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A Broadband Quantum-Limited Josephson Parametric Amplifier. Part II: Theory JOSH MUTUS, R. BARENDS, J. BOCHMANN, B. CAMPBELL, Y. CHEN, Z. CHEN, B. CHIARO, A. DUNSWORTH, E. JEFFREY, J. KELLY, A. MEGRANT, C. NEILL, P. O'MALLEY, C. QUINTANA, P. ROUSHAN, D. SANK, A. VAINSENCHER, J. WENNER, T.C. WHITE, A.N. CLELAND, J.M. MARTINIS, U.C. Santa Barbara — The quantum-limited nature of the Josephson parametric amplifier (JPA) has enabled exquisite studies of single qubit dynamics. Scaling up to larger quantum systems and higher-power dynamics requires wider bandwidth and higher saturation power. We demonstrate that both bandwidth and saturation power can be increased by an order of magnitude through careful engineering of the frequency dependent impedance environment. We can understand and engineer the interaction between the JPA and this environment using the "pumpistor" model, in which the flux-pumped SQUID is treated as a linear circuit element. At extreme low Q this interaction, previously viewed as a parasitic effect, can be used to greatly enhance bandwidth while maintaining the robust noise performance of the JPA.

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