Grounding methods to reduce stray coupling in multi-layer layouts

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Introduction

- Via inductance and coupling to neighboring structures is significant when vias pass through ground planes in multilayer layouts [1].
- Signal vias may be far from connections between ground planes.
- “Ground sleeves” consume large layout space, and are often avoided.
- We also apply these methods to bias pillars in the AIST ADP2 process and evaluate the results on bias line coupling.

Ground contacts

- “Sleeves” are connections between ground planes that fully surround signal vias. Sleeves are mostly used with PTLs (Passive Transmission Lines) in ADP2 [2] to reduce impedance mismatch and reflection.
- Ground contact positions are important, but previously only considered for effective magnetic shielding [3]. It was found that contacts parallel to direction of signal lines reduces loop area of current return paths, and thus improves shielding.
- We use the parallel (in-line) technique to reduce coupling between structures with vias through ground planes.

ADP Device Structure

- ADP multilayer device structure of today used extensively for cell library development.
- Was created after many experiments on moat configuration and flux trapping [4]. For thorough description, see [5].
- But dc bias pillar is half the unit cell length removed from nearest ground contact; could result in coupling between bias lines and SQUID structures.
- We devised experiment to measure such coupling.
- Both inductors ≈ 5 pH. Coupling results in Table II.

Source of coupling in ADP2 device structure

- Mutual inductance for experiment is low, but can be reduced further with strategic placement of ground contacts.
- Source of coupling can be visualized with current density in ground plane (GP), calculated with InductEx. In standard structure, a significant amount of return current flows underneath SQUID loop to other ground contacts.
- With ground contacts around dc bias pillar, very little current flows across device structure’s cell area. Reduced coupling.

Lines threading ground planes

- Lines that thread ground planes mostly used to connect PTLs, but also for connection to some large inductors for circuits such as eSFQ cells.
- Such interconnections create possibility for stray coupling, which could reduce circuit operating margins.
- We devised test structures to measure such coupling experimentally and provide a reference for numerical calculations with InductEx [1].

Ground contact results

- Results shown in Table I. Perpendicular ground contact reduce coupling by 15 % to 20 %.
- In-line ground contacts reduce coupling by almost 50 %; very close to 54 % of all ground sleeves [3]. Thus very efficient.

References