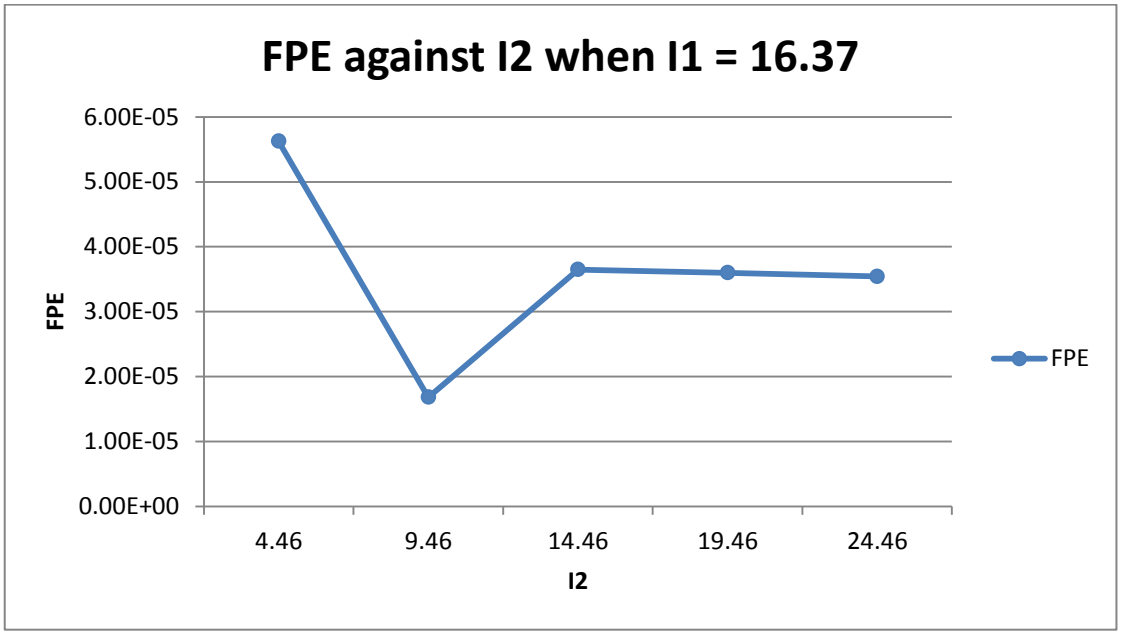

Figure 9: FPE against I2 with I1 as a constant.

From the plotted graph above, the value of FPE shows the lowest when the value of I2 is set at 9.46 and the highest when I2 is set at 4.46. The difference between the highest and the lowest FPE shows a different of 3.95e-05.

Table 14: Kc1 is fixed at 0.604, Kc2 is fixed at -0.127, and I1 is fixed at 16.37.

I2	Y1	Y2	FPE (1e-05)
4.46	89.01	91.82	5.63
9.46	88.43	90.37	1.68
14.46	88.90	90.09	3.65
19.46	89.09	89.87	3.60
24.46	89.13	89.70	3.54

4.5 Effect of the Proportional-Integral controller on the closed loop system identification when the other loop is open

In this section, different values of Kc are applied with fixed values of I1 and I2 when one loop is open.

The model used is [5*ones(2,2), 3*ones(2,2), [1 3; 7 3]]

4.5.1 First Section - The bottom loop is open with fixed value of I1.

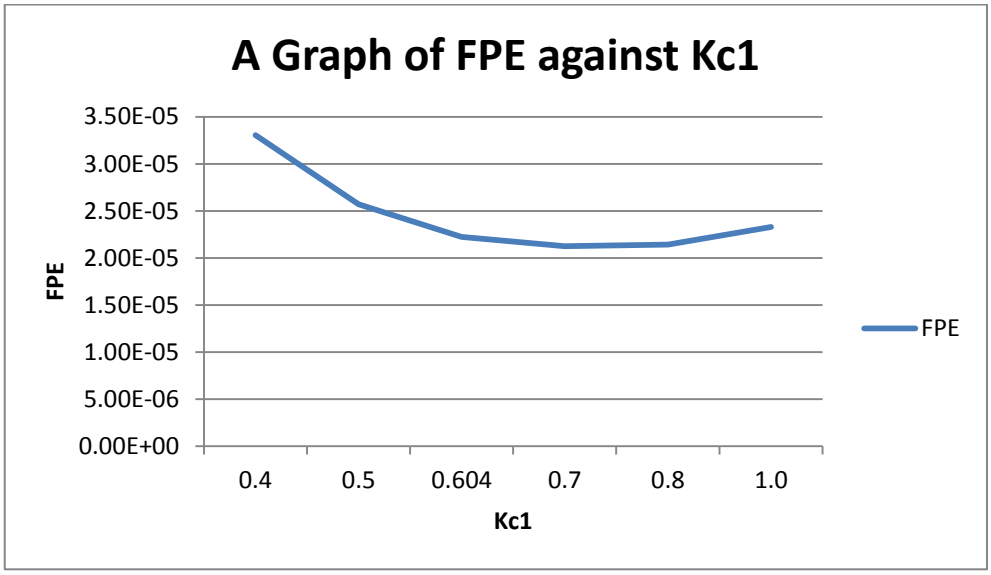

Figure 10: FPE against Kc1 when bottom loop is open.

From the plotted line, the value of FPE decreases from 3.31e-05 to 2.14e-05 when Kc1 increases from 0.4 to 0.8. It shows a slightly increment when Kc1 = 1.0.

Table 15: I1 is fixed at 16.37, Kc2 and I2 are in open loop.

Kc1	Y1	Y2	FPE (1e-05)
0.4	90.62	94.99	3.31
0.5	90.28	94.92	2.57
0.604	89.97	94.85	2.22
0.7	89.71	94.80	2.12
0.8	89.45	94.74	2.14
1.0	88.98	97.79	2.33

4.5.2 Second Section - The distillate loop is open with fixed value of I2.

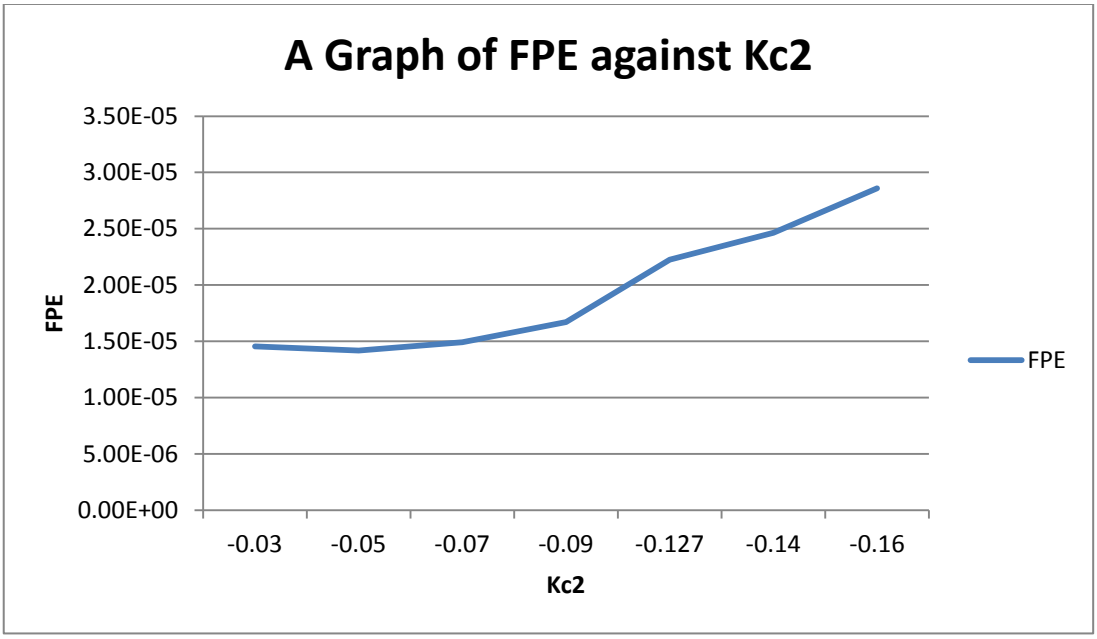

Figure 11: FPE against Kc2 when the distillate loop is open.

From the plotted graph, the value of FPE decreases when Kc2 = -0.03 and Kc2 = -0.05 but shows increment when Kc1 = -0.05 and above. The difference between the highest FPE and the lowest FPE is 1.44e-05.

Table 16: I2 is fixed at 14.46, Kc1 and I1 are in open loop.

Kc2	Y1	Y2	FPE (1e-05)
-0.03	NaN	NaN	1.46
-0.05	NaN	NaN	1.42
-0.07	NaN	NaN	1.49
-0.09	NaN	NaN	1.67
-0.127	NaN	NaN	2.23
-0.14	NaN	NaN	2.46

CHAPTER 5

CONCLUSION AND RECOMMENDATION

MIMO system plays a very important role in the industries today. It is crucial to study the effect of the controller parameters on the closed loop system identification. In this project, Wood & Berry Distillation Column represents the MIMO system. It is observed that different parameters give different effects on the closed loop system identification. Generally, it is better to keep the gain lower if only Proportional controller is used. For a distillation column, a MIMO system in this project, neither too high or too low gain give a better model accuracy for both closed loop and one loop open when Proportional-Integral controller is used.

It is recommended that MATLAB software learning to be included in the undergraduate studies to help the student to have a better understanding on the function of MATLAB.

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APPENDIX A

4.1 Model developed from MATLAB

4.1.1 Model [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]]

Kc1 is fixed at 0.5, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.5	-0.03	86.91	83.31	1.43E-05		1 0 0 1	-0.3738 0.0845 0.3521 -0.6323	-0.2547 -0.0294 -0.0550 -0.2084	-0.1216 -0.2009 -0.1545 -0.1639
0.5	-0.05	87.22	84.76	1.59E-05		1 0 0 1	-0.3778 0.0842 0.3497 -0.6331	-0.2543 -0.0317 -0.0583 -0.2074	-0.1339 -0.1882 -0.1742 -0.1451
0.5	-0.07	87.17	85.49	1.85E-05		1 0 0 1	-0.3821 0.0838 0.3470 -0.6340	-0.2538 -0.0336 -0.0611 -0.2063	-0.1454 -0.1750 -0.1947 -0.1252
0.5	-0.09	87.32	86.23	2.20E-05		1 0 0 1	-0.3864 0.0830 0.3442 -0.6354	-0.2538 -0.0348 -0.0640 -0.2048	-0.1557 -0.1620 -0.2125 -0.1050
0.5	-0.127	87.54	87.28	3.10E-05		1 0 0 1	-0.3941 0.0799 0.3388 -0.6399	-0.2566 -0.0341 -0.0708 -0.1997	-0.1707 -0.1393 -0.2446 -0.0676
0.5	-0.14	87.62	87.62	3.50E-05		1 0 0 1	-0.3967 0.0784 0.3368 -0.6421	-0.2586 -0.0329 -0.0738 -0.1972	-0.1748 -0.1320 -0.2550 -0.0547
0.5	-0.16	87.77	88.18	4.21E-05		1 0 0 1	-0.4005 0.0755 0.3338 -0.6461	-0.2627 -0.0299 -0.0789 -0.1927	-0.1796 -0.1214 -0.2699 -0.0353

Kc1 is fixed at 0.5, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0042 0 0 0	0.7597 0 0 0	0 -5.3408 0 -5.2303	0 -2.4522 0 -2.6220	0 0 0 0	0 0 0 0	0 0 -0.0439 0	0 0 0.5647 0
0 0 0 0	-0.0025 0 0 0	0.7597 0 0 0	0 -3.2291 0 -3.1233	0 -1.8461 0 -2.1008	0 0 0 0	0 0 0 0	0 0 -0.0475 0	0 0 0.5634 0
0 0 0 0	1.0e-003 * -0.9248 0 0 0	0.7597 0 0 0	0 -2.2814 0 -2.2154	0 -1.5876 0 -1.8819	0 0 0 0	0 0 0 0	0 0 -0.0519 0	0 0 0.5620 0
0 0 0 0	1.0e-003 * 0.4243 0 0 0	0.7596 0 0 0	0 -1.7530 0 -1.7080	0 -1.4415 0 -1.7603	0 0 0 0	0 0 0 0	0 0 -0.0567 0	0 0 0.5605 0
0 0 0 0	0.0020 0 0 0	0.7594 0 0 0	0 -1.2130 0 -1.1863	0 -1.2837 0 -1.6324	0 0 0 0	0 0 0 0	0 0 -0.0671 0	0 0 0.5575 0
0 0 0 0	0.0022 0 0 0	0.7594 0 0 0	0 -1.0911 0 -1.0676	0 -1.2451 0 -1.6020	0 0 0 0	0 0 0 0	0 0 -0.0712 0	0 0 0.5563 0
0 0 0 0	0.0022 0 0 0	0.7595 0 0 0	0 -0.9426 0 -0.9224	0 -1.1953 0 -1.5633	0 0 0 0	0 0 0 0	0 0 -0.0778 0	0 0 0.5544 0

Kc1 is fixed at 0.604, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.604	-0.03	87.03	83.46	2.05E-05		1 0 0 1	-0.3475 0.0567 0.3365 -0.6175	-0.2992 0.0066 -0.0533 -0.2149	-0.0723 -0.2437 -0.1116 -0.2028
0.604	-0.05	87.31	84.89	2.30E-05		1 0 0 1	-0.3500 0.0557 0.3348 -0.6180	-0.2993 0.0051 -0.0551 -0.2152	-0.0823 -0.2331 -0.1315 -0.1840
0.604	-0.07	87.51	85.91	2.68E-05		1 0 0 1	-0.3528 0.0550 0.3324 -0.6183	-0.2991 0.0037 -0.0558 -0.2160	-0.0935 -0.2219 -0.1518 -0.1638
0.604	-0.09	87.67	86.70	3.20E-05		1 0 0 1	-0.3559 0.0541 0.3295 -0.6185	-0.2992 0.0025 -0.0560 -0.2169	-0.1030 -0.2105 -0.1720 -0.1428
0.604	-0.127	87.93	87.89	4.54E-05		1 0 0 1	-0.3617 0.0520 0.3230 -0.6196	-0.3008 0.0018 -0.0559 -0.2183	-0.1182 -0.1896 -0.2086 -0.1025
0.604	-0.14	88.02	88.30	5.14E-05		1 0 0 1	-0.3638 0.0510 0.3203 -0.6202	-0.3021 0.0021 -0.0559 -0.2186	-0.1226 -0.1825 -0.2210 -0.0882
0.604	-0.16	88.19	88.95	6.19E-05		1 0 0 1	-0.3672 0.0493 0.3160 -0.6216	-0.3046 0.0032 -0.0560 -0.2189	-0.1286 -0.1719 -0.2395 -0.0661

Kc1 is fixed at 0.604, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0039 0 0 0	0.7573 0 0 0	0 -6.2381 0 -5.9331	0 -2.5068 0 -2.7167	0 0 0 0	0 0 0 0	0 0 -0.0425 0	0 0 0.5678 0
0 0 0 0	-0.0027 0 0 0	0.7573 0 0 0	0 -3.7219 0 -3.5399	0 -1.8668 0 -2.1580	0 0 0 0	0 0 0 0	0 0 -0.0463 0	0 0 0.5680 0
0 0 0 0	-0.0015 0 0 0	0.7572 0 0 0	0 -2.6383 0 -2.5065	0 -1.5946 0 -1.9254	0 0 0 0	0 0 0 0	0 0 -0.0507 0	0 0 0.5682 0
0 0 0 0	1.0e-003 *-0.6525 0 0 0	0.7571 0 0 0	0 -2.0333 0 -1.9272	0 -.14417 0 -1.7983	0 0 0 0	0 0 0 0	0 0 -0.0557 0	0 0 0.5682 0
0 0 0 0	1.0e-003 *0.2285 0 0 0	0.7569 0 0 0	0 -1.4129 0 -1.3288	0 -1.2787 0 -.16694	0 0 0 0	0 0 0 0	0 0 -0.0664 0	0 0 0.5682 0
0 0 0 0	1.0e-003 *0.2896 0 0 0	0.7569 0 0 0	0 -1.2721 0 -1.1921	0 -1.2396 0 -1.6399	0 0 0 0	0 0 0 0	0 0 -0.0705 0	0 0 0.5681 0
0 0 0 0	1.0e-003 *0.1738 0 0 0	0.7570 0 0 0	0 -1.0998 0 -1.0241	0 -1.1894 0 -1.6032	0 0 0 0	0 0 0 0	0 0 -0.0772 0	0 0 0.5678 0

