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Robust Design from Systems Physics

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A crucial challenge in engineering modern, integrated systems is to produce robust designs. However, quantifying the robustness of a design is less straightforward than quantifying the robustness of products. For products, in particular engineering materials, intuitive, plain language terms of strong versus weak and brittle versus ductile take on precise, quantitative meaning in terms of stress–strain relationships. Here, we show that a "systems physics"framing of integrated system design produces stress–strain relationships in design space. From these stress–strain relationships, we find that both the mathematical and intuitive notions of strong versus weak and brittle versus directly characterize the robustness of designs. We use this to show that the relative robustness of designs against changes in problem objectives has a simple graphical representation. This graphical representation, and its underlying stress–strain foundation, provide new metrics that can be applied to classes of designs to assess robustness from feature- to system-level.

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