# Extrapolative Scaling Expression: A Fitting Equation for Extrapolating Full *Ic*(*B*,*T*,*ε*) Data Matrixes from Limited Data

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***Abstract*—Scaling analysis of several thousand $Nb_3Sn$ critical- current ($I_c$) measurements is used to derive the extrapolative scaling expression (ESE), a global fitting equation that can quickly and accurately extrapolate (or interpolate) limited datasets to obtain full three-dimensional dependences of $I_c$ on magnetic field ($B$), temperature ($T$), and mechanical strain ($\varepsilon$). Unlike non-extrapolative fitting equations, the ESE relation is based on fundamental raw scaling data from master pinning- force curves. The results show that ESE can extrapolate critical currents at fields, temperatures, and strains that are remarkably different from the fitted minimum dataset, with errors approaching typical $I_c$ measurement errors. The scaling expression is simple and robust, providing straightforward extrapolation capability for conductor characterization and magnet design.**

**The ESE relation offers the prospect for extrapolations in several new areas, including:**

- **A reduction in the measurement space for full $I_c(B,T,\varepsilon)$ characterization to about one fifth the size through the use of minimum datasets.**
- **Combining data from separate temperature and strain apparatuses to provide flexibility in data acquisition and productive use of more limited data.**
- **Extrapolation of full $I_c(B,T,\varepsilon)$ datasets from as little as a single $I_c(B)$ curve when several core parameters have been measured in similar conductors (particularly applicable to qualifying production wires).**

**Examples are given for practical $Nb_3Sn$ conductors, including illustrations of concatenating several of these extrapolations capabilities at the same time.**

***Keywords, Index Terms*—Critical current, Extrapolation, Flux pinning, Niobium-tin, Scaling, Superconducting magnets, Superconducting Materials, Superconducting wires, Strain effect, Superconductivity, Unified scaling.**

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