Kc1 is fixed at 0.7, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.7	-0.03	87.29	83.76	2.72E-05		1 0 0 1	-0.3288 0.0366 0.3176 -0.5993	-0.3335 0.0304 -0.0458 -0.2285	-0.0364 -0.2708 -0.0797 -0.2291
0.7	-0.05	87.54	85.13	3.05E-05		1 0 0 1	-0.3299 0.0350 0.3168 -0.6001	-0.3344 0.0299 -0.0468 -0.2292	-0.0458 -0.2623 -0.0992 -0.2109
0.7	-0.07	87.74	86.14	3.59E-05		1 0 0 1	-0.3313 0.0337 0.3151 -0.6004	-0.3348 0.0293 -0.0466 -0.2306	-0.0549 -0.2531 -0.1193 -0.1913
0.7	-0.09	87.90	86.95	4.35E-05		1 0 0 1	-0.3330 0.0325 0.3129 -0.6006	-0.3354 0.0289 -0.0457 -0.2323	-0.0635 -0.2435 -0.1396 -0.1705
0.7	-0.127	88.17	88.22	6.31E-05		1 0 0 1	-0.3365 0.0301 0.3071 -0.6011	0.3375 0.0287 -0.0427 -0.2360	-0.0776 -0.2253 -0.1773 -0.1301
0.7	-0.14	88.52	88.88	7.18E-05		1 0 0 1	-0.3378 0.0292 0.3046 -0.6014	-0.3386 0.0289 -0.0414 -0.2374	-0.0820 -0.2189 -0.1904 -0.1154
0.7	-0.16	88.71	89.60	8.72E-05		1 0 0 1	-0.3401 0.0277 0.3004 -0.6022	-0.3409 0.0295 -0.0393 -0.2395	-0.0882 -0.2091 -0.2101 -0.0927

Kc1 is fixed at 0.7, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0038 0 0 0	0.7559 0 0 0	0 -6.8180 0 -6.4327	0 -2.4975 0 -2.7792	0 0 0 0	0 0 0 0	0 0 -0.0404 0	0 0 0.5701 0
0 0 0 0	-0.0028 0 0 0	0.7558 0 0 0	0 -4.0832 0 -3.8421	0 -1.8499 0 -2.1998	0 0 0 0	0 0 0 0	0 0 -0.0437 0	0 0 0.5714 0
0 0 0 0	-0.0020 0 0 0	0.7557 0 0 0	0 -2.9054 0 -2.7222	0 -1.5749 0 -1.9597	0 0 0 0	0 0 0 0	0 0 -0.0476 0	0 0 0.5726 0
0 0 0 0	-0.0013 0 0 0	0.7555 0 0 0	0 -2.2477 0 -2.0936	0 -1.4210 0 -1.8301	0 0 0 0	0 0 0 0	0 0 -0.0521 0	0 0 0.5737 0
0 0 0 0	1.0e-003 * -0.7308 0 0 0	0.7554 0 0 0	0 -1.5721 0 -1.4431	0 -1.2584 0 -1.7015	0 0 0 0	0 0 0 0	0 0 -0.0618 0	0 0 0.5756 0
0 0 0 0	1.0e-003 * -0.6996 0 0 0	0.7554 0 0 0	0 -1.4185 0 -1.2941	0 -1.2197 0 -1.6728	0 0 0 0	0 0 0 0	0 0 -0.0655 0	0 0 0.5762 0
0 0 0 0	1.0e-003 * -0.7862 0 0 0	0.7555 0 0 0	0 -1.2301 0 -1.1109	0 -1.1704 0 -1.6376	0 0 0 0	0 0 0 0	0 0 -0.0717 0	0 0 0.5770 0

Kc1 is fixed at 0.8, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.8	-0.03	87.68	84.24	3.50E-05		1 0 0 1	-0.3129 0.0197 0.2949 -0.5773	-0.3650 0.0481 -0.0347 -0.2476	-0.0072 -0.2884 -0.0530 -0.2483
0.8	-0.05	87.70	85.25	3.95E-05		1 0 0 1	-0.3129 0.0176 0.2949 -0.5785	-0.3665 0.0487 -0.0353 -0.2486	-0.0152 -0.2820 -0.0716 -0.2310
0.8	-0.07	88.03	86.40	4.71E-05		1 0 0 1	-0.3130 0.0159 0.2941 -0.5792	-0.3677 0.0491 -0.0346 -0.2500	-0.0229 -0.2749 -0.0909 -0.2123
0.8	-0.09	88.16	87.16	5.80E-05		1 0 0 1	-0.3134 0.0143 0.2926 -0.5797	-0.3689 0.0494 -0.0311 -0.2519	-0.0303 -0.2674 -0.1108 -0.1923
0.8	-0.127	88.25	88.24	8.68E-05		1 0 0 1	-0.3145 0.0114 0.2881 -0.5807	-0.3718 0.0504 -0.0287 -0.2563	-0.0429 -0.2524 -0.1481 -0.1528
0.8	-0.14	88.35	88.68	9.97E-05		1 0 0 1	-0.3150 0.0104 0.2860 -0.5812	-0.3731 0.0508 -0.0269 -0.2580	-0.0470 -0.2470 -0.1611 -0.1384
0.8	-0.16	88.52	89.41	0.000122		1 0 0 1	-0.3161 0.0089 0.2824 -0.5821	-0.3756 0.00517 -0.0238 -0.2608	-0.0528 -0.2386 -0.1810 -0.1159

Kc1 is fixed at 0.8, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0038 0 0 0	0.7548 0 0 0	0 -7.2443 0 -6.7964	0 -2.4436 0 -2.8250	0 0 0 0	0 0 0 0	0 0 -0.0377 0	0 0 0.5718 0
0 0 0 0	-0.0030 0 0 0	0.7547 0 0 0	0 -4.3562 0 -4.0667	0 -1.8054 0 -2.2336	0 0 0 0	0 0 0 0	0 0 -0.0403 0	0 0 0.5739 0
0 0 0 0	-0.0023 0 0 0	0.7545 0 0 0	0 -3.1127 0 -2.8858	0 -1.5347 0 -1.9896	0 0 0 0	0 0 0 0	0 0 -0.0434 0	0 0 0.5759 0
0 0 0 0	-0.0018 0 0 0	0.7544 0 0 0	0 -2.4183 0 -2.2224	0 -1.3837 0 -1.8590	0 0 0 0	0 0 0 0	0 0 -0.0472 0	0 0 0.5779 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.7047 0 -1.5350	0 -1.2254 0 -1.7315	0 0 0 0	0 0 0 0	0 0 -0.0552 0	0 0 0.5814 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.5423 0 -1.3773	0 -1.1880 0 -1.7036	0 0 0 0	0 0 0 0	0 0 -0.05584 0	0 0 0.5825 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.3428 0 -1.1833	0 -1.1405 0 -1.6695	0 0 0 0	0 0 0 0	0 0 -0.0635 0	0 0 0.5841 0

Kc1 is fixed at 1.0, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
1.0	-0.03	87.73	84.07	5.21E-05		1 0 0 1	-0.2880 -0.0046 0.2444 -0.5266	-0.4206 0.0685 -0.0090 -0.2959	0.0303 -0.2971 -0.0154 -0.2659
1.0	-0.05	87.82	85.13	6.02E-05		1 0 0 1	-0.2863 -0.0072 0.2457 -0.5287	-0.4230 0.0707 -0.0090 -0.2967	0.0250 -0.2947 -0.0319 -0.2505
1.0	-0.07	87.86	85.87	7.49E-05		1 0 0 1	-0.2847 -0.0095 0.2461 -0.5304	-0.4252 0.0727 -0.0080 -0.2979	0.0198 -0.2916 -0.0492 -0.2337
1.0	-0.09	87.88	86.45	9.63E-05		1 0 0 1	-0.2831 -0.0116 0.2457 -0.5319	-0.4275 0.0746 -0.0061 -0.2994	0.0148 -0.2879 -0.0673 -0.2154
1.0	-0.127	87.90	87.39	1.54E-04		1 0 0 1	-0.2805 -0.0150 0.2432 -0.5350	-0.4319 0.0779 -0.0010 -0.3029	0.0058 -0.2798 -0.1016 -0.1786
1.0	-0.14	87.91	87.75	0.00018		1 0 0 1	-0.2796 -0.0162 0.2418 -0.5363	-0.4337 0.0790 0.0011 -0.3043	0.0028 -0.2766 -0.1137 -0.1649
1.0	-0.16	87.95	88.38	0.000226		1 0 0 1	-0.2785 -0.0179 0.2392 -0.5386	-0.4366 0.0807 0.0045 -0.3065	-0.0017 -0.2715 -0.1322 -0.1435

Kc1 is fixed at 1.0, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0038 0 0 0	0.7535 0 0 0	0 -7.5530 0 -7.0476	0 -2.2692 0 -2.8779	0 0 0 0	0 0 0 0	0 0 -0.0315 0	0 0 0.5734 0
0 0 0 0	-0.0033 0 0 0	0.7533 0 0 0	0 -4.5799 0 -4.2326	0 -1.6759 0 -2.2796	0 0 0 0	0 0 0 0	0 0 -0.0325 0	0 0 0.5764 0
0 0 0 0	-0.0028 0 0 0	0.7531 0 0 0	0 -3.3008 0 -3.0129	0 -1.4248 0 -2.0344	0 0 0 0	0 0 0 0	0 0 -0.0340 0	0 0 0.5794 0
0 0 0 0	-0.0024 0 0 0	0.7529 0 0 0	0 -2.5868 0 -2.3262	0 -1.2855 0 -1.9046	0 0 0 0	0 0 0 0	0 0 -0.0358 0	0 0 0.5824 0
0 0 0 0	-0.0021 0 0 0	0.7526 0 0 0	0 -1.8535 0 -1.6126	0 -1.1413 0 -1.7805	0 0 0 0	0 0 0 0	0 0 -0.0400 0	0 0 0.5877 0
0 0 0 0	-0.0020 0 0 0	0.7525 0 0 0	0 -1.6865 0 -1.4484	0 -1.1077 0 -1.7357	0 0 0 0	0 0 0 0	0 0 -0.0417 0	0 0 0.5895 0
0 0 0 0	-0.0020 0 0 0	0.7524 0 0 0	0 -1.4813 0 -1.2461	0 -1.0653 0 -1.7210	0 0 0 0	0 0 0 0	0 0 -0.0445 0	0 0 0.5920 0

Kc2 is fixed at -0.03, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.03	86.10	82.39	9.21E-06		1 0 0 1	-0.4082 0.1203 0.3591 -0.6390	-0.1994 -0.0791 -0.0448 -0.2153	-0.1823 -0.1435 -0.2070 -0.1134
0.5	-0.03	86.64	83.00	1.43E-05		1 0 0 1	-0.3738 0.0845 0.3521 -0.6323	-0.2547 -0.0294 -0.0550 -0.2084	-0.1216 -0.2009 -0.1545 -0.1639
0.604	-0.03	87.03	83.46	2.05E-05		1 0 0 1	-0.3475 0.0567 0.3365 -0.6175	-0.2992 0.0066 -0.0533 -0.2149	-0.0723 -0.2437 -0.1116 -0.2028
0.7	-0.03	87.52	84.07	2.72E-05		1 0 0 1	-0.3288 0.0366 0.3176 -0.5993	-0.3335 0.0304 -0.0458 -0.2284	-0.0364 -0.2708 -0.0797 -0.2291
0.8	-0.03	87.49	83.96	3.50E-05		1 0 0 1	-0.3129 0.0197 0.2949 -0.5773	-0.3650 0.0481 -0.0347 -0.2476	-0.0072 -0.2884 -0.0530 -0.2483
1.0	-0.03	87.73	84.07	5.21E-05		1 0 0 1	-0.2880 -0.0046 0.2444 -0.5266	-0.4206 0.0685 -0.0090 -0.2959	0.0303 -0.2971 -0.0154 -0.2659

Kc2 is fixed at -0.03, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0050 0 0 0	0.7634 0 0 0	0 -4.4952 0 -4.4036	0 -2.3231 0 -2.4999	0 0 0 0	0 0 0 0	0 0 -0.0431 0	0 0 0.5613 0
0 0 0 0	-0.0045 0 0 0	0.7597 0 0 0	0 -5.4308 0 -5.2303	0 -2.4522 0 -2.6220	0 0 0 0	0 0 0 0	0 0 -0.0439 0	0 0 0.5647 0
0 0 0 0	-0.0039 0 0 0	0.7573 0 0 0	0 -6.2381 0 -5.9331	0 -2.5068 0 -2.7167	0 0 0 0	0 0 0 0	0 0 -0.0425 0	0 0 0.5678 0
0 0 0 0	-0.0038 0 0 0	0.7559 0 0 0	0 -6.8180 0 -6.4327	0 -2.4975 0 -2.7792	0 0 0 0	0 0 0 0	0 0 -0.0404 0	0 0 0.5701 0
0 0 0 0	-0.0038 0 0 0	0.7548 0 0 0	0 -7.2443 0 -6.7964	0 -2.4436 0 -2.8250	0 0 0 0	0 0 0 0	0 0 -0.0377 0	0 0 0.5718 0
0 0 0 0	-0.0038 0 0 0	0.7535 0 0 0	0 -7.5530 0 -7.0476	0 -2.2692 0 -2.8779	0 0 0 0	0 0 0 0	0 0 -0.0315 0	0 0 0.5734 0

Kc2 is fixed at -0.05, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.05	86.48	83.97	1.01E-05		1 0 0 1	-0.4131 0.1198 0.3576 -0.6416	-0.1996 -0.0809 -0.0517 -0.2110	-0.1957 -0.1292 -0.2249 -0.0961
0.5	-0.05	86.95	84.49	1.59E-05		1 0 0 1	-0.3778 0.0842 0.3497 -0.6331	-0.2543 -0.0317 -0.0583 -0.2074	-0.1339 -0.1882 -0.1742 -0.1451
0.604	-0.05	87.31	84.89	2.30E-05		1 0 0 1	-0.3500 0.0557 0.3348 -0.6180	-0.2993 0.0051 -0.0551 -0.2152	-0.0823 -0.2331 -0.1315 -0.1840
0.7	-0.05	87.54	85.13	3.05E-05		1 0 0 1	-0.3299 0.0350 0.3168 -0.6001	-0.3344 0.0299 -0.0468 -0.2292	-0.0458 -0.2623 -0.0992 -0.2109
0.8	-0.05	87.70	85.25	3.95E-05		1 0 0 1	-0.3129 0.0176 0.2949 -0.5785	-0.3665 0.0487 -0.0353 -0.2486	-0.0152 -0.2820 -0.0716 -0.2310
1.0	-0.05	87.82	85.13	6.02E-05		1 0 0 1	-0.2863 -0.0072 0.2457 -0.5287	-0.4230 0.0707 -0.0090 -0.2967	0.0250 -0.2947 -0.0319 -0.2505

