$$\frac{d\underline{M}}{dt} = -\gamma\left(\underline{B} \times \underline{M}\right) - \frac{\underline{M} - \underline{M}_0}{T}$$

$$\frac{d}{dt}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = -\gamma \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 0 & B_0 \\ M_x & M_y & M_z \end{vmatrix} - \begin{pmatrix} M_x - 0 \\ M_y - 0 \\ M_z - M_0 \end{pmatrix} \frac{1}{T}$$

since, here, $\underline{B} = \begin{pmatrix} 0 \\ 0 \\ B_0 \end{pmatrix}$, $\underline{M}_0 = \begin{pmatrix} 0 \\ 0 \\ M_0 \end{pmatrix}$

$$\frac{d}{dt}\begin{pmatrix} M_x \\ M_z \\ M_y \end{pmatrix} = -\gamma \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 0 & B_0 \\ M_x & M_y & M_z \end{vmatrix} - \begin{pmatrix} M_x \\ M_y \\ M_z - M_0 \end{pmatrix} \frac{1}{T}$$

$$\frac{dM_x}{dt} = -\gamma\left(0(M_z) - B_0 M_y\right) - \frac{M_x}{T} = +\gamma B_0 M_y - \frac{M_x}{T}$$

$$\frac{dM_y}{dt} = - -\gamma\left(0(M_z) - B_0 M_x\right) - \frac{M_y}{T} = -\gamma B_0 M_x - \frac{M_y}{T}$$

$$\frac{dM_z}{dt} = -\gamma\left(0(M_y) - 0(M_x)\right) - \frac{M_z - M_0}{T} = -\frac{M_z - M_0}{T}$$

In matrix form:

$$\cancel{\frac{dM_x}{dt}} \quad \frac{d}{dt}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = \begin{pmatrix} -\frac{1}{T} & \gamma B_0 & 0 \\ -\gamma B_0 & -\frac{1}{T} & 0 \\ 0 & 0 & -\frac{1}{T} \end{pmatrix} \begin{pmatrix} M_x \\ M_z \\ M_y \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ \frac{M_0}{T} \end{pmatrix}$$

as used in report.

$$\frac{d\underline{M}}{dt} = -\gamma(\underline{B} \times \underline{M}) - \frac{\underline{M} - \underline{M_0}}{T}$$

$$\frac{d}{dt}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = -\gamma \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ B_1\cos\omega t & -B_1\sin\omega t & B_0 \\ M_x & M_y & M_z \end{vmatrix} - \begin{pmatrix} M_x - 0 \\ M_y - 0 \\ M_z - M_0 \end{pmatrix}\frac{1}{T}$$

since here, $\underline{B} = \begin{pmatrix} B_1\cos\omega t \\ -B_1\sin\omega t \\ B_0 \end{pmatrix}$ and $\underline{M_0} = \begin{pmatrix} 0 \\ 0 \\ M_0 \end{pmatrix}$

$$\frac{d}{dt}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = -\gamma \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ B_1\cos\omega t & -B_1\sin\omega t & B_0 \\ M_x & M_y & M_z \end{vmatrix} - \begin{pmatrix} M_x \\ M_y \\ M_z - M_0 \end{pmatrix}\frac{1}{T}$$

$$\frac{dM_x}{dt} = -\gamma\left(-B_1\sin\omega t(M_z) - B_0(M_y)\right) - \frac{M_x}{T}$$

$$\frac{dM_y}{dt} = +\gamma\left(B_1\cos\omega t(M_z) - \overset{B_0(M_x))}{\cancel{(B_1\sin\omega t(M_x))}}\right) - \frac{M_y}{T}$$

$$\frac{dM_z}{dt} = -\gamma\left(B_1\cos\omega t(M_y) + B_1\sin\omega t(M_x)\right) - \frac{M_z - M_0}{T}$$

$$\frac{dM_x}{dt} = +\gamma B_1\sin\omega t\, M_z + \gamma B_0 M_y - \frac{M_x}{T}$$

