By substituting integrals (10), (11) and (12) into equations (3), (4) and (5), we get the approximation formulas of displacements, velocities and accelerations of system at time t_{n+1}

$$\ddot{\boldsymbol{q}}_{n+1} = \ddot{\boldsymbol{q}}_n + (1-\alpha)\, h\dddot{\boldsymbol{q}}_n + \alpha h \dddot{\boldsymbol{q}}_{n+1}, \tag{14}$$

$$\dot{\boldsymbol{q}}_{n+1} = \dot{\boldsymbol{q}}_n + h\ddot{\boldsymbol{q}}_n + \left(\frac{1}{2} - \gamma\right) h^2 \dddot{\boldsymbol{q}}_n + \gamma h^2 \dddot{\boldsymbol{q}}_{n+1}, \tag{15}$$

$$\boldsymbol{q}_{n+1} = \boldsymbol{q}_n + h\dot{\boldsymbol{q}}_n + \frac{h^2}{2}\ddot{\boldsymbol{q}}_n + \left(\frac{1}{6} - \beta\right) h^3 \dddot{\boldsymbol{q}}_n + \beta h^3 \dddot{\boldsymbol{q}}_{n+1}. \tag{16}$$

Thus, we have established the approximation formulas (14), (15), (16) to approach solving the system of third order differential equations.

Let us then assume that the equations of dynamics

$$\boldsymbol{M}\dddot{\boldsymbol{q}} + \boldsymbol{B}\ddot{\boldsymbol{q}} + \boldsymbol{C}\dot{\boldsymbol{q}} + \boldsymbol{K}\boldsymbol{q} = \boldsymbol{f}\,(t)\,, \tag{17}$$

are linear, i.e., that matrices $\boldsymbol{M}, \boldsymbol{B}, \boldsymbol{C}$ and $\boldsymbol{K}$ are independent of $\boldsymbol{q}$, and let us introduce the numerical scheme (14), (15) and (16) in the equations of motion at time t_{n+1} so as to compute $\dddot{\boldsymbol{q}}_{n+1}$

$$\begin{aligned}&\left[\boldsymbol{M} + \alpha h\boldsymbol{B} + \gamma h^2\boldsymbol{C} + \beta h^3\boldsymbol{K}\right]\dddot{\boldsymbol{q}}_{n+1} = \boldsymbol{f}_{n+1} - \boldsymbol{B}\left[\ddot{\boldsymbol{q}}_n + (1-\alpha)\, h\dddot{\boldsymbol{q}}_n\right] \\ &- \boldsymbol{C}\left[\dot{\boldsymbol{q}}_n + h\ddot{\boldsymbol{q}}_n + \left(\frac{1}{2} - \gamma\right) h^2\dddot{\boldsymbol{q}}_n\right] - \boldsymbol{K}\left[\boldsymbol{q}_n + h\dot{\boldsymbol{q}}_n + \frac{h^2}{2}\ddot{\boldsymbol{q}}_n + \left(\frac{1}{6} - \beta\right) h^3\dddot{\boldsymbol{q}}_n\right].\end{aligned} \tag{18}$$

By solving the system of linear equations (18) we obtain $\dddot{\boldsymbol{q}}_{n+1}$. Then, by using Newmark formulas (14), (15) and (16) we get accelerations, velocities and displacements $\ddot{\boldsymbol{q}}_{n+1}, \dot{\boldsymbol{q}}_{n+1}$ and $\boldsymbol{q}_{n+1}$. We determine the initial conditions of $\dddot{\boldsymbol{q}}\,(t_0)$ from the given values of $\boldsymbol{q}\,(t_0)$, $\dot{\boldsymbol{q}}\,(t_0)$ and $\ddot{\boldsymbol{q}}\,(t_0)$

$$\dddot{\boldsymbol{q}}\,(t_0) = \boldsymbol{M}^{-1}\left[\boldsymbol{f}\,(t_0) - \boldsymbol{B}\ddot{\boldsymbol{q}}\,(t_0) - \boldsymbol{C}\dot{\boldsymbol{q}}\,(t_0) - \boldsymbol{K}\boldsymbol{q}\,(t_0)\right]. \tag{19}$$