Kc2 is fixed at -0.05, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	-0.0027 0 0 0	0.7635 0 0 0	0 -2.6698 0 -2.6446	0 -1.7811 0 -2.0341	0 0 0 0	0 0 0 0	0 0 -0.0450 0	0 0 0.5583 0
0 0 0 0	-0.0025 0 0 0	0.7597 0 0 0	0 -3.2291 0 -3.1233	0 -1.8461 0 -2.1008	0 0 0 0	0 0 0 0	0 0 -0.0475 0	0 0 0.5634 0
0 0 0 0	-0.0027 0 0 0	0.7573 0 0 0	0 -3.7219 0 -3.5399	0 -1.8668 0 -2.1580	0 0 0 0	0 0 0 0	0 0 -0.0463 0	0 0 0.5680 0
0 0 0 0	-0.0028 0 0 0	0.7558 0 0 0	0 -4.0832 0 -3.8421	0 -1.8499 0 -2.1988	0 0 0 0	0 0 0 0	0 0 -0.0437 0	0 0 0.5714 0
0 0 0 0	-0.0030 0 0 0	0.7547 0 0 0	0 -4.3562 0 -4.0667	0 -1.8054 0 -2.2336	0 0 0 0	0 0 0 0	0 0 -0.0403 0	0 0 0.5739 0
0 0 0 0	-0.0033 0 0 0	0.7533 0 0 0	0 -4.5799 0 -4.2326	0 -1.6759 0 -2.2796	0 0 0 0	0 0 0 0	0 0 -0.0325 0	0 0 0.5764 0

Kc2 is fixed at -0.07, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.07	86.72	84.98	1.19E-05		1 0 0 1	-0.4180 0.1186 0.3565 -0.6455	-0.2002 -0.0818 -0.0591 -0.2054	-0.2077 -0.1148 -0.2416 -0.0784
0.5	-0.07	87.17	85.49	1.85E-05		1 0 0 1	-0.3821 0.0838 0.3470 -0.6340	-0.2538 -0.0336 -0.0611 -0.2063	-0.1454 -0.1750 -0.1937 -0.1252
0.604	-0.07	87.51	85.91	2.68E-05		1 0 0 1	-0.3528 0.0550 0.3324 -0.6183	-0.2991 0.0037 -0.0558 -0.2160	-0.0935 -0.2219 -0.1518 -0.1638
0.7	-0.07	87.95	86.38	3.59E-05		1 0 0 1	-0.3313 0.0337 0.3151 -0.6004	-0.3348 0.0293 -0.0466 -0.2306	-0.0549 -0.2531 -0.1193 -0.1913
0.8	-0.07	87.87	86.21	4.71E-05		1 0 0 1	-0.3130 0.0159 0.2941 -0.5792	-0.3677 0.0491 -0.0346 -0.2500	-0.0229 -0.2749 -0.0909 -0.2123
1.0	-0.07	87.86	85.87	7.49E-05		1 0 0 1	-0.2847 -0.0095 0.2461 -0.5304	-0.4252 0.0727 -0.0080 -0.2979	0.0198 -0.2916 -0.0492 -0.2337

Kc2 is fixed at -0.07, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	1.0e-003 * -0.4011 0 0 0	0.7635 0 0 0	0 -1.8855 0 -1.8902	0 -1.5488 0 -1.8358	0 0 0 0	0 0 0 0	0 0 -0.0477 0	0 0 0.5549 0
0 0 0 0	1.0e-003 * -0.9248 0 0 0	0.7597 0 0 0	0 -2.2814 0 -2.2154	0 -1.5876 0 -1.8819	0 0 0 0	0 0 0 0	0 0 -0.0519 0	0 0 0.5620 0
0 0 0 0	-0.0015 0 0 0	0.7572 0 0 0	0 -2.6383 0 -2.5065	0 -1.5946 0 -1.9254	0 0 0 0	0 0 0 0	0 0 -0.0507 0	0 0 0.5682 0
0 0 0 0	-0.0020 0 0 0	0.7557 0 0 0	0 -2.9054 0 -2.7222	0 -1.5749 0 -1.9597	0 0 0 0	0 0 0 0	0 0 -0.0476 0	0 0 0.5726 0
0 0 0 0	-0.0023 0 0 0	0.7545 0 0 0	0 -3.1127 0 -2.8858	0 -1.5347 0 -1.9896	0 0 0 0	0 0 0 0	0 0 -0.0434 0	0 0 0.5759 0
0 0 0 0	-0.0028 0 0 0	0.7531 0 0 0	0 -3.3008 0 -3.0129	0 -3.3008 0 -3.0129	0 0 0 0	0 0 0 0	0 0 -0.0340 0	0 0 0.5794 0

Kc2 is fixed at -0.09, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.09	86.87	85.67	1.43E-05		1 0 0 1	-0.4224 0.1164 0.3561 -0.6508	-0.2021 -0.0810 -0.0679 -0.1979	-0.2177 -0.1010 -0.2566 -0.0612
0.5	-0.09	87.32	86.23	2.20E-05		1 0 0 1	-0.3864 0.0830 0.3442 -0.6354	-0.2538 -0.0348 -0.0640 -0.2048	-0.1557 -0.1620 -0.2125 -0.1050
0.604	-0.09	87.67	86.70	3.20E-05		1 0 0 1	-0.3559 0.0541 0.3295 -0.6185	-0.2992 0.0025 -0.0560 -0.2169	-0.1030 -0.2105 -0.1720 -0.1428
0.7	-0.09	87.90	86.95	4.35E-05		1 0 0 1	-0.3330 0.0325 0.3129 -0.6006	-0.3354 0.0289 -0.0457 -0.2323	-0.0635 -0.2435 -0.1396 -0.1705
0.8	-0.09	88.01	86.98	5.80E-05		1 0 0 1	-0.3134 0.0143 0.2926 -0.5797	-0.3689 0.0494 -0.0331 -0.2519	-0.0303 -0.2674 -0.1108 -0.1923
1.0	-0.09	87.89	86.48	9.63E-05		1 0 0 1	-0.2831 -0.0116 0.2457 -0.5319	-0.4275 0.0746 -0.0061 -0.2994	0.0148 -0.2879 -0.0673 -0.2154

Kc2 is fixed at -0.09, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	0.0017 0 0 0	0.7636 0 0 0	0 -1.4497 0 -1.4713	0 -1.4160 0 -1.7228	0 0 0 0	0 0 0 0	0 0 -0.0510 0	0 0 0.5512 0
0 0 0 0	1.0e-003 *-0.4243 0 0 0	0.7596 0 0 0	0 -1.7530 0 -1.7080	0 -1.4415 0 -1.7603	0 0 0 0	0 0 0 0	0 0 -0.0567 0	0 0 0.5605 0
0 0 0 0	1.0e-003 *-0.6525 0 0 0	0.7571 0 0 0	0 -2.0333 0 -1.9272	0 -.14417 0 -1.7983	0 0 0 0	0 0 0 0	0 0 -0.0557 0	0 0 0.5682 0
0 0 0 0	-0.0013 0 0 0	0.7555 0 0 0	0 -2.2477 0 -2.0936	0 -1.4210 0 -1.8301	0 0 0 0	0 0 0 0	0 0 -0.0521 0	0 0 0.5737 0
0 0 0 0	-0.0018 0 0 0	0.7544 0 0 0	0 -2.4183 0 -2.2224	0 -1.3837 0 -1.8590	0 0 0 0	0 0 0 0	0 0 -0.0472 0	0 0 0.5779 0
0 0 0 0	-0.0024 0 0 0	0.7529 0 0 0	0 -2.5868 0 -2.3262	0 -1.2855 0 -1.9046	0 0 0 0	0 0 0 0	0 0 -0.0358 0	0 0 0.5824 0

Kc2 is fixed at -0.127, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.127	87.07	86.55	2.07E-05		1 0 0 1	-0.4290 0.1091 0.3572 -0.6650	-0.2107 -0.0741 -0.0895 -0.1783	-0.2302 -0.0790 -0.2789 -0.0317
0.5	-0.127	87.54	87.28	3.10E-05		1 0 0 1	-0.3941 0.0799 0.3388 -0.6399	-0.2566 -0.0341 -0.0708 -0.1997	-0.1707 -0.1393 -0.2446 -0.0676
0.604	-0.127	87.93	87.89	4.54E-05		1 0 0 1	-0.3617 0.0520 0.3230 -0.6196	-0.3008 0.0018 -0.0559 -0.2183	-0.1182 -0.1896 -0.2086 -0.1025
0.7	-0.127	88.17	88.22	6.31E-05		1 0 0 1	-0.3365 0.0301 0.3071 -0.6011	0.3375 0.0287 -0.0427 -0.2360	-0.0776 -0.2253 -0.1773 -0.1301
0.8	-0.127	88.25	88.24	8.68E-05		1 0 0 1	-0.3145 0.0114 0.2881 -0.5807	-0.3718 0.0504 -0.0287 -0.2563	-0.0429 -0.2524 -0.1481 -0.1528
1.0	-0.127	87.90	87.39	1.54E-04		1 0 0 1	-0.2805 -0.0150 0.2432 -0.5350	-0.4319 0.0779 -0.0010 -0.3029	0.0058 -0.2798 -0.1016 -0.1786

Kc2 is fixed at -0.127, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	0.0045 0 0 0	0.7634 0 0 0	0 -1.0073 0 -1.0450	0 -1.2693 0 -1.5977	0 0 0 0	0 0 0 0	0 0 -0.0587 0	0 0 0.5439 0
0 0 0 0	0.0020 0 0 0	0.7594 0 0 0	0 -1.2130 0 -1.1863	0 -1.2837 0 -1.6324	0 0 0 0	0 0 0 0	0 0 -0.0671 0	0 0 0.5575 0
0 0 0 0	1.0e-003 *0.2285 0 0 0	0.7569 0 0 0	0 -1.4129 0 -1.3288	0 -1.2787 0 -.16694	0 0 0 0	0 0 0 0	0 0 -0.0664 0	0 0 0.5682 0
0 0 0 0	1.0e-003 * -0.7308 0 0 0	0.7554 0 0 0	0 -1.5721 0 -1.4431	0 -1.2584 0 -1.7015	0 0 0 0	0 0 0 0	0 0 -0.0618 0	0 0 0.5756 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.7047 0 -1.5350	0 -1.2254 0 -1.7315	0 0 0 0	0 0 0 0	0 0 -0.0552 0	0 0 0.5814 0
0 0 0 0	-0.0021 0 0 0	0.7526 0 0 0	0 -1.8535 0 -1.6126	0 -1.1413 0 -1.7805	0 0 0 0	0 0 0 0	0 0 -0.0400 0	0 0 0.5877 0

Kc2 is fixed at -0.14, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.14	87.15	86.83	2.36E-05		1 0 0 1	-0.4307 0.1056 0.3582 -0.6712	-0.2154 -0.0699 -0.0986 -0.1696	-0.2327 -0.0726 -0.2850 -0.0222
0.5	-0.14	87.62	87.62	3.50E-05		1 0 0 1	-0.3967 0.0784 0.3368 -0.6421	-0.2586 -0.0329 -0.0738 -0.1972	-0.1748 -0.1320 -0.2550 -0.0547
0.604	-0.14	88.02	88.30	5.14E-05		1 0 0 1	-0.3638 0.0510 0.3203 -0.6202	-0.3021 0.0021 -0.0559 -0.2186	-0.1226 -0.1825 -0.2210 -0.0882
0.7	-0.14	88.27	88.66	7.18E-05		1 0 0 1	-0.3378 0.0292 0.3046 -0.6014	-0.3386 0.0289 -0.0414 -0.2374	-0.0820 -0.2189 -0.1904 -0.1154
0.8	-0.14	88.35	88.68	9.97E-05		1 0 0 1	-0.3150 0.0104 0.2860 -0.5812	-0.3731 0.0508 -0.0269 -0.2580	-0.0470 -0.2470 -0.1611 -0.1384
1.0	-0.14	87.91	87.75	1.80E-04		1 0 0 1	-0.2796 -0.0162 0.2418 -0.5363	-0.4337 0.0790 0.0011 -0.3043	0.0028 -0.2766 -0.1137 -0.1649

Kc2 is fixed at -0.14, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	0.0051 0 0 0	0.7634 0 0 0	0 -0.9084 0 -0.9491	0 -1.2325 0 -1.5662	0 0 0 0	0 0 0 0	0 0 -0.0618 0	0 0 0.5412 0
0 0 0 0	0.0022 0 0 0	0.7594 0 0 0	0 -1.0911 0 -1.0676	0 -1.2451 0 -1.6020	0 0 0 0	0 0 0 0	0 0 -0.0712 0	0 0 0.5563 0
0 0 0 0	1.0e-003 *0.2896 0 0 0	0.7569 0 0 0	0 -1.2721 0 -1.1921	0 -1.2396 0 -1.6399	0 0 0 0	0 0 0 0	0 0 -0.0705 0	0 0 0.5681 0
0 0 0 0	1.0e-003 * -0.6996 0 0 0	0.7554 0 0 0	0 -1.4185 0 -1.2941	0 -1.2197 0 -1.6728	0 0 0 0	0 0 0 0	0 0 -0.0655 0	0 0 0.5762 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.5423 0 -1.3773	0 -1.1880 0 -1.7036	0 0 0 0	0 0 0 0	0 0 -0.0584 0	0 0 0.5825 0
0 0 0 0	-0.0020 0 0 0	0.7535 0 0 0	0 -1.6865 0 -1.4484	0 -1.1077 0 -1.7537	0 0 0 0	0 0 0 0	0 0 -0.0417 0	0 0 0.5895 0

Kc2 is fixed at -0.16, I1 and I2 are fixed at 999999999

Kc1	Kc2	Y1	Y2	FPE		A0	A1	A2	A3
0.4	-0.16	87.28	87.27	2.87E-05		1 0 0 1	-0.4328 0.0991 0.3601 -0.6819	-0.2245 -0.0615 -0.1143 -0.1545	-0.2345 -0.0640 -0.2928 -0.0087
0.5	-0.16	87.77	88.18	4.21E-05		1 0 0 1	-0.4005 0.0755 0.3338 -0.6461	-0.2627 -0.0299 -0.0789 -0.1927	-0.1796 -0.1214 -0.2699 -0.0343
0.604	-0.16	88.19	88.95	6.19E-05		1 0 0 1	-0.3672 0.0493 0.3160 -0.6216	-0.3046 0.0032 -0.0560 -0.2189	-0.1286 -0.1719 -0.2395 -0.0661
0.7	-0.16	88.45	89.37	8.72E-05		1 0 0 1	-0.3401 0.0277 0.3004 -0.6022	-0.3409 0.0295 -0.0393 -0.2395	-0.0882 -0.2091 -0.2101 -0.0927
0.8	-0.16	88.70	89.59	0.000122		1 0 0 1	-0.3161 0.0089 0.2824 -0.5821	-0.3756 0.0517 -0.0238 -0.2608	-0.0528 -0.2386 -0.1810 -0.1159
1.0	-0.16	87.95	88.38	0.000226		1 0 0 1	-0.2785 -0.0179 0.2392 -0.5386	-0.4366 0.0807 0.0045 -0.3065	-0.0017 -0.2715 -0.1322 -0.1435

Kc2 is fixed at -0.16, I1 and I2 are fixed at 999999999

B0	B1	B2	B3	B4	B5	B6	B7	B8
0 0 0 0	0.0055 0 0 0	0.7634 0 0 0	0 -0.7888 0 -0.8324	0 -1.1843 0 -1.5249	0 0 0 0	0 0 0 0	0 0 -0.0673 0	0 0 0.5369 0
0 0 0 0	0.0022 0 0 0	0.7595 0 0 0	0 -0.9426 0 -0.9224	0 -1.1953 0 -1.5633	0 0 0 0	0 0 0 0	0 0 -0.0778 0	0 0 0.5544 0
0 0 0 0	1.0e-003 *0.1738 0 0 0	0.7570 0 0 0	0 -1.0998 0 -1.0241	0 -1.1894 0 -1.6032	0 0 0 0	0 0 0 0	0 0 -0.0772 0	0 0 0.5678 0
0 0 0 0	1.0e-003 * -0.7862 0 0 0	0.7555 0 0 0	0 -1.2301 0 -1.1109	0 -1.1704 0 -1.6376	0 0 0 0	0 0 0 0	0 0 -0.0717 0	0 0 0.5770 0
0 0 0 0	-0.0013 0 0 0	0.7542 0 0 0	0 -1.3428 0 -1.1833	0 -1.1405 0 -1.6695	0 0 0 0	0 0 0 0	0 0 -0.0635 0	0 0 0.5841 0
0 0 0 0	-0.0020 0 0 0	0.7524 0 0 0	0 -1.4813 0 -1.2461	0 -1.0653 0 -1.7210	0 0 0 0	0 0 0 0	0 0 -0.0445 0	0 0 0.5920 0

