

## ED4-3-INV

### Performance Improvement of Superconducting Circuit by Introducing $\pi$ -Shifted Josephson Junctions

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Hybridization of Josephson junctions (JJs) and  $\pi$ -shifted Josephson junction ( $\pi$ -JJs), which induces the static superconducting phase shift of  $\pi$  across the junction, is one of effective methods to improve the performance of superconducting integrated circuits. We can reduce circuit area of the superconducting circuits by replacing the large inductances with the  $\pi$ -JJs. Moreover, we can drastically simplify the circuit structure of superconducting flip-flop with complementally outputs by using a symmetric storage loop composed of both the JJ and the  $\pi$ -JJ. We will discuss the improvement of performances of superconducting circuits by introducing  $\pi$ -JJs into the conventional superconducting circuits quantitatively in terms of the circuit area, the operating margin, and the operating frequency on the basis of the analog circuit simulations by the PJSIM we developed. We will show a possible application to superconducting single-flux-quantum containing  $\pi$ -JJs to dual-rail circuit that can remove static power consumption.

Keywords: SFQ circuit,  $\pi$ -Josephson junction, circuit simulator