TABLE III
GRDG FOR NOMINAL MODEL OF THE DL COLUMN

Controller Structure	GRDG
Diagonal	$[1.0000 \quad 0.4101 \quad 1.1284]^T$
bd [(1,2),3]	$[1.0000 \quad 0.8284 \quad 1.1284]^T$
bd [(1,3),2]	$[1.0000 \quad 0.4101 \quad 0.3434]^T$
bd [(2,3),1]	$[1.0000 \quad 0.5817 \quad 1.7849]^T$
Full	$[1.0000 \quad 1.0000 \quad 1.0000]^T$

TABLE IV
GRDG FOR UNCERTAIN SYSTEM OF DL COLUMN (α =0.01)

Controller Structure	GRDG
Diagonal	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.3695 \le \delta_2 \le 0.4488 \\ 1.0215 \le \delta_3 \le 1.2324 \end{bmatrix}$
bd [(1,2),3]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.7714 \le \delta_2 \le 0.8842 \\ 1.0215 \le \delta_3 \le 1.2324 \end{bmatrix}$
bd [(1,3),2]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.3695 \le \delta_2 \le 0.4488 \\ 0.2045 \le \delta_3 \le 0.4782 \end{bmatrix}$
bd [(2,3),1]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.5188 \le \delta_2 \le 0.6439 \\ 1.5899 \le \delta_3 \le 1.9803 \end{bmatrix}$
Full	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.9207 \le \delta_2 \le 1.0793 \\ 0.7729 \le \delta_3 \le 1.2261 \end{bmatrix}$

TABLE V
GRDG FOR UNCERTAIN SYSTEM OF DL COLUMN (α =0.1)

Controller Structure	GRDG
Diagonal	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ -0.1101 \le \delta_2 \le 0.7390 \\ -0.1254 \le \delta_3 \le 2.2611 \end{bmatrix}$
bd [(1,2),3]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.1699 \le \delta_2 \le 1.3639 \\ -0.1254 \le \delta_3 \le 2.2611 \end{bmatrix}$
bd [(1,3),2]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ -0.1101 \le \delta_2 \le 0.7390 \\ -1.2980 \le \delta_3 \le 1.7356 \end{bmatrix}$
bd [(2,3),1]	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ -0.1292 \le \delta_2 \le 1.2242 \\ -0.3017 \le \delta_3 \le 4.0287 \end{bmatrix}$
Full	$\begin{bmatrix} 1 \le \delta_1 \le 1 \\ 0.1508 \le \delta_2 \le 1.8491 \\ -1.4743 \le \delta_3 \le 3.5032 \end{bmatrix}$

For α =0.01 (Table IV), it is obvious that block diagonal controller bd[(1,3),2] will be recommended. As the value of α increased to 0.1 (Table V), the control structure bd[(1,3),2] may not be the best choice. Its performance may not be as good as that of the diagonal control structure as indicated in Table V.

The two examples clearly show that further extensions of traditional steady state process analysis techniques (i.e. sensitivity analysis of RGA and RDGA to gain uncertainties) are required for selecting robust decentralized control structure based on uncertain process models. The proposed method gives more accurate results that the previous methods reported in the literature.

V. CONCLUSIONS

A new and accurate method for determining RGA and RDGA ranges for uncertain systems is presented in this paper. It is shown through examples that the propose method is easy to use and gives more accurate results than the previous methods reported in the literature. Extension to the analysis for dynamic RGA and RDGA uncertainty bounds is open for future work.

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