The axial force of this CMNSM is divided into three parts for calculation, and specific expressions are listed below. According to Eqs. (1)–(11), the axial force of the top moving magnet is presented as

$$
\begin{aligned}
F_z^{\mathrm{u}}(z) &= \sum_{u_z}^{N_\mathrm{c}}\sum_{t_z}^{N_\mathrm{c}} 2\pi r_1 I_{1\mathrm{u}}\left(I_{4\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{2t}, r_6, z_{1u}\right)+I_{3\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{2t}, r_5, z_{1u}\right)\right)\\
&+\sum_{u_z}^{N_\mathrm{c}}\sum_{t_z}^{N_\mathrm{c}} 2\pi r_2 I_{2\mathrm{u}}\left(I_{4\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{2t}, r_6, z_{1u}\right)+I_{3\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{2t}, r_5, z_{1u}\right)\right)\\
&+\sum_{t_z}^{N_\mathrm{c}}\sum_{n_z}^{N_\mathrm{s}} 2\pi r_1 I_{1\mathrm{u}}\left(Q_{\mathrm{s}3}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{2t}, r_3, z_{3n}\right)+Q_{\mathrm{s}4}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{2t}, r_4, z_{3n}\right)\right)\\
&+\sum_{t_z}^{N_\mathrm{c}}\sum_{n_z}^{N_\mathrm{s}} 2\pi r_2 I_{2\mathrm{u}}\left(Q_{\mathrm{s}3}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{2t}, r_3, z_{3n}\right)+Q_{\mathrm{s}4}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{2t}, r_4, z_{3n}\right)\right)\\
&+\sum_{t_z}^{N_\mathrm{c}}\sum_{k_r}^{N_\mathrm{v}}\sum_{j_z}^{N_\mathrm{v}} 2\pi r_1 I_{1\mathrm{u}} Q_{\mathrm{v}2}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{2t}, r_{\mathrm{v}k}, z_{\mathrm{v}j}\right)+\sum_{t_z}^{N_\mathrm{c}}\sum_{k_r}^{N_\mathrm{v}}\sum_{j_z}^{N_\mathrm{v}} 2\pi r_2 I_{2\mathrm{u}} Q_{\mathrm{v}2}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{2t}, r_{\mathrm{v}k}, z_{\mathrm{v}j}\right)\\
&+\sum_{w_z}^{N_\mathrm{c}}\sum_{t_z}^{N_\mathrm{c}} 2\pi r_1 I_{1\mathrm{u}}\left(I_{4\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{2t}, r_6, z_{6w}\right)+I_{3\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{2t}, r_5, z_{6w}\right)\right)\\
&+\sum_{w_z}^{N_\mathrm{c}}\sum_{t_z}^{N_\mathrm{c}} 2\pi r_2 I_{2\mathrm{u}}\left(I_{4\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{2t}, r_6, z_{6w}\right)+I_{3\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{2t}, r_5, z_{6w}\right)\right).
\end{aligned}
\tag{S1}
$$

By the same principle, the axial force of lower moving magnet can be calculated as

$$
\begin{aligned}
F_z^{\mathrm{l}}(z) &= \sum_{u_z}^{N_\mathrm{c}}\sum_{q_z}^{N_\mathrm{c}} 2\pi r_1 I_{1\mathrm{b}}\left(I_{4\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{5\mathrm{q}}, r_6, z_{1\mathrm{u}}\right)+I_{3\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{5\mathrm{q}}, r_5, z_{1\mathrm{u}}\right)\right)\\
&+\sum_{u_z}^{N_\mathrm{c}}\sum_{q_z}^{N_\mathrm{c}} 2\pi r_2 I_{2\mathrm{b}}\left(I_{4\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{5\mathrm{q}}, r_6, z_{1\mathrm{u}}\right)+I_{3\mathrm{u}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{5\mathrm{q}}, r_5, z_{1\mathrm{u}}\right)\right)\\
&+\sum_{q_z}^{N_\mathrm{c}}\sum_{n_z}^{N_\mathrm{s}} 2\pi r_1 I_{1\mathrm{b}}\left(Q_{\mathrm{s}3}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{5\mathrm{q}}, r_3, z_{3n}\right)+Q_{\mathrm{s}4}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{5\mathrm{q}}, r_4, z_{3n}\right)\right)\\
&+\sum_{q_z}^{N_\mathrm{c}}\sum_{n_z}^{N_\mathrm{s}} 2\pi r_2 I_{2\mathrm{b}}\left(Q_{\mathrm{s}3}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{5\mathrm{q}}, r_3, z_{3n}\right)+Q_{\mathrm{s}4}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{5\mathrm{q}}, r_4, z_{3n}\right)\right)\\
&+\sum_{q_z}^{N_\mathrm{c}}\sum_{k_r}^{N_\mathrm{v}}\sum_{j_z}^{N_\mathrm{v}} 2\pi r_1 I_{1\mathrm{b}} Q_{\mathrm{v}2}P_\mathrm{r}^\mathrm{q}\left(r_1, z+z_{5\mathrm{q}}, r_{vk}, z_{\mathrm{v}j}\right)+\sum_{q_z}^{N_\mathrm{c}}\sum_{k_r}^{N_\mathrm{v}}\sum_{j_z}^{N_\mathrm{v}} 2\pi r_2 I_{2\mathrm{b}} Q_{\mathrm{v}2}P_\mathrm{r}^\mathrm{q}\left(r_2, z+z_{5\mathrm{q}}, r_{\mathrm{v}\mathrm{k}}, z_{\mathrm{v}\mathrm{j}}\right)\\
&+\sum_{w_z}^{N_\mathrm{c}}\sum_{q_z}^{N_\mathrm{c}} 2\pi r_1 I_{1\mathrm{b}}\left(I_{4\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{5\mathrm{q}}, r_6, z_{6w}\right)+I_{3\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_1, z+z_{5\mathrm{q}}, r_5, z_{6w}\right)\right)\\
&+\sum_{w_z}^{N_\mathrm{c}}\sum_{q_z}^{N_\mathrm{c}} 2\pi r_2 I_{2\mathrm{b}}\left(I_{4\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{5\mathrm{q}}, r_6, z_{6w}\right)+I_{3\mathrm{b}}P_\mathrm{r}^\mathrm{c}\left(r_2, z+z_{5\mathrm{q}}, r_5, z_{6w}\right)\right).
\end{aligned}
\tag{S2}
$$

