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梅森公式在多回路控制系统中的应用

崔 平 远[1)]

(哈尔滨工业大学)

直观回路是指系统方块图中显而易见的只穿过被控对象一次的回路. 如图 1，它只有两个直观回路：$\delta_1 \to X_2(s) \to A \to \delta_1$ 和 $\delta_2 \to X_1(s) \to B \to \delta_2$.

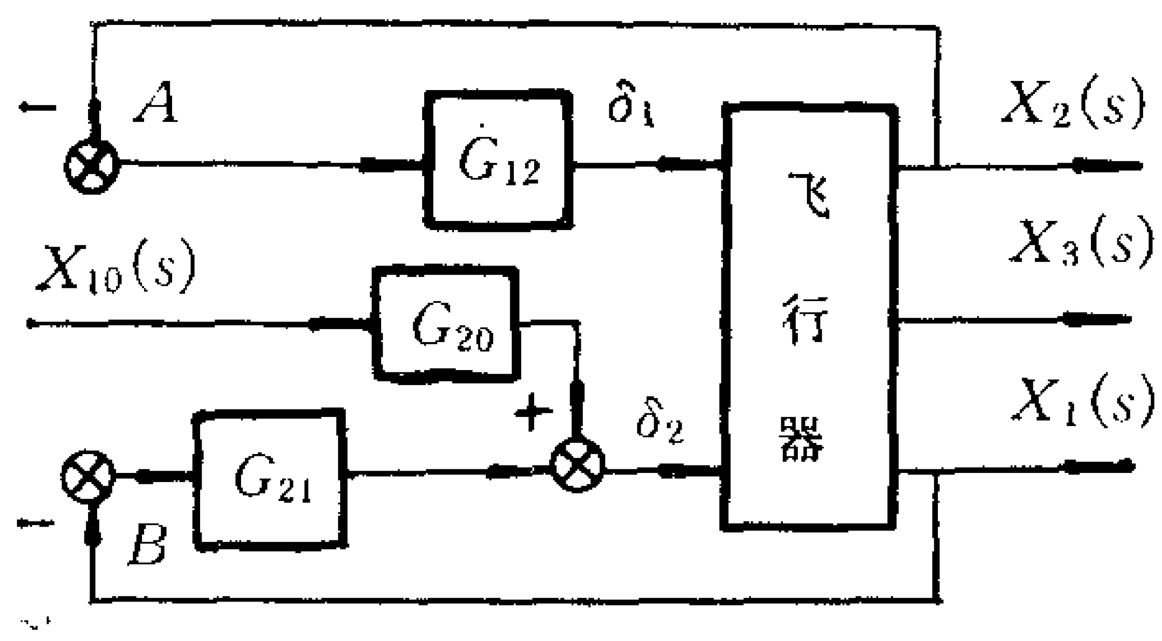

图 1

设已知图 1 中飞行器的开环传递函数为

$$\begin{bmatrix} a_{11}(s) & a_{12}(s) & a_{13}(s) \\ a_{21}(s) & a_{22}(s) & a_{23}(s) \\ a_{31}(s) & a_{32}(s) & a_{33}(s) \end{bmatrix} \begin{bmatrix} X_1(s) \\ X_2(s) \\ X_3(s) \end{bmatrix} = \begin{bmatrix} b_{11}(s) & b_{12}(s) \\ b_{21}(s) & b_{22}(s) \\ b_{31}(s) & b_{32}(s) \end{bmatrix} \begin{bmatrix} \delta_1(s) \\ \\ \delta_2(s) \end{bmatrix}. \tag{1}$$

根据 (1) 式，省掉 s 后有：

$$W_{\delta_1}^{X_1}(s) = X_1(s)/\delta_1(s) = \begin{vmatrix} b_{11} & a_{12} & a_{13} \\ b_{21} & a_{22} & a_{23} \\ b_{31} & a_{32} & a_{33} \end{vmatrix} \Bigg/ \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix}. \tag{2}$$

