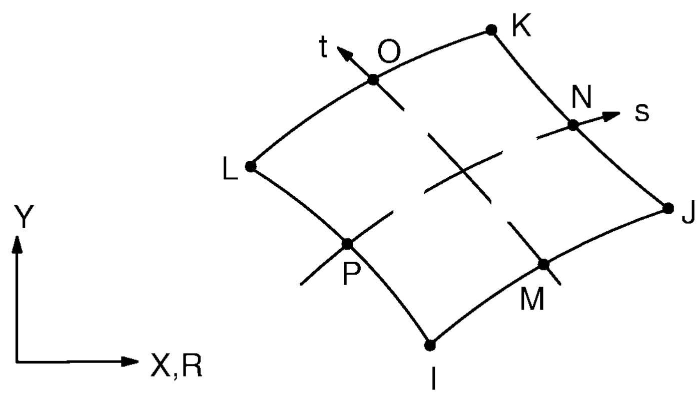
14.53 PLANE53 — 2–D 8–Node Magnetic Solid



Matrix or Vector	Geometry	Shape Functions	Integration Points
Magnetic Potential Coefficient Matrix	Quad	Equation (12.6.7–9)	2 x 2
	Triangle	Equation (12.6.2–9)	3
Damping (Eddy Current) Matrix	Quad	Equations (12.6.7–9) and (12.6.7–21)	Same as coefficient matrix
	Triangle	Equations (12.6.2–9) and (12.6.2–21)	Same as coefficient matrix
Permanent Magnet and Applied Current Load Vector	Same as coefficient matrix		Same as coefficient matrix

Load Type	Distribution
Current Density, Voltage Load and Phase Angle Distribution	Bilinear across element

References: Silvester et al.(72), Weiss et al.(94), Garg et al.(95)

14.53.1 Other Applicable Sections

Section 5.2 has a complete derivation of the matrices and load vectors of a general magnetic analysis element. Section 11.0 contains a discussion of coupled field analyses. Section 13.1 describes integration point locations.

14.53.2 Assumptions and Restrictions

A dropped midside node implies that the edge is straight and that the solution varies linearly along that edge.

14.53.3 The VOLT DOF in 2D and Axisymmetric Skin Effect Analysis

KEYOPT(1) = 1 can be used to model skin effect problems. The corresponding DOFs are AZ and VOLT. Here, AZ represents the z– or θ–component of the magnetic vector potential for 2D or axisymmetric geometry, respectively. VOLT has different meanings for 2D and axisymmetric geometry. The difference is explained below for a transient case.

A skin effect analysis is used to find the eddy current distribution in a massive conductor when a source current is applied to it. In a general 3D case, the (total) current density {J} is given by

$$\{J\} = -\sigma \frac{\partial\{A\}}{\partial t} - \sigma \frac{\partial\{\nabla \nu\}}{\partial t} \tag{14.53–1}$$

where: ν = (time–integrated) electric scalar potential

Refer to Section 5.3.2 for definitions of other variables. For a 2D massive conductor, the z–component of {J} may be rewritten as:

$$J_z = -\sigma \frac{\partial A_z}{\partial t} + \sigma \frac{\partial\{\nabla \tilde{V}\}}{\partial t} \tag{14.53–2}$$

where $\Delta\tilde{V}$ may be termed as the (time–integrated) source voltage drop per unit length and is defined by:

$$\Delta\tilde{V} = -\hat{z} \cdot \nabla \nu \tag{14.53–3}$$

For an axisymmetric massive conductor, the θ–component of {J} may be rewritten as

$$J_\theta = -\sigma \frac{\partial A_\theta}{\partial t} + \frac{\sigma}{2\pi r} \frac{\partial\{\nabla \tilde{V}\}}{\partial t} \tag{14.53–4}$$

where the (time–integrated) source voltage drop in a full 2π radius is defined by

$$\Delta\tilde{V} = -2\pi r\hat{\theta} \cdot \nabla\nu \qquad (14.53\text{–}5)$$

When KEYOPT(1)=1, the VOLT DOF represents the definition given by equation (14.53–3) and (14.53–5) for a 2D and axisymmetric conductor, respectively. Also, all VOLT DOFs in a massive conductor region must be coupled together so that $\Delta\tilde{V}$ has a single value.