Similarly, the axial force of the middle moving magnet is

$$
\begin{aligned}
F_{\mathrm{z}}^{\mathrm{m}}(z) &= \sum_{i_z}^{N_{\mathrm{s}}}\sum_{u_z}^{N_{\mathrm{c}}} Q_{\mathrm{s1}}\left(I_{4\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_1, z+z_{4i}, r_6, z_{1u}\right) + I_{3\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_1, z+z_i, r_5, z_{1u}\right)\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{u_z}^{N_{\mathrm{c}}} Q_{\mathrm{s2}}\left(I_{4\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_2, z+z_{4i}, r_6, z_{1u}\right) + I_{3\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_2, z+z_{4i}, r_5, z_{1u}\right)\right) \\
&+ \sum_{p_r}^{N_{\mathrm{v}}}\sum_{m_z}^{N_{\mathrm{v}}}\sum_{u_z}^{N_{\mathrm{c}}} Q_{\mathrm{v1}}\left(I_{4\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_{vp}, z+z_{vm}, r_6, z_{1u}\right) + I_{3\mathrm{u}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_{vp}, z+z_{vm}, r_5, z_{1u}\right)\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{n_z}^{N_{\mathrm{s}}} Q_{\mathrm{s1}}\left(Q_{\mathrm{s3}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_1, z+z_{4i}, r_3, z_{3n}\right) + Q_{\mathrm{s4}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_1, z+z_{4i}, r_4, z_{3n}\right)\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{n_z}^{N_{\mathrm{s}}} Q_{\mathrm{s2}}\left(Q_{\mathrm{s3}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_2, z+z_{4i}, r_3, z_{3n}\right) + Q_{\mathrm{s4}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_2, z+z_{4i}, r_4, z_{3n}\right)\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{j_z}^{N_{\mathrm{v}}}\sum_{k_r}^{N_{\mathrm{v}}} \left(Q_{\mathrm{s1}}+Q_{\mathrm{s2}}\right) Q_{\mathrm{v2}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_1, z+z_{4i}, r_{vk}, z_{vj}\right) \\
&+ \sum_{p_r}^{N_{\mathrm{v}}}\sum_{m_z}^{N_{\mathrm{v}}}\sum_{n_z}^{N_{\mathrm{s}}} Q_{\mathrm{v1}}\left(Q_{\mathrm{s3}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_{vp}, z+z_{vm}, r_3, z_{3n}\right) + Q_{\mathrm{s4}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_{vp}, z+z_{vm}, r_4, z_{3n}\right)\right) \\
&+ \sum_{j_z}^{N_{\mathrm{v}}}\sum_{k_r}^{N_{\mathrm{v}}}\sum_{m_z}^{N_{\mathrm{v}}}\sum_{p_r}^{N_{\mathrm{v}}} Q_{\mathrm{v1}}Q_{\mathrm{v2}}P_{\mathrm{z}}^{\mathrm{q}}\left(r_{vp}, z+z_{vm}, r_{vk}, z_{vj}\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{w_z}^{N_{\mathrm{c}}} Q_{\mathrm{s1}}\left(I_{4\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_1, z+z_{4i}, r_6, z_{6w}\right) + I_{3\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_1, z+z_{4i}, r_5, z_{6w}\right)\right) \\
&+ \sum_{i_z}^{N_{\mathrm{s}}}\sum_{w_z}^{N_{\mathrm{c}}} Q_{\mathrm{s2}}\left(I_{4\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_2, z+z_{4i}, r_6, z_{6w}\right) + I_{3\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_2, z+z_{4i}, r_5, z_{6w}\right)\right) \\
&+ \sum_{p_r}^{N_{\mathrm{v}}}\sum_{m_z}^{N_{\mathrm{v}}}\sum_{w_z}^{N_{\mathrm{c}}} Q_{\mathrm{v1}}\left(I_{4\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_{vp}, z+z_{vm}, r_6, z_{6w}\right) + I_{3\mathrm{b}}P_{\mathrm{z}}^{\mathrm{c}}\left(r_{vp}, z+z_{vm}, r_5, z_{6w}\right)\right)
\end{aligned} \tag{S3}
$$

In Eqs. (S1)–(S3), $z$ represents the axial displacement of the moving magnet, which is equal to 0 when the CMNSM is at the equilibrium position.