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A Global Routing Method with Wire Length Budgeting for PTL Routing of SFQ Logic Circuits

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We propose a global routing method for the layout design of SFQ (Single-Flux-Quantum) logic circuits. In the proposed method, global routing is performed where coarse wiring routes are searched before detailed routing, and wire length is also budgeted to each net considering the available routing resources. This prevents the routing congestions caused by detouring routes for length matching during detailed routing of SFQ circuits and guarantees the routability.
In general, routing problem is solved in two steps called global routing and detailed routing because of the large complexity of the problem. Exact wiring routes are determined based on the global routing solution and therefore a global router should find a routing solution with high probability of routing completion.
The routing problem of SFQ circuits, however, cannot be solved by using the existing router because of its strict timing requirements. In SFQ circuits, wire length matching of PTLs (Passive Transmission Lines) is performed to meet the timing constraints, where shorter routes are detoured to extend the length. However, constraints and optimization objectives for SFQ circuits cannot be processed effectively by existing global routers, and the following detailed routing may fail.
To address this issue, we propose a global routing method with wire length budgeting. We focus on grid based global routing, where a given routing area is gridded into rectangular subregions and paths connecting them are searched to determine coarse wiring routes for given nets. In the proposed method, in addition to searching a path connecting subregions, wire length is also budgeted to each net at each subregion on the path. The successful length matching in detailed routing is guaranteed when a sufficiently long wire length is budgeted without excessive use of the given routing resources. We formulate our global routing problem and propose an algorithm to solve it. In our algorithm, routes are searched first, and an additional wire length is specified for each net considering the length matching constraints. Then, the wire length at each subregion on the path of each net is computed so that the specified additional wire length is budgeted while preventing the excessive use of routing resources.

Keywords: Single Flux Quantum, layout design, global routing, Passive Transmission Line