$$\frac{dM_y}{dt} = \gamma B_1\cos\omega t\, M_z - \gamma B_0 M_x - \frac{M_y}{T}$$

$$\frac{dM_z}{dt} = -\gamma B_1\cos\omega t\, M_y + B_1\sin\omega t\, M_x - \frac{M_z}{T} + \frac{M_0}{T}$$

in matrix form:

$$\frac{d}{dt}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} = \begin{pmatrix} -\frac{1}{T} & \gamma B_0 & \gamma B_1\sin\omega t \\ -\gamma B_0 & -\frac{1}{T} & \gamma B_1\cos\omega t \\ \gamma B_1\sin\omega t & -\gamma B_1\cos\omega t & -\frac{1}{T} \end{pmatrix}\begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ \frac{M_0}{T} \end{pmatrix}$$

as used in report.

switch to rotating axes from non-rotating axes:

$$\hat{i}' = \hat{i}\cos\omega t - \hat{j}\sin\omega t, \quad \hat{j}' = \hat{j}\cos\omega t + \hat{i}\sin\omega t.$$
$$\hat{k}' = \hat{k}$$

Thus
$$M_x' = M_x\cos\omega t - M_y\sin\omega t$$
$$M_y' = M_y\cos\omega t + M_x\sin\omega t$$

$$\frac{dM_x'}{dt} = \frac{dM_x}{dt}\cos\omega t - M_x\omega\sin\omega t - \frac{dM_y}{dt}\sin\omega t - M_y\omega\cos\omega t$$

$$= \frac{dM_x}{dt}\cos\omega t - \frac{dM_y}{dt}\sin\omega t - \underbrace{\omega(M_x\sin\omega t + M_y\cos\omega t)}_{-\omega M_y'}$$

↓ from prev.

$$= \left(\gamma B_1\sin\omega t\, M_z + \gamma B_0 M_y - \frac{M_x}{T}\right)\cos\omega t - \left(-\gamma B_0 M_x + \gamma B_1 M_z\cos\omega t - \frac{M_y}{T}\right)\sin\omega t - \omega M_y'$$

$$= \gamma B_1 M_z\sin\omega t\cos\omega t - \gamma B_1 M_z\sin\omega t\cos\omega t + \gamma B_0(M_y\cos\omega t + M_x\sin\omega t) - \frac{1}{T}(M_x\cos\omega t - M_y\sin\omega t)$$

$$= 0 + \gamma B_0 M_y' - \frac{1}{T}M_x' - \omega M_y'$$

$$= \cancel{(\gamma B_0 - \tfrac{1}{T})M_y \;\omega t} \quad \boxed{(\gamma B_0 - \omega)M_y' - \frac{1}{T}M_x'} = \frac{dM_x'}{dt}$$

and similarly,

$$\frac{dM_y'}{dt} = \frac{dM_y}{dt}\cos\omega t - \omega M_y\sin\omega t + \frac{dM_x}{dt}\sin\omega t + \omega M_x\cos\omega t$$

$$= \frac{dM_y}{dt}\cos\omega t + \frac{dM_x}{dt}\sin\omega t + \omega M_x'$$

↓

$$= \left(-\gamma B_0 M_x + \gamma B_1 M_z\cos\omega t - \frac{M_y}{T}\right)\cos\omega t + \left(\gamma B_1\sin\omega t\, M_z + \gamma B_0 M_y - \frac{M_x}{T}\right)\sin\omega t + \omega M_x'$$

$$= -\gamma B_0(M_x\cos\omega t - M_y\sin\omega t) + \gamma B_1 M_z(\cos^2\omega t + \sin^2\omega t) - \frac{1}{T}(M_y\cos\omega t + M_x\sin\omega t) + \omega M_x'$$

$$= -\gamma B_0 M_x' + \gamma B_1 M_z - \frac{1}{T}(M_y') + \omega M_x'$$

$$= \boxed{(-\gamma B_0 + \omega)M_x' + \gamma B_1 M_z - \frac{1}{T}M_y'} = \frac{dM_y'}{dt}$$