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# Type the Title of the Paper Here Theoretical analysis of resonant type on tolerance and frequency selectivity against FOD

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This paper discusses theoretical analysis of the foreign object detection (FOD) problem under the resonant type wireless power transfer system (WPT). With aid of resonant circuits, the resonant WPT systems enable high efficient power transfer even in small coupling coefficient systems. The resonant circuits also exhibit sensitive frequency selectivity characterized by the Q factor. To solve the above FOD problem, this paper constructs based on the 3 x 3 Z matrix the hybrid model (Fig. 2.1) coexisting both the resonant circuits (transmitter and receiver) and the non-resonant circuit (foreign object) .

$$\begin{pmatrix} E \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} & Z_{13} \\ Z_{21} & Z_{22} & Z_{23} \\ Z_{31} & Z_{32} & Z_{33} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} \qquad (2.1)$$

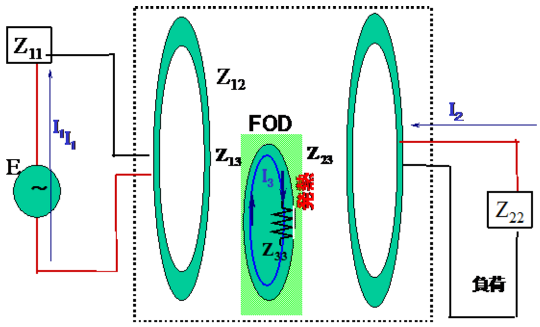


Fig 2.1 Z-matrix model

When the transmitter and the receiver are in the resonant state, the total impedance can be simplified as this:

$$Z \fallingdotseq \left\{ Z_{11} - \frac{Z_{21}^2}{Z_{22}} \right\} Fo \qquad (2.20)$$

where Fo is the FOD factor defind as this:

$$Fo = 1 - \frac{Z_{31}^2 / Z_{11} Z_{33}}{1 - \dfrac{Z_{21}^2}{Z_{22} Z_{11}}} - \frac{(Z_{12}^2 / Z_{11} Z_{22})}{1 - \dfrac{Z_{12}^2}{Z_{22} Z_{11}}} \left( \frac{Z_{32}^2}{Z_{22} Z_{33}} \right) \qquad (2.21)$$

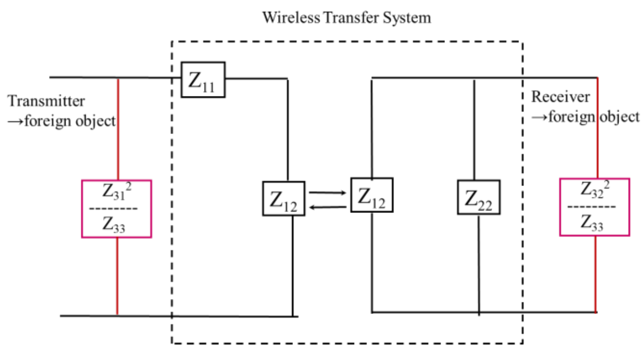


Fig 2.2 Equivalent Circuit for FOD

From the above results, the equivalent circuit of the foreign object can be modeled as a parallel circuit illustrated as Fig .2.2.

Therefore, the consumption energy of the forging object can be approximated as this:

$$R_1 I_3 I_3^* = \frac{Q_3}{1+Q_3^2} (k_{31}^2 R_1 Q_1 I_1 I_1^* + k_{32}^2 R_2 Q_2 I_2 I_2^*) \quad (3.3).$$

For large resonance frequency, the FOD factor asymputotes as this:

$$Fo \rightarrow 1 \quad (2.23).$$

This result shows that with the frequency selectivity the energy transfer concentrates between the transmitter and the receiver and that the energy transfer to the foreign object is very small comparing with that of the receiver. Based on this energy distribution, the consumption energy of the forging object can be approximated as this:

$$R_3 I_3 I_3^* \fallingdotseq \frac{Q_3}{1+Q_3^2} \left\{ k_{31}^2 Q_1 \left( \frac{k_{12}^2 Q_1 Q_2}{1+ k_{12}^2 Q_1 Q_2} \right)^2 + k_{32}^2 Q_2 \frac{k_{12}^2 Q_1 Q_2}{1+k_{12}^2 Q_1 Q_2} \right\} \frac{V^2}{R_1} \qquad (3.5)$$

This results shows that the heat effects on the foreign objects become negligible small for high resonance frequency (more than MHz order)