4.1.2 Model [3*ones(2,2), 2*ones(2,2), [1 3; 7 3]]

Kc1 is fixed at 0.4, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	NaN	NaN	1.03E-05		1 0 0 1	-0.2686 0.1005 -0.6230 0.4799	-0.0846 -0.0721 0.9573 -1.0869	-0.3968 0.2504 -0.2177 0.0741	-0.1190 -0.0952 -0.1222 -0.0808	-0.0327 -0.1288 -0.0145 -0.1429
-0.05	NaN	NaN	1.61E-05		1 0 0 1	-0.2721 0.0969 -0.5303 0.3822	-0.0931 -0.0708 0.8902 -1.0261	-0.3659 0.2174 -0.2144 0.0695	-0.1379 -0.0777 -0.1416 -0.0642	-0.0232 -0.1282 0.0065 -0.1572
-0.07	88.81	88.35	2.34E-05		1 0 0 1	-0.2739 0.0912 -0.4362 0.2830	-0.1019 -0.0700 0.8198 -0.9625	-0.3383 0.1875 -0.2142 0.0686	-0.1562 -0.0599 -0.1553 -0.0522	-0.0101 -0.1295 0.0242 -0.1678
-0.09	88.84	89.02	3.07E-05		1 0 0 1	-0.2744 0.0843 -0.3413 0.1830	-0.1103 -0.0699 0.7463 -0.8959	-0.3125 0.1594 -0.2173 0.0714	-0.1730 -0.0426 -0.1633 -0.0453	0.0058 -0.1329 0.0374 -0.1741
-0.127	88.91	89.66	4.07E-05		1 0 0 1	-0.2745 0.0729 -0.1764 0.0080	-0.1217 -0.0735 0.6136 -0.7767	-0.2680 0.1111 -0.2315 0.0860	-0.1976 -0.0154 -0.1658 -0.0437	0.0382 -0.1431 0.0521 -0.1769
-0.14	88.97	89.94	4.26E-05		1 0 0 1	-0.2750 0.0701 -0.1238 -0.0482	-0.1240 -0.0763 0.5701 -0.7380	-0.2540 0.0960 -0.2390 0.0936	-0.2040 -0.0079 -0.1635 -0.0459	0.0493 -0.1473 0.0550 -0.1758
-0.16	89.12	90.44	4.39E-05		1 0 0 1	-0.2765 0.0676 -0.0482 -0.1294	-0.1256 -0.0821 0.5066 -0.6820	-0.2353 0.0757 -0.2526 0.1075	-0.2116 0.0015 -0.1572 -0.0519	0.0652 -0.1539 0.0574 -0.1722

Kc1 is fixed at 0.4, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0064 0 0 0	0.7902 0 0 0	0.9097 7.5153 0 6.7079	0 -5.8993 0 -6.1035	0 -4.5612 0 -4.9738	0 0 0 0	0 0 0.0129 0	0 0 0.5901 0	0 0 0.6914 0
0 0 0 0	0.0090 0 0 0	0.7901 0 0 0	0.8400 3.9714 0 3.4627	0 -3.8356 0 -4.2321	0 -2.9560 0 -3.4480	0 0 0 0	0 0 0.0287 0	0 0 0.5964 0	0 0 0.6396 0
0 0 0 0	0.0114 0 0 0	0.7898 0 0 0	0.7758 2.4825 0 2.0702	0 -2.9552 0 -3.4206	0 -2.2563 0 -2.7403	0 0 0 0	0 0 0.0410 0	0 0 0.6007 0	0 0 0.5852 0
0 0 0 0	0.0134 0 0 0	0.7893 0 0 0	0.7140 1.6538 0 1.2966	0 -2.4699 0 -2.9613	0 -1.8564 0 -2.3044	0 0 0 0	0 0 0.0492 0	0 0 0.6029 0	0 0 0.5281 0
0 0 0 0	0.0146 0 0 0	0.7880 0 0 0	0.5887 0.7816 0 0.5362	0 -1.9834 0 -2.4829	0 -1.4286 0 -1.7957	0 0 0 0	0 0 0.0561 0	0 0 0.6025 0	0 0 0.4245 0
0 0 0 0	0.0140 0 0 0	0.7876 0 0 0	0.5428 0.5806 0 0.3757	0 -1.8761 0 -2.3732	0 -1.3277 0 -1.6667	0 0 0 0	0 0 0.0564 0	0 0 0.6014 0	0 0 0.3903 0
0 0 0 0	0.0120 0 0 0	0.7871 0 0 0	0.4731 0.3395 0 0.1885	0 -1.7476 0 -0.2383	0 -1.2022 0 -1.4986	0 0 0 0	0 0 0.0550 0	0 0 0.5989 0	0 0 0.3402 0

Kc1 is fixed at 0.5, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	NaN	NaN	9.53E-06		1 0 0 1	-0.2504 0.0808 -0.5799 0.4362	-0.1068 -0.0519 0.8672 -0.9981	-0.4417 0.2943 -0.2187 0.0744	-0.0916 -0.1289 -0.0921 -0.1161	-0.0114 -0.1440 -0.0144 -0.1377
-0.05	88.83	87.69	1.41E-05		1 0 0 1	-0.2540 0.0779 -0.4936 0.3451	-0.1155 -0.0499 0.8030 -0.9403	-0.4103 0.2610 -0.2142 0.0685	-0.1041 -0.1187 -0.1057 -0.1059	-0.0063 -0.1383 -0.0020 -0.1422
-0.07	88.88	88.50	2.04E-05		1 0 0 1	-0.2563 0.0736 -0.4066 0.2530	-0.1250 -0.0479 0.7366 -0.8809	-0.3809 0.2294 -0.2118 0.0654	-0.1161 -0.1081 -0.1151 -0.0989	0.0016 -0.1339 0.0084 -0.1443
-0.09	88.93	89.18	2.70E-05		1 0 0 1	-0.2574 0.0683 -0.3182 0.1590	-0.1345 -0.0461 0.6671 -0.8186	-0.3519 0.1981 -0.2117 0.0649	-0.1271 -0.0975 -0.1200 -0.0957	0.0119 -0.1313 0.0156 -0.1432
-0.127	88.91	89.91	3.70E-05		1 0 0 1	-0.2579 0.0590 -0.1568 -0.0130	-0.1501 -0.0449 0.5356 -0.7012	-0.2981 0.1403 -0.2176 0.0704	-0.1437 -0.0800 -0.1179 -0.0990	0.0344 -0.1309 0.0208 -0.1339
-0.14	88.96	90.24	3.91E-05		1 0 0 1	-0.2580 0.0565 -0.1017 -0.0720	-0.1545 -0.0454 0.4896 -0.6603	-0.2797 0.1206 -0.2213 0.0739	-0.1481 -0.0749 -0.1141 -0.1028	0.0424 -0.1318 0.0205 -0.1288
-0.16	89.10	90.81	4.09E-05		1 0 0 1	-0.2588 0.0539 -0.0180 -0.1618	-0.1599 -0.0473 0.4190 -0.5973	-0.2532 0.0924 -0.2282 0.0803	-0.1533 -0.0683 -0.1051 -0.1113	0.0540 -0.1338 0.0183 -0.1192

Kc1 is fixed at 0.5, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0059 0 0 0	0.7852 0 0 0	0.8862 9.0851 0 7.7548	0 -6.9184 0 -6.8765	0 -5.0201 0 -5.1934	0 0 0 0	0 0 -0.0069 0	0 0 0.5802 0	0 0 0.6442 0
0 0 0 0	0.0079 0 0 0	0.7850 0 0 0	0.8237 4.8506 0 4.0042	0 -4.4280 0 -4.6641	0 -3.1745 0 -3.5163	0 0 0 0	0 0 0.0022 0	0 0 0.5831 0	0 0 0.5948 0
0 0 0 0	0.0097 0 0 0	0.7846 0 0 0	0.7641 3.0507 0 2.3970	0 -3.3610 0 -3.7074	0 -2.3706 0 -2.7485	0 0 0 0	0 0 0.0094 0	0 0 0.5849 0	0 0 0.5438 0
0 0 0 0	0.0110 0 0 0	0.7841 0 0 0	0.7036 2.0422 0 1.4998	0 -2.7701 0 -3.1677	0 -1.9138 0 -2.2810	0 0 0 0	0 0 0.0140 0	0 0 0.5851 0	0 0 0.4903 0
0 0 0 0	0.0110 0 0 0	0.7832 0 0 0	0.5830 0.9776 0 0.5908	0 -2.1748 0 -2.6058	0 -1.4325 0 -1.7368	0 0 0 0	0 0 0.0164 0	0 0 0.5821 0	0 0 0.3888 0
0 0 0 0	0.0101 0 0 0	0.7829 0 0 0	0.5386 0.7304 0 0.3883	0 -2.0431 0 -2.4765	0 -1.3208 0 -1.5974	0 0 0 0	0 0 0.0137 0	0 0 0.5803 0	0 0 0.3532 0
0 0 0 0	0.0082 0 0 0	0.7828 0 0 0	0.4704 0.4306 0 0.1410	0 -1.8849 0 -2.3171	0 -1.1831 0 -1.4138	0 0 0 0	0 0 0.0135 0	0 0 0.5768	0 0 0.2984 0

Kc1 is fixed at 0.604, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	88.79	86.51	9.71E-06		1 0 0 1	-0.2349 0.0642 -0.5412 0.5971	-0.1239 -0.0370 0.7913 -0.9233	-0.4877 0.3399 -0.2242 0.0799	-0.0644 -0.1642 -0.0622 -0.1504	0.0074 -0.1576 -0.0175 -0.1311
-0.05	88.90	87.82	1.36E-05		1 0 0 1	-0.2374 0.0610 -0.4583 0.3095	-0.1328 -0.0343 0.7292 -0.8675	-0.4559 0.3063 -0.2192 0.0735	-0.0733 -0.1565 -0.0713 -0.1452	0.0098 -0.1489 -0.0130 -0.1268
-0.07	88.97	88.71	1.94E-05		1 0 0 1	-0.2391 0.0569 -0.3750 0.2208	-0.1426 -0.0316 0.6653 -0.8108	-0.4250 0.2733 -0.2158 0.0691	-0.0817 -0.1501 -0.0770 -0.1424	0.0144 -0.1409 -0.0096 -0.1206
-0.09	88.93	89.20	2.59E-05		1 0 0 1	-0.2400 0.0523 -0.2902 0.1301	-0.1525 -0.0290 0.5987 -0.7519	-0.3934 0.2395 -0.2141 0.0666	-0.0893 -0.1437 -0.0788 -0.1424	0.0209 -0.1342 -0.0084 -0.1121
-0.127	88.90	90.09	3.65E-05		1 0 0 1	-0.2402 0.0444 -0.1308 -0.0412	-0.1698 -0.0253 0.4702 -0.6380	-0.3321 0.1741 -0.2148 0.0659	-0.1007 -0.1326 -0.0721 -0.1503	0.0361 -0.1261 -0.0121 -0.0912
-0.14	88.93	90.42	3.91E-05		1 0 0 1	-0.2402 0.0423 -0.0739 -0.1023	-0.1751 -0.0246 0.4238 -0.5968	-0.3102 0.1509 -0.2159 0.0664	-0.1037 -0.1293 -0.0666 -0.1556	0.0416 -0.1245 -0.0149 -0.0826
-0.16	89.03	91.02	4.18E-05		1 0 0 1	-0.2406 0.0401 0.0154 -0.1982	-0.1823 -0.0246 0.3509 -0.5316	-0.2774 0.1164 -0.2178 0.0671	-0.1071 -0.1250 -0.0551 -0.1662	0.0497 -0.1227 -0.0202 -0.0686

Kc1 is fixed at 0.604, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0048 0 0 0	0.7820 0 0 0	0.8581 10.6413 0 8.7050	0 -7.9568 0 -7.6502	0 -5.4538 0 -5.3222	0 0 0 0	0 0 -0.0231 0	0 0 0.5735 0	0 0 0.5972 0
0 0 0 0	0.0064 0 0 0	0.7817 0 0 0	0.8028 5.7366 0 4.4725	0 -5.0378 0 -5.0952	0 -3.3851 0 -3.5156	0 0 0 0	0 0 -0.0194 0	0 0 0.5741 0	0 0 0.5482 0
0 0 0 0	0.0077 0 0 0	0.7813 0 0 0	0.7480 3.6348 0 2.6593	0 -3.7842 0 -3.9914	0 -2.4833 0 2.6935	0 0 0 0	0 0 -0.0165 0	0 0 0.5741 0	0 0 0.4980 0
0 0 0 0	0.0085 0 0 0	0.7809 0 0 0	0.6911 2.4504 0 1.6448	0 -3.0881 0 -3.3704	0 -1.9720 0 -2.1969	0 0 0 0	0 0 -0.0151 0	0 0 0.5732 0	0 0 0.4457 0
0 0 0 0	0.0079 0 0 0	0.7802 0 0 0	0.5763 1.1950 0 0.5969	0 -2.3839 0 -2.7260	0 -1.4376 0 -1.6221	0 0 0 0	0 0 -0.0162 0	0 0 0.5691 0	0 0 0.3444 0
0 0 0 0	0.0071 0 0 0	0.7801 0 0 0	0.5336 0.9017 0 0.3547	0 -2.2274 0 -2.5784	0 -1.3150 0 -1.4751	0 0 0 0	0 0 -0.0174 0	0 0 0.5672 0	0 0 0.3076 0
0 0 0 0	0.0054 0 0 0	0.7802 0 0 0	0.4675 0.5432 0 0.0510	0 -2.0386 0 -2.3971	0 -1.1644 0 -1.2814	0 0 0 0	0 0 -0.0197 0	0 0 0.5639 0	0 0 0.2494 0

Kc1 is fixed at 0.7, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	88.87	87.65	1.07E-05		1 0 0 1	-0.2230 0.0518 -0.5117 0.3675	-0.1362 -0.0267 0.7351 -0.8678	-0.5286 0.3810 -0.2320 0.0880	-0.0396 -0.1925 -0.0356 -0.1801	0.0219 -0.1682 -0.0220 -0.1249
-0.05	88.96	87.92	1.46E-05		1 0 0 1	-0.2244 0.0482 -0.4306 0.2817	-0.1453 -0.0236 0.6748 -0.8140	-0.4965 0.3474 -0.2265 0.0812	-0.0465 -0.1891 -0.0418 -0.1782	0.0227 -0.1577 -0.0238 -0.1134
-0.07	88.98	88.71	2.05E-05		1 0 0 1	-0.2253 0.0440 -0.3491 0.1942	-0.1552 -0.0205 0.6129 -0.7594	-0.4644 0.3133 -0.2226 0.0759	-0.0530 -0.1852 -0.0448 -0.1783	0.0251 -0.1475 -0.0262 -0.1003
-0.09	88.96	89.30	2.74E-05		1 0 0 1	-0.2256 0.0396 -0.2659 0.1045	-0.1653 -0.0174 0.5484 -0.7031	-0.4309 0.2776 -0.2199 0.0720	-0.0588 -0.1812 -0.0443 -0.1806	0.0292 -0.1383 -0.0300 -0.0855
-0.127	88.89	90.18	3.92E-05		1 0 0 1	-0.2253 0.0325 -0.1067 -0.0678	-0.1831 -0.0125 0.4235 -0.5933	-0.3637 0.2065 -0.2171 0.0666	-0.0673 -0.1740 -0.0337 -0.1919	0.0392 -0.1252 -0.0404 -0.0552
-0.14	88.99	90.51	4.25E-05		1 0 0 1	-0.2551 0.0307 -0.0486 -0.1305	-0.1888 -0.0112 0.3778 -0.5528	-0.3391 0.1806 -0.2162 0.0647	-0.0694 -0.1718 -0.0271 -0.1981	0.0430 -0.1217 -0.0448 -0.0442
-0.16	88.92	91.10	4.63E-05		1 0 0 1	-0.2253 0.0286 0.0438 -0.2298	-0.1968 -0.0100 0.3059 -0.4886	-0.3013 0.1412 -0.2143 0.0611	-0.0718 -0.1689 -0.0137 -0.2101	0.0487 -0.1172 -0.0521 -0.0274

