Advancing the Design and Measurement of Modern Superconducting Quantum Systems

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As we enter the kilo-qubit era, there are several challenges to tackle to enable the successful design and operation of a Quantum Processing Unit (QPU) surpassing the 1000-qubit mark [1]. Starting from the design phase, modern superconducting quantum systems require accurate quantum effects modeling to obtain reliable simulation results that can be used for successful chip fabrication. For example, flux quantization modeling becomes essential to successfully design flux-tunable devices and complex Josephson Traveling Wave Parametric Amplifiers (JTWPAs) [1, 2]. Moreover, high-scale quantum chips often deploy tunable couplers and require accurate modeling of coupling effects and qubit crosstalk. Multi-layer layout and 3D geometries also become necessary to fit hundreds of qubits in the same QPU. On the measurement side, the design of control, readout and flux lines going into the cryostat must accurately minimize thermal leakage, which can impact experimental quality and QPU operation. [1]. The capability to deploy Frequency Division Multiplexing (FDM) on both the qubit control and readout lines, becomes essential to ensure that the number of cryogenic signal lines gets optimized [3]. This talk will outline how to solve these challenges using the Keysight QuantumPro software [1, 2] and the Keysight Quantum Control System [3].

References

[1] M. A. Hassan et al., "Towards a Faster Development of Superconducting Quantum Systems Using Electronic Design Automation", in *IEEE Microwave Magazine*, vol. 26, no. 10, pp. 18-25 (2025).

[2] O. Naaman et al., "Modeling flux-quantizing Josephson junction circuits in Keysight ADS", *in IEEE Transactions on Applied Superconductivity, vol. 35, no. 2, pp. 1-11*(2025).

[3] "Keysight Installs World's Largest Commercial Quantum Control System at AIST's Leading-Edge G-QuAT Center", in Press Releases (2025).

Figures

Figure 1: QuantumPro simulations, including both thermal and quantum noise effects, can be used to design cryogenic signal lines for highly scalable QPUs [1].

Figure 2: Keysight's 1000-Qubit Quantum Control System solution installed at the National Institute of Advanced Industrial Science and Technology (AIST) in Tsukuba, Japan [3].