其中 $W_{\delta_1}^{X_1}(s)$ 是由 δ_1 到 X_1 的开环传递函数. 令上式的分母为△，(2)式可写成

$$W_{\delta_1}^{X_1}(s) = X_1(s)/\delta_1(s) = N_{\delta_1}^{X_1}/\Delta.$$

同理有 $W_{\delta_1}^{X_2} = X_2(s)/\delta_1(s) = N_{\delta_1}^{X_2}/\Delta$，$W_{\delta_1}^{X_3} = X_3(s)/\delta_1(s) = N_{\delta_1}^{X_3}/\Delta$，$W_{\delta_2}^{X_1} = X_1(s)/\delta_2(s) = N_{\delta_2}^{X_1}/\Delta$，$W_{\delta_2}^{X_2} = X_2(s)/\delta_2(s) = N_{\delta_2}^{X_2}/\Delta$，$W_{\delta_2}^{X_3} = X_3(s)/\delta_2(s) = N_{\delta_2}^{X_3}/\Delta$. 其中 $N_{\delta_i}^{X_j}$ 是用 (1) 式中右端 [δ] 的系数行列式中的第 j 列置换△中第 i 列后的行列式.

根据图 1 中的直观回路用梅森公式求出 $X_1(s)$ 与 $X_{10}(s)$ 间的示意传递函数为：

$$\frac{X_1(s)}{X_{10}(s)} \to \frac{(1 + G_{12}N_{\delta_1}^{X_2}/\Delta)G_{20}N_{\delta_2}^{X_1}/\Delta}{1 + G_{21}N_{\delta_2}^{X_1}/\Delta + G_{12}N_{\delta_1}^{X_2} + G_{21}N_{\delta_2}^{X_1}G_{12}N_{\delta_1}^{X_2}/\Delta^2}$$
$$= \frac{G_{20}(N_{\delta_2}^{X_1} + G_{12}N_{\delta_2}^{X_1}N_{\delta_1}^{X_2}/\Delta)}{\Delta + G_{21}N_{\delta_2}^{X_1} + G_{12}N_{\delta_1}^{X_2} + G_{21}G_{12}N_{\delta_2}^{X_1}N_{\delta_1}^{X_2}/\Delta}. \tag{3}$$

把 (3) 式中 $N_{\delta_j}^{X_i}\cdots N_{\delta_m}^{X_k}/\Delta^{n-1}$ 改写为 $N_{\delta_i}^{X_i}\cdots{}_{\delta_m}^{X_k}$ 后就得到实际的传递函数(其中 n 是 $N_{\delta_\delta}^{X_i}$ 连乘的个数).

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1) 本文的作者系在校大学生.

$$\frac{X_1(s)}{X_{10}(s)}=\frac{G_{20}(N_{\delta_2}^{X_1}+G_{12}N_{\delta_2\delta_1}^{X_1X_2})}{\Delta+G_{21}N_{\delta_2}^{X_1}+G_{12}N_{\delta_1}^{X_2}+G_{21}G_{12}N_{\delta_2\delta_1}^{X_1X_2}}.$$

其中 $N_{\delta_2\delta_1}^{X_1X_2}$ 是用 [δ] 的系数行列式中的第 2 列和第 1 列分别置换Δ中的第 1 列和第 2 行后的行列式.

AN APPLICATION OF MASSON FORMULA IN MULTILOOP CONTROL SYSTEM

Cui Pingyuan

(*Harbin Institute of technology*)

1985 年 IFAC 的部分会议

Title	1985	Place
7 th IFAC/IFORS Symposium Identification and System Parameter Estimation	July 3—7	York, UK
IFAC Symposium Automation for Mineral Resource Development	July 9—11	Brisbane, AUS
IFAC Symposium Planning and Operation of Electric Energy Systems	July 22—25	Rio de Janeiro, BR
3rd IFAC/IFIP Symposium Computer Aided Design in Control and Engineenng Systems	July 31— Aug. 2	Copenhagen, DK
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2nd IMACS/IFAC/WGMA Tntl. Symposium Systems Analysis and Simulation	Aug. 26—31 1985	Berlin, GDR
2nd IFAC/IFIP/IFORS/IEA Conterence Analysis, Design and Evaluation of Man-Machine Systems	Sept. 10—12	Varese, I
7th IFAC/IFIP/IMACS Symposium Digital Computer Application to Process Control	Sept. 17—20	Vienna, A
4th IFAC Workshop Safety of Computer Control Systems (SAFECOMP 85)	Oct. 1—3 1985	Como, I
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