Kc1 is fixed at 0.7, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0039 0 0 0	0.7799 0 0 0	0.8301 12.0169 0 9.5088	0 -8.9073 0 -8.3666	0 -5.8098 0 -5.3736	0 0 0 0	0 0 -0.0351 0	0 0 0.5696 0	0 0 0.5569 0
0 0 0 0	0.0051 0 0 0	0.7796 0 0 0	0.7806 6.5275 0 4.8544	0 -5.5991 0 -5.4955	0 -3.5591 0 -5.4955	0 0 0 0	0 0 -0.0353 0	0 0 0.5690 0	0 0 0.5076 0
0 0 0 0	0.0061 0 0 0	0.7793 0 0 0	0.7302 4.1638 0 2.8581	0 -4.1767 0 -4.2555	0 -2.5774 0 -2.6023	0 0 0 0	0 0 -0.0355 0	0 0 0.5681 0	0 0 0.4572 0
0 0 0 0	0.0066 0 0 0	0.7789 0 0 0	0.6769 2.8268 0 1.7395	0 -3.3856 0 -3.5593	0 -2.0213 0 -2.0817	0 0 0 0	0 0 -0.0364 0	0 0 0.5667 0	0 0 0.4049 0
0 0 0 0	0.0059 0 0 0	0.7785 0 0 0	0.5679 1.4051 0 0.5698	0 -2.5832 0 -2,8404	0 -1.4426 0 -1.4839	0 0 0 0	0 0 -0.0396 0	0 0 0.5627 0	0 0 0.3025 0
0 0 0 0	0.0052 0 0 0	0.7784 0 0 0	0.5270 1.0715 0 0.2941	0 -2.4041 0 -2.6768	0 -1.3105 0 -1.3324	0 0 0 0	0 0 -0.0410 0	0 0 0.5610 0	0 0 0.2648 0
0 0 0 0	0.0037 0 0 0	0.7786 0 0 0	0.4631 0.6610 0 -0.0555	0 -2.1875 0 -2.4772	0 -1.1486 0 -1.1349	0 0 0 0	0 0 -0.0429 0	0 0 0.5583 0	0 0 0.2047 0

Kc1 is fixed at 0.8, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	88.93	86.76	1.24E-05		1 0 0 1	-0.2129 0.0414 -0.4866 0.3425	-0.1468 -0.0184 0.6879 -0.8213	-0.5695 0.4227 -0.2422 0.0989	-0.0137 -0.2236 -0.0086 -0.2096	0.0344 -0.1775 -0.0278 -0.1181
-0.05	89.01	88.01	1.68E-05		1 0 0 1	-0.2131 0.0373 -0.4068 0.2577	-0.1560 -0.0150 0.6299 -0.7699	-0.5371 0.3889 -0.2364 0.0915	-0.0194 -0.2219 -0.0126 -0.2102	0.0339 -0.1657 -0.0354 -0.1000
-0.07	89.02	88.80	2.34E-05		1 0 0 1	-0.2131 0.0330 -0.3261 0.1706	-0.1658 -0.0115 0.5699 -0.7177	-0.5038 0.3539 -0.2319 0.0853	-0.0246 -0.2197 -0.0134 -0.2123	0.0347 -0.1539 -0.0432 -0.0804
-0.09	88.98	89.37	3.13E-05		1 0 0 1	-0.2128 0.0287 -0.2438 0.0808	-0.1760 -0.0081 0.5079 -0.6640	-0.4684 0.3166 -0.2284 0.0800	-0.0293 -0.2173 -0.0109 -0.2164	0.0367 -0.1428 -0.0515 -0.0597
-0.127	88.87	90.23	4.52E-05		1 0 0 1	-0.2118 0.0220 -0.0844 -0.0930	-0.1940 -0.0025 0.3875 -0.5594	-0.3960 0.2406 -0.2222 0.0701	-0.0360 -0.2127 0.0028 -0.2300	0.0427 -0.1258 -0.0676 -0.0210
-0.14	89.08	90.72	4.93E-05		1 0 0 1	-0.2115 0.0203 -0.0255 -0.1568	-0.1999 -0.0009 0.3436 -0.5208	-0.3689 0.2123 -0.2194 0.0660	-0.0376 -0.2112 0.0104 -0.2368	0.0452 -0.1210 -0.0733 -0.0081
-0.16	88.79	91.08	5.45E-05		1 0 0 1	-0.2114 0.0184 0.0679 -0.2572	-0.2084 0.0011 0.2749 -0.4596	-0.3267 0.1685 -0.2141 0.0585	-0.0394 -0.2093 0.0249 -0.2496	0.0489 -0.1145 -0.0818 0.0105

Kc1 is fixed at 0.8, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0031 0 0 0	0.7784 0 0 0	0.7996 13.3996 0 10.3025	0 -9.9034 0 -9.1376	0 -6.1316 0 -5.3642	0 0 0 0	0 0 -0.0453 0	0 0 0.5673 0	0 0 0.5181 0
0 0 0 0	0.0041 0 0 0	0.7781 0 0 0	0.7552 7.3285 0 5.2227	0 -6.1889 0 -5.9291	0 -3.7169 0 -3.3776	0 0 0 0	0 0 -0.0486 0	0 0 0.5660 0	0 0 0.4683 0
0 0 0 0	0.0048 0 0 0	0.7778 0 0 0	0.7091 4.7055 0 3.0393	0 -4.5907 0 -4.5432	0 -2.6631 0 -2.4729	0 0 0 0	0 0 -0.0514 0	0 0 0.5647 0	0 0 0.4171 0
0 0 0 0	0.0052 0 0 0	0.7775 0 0 0	0.6595 3.2181 0 1.8139	0 -3.7010 0 -3.7668	0 -2.0665 0 -1.9309	0 0 0 0	0 0 -0.0541 0	0 0 0.5632 0	0 0 0.3641 0
0 0 0 0	0.0045 0 0 0	0.7772 0 0 0	0.5568 1.6327 0 0.5226	0 -2.7966 0 -2.9696	0 -1.4473 0 -1.3157	0 0 0 0	0 0 -0.0586 0	0 0 0.5598 0	0 0 0.2604 0
0 0 0 0	0.0039 0 0 0	0.7772 0 0 0	0.5179 1.2594 0 0.2153	0 -2.5942 0 -2.7898	0 -1.3064 0 -1.1625	0 0 0 0	0 0 -0.0599 0	0 0 0.5585 0	0 0 0.2220 0
0 0 0 0	0.0027 0 0 0	0.7774 0 0 0	0.4567 0.7977 0 -0.1744	0 -2.3486 0 -2.5721	0 -1.1341 0 -0.9666	0 0 0 0	0 0 -0.0614 0	0 0 0.5565 0	0 0 0.1614 0

Kc1 is fixed at 1.0, I1 and I2 are set at 16.37 and 14.46 respectively

Kc2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	89.06	86.97	1.75E-05		1 0 0 1	-0.1977 0.0261 -0.4481 0.3046	-0.1641 -0.0062 0.6186 -0.7541	-0.6458 0.5025 -0.2687 0.1270	0.0397 -0.2868 0.0455 -0.2677	0.0523 -0.1902 -0.0432 -0.1017
-0.05	89.11	88.16	2.42E-05		1 0 0 1	-0.1961 0.0241 -0.3703 0.2210	-0.1735 -0.0024 0.5659 -0.7084	-0.6124 0.4684 -0.2620 0.1182	0.0349 -0.2868 0.0443 -0.2708	0.0502 -0.1772 -0.0605 -0.0723
-0.07	89.11	88.93	3.37E-05		1 0 0 1	-0.1946 0.0168 -0.2905 0.1333	-0.1834 0.0014 0.5108 -0.6620	-0.5770 0.4319 -0.2564 0.1099	0.0306 -0.2862 0.0462 -0.2750	0.0487 -0.1636 -0.0771 -0.0414
-0.09	89.05	89.48	4.47E-05		1 0 0 1	-0.1932 9.9126 -0.2090 0.0427	-0.1934 0.0051 0.4542 -0.6148	-0.5385 0.3920 -0.2512 0.1017	0.0267 -0.2854 0.0512 -0.2806	0.0480 -0.1503 -0.0926 -0.0106
-0.127	88.84	90.22	6.48E-05		1 0 0 1	-0.1908 0.0064 -0.0512 -0.1323	-0.2116 0.0115 0.3464 -0.5237	-0.4572 0.3081 -0.2389 0.0837	0.0213 -0.2382 0.0685 -0.2960	0.0485 -0.1284 -0.1174 0.0413
-0.14	88.72	90.45	7.10E-05		1 0 0 1	-0.1902 0.0049 0.0066 -0.1953	-0.2177 0.0135 0.3081 -0.4906	-0.4260 0.2761 -0.2330 0.0759	0.0199 -0.2824 0.0770 -0.3031	0.0491 -0.1218 -0.1249 0.0570
-0.16	88.49	90.86	7.94E-05		1 0 0 1	-0.1895 0.0032 0.0967 -0.2923	-0.2267 0.0163 0.2499 -0.4392	-0.3766 0.2257 -0.2220 0.0625	0.0183 -0.2813 0.0922 -0.3160	0.0501 -0.1127 -0.1352 0.0775

Kc1 is fixed at 1.0, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0021 0 0 0	0.7762 0 0 0	0.7365 16.0515 0 11.7966	0 -11.9715 0 -10.8182	0 -6.6025 0 -5.1205	0 0 0 0	0 0 -0.0610 0	0 0 0.5656 0	0 0 0.4469 0
0 0 0 0	0.0028 0 0 0	0.7760 0 0 0	0.7004 8.8772 0 5.9006	0 -7.4131 0 -6.8836	0 -3.9458 0 -3.0523	0 0 0 0	0 0 -0.0686 0	0 0 0.5642 0	0 0 0.3959 0
0 0 0 0	0.0034 0 0 0	0.7758 0 0 0	0.6614 5.7665 0 3.3548	0 -5.4511 0 -5.1841	0 -2.7851 0 -2.1024	0 0 0 0	0 0 -0.0748 0	0 0 0.5631 0	0 0 0.3429 0
0 0 0 0	0.0036 0 0 0	0.7756 0 0 0	0.6187 3.9982 0 1.9240	0 -4.3576 0 -4.2360	0 -2.1282 0 -1.5368	0 0 0 0	0 0 -0.0796 0	0 0 0.5623 0	0 0 0.2884 0
0 0 0 0	0.0032 0 0 0	0.7754 0 0 0	0.5281 2.1098 0 0.4126	0 -3.2432 0 -3.2735	0 -1.4485 0 -0.9155	0 0 0 0	0 0 -0.0853 0	0 0 0.5608 0	0 0 0.1832 0
0 0 0 0	0.0028 0 0 0	0.7754 0 0 0	0.4932 1.6633 0 0.0549	0 -2.9927 0 -0.30600	0 -1.2945 0 -0.7696	0 0 0 0	0 0 -0.0864 0	0 0 0.5602 0	0 0 0.1451 0
0 0 0 0	0.0021 0 0 0	0.7756 0 0 0	0.4378 1.1087 0 -0.3908	0 -2.6880 0 -2.8047	0 -1.1070 0 -0.5931	0 0 0 0	0 0 -0.0871 0	0 0 0.5590 0	0 0 0.0864 0

Kc2 is fixed at -0.03, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	NaN	NaN	1.61E-05		1 0 0 1	-0.2721 0.0969 -0.5303 0.3822	-0.0931 -0.0708 0.8902 -1.0261	-0.3659 0.2174 -0.2144 0.0695	-0.1379 -0.0777 -0.1416 -0.0642	-0.0232 -0.1282 0.0065 -0.1572
0.5	88.83	87.69	1.41E-05		1 0 0 1	-0.2540 0.0779 -0.4936 0.3451	-0.1155 -0.0499 0.8030 -0.9403	-0.4103 0.2610 -0.2142 0.0685	-0.1041 -0.1187 -0.1057 -0.1059	-0.0063 -0.1383 -0.0020 -0.1422
0.604	88.90	87.82	1.36E-05		1 0 0 1	-0.2374 0.0610 -0.4583 0.3095	-0.1328 -0.0343 0.7292 -0.8675	-0.4559 0.3063 -0.2192 0.0735	-0.0733 -0.1565 -0.0713 -0.1452	0.0098 -0.1489 -0.0130 -0.1268
0.7	88.96	87.92	1.46E-05		1 0 0 1	-0.2244 0.0482 -0.4306 0.2817	-0.1453 -0.0236 0.6748 -0.8140	-0.4965 0.3474 -0.2265 0.0812	-0.0465 -0.1891 -0.0418 -0.1782	0.0227 -0.1577 -0.0238 -0.1134
0.8	89.01	88.01	1.68E-05		1 0 0 1	-0.2131 0.0373 -0.4068 0.2577	-0.1560 -0.0150 0.6299 -0.7699	-0.5371 0.3889 -0.2364 0.0915	-0.0194 -0.2219 -0.0126 -0.2102	0.0339 -0.1657 -0.0354 -0.1000
1.0	89.11	88.16	2.42E-05		1 0 0 1	-0.1961 0.0241 -0.3703 0.2210	-0.1735 -0.0024 0.5659 -0.7084	-0.6124 0.4684 -0.2620 0.1182	0.0349 -0.2868 0.0443 -0.2708	0.0502 -0.1772 -0.0605 -0.0723

Kc2 is fixed at -0.03, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0090 0 0 0	0.7901 0 0 0	0.8400 3.9714 0 3.4627	0 -3.8356 0 -4.2321	0 -2.9560 0 -3.4480	0 0 0 0	0 0 0.0287 0	0 0 0.5964 0	0 0 0.6396 0
0 0 0 0	0.0079 0 0 0	0.7850 0 0 0	0.8237 4.8506 0 4.0042	0 -4.4280 0 -4.6641	0 -3.1745 0 -3.5163	0 0 0 0	0 0 0.0022 0	0 0 0.5831 0	0 0 0.5948 0
0 0 0 0	0.0064 0 0 0	0.7817 0 0 0	0.8028 5.7366 0 4.4725	0 -5.0378 0 -5.0952	0 -3.3851 0 -3.5156	0 0 0 0	0 0 -0.0194 0	0 0 0.5741 0	0 0 0.5482 0
0 0 0 0	0.0051 0 0 0	0.7796 0 0 0	0.7806 6.5275 0 4.8544	0 -5.5991 0 -5.4955	0 -3.5591 0 -5.4955	0 0 0 0	0 0 -0.0353 0	0 0 0.5690 0	0 0 0.5076 0
0 0 0 0	0.0041 0 0 0	0.7781 0 0 0	0.7552 7.3285 0 5.2227	0 -6.1889 0 -5.9291	0 -3.7169 0 -3.3776	0 0 0 0	0 0 -0.0486 0	0 0 0.5660 0	0 0 0.4683 0
0 0 0 0	0.0028 0 0 0	0.7760 0 0 0	0.7004 8.8772 0 5.9006	0 -7.4131 0 -6.8836	0 -3.9458 0 -3.0523	0 0 0 0	0 0 -0.0686 0	0 0 0.5642 0	0 0 0.3959 0

