

$$\begin{bmatrix} \left[\frac{\partial R_k}{\partial \ddot{q}_k} + \gamma h \frac{\partial R_k}{\partial \dot{q}_k} + \beta h^2 \frac{\partial R_k}{\partial q_k} \right] & \gamma h & \beta h^2 \\ -1 & & \\ & & -1 \end{bmatrix} \begin{bmatrix} \left[(1-\gamma)h \frac{\partial R_{k+1}}{\partial \dot{q}_{k+1}} + \frac{1-2\beta}{2} h^2 \frac{\partial R_{k+1}}{\partial q_{k+1}} \right] & (1-\gamma)h & \frac{1-2\beta}{2} h^2 \\ \left[\frac{\partial R_{k+1}}{\partial \dot{q}_{k+1}} + h \frac{\partial R_{k+1}}{\partial q_{k+1}} \right] & 1 & h \\ \left[\frac{\partial R_{k+1}}{\partial q_{k+1}} \right] & & 1 \end{bmatrix} \\ \left[\frac{\partial R_{k+1}}{\partial \ddot{q}_{k+1}} + \gamma h \frac{\partial R_{k+1}}{\partial \dot{q}_{k+1}} + \beta h^2 \frac{\partial R_{k+1}}{\partial q_{k+1}} \right] & \gamma h & \beta h^2 \\ & -1 & \\ & & -1 \end{bmatrix} \begin{bmatrix} \left[(1-\gamma)h \frac{\partial R_{k+2}}{\partial \dot{q}_{k+2}} + \frac{1-2\beta}{2} h^2 \frac{\partial R_{k+2}}{\partial q_{k+2}} \right] & (1-\gamma)h & \frac{1-2\beta}{2} h^2 \\ \left[\frac{\partial R_{k+2}}{\partial \dot{q}_{k+2}} + h \frac{\partial R_{k+2}}{\partial q_{k+2}} \right] & 1 & h \\ \left[\frac{\partial R_{k+2}}{\partial q_{k+2}} \right] & & 1 \end{bmatrix} \\ \left[\frac{\partial R_{k+2}}{\partial \ddot{q}_{k+2}} + \gamma h \frac{\partial R_{k+2}}{\partial \dot{q}_{k+2}} + \beta h^2 \frac{\partial R_{k+2}}{\partial q_{k+2}} \right] & \gamma h & \beta h^2 \\ & -1 & \\ & & -1 \end{bmatrix} \begin{bmatrix} \rho_k \\ \sigma_k \\ \tau_k \\ \rho_{k+1} \\ \sigma_{k+1} \\ \tau_{k+1} \\ \rho_{k+2} \\ \sigma_{k+2} \\ \tau_{k+2} \end{bmatrix} = - \begin{bmatrix} \left[\frac{\partial f_k}{\partial \ddot{q}_k} + \gamma h \frac{\partial f_k}{\partial \dot{q}_k} + \beta h^2 \frac{\partial f_k}{\partial q_k} \right] \\ \left[\frac{\partial f_k}{\partial \dot{q}_k} + h \frac{\partial f_k}{\partial q_k} \right] \\ \left[\frac{\partial f_k}{\partial q_k} \right] \\ \left[\frac{\partial f_{k+1}}{\partial \ddot{q}_{k+1}} + \gamma h \frac{\partial f_{k+1}}{\partial \dot{q}_{k+1}} + \beta h^2 \frac{\partial f_{k+1}}{\partial q_{k+1}} \right] \\ \left[\frac{\partial f_{k+1}}{\partial \dot{q}_{k+1}} + h \frac{\partial f_{k+1}}{\partial q_{k+1}} \right] \\ \left[\frac{\partial f_{k+2}}{\partial q_{k+2}} \right] \\ \left[\frac{\partial R_{k+2}}{\partial \ddot{q}_{k+2}} + \gamma h \frac{\partial R_{k+2}}{\partial \dot{q}_{k+2}} + \beta h^2 \frac{\partial R_{k+2}}{\partial q_{k+2}} \right] \\ \left[\frac{\partial f_{k+2}}{\partial \dot{q}_{k+2}} + h \frac{\partial f_{k+2}}{\partial q_{k+2}} \right] \\ \left[\frac{\partial f_{k+2}}{\partial q_{k+2}} \right] \end{bmatrix}$$