Kc2 is fixed at -0.05, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	NaN	NaN	1.61E-05		1 0 0 1	-0.2721 0.0969 -0.5303 0.3822	-0.0931 -0.0708 0.8902 -1.0261	-0.3659 0.2174 -0.2144 0.0695	-0.1379 -0.0777 -0.1416 -0.0642	-0.0232 -0.1282 0.0065 -0.1572
0.5	88.83	87.69	1.41E-05		1 0 0 1	-0.2540 0.0779 -0.4936 0.3451	-0.1155 -0.0499 0.8030 -0.9403	-0.4103 0.2610 -0.2142 0.0685	-0.1041 -0.1187 -0.1057 -0.1059	-0.0063 -0.1383 -0.0020 -0.1422
0.604	88.90	87.82	1.36E-05		1 0 0 1	-0.2374 0.0610 -0.4583 0.3095	-0.1328 -0.0343 0.7292 -0.8675	-0.4559 0.3063 -0.2192 0.0735	-0.0733 -0.1565 -0.0713 -0.1452	0.0098 -0.1489 -0.0130 -0.1268
0.7	88.96	87.92	1.46E-05		1 0 0 1	-0.2244 0.0482 -0.4306 0.2817	-0.1453 -0.0236 0.6748 -0.8140	-0.4965 0.3474 -0.2265 0.0812	-0.0465 -0.1891 -0.0418 -0.1782	0.0227 -0.1577 -0.0238 -0.1134
0.8	89.01	88.01	1.68E-05		1 0 0 1	-0.2131 0.0373 -0.4068 0.2577	-0.1560 -0.0150 0.6299 -0.7699	-0.5371 0.3889 -0.2364 0.0915	-0.0194 -0.2219 -0.0126 -0.2102	0.0339 -0.1657 -0.0354 -0.1000
1.0	89.11	88.16	2.42E-05		1 0 0 1	-0.1961 0.0241 -0.3703 0.2210	-0.1735 -0.0024 0.5659 -0.7084	-0.6124 0.4684 -0.2620 0.1182	0.0349 -0.2868 0.0443 -0.2708	0.0502 -0.1772 -0.0605 -0.0723

Kc2 is fixed at -0.05, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0090 0 0 0	0.7901 0 0 0	0.8400 3.9714 0 3.4627	0 -3.8356 0 -4.2321	0 -2.9560 0 -3.4480	0 0 0 0	0 0 0.0287 0	0 0 0.5964 0	0 0 0.6396 0
0 0 0 0	0.0079 0 0 0	0.7850 0 0 0	0.8237 4.8506 0 4.0042	0 -4.4280 0 -4.6641	0 -3.1745 0 -3.5163	0 0 0 0	0 0 0.0022 0	0 0 0.5831 0	0 0 0.5948 0
0 0 0 0	0.0064 0 0 0	0.7817 0 0 0	0.8028 5.7366 0 4.4725	0 -5.0378 0 -5.0952	0 -3.3851 0 -3.5156	0 0 0 0	0 0 -0.0194 0	0 0 0.5741 0	0 0 0.5482 0
0 0 0 0	0.0051 0 0 0	0.7796 0 0 0	0.7806 6.5275 0 4.8544	0 -5.5991 0 -5.4955	0 -3.5591 0 -5.4955	0 0 0 0	0 0 -0.0353 0	0 0 0.5690 0	0 0 0.5076 0
0 0 0 0	0.0041 0 0 0	0.7781 0 0 0	0.7552 7.3285 0 5.2227	0 -6.1889 0 -5.9291	0 -3.7169 0 -3.3776	0 0 0 0	0 0 -0.0486 0	0 0 0.5660 0	0 0 0.4683 0
0 0 0 0	0.0028 0 0 0	0.7760 0 0 0	0.7004 8.8772 0 5.9006	0 -7.4131 0 -6.8836	0 -3.9458 0 -3.0523	0 0 0 0	0 0 -0.0686 0	0 0 0.5642 0	0 0 0.3959 0

Kc2 is fixed at -0.07, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	88.81	88.35	2.34E-05		1 0 0 1	-0.2739 0.0912 -0.4362 0.2830	-0.1019 -0.0700 0.8198 -0.9625	-0.3383 0.1875 -0.2142 0.0686	-0.1562 -0.0599 -0.1553 -0.0522	-0.0101 -0.1295 0.0242 -0.1678
0.5	88.88	88.50	2.04E-05		1 0 0 1	-0.2563 0.0736 -0.4066 0.2530	-0.1250 -0.0479 0.7366 -0.8809	-0.3809 0.2294 -0.2118 0.0654	-0.1161 -0.1081 -0.1151 -0.0989	0.0016 -0.1339 0.0084 -0.1443
0.604	88.97	88.71	1.94E-05		1 0 0 1	-0.2391 0.0569 -0.3750 0.2208	-0.1426 -0.0316 0.6653 -0.8108	-0.4250 0.2733 -0.2158 0.0691	-0.0817 -0.1501 -0.0770 -0.1424	0.0144 -0.1409 -0.0096 -0.1206
0.7	88.98	88.71	2.05E-05		1 0 0 1	-0.2253 0.0440 -0.3491 0.1942	-0.1552 -0.0205 0.6129 -0.7594	-0.4644 0.3133 -0.2226 0.0759	-0.0530 -0.1852 -0.0448 -0.1783	0.0251 -0.1475 -0.0262 -0.1003
0.8	89.02	88.80	2.34E-05		1 0 0 1	-0.2131 0.0330 -0.3261 0.1706	-0.1658 -0.0115 0.5699 -0.7177	-0.5038 0.3539 -0.2319 0.0853	-0.0246 -0.2197 -0.0134 -0.2123	0.0347 -0.1539 -0.0432 -0.0804
1.0	89.11	88.93	3.37E-05		1 0 0 1	-0.1946 0.0168 -0.2905 0.1333	-0.1834 0.0014 0.5108 -0.6620	-0.5770 0.4319 -0.2564 0.1099	0.0306 -0.2862 0.0462 -0.2750	0.0487 -0.1636 -0.0771 -0.0414

Kc2 is fixed at -0.07, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0114 0 0 0	0.7898 0 0 0	0.7758 2.4825 0 2.0702	0 -2.9552 0 -3.4206	0 -2.2563 0 -2.7403	0 0 0 0	0 0 0.0410 0	0 0 0.6007 0	0 0 0.5852 0
0 0 0 0	0.0097 0 0 0	0.7846 0 0 0	0.7641 3.0507 0 2.3970	0 -3.3610 0 -3.7074	0 -2.3706 0 -2.7485	0 0 0 0	0 0 0.0094 0	0 0 0.5849 0	0 0 0.5438 0
0 0 0 0	0.0077 0 0 0	0.7813 0 0 0	0.7480 3.6348 0 2.6593	0 -3.7842 0 -3.9914	0 -2.4833 0 2.6935	0 0 0 0	0 0 -0.0165 0	0 0 0.5741 0	0 0 0.4980 0
0 0 0 0	0.0061 0 0 0	0.7793 0 0 0	0.7302 4.1638 0 2.8581	0 -4.1767 0 -4.2555	0 -2.5774 0 -2.6023	0 0 0 0	0 0 -0.0355 0	0 0 0.5681 0	0 0 0.4572 0
0 0 0 0	0.0048 0 0 0	0.7778 0 0 0	0.7091 4.7055 0 3.0393	0 -4.5907 0 -4.5432	0 -2.6631 0 -2.4729	0 0 0 0	0 0 -0.0514 0	0 0 0.5647 0	0 0 0.4171 0
0 0 0 0	0.0034 0 0 0	0.7758 0 0 0	0.6614 5.7665 0 3.3548	0 -5.4511 0 -5.1841	0 -2.7851 0 -2.1024	0 0 0 0	0 0 -0.0748 0	0 0 0.5631 0	0 0 0.3429 0

Kc2 is fixed at -0.09, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	88.84	89.02	3.07E-05		1 0 0 1	-0.2744 0.0843 -0.3413 0.1830	-0.1103 -0.0699 0.7463 -0.8959	-0.3125 0.1594 -0.2173 0.0714	-0.1730 -0.0426 -0.1633 -0.0453	0.0058 -0.1329 0.0374 -0.1741
0.5	88.93	89.18	2.70E-05		1 0 0 1	-0.2574 0.0683 -0.3182 0.1590	-0.1345 -0.0461 0.6671 -0.8186	-0.3519 0.1981 -0.2117 0.0649	-0.1271 -0.0975 -0.1200 -0.0957	0.0119 -0.1313 0.0156 -0.1432
0.604	88.93	89.20	2.59E-05		1 0 0 1	-0.2400 0.0523 -0.2902 0.1301	-0.1525 -0.0290 0.5987 -0.7519	-0.3934 0.2395 -0.2141 0.0666	-0.0893 -0.1437 -0.0788 -0.1424	0.0209 -0.1342 -0.0084 -0.1121
0.7	88.96	89.30	2.74E-05		1 0 0 1	-0.2256 0.0396 -0.2659 0.1045	-0.1653 -0.0174 0.5484 -0.7031	-0.4309 0.2776 -0.2199 0.0720	-0.0588 -0.1812 -0.0443 -0.1806	0.0292 -0.1383 -0.0300 -0.0855
0.8	88.98	89.37	3.13E-05		1 0 0 1	-0.2128 0.0287 -0.2438 0.0808	-0.1760 -0.0081 0.5079 -0.6640	-0.4684 0.3166 -0.2284 0.0800	-0.0293 -0.2173 -0.0109 -0.2164	0.0367 -0.1428 -0.0515 -0.0597
1.0	89.05	89.48	4.47E-05		1 0 0 1	-0.1932 9.9126 -0.2090 0.0427	-0.1934 0.0051 0.4542 -0.6148	-0.5385 0.3920 -0.2512 0.1017	0.0267 -0.2854 0.0512 -0.2806	0.0480 -0.1503 -0.0926 -0.0106

Kc2 is fixed at -0.09, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0134 0 0 0	0.7893 0 0 0	0.7140 1.6538 0 1.2966	0 -2.4699 0 -2.9613	0 -1.8564 0 -2.3044	0 0 0 0	0 0 0.0492 0	0 0 0.6029 0	0 0 0.5281 0
0 0 0 0	0.0110 0 0 0	0.7841 0 0 0	0.7036 2.0422 0 1.4998	0 -2.7701 0 -3.1677	0 -1.9138 0 -2.2810	0 0 0 0	0 0 0.0140 0	0 0 0.5851 0	0 0 0.4903 0
0 0 0 0	0.0085 0 0 0	0.7809 0 0 0	0.6911 2.4504 0 1.6448	0 -3.0881 0 -3.3704	0 -1.9720 0 -2.1969	0 0 0 0	0 0 -0.0151 0	0 0 0.5732 0	0 0 0.4457 0
0 0 0 0	0.0066 0 0 0	0.7789 0 0 0	0.6769 2.8268 0 1.7395	0 -3.3856 0 -3.5593	0 -2.0213 0 -2.0817	0 0 0 0	0 0 -0.0364 0	0 0 0.5667 0	0 0 0.4049 0
0 0 0 0	0.0052 0 0 0	0.7775 0 0 0	0.6595 3.2181 0 1.8139	0 -3.7010 0 -3.7668	0 -2.0665 0 -1.9309	0 0 0 0	0 0 -0.0541 0	0 0 0.5632 0	0 0 0.3641 0
0 0 0 0	0.0036 0 0 0	0.7756 0 0 0	0.6187 3.9982 0 1.9240	0 -4.3576 0 -4.2360	0 -2.1282 0 -1.5368	0 0 0 0	0 0 -0.0796 0	0 0 0.5623 0	0 0 0.2884 0

Kc2 is fixed at -0.127, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	88.91	89.66	4.07E-05		1 0 0 1	-0.2745 0.0729 -0.1764 0.0080	-0.1217 -0.0735 0.6136 -0.7767	-0.2680 0.1111 -0.2315 0.0860	-0.1976 -0.0154 -0.1658 -0.0437	0.0382 -0.1431 0.0521 -0.1769
0.5	88.91	89.91	3.70E-05		1 0 0 1	-0.2579 0.0590 -0.1568 -0.0130	-0.1501 -0.0449 0.5356 -0.7012	-0.2981 0.1403 -0.2176 0.0704	-0.1437 -0.0800 -0.1179 -0.0990	0.0344 -0.1309 0.0208 -0.1339
0.604	88.90	90.09	3.65E-05		1 0 0 1	-0.2402 0.0444 -0.1308 -0.0412	-0.1698 -0.0253 0.4702 -0.6380	-0.3321 0.1741 -0.2148 0.0659	-0.1007 -0.1326 -0.0721 -0.1503	0.0361 -0.1261 -0.0121 -0.0912
0.7	88.89	90.18	3.92E-05		1 0 0 1	-0.2253 0.0325 -0.1067 -0.0678	-0.1831 -0.0125 0.4235 -0.5933	-0.3637 0.2065 -0.2171 0.0666	-0.0673 -0.1740 -0.0337 -0.1919	0.0392 -0.1252 -0.0404 -0.0552
0.8	88.87	90.23	4.52E-05		1 0 0 1	-0.2118 0.0220 -0.0844 -0.0930	-0.1940 -0.0025 0.3875 -0.5594	-0.3960 0.2406 -0.2222 0.0701	-0.0360 -0.2127 0.0028 -0.2300	0.0427 -0.1258 -0.0676 -0.0210
1.0	88.84	90.22	6.48E-05		1 0 0 1	-0.1908 0.0064 -0.0512 -0.1323	-0.2116 0.0115 0.3464 -0.5237	-0.4572 0.3081 -0.2389 0.0837	0.0213 -0.2382 0.0685 -0.2960	0.0485 -0.1284 -0.1174 0.0413

Kc2 is fixed at -0.127, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0146 0 0 0	0.7880 0 0 0	0.5887 0.7816 0 0.5362	0 -1.9834 0 -2.4829	0 -1.4286 0 -1.7957	0 0 0 0	0 0 0.0561 0	0 0 0.6025 0	0 0 0.4245 0
0 0 0 0	0.0110 0 0 0	0.7832 0 0 0	0.5830 0.9776 0 0.5908	0 -2.1748 0 -2.6058	0 -1.4325 0 -1.7368	0 0 0 0	0 0 0.0164 0	0 0 0.5821 0	0 0 0.3888 0
0 0 0 0	0.0079 0 0 0	0.7802 0 0 0	0.5763 1.1950 0 0.5969	0 -2.3839 0 -2.7260	0 -1.4376 0 -1.6221	0 0 0 0	0 0 -0.0162 0	0 0 0.5691 0	0 0 0.3444 0
0 0 0 0	0.0059 0 0 0	0.7785 0 0 0	0.5679 1.4051 0 0.5698	0 -2.5832 0 -2,8404	0 -1.4426 0 -1.4839	0 0 0 0	0 0 -0.0396 0	0 0 0.5627 0	0 0 0.3025 0
0 0 0 0	0.0045 0 0 0	0.7772 0 0 0	0.5568 1.6327 0 0.5226	0 -2.7966 0 -2.9696	0 -1.4473 0 -1.3157	0 0 0 0	0 0 -0.0586 0	0 0 0.5598 0	0 0 0.2604 0
0 0 0 0	0.0032 0 0 0	0.7754 0 0 0	0.5281 2.1098 0 0.4126	0 -3.2432 0 -3.2735	0 -1.4485 0 -0.9155	0 0 0 0	0 0 -0.0853 0	0 0 0.5608 0	0 0 0.1832 0

Kc2 is fixed at -0.14, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	88.97	89.94	4.26E-05		1 0 0 1	-0.2750 0.0701 -0.1238 -0.0482	-0.1240 -0.0763 0.5701 -0.7380	-0.2540 0.0960 -0.2390 0.0936	-0.2040 -0.0079 -0.1635 -0.0459	0.0493 -0.1473 0.0550 -0.1758
0.5	88.96	90.24	3.91E-05		1 0 0 1	-0.2580 0.0565 -0.1017 -0.0720	-0.1545 -0.0454 0.4896 -0.6603	-0.2797 0.1206 -0.2213 0.0739	-0.1481 -0.0749 -0.1141 -0.1028	0.0424 -0.1318 0.0205 -0.1288
0.604	88.93	90.42	3.91E-05		1 0 0 1	-0.2402 0.0423 -0.0739 -0.1023	-0.1751 -0.0246 0.4238 -0.5968	-0.3102 0.1509 -0.2159 0.0664	-0.1037 -0.1293 -0.0666 -0.1556	0.0416 -0.1245 -0.0149 -0.0826
0.7	88.99	90.51	4.25E-05		1 0 0 1	-0.2551 0.0307 -0.0486 -0.1305	-0.1888 -0.0112 0.3778 -0.5528	-0.3391 0.1806 -0.2162 0.0647	-0.0694 -0.1718 -0.0271 -0.1981	0.0430 -0.1217 -0.0448 -0.0442
0.8	89.08	90.72	4.93E-05		1 0 0 1	-0.2115 0.0203 -0.0255 -0.1568	-0.1999 -0.0009 0.3436 -0.5208	-0.3689 0.2123 -0.2194 0.0660	-0.0376 -0.2112 0.0104 -0.2368	0.0452 -0.1210 -0.0733 -0.0081
1.0	88.72	90.45	7.10E-05		1 0 0 1	-0.1902 0.0049 0.0066 -0.1953	-0.2177 0.0135 0.3081 -0.4906	-0.4260 0.2761 -0.2330 0.0759	0.0199 -0.2824 0.0770 -0.3031	0.0491 -0.1218 -0.1249 0.0570

Kc2 is fixed at -0.14, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0140 0 0 0	0.7876 0 0 0	0.5428 0.5806 0 0.3757	0 -1.8761 0 -2.3732	0 -1.3277 0 -1.6667	0 0 0 0	0 0 0.0564 0	0 0 0.6014 0	0 0 0.3903 0
0 0 0 0	0.0101 0 0 0	0.7829 0 0 0	0.5386 0.7304 0 0.3883	0 -2.0431 0 -2.4765	0 -1.3208 0 -1.5974	0 0 0 0	0 0 0.0137 0	0 0 0.5803 0	0 0 0.3532 0
0 0 0 0	0.0071 0 0 0	0.7801 0 0 0	0.5336 0.9017 0 0.3547	0 -2.2274 0 -2.5784	0 -1.3150 0 -1.4751	0 0 0 0	0 0 -0.0174 0	0 0 0.5672 0	0 0 0.3076 0
0 0 0 0	0.0052 0 0 0	0.7784 0 0 0	0.5270 1.0715 0 0.2941	0 -2.4041 0 -2.6768	0 -1.3105 0 -1.3324	0 0 0 0	0 0 -0.0410 0	0 0 0.5610 0	0 0 0.2648 0
0 0 0 0	0.0039 0 0 0	0.7772 0 0 0	0.5179 1.2594 0 0.2153	0 -2.5942 0 -2.7898	0 -1.3064 0 -1.1625	0 0 0 0	0 0 -0.0599 0	0 0 0.5585 0	0 0 0.2220 0
0 0 0 0	0.0028 0 0 0	0.7754 0 0 0	0.4932 1.6633 0 0.0549	0 -2.9927 0 -0.30600	0 -1.2945 0 -0.7696	0 0 0 0	0 0 -0.0864 0	0 0 0.5602 0	0 0 0.1451 0

Kc2 is fixed at -0.16, I1 and I2 are set at 16.37 and 14.46 respectively

Kc1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	89.12	90.44	4.39E-05		1 0 0 1	-0.2765 0.0676 -0.0482 -0.1294	-0.1256 -0.0821 0.5066 -0.6820	-0.2353 0.0757 -0.2526 0.1075	-0.2116 0.0015 -0.1572 -0.0519	0.0652 -0.1539 0.0574 -0.1722
0.5	89.10	90.81	4.09E-05		1 0 0 1	-0.2588 0.0539 -0.0180 -0.1618	-0.1599 -0.0473 0.4190 -0.5973	-0.2532 0.0924 -0.2282 0.0803	-0.1533 -0.0683 -0.1051 -0.1113	0.0540 -0.1338 0.0183 -0.1192
0.604	89.03	91.02	4.18E-05		1 0 0 1	-0.2406 0.0401 0.0154 -0.1982	-0.1823 -0.0246 0.3509 -0.5316	-0.2774 0.1164 -0.2178 0.0671	-0.1071 -0.1250 -0.0551 -0.1662	0.0497 -0.1227 -0.0202 -0.0686
0.7	88.92	91.10	4.63E-05		1 0 0 1	-0.2253 0.0286 0.0438 -0.2298	-0.1968 -0.0100 0.3059 -0.4886	-0.3013 0.1412 -0.2143 0.0611	-0.0718 -0.1689 -0.0137 -0.2101	0.0487 -0.1172 -0.0521 -0.0274
0.8	88.79	91.08	5.45E-05		1 0 0 1	-0.2114 0.0184 0.0679 -0.2572	-0.2084 0.0011 0.2749 -0.4596	-0.3267 0.1685 -0.2141 0.0585	-0.0394 -0.2093 0.0249 -0.2496	0.0489 -0.1145 -0.0818 0.0105
1.0	88.49	90.86	7.94E-05		1 0 0 1	-0.1895 0.0032 0.0967 -0.2923	-0.2267 0.0163 0.2499 -0.4392	-0.3766 0.2257 -0.2220 0.0625	0.0183 -0.2813 0.0922 -0.3160	0.0501 -0.1127 -0.1352 0.0775

Kc2 is fixed at -0.16, I1 and I2 are set at 16.37 and 14.46 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0120 0 0 0	0.7871 0 0 0	0.4731 0.3395 0 0.1885	0 -1.7476 0 -0.2383	0 -1.2022 0 -1.4986	0 0 0 0	0 0 0.0550 0	0 0 0.5989 0	0 0 0.3402 0
0 0 0 0	0.0082 0 0 0	0.7828 0 0 0	0.4704 0.4306 0 0.1410	0 -1.8849 0 -2.3171	0 -1.1831 0 -1.4138	0 0 0 0	0 0 0.0135 0	0 0 0.5768	0 0 0.2984 0
0 0 0 0	0.0054 0 0 0	0.7802 0 0 0	0.4675 0.5432 0 0.0510	0 -2.0386 0 -2.3971	0 -1.1644 0 -1.2814	0 0 0 0	0 0 -0.0197 0	0 0 0.5639 0	0 0 0.2494 0
0 0 0 0	0.0037 0 0 0	0.7786 0 0 0	0.4631 0.6610 0 -0.0555	0 -2.1875 0 -2.4772	0 -1.1486 0 -1.1349	0 0 0 0	0 0 -0.0429 0	0 0 0.5583 0	0 0 0.2047 0
0 0 0 0	0.0027 0 0 0	0.7774 0 0 0	0.4567 0.7977 0 -0.1744	0 -2.3486 0 -2.5721	0 -1.1341 0 -0.9666	0 0 0 0	0 0 -0.0614 0	0 0 0.5565 0	0 0 0.1614 0
0 0 0 0	0.0021 0 0 0	0.7756 0 0 0	0.4378 1.1087 0 -0.3908	0 -2.6880 0 -2.8047	0 -1.1070 0 -0.5931	0 0 0 0	0 0 -0.0871 0	0 0 0.5590 0	0 0 0.0864 0

I2 is fixed at 14.46, Kc1 and Kc2 are set at 0.604 and -0.127 respectively

I1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
6.37	89.90	90.89	3.64E-05		1 0 0 1	-0.2543 0.0523 -0.1379 -0.0416	-0.1683 -0.0339 0.4387 -0.6143	-0.3647 0.1992 -0.2231 0.0687	-0.1107 -0.1235 -0.0707 -0.1517	0.0377 -0.1157 -0.0139 -0.0733
11.37	89.41	90.42	3.74E-05		1 0 0 1	-0.2442 0.0458 -0.1518 -0.0227	-0.1702 -0.0276 0.4754 -0.6458	-0.3524 0.1918 -0.2211 0.0704	-0.1045 -0.1297 -0.0746 -0.1482	0.0365 -0.1231 -0.0111 -0.0875
16.37	88.90	90.09	3.65E-05		1 0 0 1	-0.2402 0.0444 -0.1308 -0.0412	-0.1698 -0.0253 0.4702 -0.6380	-0.3321 0.1741 -0.2148 0.0659	-0.1007 -0.1326 -0.0721 -0.1503	0.0361 -0.1261 -0.0121 -0.0912
21.37	88.65	89.95	3.56E-05		1 0 0 1	-0.2378 0.0442 -0.1009 -0.0692	-0.1692 -0.0239 0.4551 -0.6211	-0.3103 0.1542 -0.2067 0.0591	-0.0981 -0.1342 -0.0689 -0.1529	0.0362 -0.1279 -0.0118 -0.0938
26.37	88.49	89.87	3.52E-05		1 0 0 1	-0.2361 0.0443 -0.0691 -0.0994	-0.1687 -0.0227 0.4374 -0.6018	-0.2891 0.1345 -0.1979 0.0516	-0.0963 -0.1349 -0.0659 -0.1552	0.0369 -0.1292 -0.0104 -0.0965

I2 is fixed at 14.46, Kc1 and Kc2 are set at 0.604 and -0.127 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0074 0 0 0	0.8142 0 0 0	0.6113 1.4047 0 0.6457	0 -2.2535 0 -2.6131	0 -1.4016 0 -1.5815	0 0 0 0	0 0 -0.0225 0	0 0 0.5843 0	0 0 0.3433 0
0 0 0 0	0.0081 0 0 0	0.7897 0 0 0	0.6055 1.3423 0 0.6807	0 -2.3499 0 -2.6972	0 -1.4315 0 -1.6268	0 0 0 0	0 0 -0.0174 0	0 0 0.5741 0	0 0 0.3567 0
0 0 0 0	0.0079 0 0 0	0.7802 0 0 0	0.5763 1.1950 0 0.5969	0 -2.3839 0 -2.7260	0 -1.4376 0 -1.6221	0 0 0 0	0 0 -0.0162 0	0 0 0.5691 0	0 0 0.3444 0
0 0 0 0	0.0077 0 0 0	0.7751 0 0 0	0.5428 1.0319 0 0.4851	0 -2.3977 0 -2.7414	0 -1.4371 0 -1.6122	0 0 0 0	0 0 -0.0146 0	0 0 0.5668 0	0 0 0.3272 0
0 0 0 0	0.0076 0 0 0	0.7720 0 0 0	0.5099 0.8725 0 0.3684	0 -2.4028 0 -2.7520	0 -1.4346 0 -1.6031	0 0 0 0	0 0 -0.0123 0	0 0 0.5658 0	0 0 0.3094 0

I1 is fixed at 16.37, Kc1 and Kc2 are set at 0.604 and -0.127 respectively

I2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
4.46	89.01	91.82	5.63E-05		1 0 0 1	-0.2717 0.1024 0.0486 -0.2122	-0.1121 -0.0597 0.3026 -0.4533	-0.4244 0.2832 -0.2377 0.0954	-0.0315 -0.1922 0.0079 -0.2174	-0.0202 -0.1302 -0.1353 -0.0179
9.46	88.43	90.37	1.68E-05		1 0 0 1	-0.2457 0.0759 0.1425 -0.3021	-0.1494 -0.0231 0.2791 -0.4332	-0.1473 0.0076 -0.1600 0.0209	-0.0800 -0.1394 -0.0314 -0.1821	0.0425 -0.1524 -0.0313 -0.0875
14.46	88.90	90.09	3.65E-05		1 0 0 1	-0.2402 0.0444 -0.1308 -0.0412	-0.1698 -0.0253 0.4702 -0.6380	-0.3321 0.1741 -0.2148 0.0659	-0.1007 -0.1326 -0.0721 -0.1503	0.0361 -0.1261 -0.0121 -0.0912
19.46	89.09	89.87	3.60E-05		1 0 0 1	-0.2436 0.0440 -0.1864 0.0111	-0.1688 -0.0296 0.5042 -0.6750	-0.3690 0.2082 -0.2295 0.0776	-0.1025 -0.1326 -0.0790 -0.1448	0.0309 -0.1201 -0.0151 -0.0855
24.46	89.13	89.70	3.54E-05		1 0 0 1	-0.2452 0.0443 -0.2043 0.0278	-0.1680 -0.0313 0.5147 -0.6866	-0.3795 0.2177 -0.2343 0.0813	-0.1035 -0.1322 -0.0817 -0.1425	0.0291 -0.1181 -0.0160 -0.0834

I1 is fixed at 16.37, Kc1 and Kc2 are set at 0.604 and -0.127 respectively

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	-0.0039 0 0 0	0.7795 0 0 0	0.6202 1.5421 0 -0.0317	0 -2.7865 0 -2.6552	0 -1.3629 0 -1.0481	0 0 0 0	0 0 -0.1016 0	0 0 0.5254 0	0 0 0.1805 0
0 0 0 0	0.0019 0 0 0	0.7805 0 0 0	0.2640 -0.2594 0 -0.3942	0 -2.4259 0 -2.7306	0 -1.4317 0 -1.4234	0 0 0 0	0 0 -0.0260 0	0 0 0.5598 0	0 0 0.1711 0
0 0 0 0	0.0079 0 0 0	0.7802 0 0 0	0.5763 1.1950 0 0.5969	0 -2.3839 0 -2.7260	0 -1.4376 0 -1.6221	0 0 0 0	0 0 -0.0162 0	0 0 0.5691 0	0 0 0.3444 0
0 0 0 0	0.0082 0 0 0	0.7800 0 0 0	0.6314 1.4699 0 0.7974	0 -2.3484 0 -2.6843	0 -1.4204 0 -1.6244	0 0 0 0	0 0 -0.0196 0	0 0 0.5680 0	0 0 0.3755 0
0 0 0 0	0.0082 0 0 0	0.7799 0 0 0	0.6467 1.5487 0 0.8620	0 -2.3258 0 -2.6608	0 -1.4110 0 -1.6209	0 0 0 0	0 0 -0.0208 0	0 0 0.5675 0	0 0 0.3852 0

Kc2 and I2 are in open loop, and I1 is set at 16.37

Kc1	I1	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
0.4	16.37	90.62	94.99	3.31E-05		1 0 0 1	-0.3318 0.1184 -0.2522 0.0559	-0.0996 -0.1086 0.6227 -0.8082	-0.2622 -0.0064 -0.1939 -0.0562	-0.1833 0.0920 -0.1650 0.0796	0.0105 -0.0383 0.0300 -0.0717
0.5	16.37	90.28	94.92	2.57E-05		1 0 0 1	-0.3032 0.0929 -0.2250 0.0296	-0.1308 -0.0749 0.5500 -0.7353	-0.2983 -0.0074 -0.1767 -0.0826	-0.1422 0.0666 -0.1293 0.0540	0.0133 -0.0288 0.0138 -0.0479
0.604	16.37	89.97	94.85	2.22E-05		1 0 0 1	-0.2774 0.0697 -0.2093 0.0152	-0.1522 -0.0520 0.5033 -0.6881	-0.3416 -0.0074 -0.1711 -0.0986	-0.1091 0.0521 -0.0966 0.0347	0.0219 -0.0238 -0.0004 -0.0306
0.7	16.37	89.71	94.80	2.12E-05		1 0 0 1	-0.2577 0.0523 -0.2038 0.0111	-0.1663 -0.0373 0.4775 -0.6617	-0.3828 -0.0070 -0.1719 -0.1095	-0.0818 0.0435 -0.0695 0.0225	0.0308 -0.0208 -0.0115 -0.0192
0.8	16.37	89.45	94.74	2.14E-05		1 0 0 1	-0.2411 0.0378 -0.2037 0.0124	-0.1774 -0.0261 0.4614 -0.6451	-0.4255 -0.0066 -0.1768 -0.1191	-0.0545 0.0373 -0.0428 0.0140	0.0395 -0.0183 -0.0217 -0.0103
1.0	16.37	88.98	97.79	2.33E-05		1 0 0 1	-0.2164 0.0172 -0.2095 0.0209	-0.1938 -0.0108 0.4458 -0.6295	-0.5075 -0.0068 -0.1956 -0.1330	0.0002 0.0297 0.0101 0.0048	0.0533 -0.0144 -0.0425 0.0029

Kc2 and I2 are in open loop, and I1 is set at 16.37

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	0.0011 0 0 0	0.7915 0 0 0	0.5572 0.8236 0 0.6952	0 -1.9317 0 -2.3693	0 -1.4353 0 -1.8487	0 0 0 0	0 0 0.0550 0	0 0 0.5979 0	0 0 0.4295 0
0 0 0 0	0.0021 0 0 0	0.7864 0 0 0	0.5844 1.1231 0 0.7646	0 -2.1368 0 -2.4988	0 -1.4796 0 -1.8517	0 0 0 0	0 0 0.0207 0	0 0 0.5840 0	0 0 0.3995 0
0 0 0 0	0.0022 0 0 0	0.7829 0 0 0	0.6052 1.4715 0 0.8477	0 -2.3609 0 -2.6434	0 -1.5348 0 -1.8435	0 0 0 0	0 0 -0.0046 0	0 0 0.5766 0	0 0 0.3713 0
0 0 0 0	0.0020 0 0 0	0.7807 0 0 0	0.6142 1.8009 0 0.9451	0 -2.5734 0 -2.7897	0 -1.5863 0 -1.8338	0 0 0 0	0 0 -0.0217 0	0 0 0.5737 0	0 0 0.3491 0
0 0 0 0	0.0017 0 0 0	0.7790 0 0 0	0.6148 2.1434 0 1.0672	0 -2.8007 0 -2.9569	0 -1.6361 0 -1.8212	0 0 0 0	0 0 -0.0351 0	0 0 0.5729 0	0 0 0.3284 0
0 0 0 0	0.0013 0 0 0	0.7766 0 0 0	0.5978 2.8183 0 1.3475	0 -3.2819 0 -3.3414	0 -1.7111 0 -3.3414	0 0 0 0	0 0 -0.0545 0	0 0 0.5745 0	0 0 0.2875 0

Kc1 and I1 are in open loop, and I2 is set at 14.46

Kc2	I2	Y1	Y2	FPE		A0	A1	A2	A3	A4	A5
-0.03	14.46	NaN	NaN	1.46E-05		1 0 0 1	-0.2253 0.0478 -0.8138 0.6626	-0.1285 -0.0323 1.3110 -1.4500	-0.1661 0.3808 -0.1688 0.3923	-0.3125 -0.1399 -0.2895 -0.1538	-0.0348 -0.2157 -0.0312 -0.2214
-0.05	14.46	NaN	NaN	1.42E-05		1 0 0 1	-0.2482 0.0673 -0.7393 0.5832	-0.1222 -0.0428 1.2399 -1.3847	-0.1740 0.3384 -0.1803 0.3689	-0.3074 -0.1369 -0.2914 -0.1540	-0.0326 -0.1970 -0.0188 -0.2164
-0.07	14.46	NaN	NaN	1.49E-05		1 0 0 1	-0.2691 0.0832 -0.6689 0.5065	-0.1176 -0.0534 1.1714 -1.3237	-0.1846 0.2979 -0.1953 0.3499	-0.3011 -0.1344 -0.2897 -0.1521	-0.0274 -0.1791 -0.0043 -0.2094
-0.09	14.46	NaN	NaN	1.67E-05		1 0 0 1	-0.2882 0.0959 -0.6030 0.4330	-0.1143 -0.0640 1.1056 -1.2670	-0.1977 0.2610 -0.2137 0.3355	-0.2931 -0.1328 -0.2844 -0.1541	-0.0196 -0.1620 0.0121 -0.2007
-0.127	14.46	NaN	NaN	2.23E-05		1 0 0 1	-0.3184 0.1122 -0.4960 0.3107	-0.1103 -0.0838 0.9945 -1.1750	-0.2271 0.2063 -0.2545 0.3208	-0.2751 -0.1325 -0.2673 -0.1615	0.0003 -0.1339 0.0462 -0.1839
-0.14	14.46	NaN	NaN	2.46E-05		1 0 0 1	-0.3275 0.1162 -0.4641 0.2736	-0.1092 -0.0906 0.9603 -1.1475	-0.2386 -0.1920 -0.2700 0.3192	-0.2681 -0.1332 -0.2601 -0.1647	0.0084 -0.1256 0.0589 -0.1790
-0.16	14.46	NaN	NaN	2.86E-05		1 0 0 1	-0.3400 0.1209 -0.4216 0.2238	-0.1077 -0.1011 0.9142 -1.1111	-0.2569 0.1749 -0.2942 0.3204	-0.2572 -0.1348 -0.2493 -0.1696	0.0216 -0.1146 0.0790 -0.1737

Kc1 and I1 are in open loop, and I2 is set at 14.46

B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
0 0 0 0	1e-003 * 0.1870 0 0 0	0.7817 0 0 0	1.1674 13.1799 0 12.9352	0 -9.3917 0 -9.8495	0 -7.0303 0 7.6024	0 0 0 0	0 0 0.0558 0	0 0 0.6115 0	0 0 0.9180 0
0 0 0 0	1e-003 * 0.5179 0 0 0	0.7820 0 0 0	1.0663 6.8976 0 7.0660	0 -5.8550 0 -6.4406	0 -4.3150 0 -4.9993	0 0 0 0	0 0 0.0669 0	0 0 0.6136 0	0 0 0.8716 0
0 0 0 0	0.0012 0 0 0	0.7824 0 0 0	0.9663 4.2013 0 4.5756	0 -4.3405 0 -4.9712	0 -3.1287 0 -3.8221	0 0 0 0	0 0 0.0762 0	0 0 0.6152 0	0 0 0.8276 0
0 0 0 0	0.0022 0 0 0	0.7827 0 0 0	0.8701 2.7200 0 3.2132	0 -3.5010 0 -4.1467	0 -2.4523 0 -3.1191	0 0 0 0	0 0 0.0830 0	0 0 0.6158 0	0 0 0.7858 0
0 0 0 0	0.0052 0 0 0	0.7830 0 0 0	0.7180 1.2821 0 1.8760	0 -2.6526 0 -3.2928	0 -1.7378 0 -2.3257	0 0 0 0	0 0 0.0886 0	0 0 0.6141 0	0 0 0.7167 0
0 0 0 0	0.0065 0 0 0	0.7829 0 0 0	0.6623 0.9849 0 1.5928	0 -2.4640 0 -3.0979	0 -1.5724 0 -2.1324	0 0 0 0	0 0 0.0886 0	0 0 0.6127 0	0 0 0.6957 0
0 0 0 0	0.0084 0 0 0	0.7826 0 0 0	0.5959 0.6496 0 1.2673	0 -2.2371 0 -2.8601	0 -1.3696 0 -1.8919	0 0 0 0	0 0 0.0873 0	0 0 0.6102 0	0 0 0.6676 0

APPENDIX B

4.2 Effect of the Proportional controller on the closed loop system identification when both loops are closed

4.2.1 First Section – Different constant of Kc1 with varying value of Kc2

Kc1 is fixed at 0.5, I1 and I2 are fixed at 999999999

Kc2	Y1	Y2	FPE (1e-05)
-0.03	86.91	83.31	1.43
-0.05	87.22	84.76	1.59
-0.07	87.17	85.49	1.85
-0.09	87.32	86.23	2.20
-0.127	87.54	87.28	3.10
-0.14	87.62	87.62	3.50

Kc1 is fixed at 0.604, I1 and I2 are fixed at 999999999

Kc2	Y1	Y2	FPE (1e-05)
-0.03	87.03	83.46	2.05
-0.05	87.31	84.89	2.30
-0.07	87.51	85.91	2.68
-0.09	87.67	86.70	3.20
-0.127	87.93	87.89	4.54
-0.14	88.02	88.30	5.14

Kc1 is fixed at 0.7, I1 and I2 are fixed at 999999999

Kc2	Y1	Y2	FPE (1e-05)
-0.03	87.29	83.76	2.72
-0.05	87.54	85.13	3.05
-0.07	87.74	86.14	3.59
-0.09	87.90	86.95	4.35
-0.127	88.17	88.22	6.31
-0.14	88.52	88.88	7.18

Kc1 is fixed at 0.8, I1 and I2 are fixed at 999999999

Kc2	Y1	Y2	FPE (1e-05)
-0.03	87.68	84.24	3.50
-0.05	87.70	85.25	3.90
-0.07	88.03	86.40	4.71
-0.09	88.16	87.16	5.80

-0.127	88.25	88.24	8.68
-0.14	88.35	88.68	9.97

Kc1 is fixed at 1.0, I1 and I2 are fixed at 999999999

Kc2	Y1	Y2	FPE (1e-05)
-0.03	87.73	84.07	5.21
-0.05	87.82	85.13	6.02
-0.07	87.86	85.87	7.49
-0.09	87.88	86.45	9.63
-0.127	87.90	87.39	15.40
-0.14	87.91	87.75	17.99

4.2.2 Second Section - Kc2 will be held constant with different value of Kc1

Kc2 is fixed at -0.05, I1 and I2 are fixed at 999999999

Kc1	Y1	Y2	FPE (1e-05)
0.4	86.48	83.97	1.01
0.5	86.95	84.49	1.59
0.604	87.31	84.89	2.30
0.7	87.54	85.13	3.05
0.8	87.70	85.25	3.95
1.0	87.82	85.13	6.02

Kc2 is fixed at -0.07, I1 and I2 are fixed at 999999999

Kc1	Y1	Y2	FPE (1e-05)
0.4	86.72	84.98	1.19
0.5	87.17	85.49	1.85
0.604	87.51	85.91	2.68
0.7	87.95	86.38	3.59
0.8	87.87	86.21	4.71
1.0	87.86	85.87	7.49

Kc2 is fixed at -0.09, I1 and I2 are fixed at 999999999

Kc1	Y1	Y2	FPE (1e-05)
0.4	86.87	85.67	1.43
0.5	87.32	86.23	2.20
0.604	87.67	86.70	3.20
0.7	87.90	86.95	4.35
0.8	88.01	86.98	5.80

1.0	87.89	86.48	9.63

Kc2 is fixed at -0.127, I1 and I2 are fixed at 999999999

Kc1	**Y1**	**Y2**	**FPE (1e-05)**
0.4	87.07	86.55	2.07
0.5	87.54	87.28	3.10
0.604	87.93	87.89	4.54
0.7	88.17	88.22	6.31
0.8	88.25	88.24	8.68
1.0	87.90	87.39	15.40

Kc2 is fixed at -0.14, I1 and I2 are fixed at 999999999

Kc1	**Y1**	**Y2**	**FPE (1e-05)**
0.4	87.15	86.83	2.36
0.5	87.62	87.62	3.50
0.604	88.02	88.30	5.14
0.7	88.27	88.66	7.18
0.8	88.35	88.68	9.97
1.0	87.91	87.75	18.00

Kc2 is fixed at -0.16, I1 and I2 are fixed at 999999999

Kc1	**Y1**	**Y2**	**FPE (1e-05)**
0.4	87.28	87.27	2.87
0.5	87.77	88.18	4.21
0.604	88.19	88.95	6.19
0.7	88.45	89.37	8.72
0.8	88.70	89.59	12.24
1.0	87.95	88.38	22.59

4.3 Effect of the Proportional-Integral controller on the closed loop system identification when both loops are closed

4.3.1 First Section - Kc1 will be kept as a constant with different value of Kc2

Kc1 is fixed at 0.5, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc2	Y1	Y2	FPE (1e-05)
-0.03	NaN	NaN	0.95
-0.05	88.83	87.69	1.41
-0.07	88.88	88.50	2.04
-0.09	88.93	89.18	2.70
-0.127	88.91	89.91	3.70
-0.14	88.96	90.24	3.91
-0.16	89.10	90.81	4.09

Kc1 is fixed at 0.604, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc2	Y1	Y2	FPE (1e-05)
-0.03	88.79	86.51	0.97
-0.05	88.90	87.82	1.36
-0.07	88.97	88.71	1.94
-0.09	88.93	89.20	2.59
-0.127	88.90	90.09	3.65
-0.14	88.93	90.42	3.91
-0.16	89.03	91.02	4.18

Kc1 is fixed at 0.7, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc2	Y1	Y2	FPE (1e-05)
-0.03	88.87	87.65	1.07
-0.05	88.96	87.92	1.46
-0.07	88.98	88.71	2.05
-0.09	88.96	89.30	2.74
-0.127	88.89	90.18	3.92
-0.14	88.99	90.51	4.25
-0.16	88.92	91.10	4.63

Kc1 is fixed at 0.8, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc2	Y1	Y2	FPE (1e-05)
-0.03	88.93	86.76	1.24
-0.05	89.01	88.01	1.68
-0.07	89.02	88.80	2.34
-0.09	88.98	89.37	3.13
-0.127	88.87	90.23	4.52
-0.14	89.08	90.72	4.93
-0.16	88.79	91.08	5.45

Kc1 is fixed at 1.0, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc2	Y1	Y2	FPE (1e-05)
-0.03	89.06	86.97	1.75
-0.05	89.11	88.16	2.42
-0.07	89.11	88.93	3.37
-0.09	89.05	89.48	4.47
-0.127	88.84	90.22	6.48
-0.14	88.72	90.45	7.10
-0.16	88.49	90.86	7.94

4.3.2 Second Section - Kc2 will be held constant with different value of Kc1

Kc2 is fixed at -0.05, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	NaN	NaN	1.61
0.5	88.83	87.69	1.41
0.604	88.90	87.82	1.36
0.7	88.96	87.92	1.46
0.8	89.01	88.01	1.68
1.0	89.11	88.16	2.42

Kc2 is fixed at -0.07, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	88.81	88.35	2.34
0.5	88.88	88.50	2.04
0.604	88.97	88.71	1.94
0.7	88.98	88.71	2.05
0.8	89.02	88.80	2.34
1.0	89.11	88.93	3.37

Kc2 is fixed at -0.09, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	88.84	89.02	3.07
0.5	88.93	89.18	2.70
0.604	88.93	89.20	2.59
0.7	88.96	89.30	2.74
0.8	88.98	89.37	3.13
1.0	89.05	89.48	4.47

Kc2 is fixed at -0.127, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	88.91	89.66	4.07
0.5	88.91	89.91	3.70
0.604	88.90	90.09	3.65
0.7	88.89	90.18	3.92
0.8	88.87	90.23	4.52
1.0	88.84	90.22	6.48

Kc2 is fixed at -0.14, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	88.97	89.94	4.26
0.5	88.96	90.24	3.91
0.604	88.93	90.42	3.91
0.7	88.99	90.51	4.25
0.8	89.08	90.72	4.93
1.0	88.72	90.45	7.10

Kc2 is fixed at -0.16, I1 is fixed at 16.37 and I2 is fixed at 14.46

Kc1	Y1	Y2	FPE (1e-05)
0.4	89.12	90.44	4.39
0.5	89.10	90.81	4.09
0.604	89.03	91.02	4.18
0.7	88.92	91.10	4.63
0.8	88.79	91.08	5.45
1.0	88.49	90.86	7.94