FALAPHEL
General Meeting 12/10/2022

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Outline

- Status of 25 Gb/s RR-driver in 28 nm (Heavy-Ions Test)
- Next submission is approaching (26 October)

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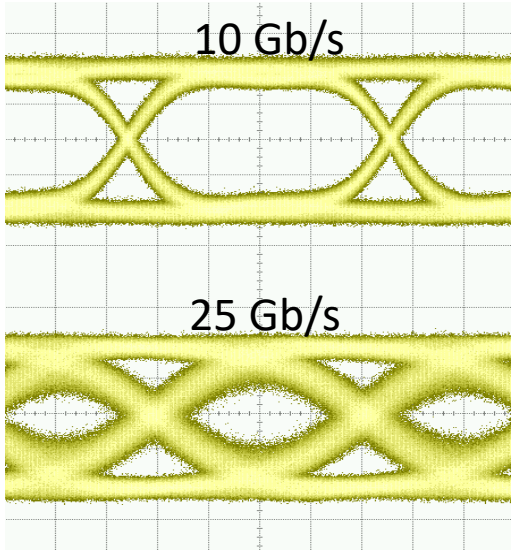
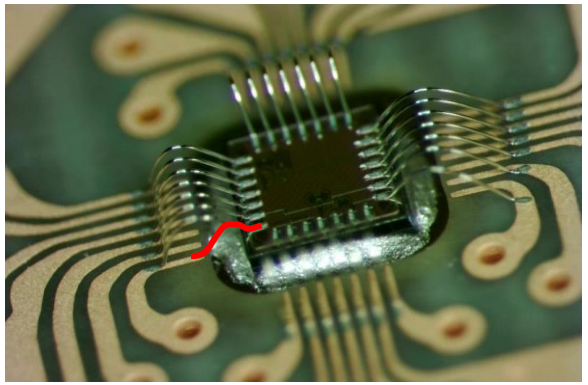
25 Gb/s Driver

Driver for SiPh Ring Resonator operating up to 25 Gb/s:

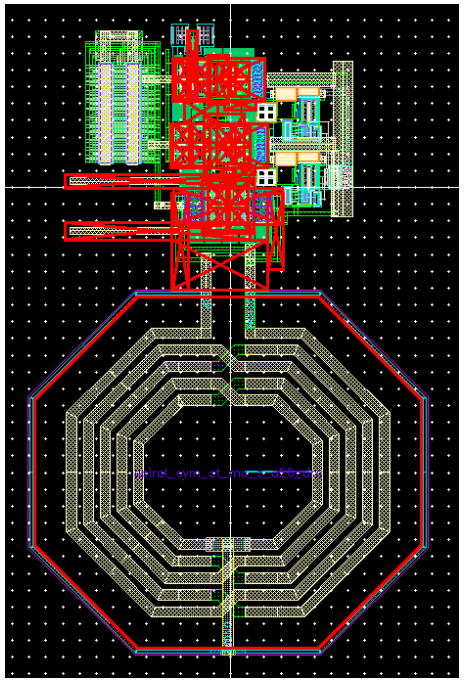
- 28 nm HPC technology
- 8 Metal technology
- CML stages
- Passive and Active Bandwidth enanchement techniques (inductors)





Only preliminary electrical tests

Radiation and optical tests: waiting



Layout of the 25 Gb/s driver in 28 nm

Heavy-Ions Test setup

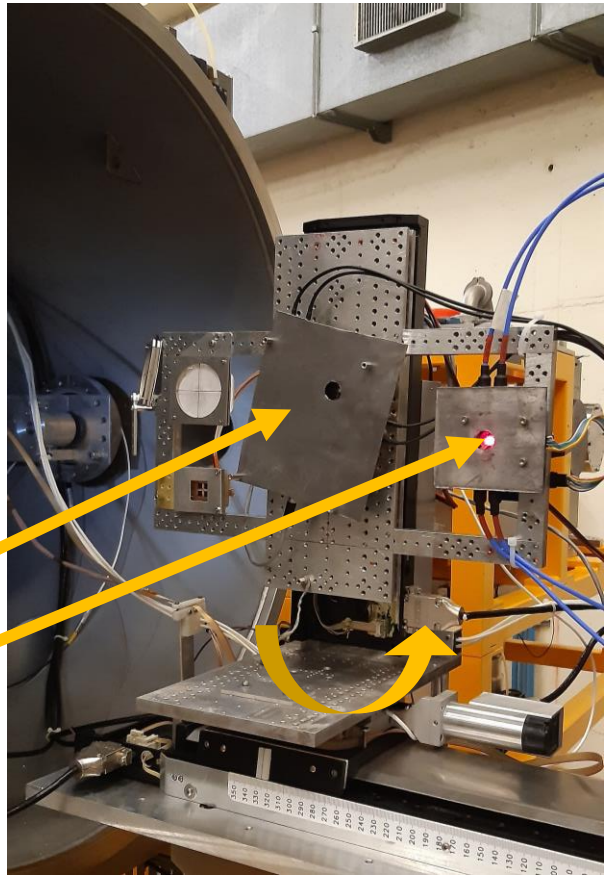
Both chip hosting the PLL (65nm) and the driver (28nm) are mounted on testing boards with COTS components protected from ions by lead shield.

Test cases:

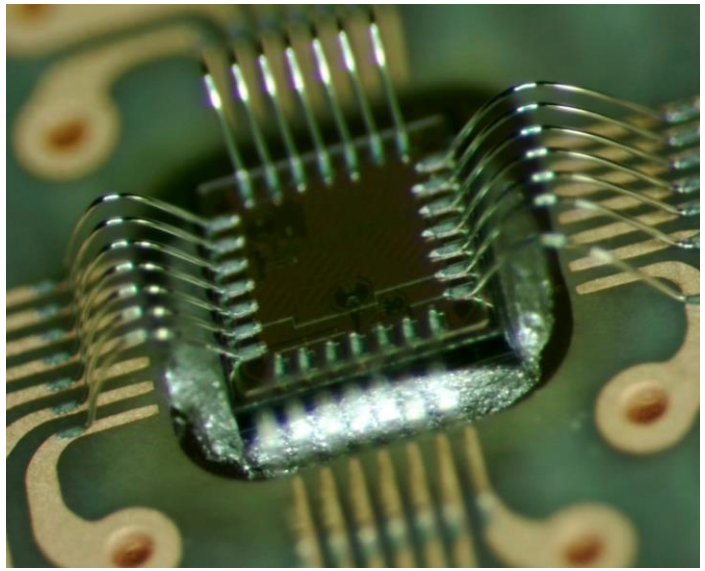
- Eight ion species (O, F, Si, Cl, Ni, Br, Ag, I)
- Four inclination angles between the flux direction and chip surface

Setup Instruments:

- FPGA Kintex Ultrascale KCU116
- Oscilloscope Tektronix 23 GHz
- Multimeters/Power Supplier
- Cables



Test Chip2: Driver in 28 nm CMOS technology



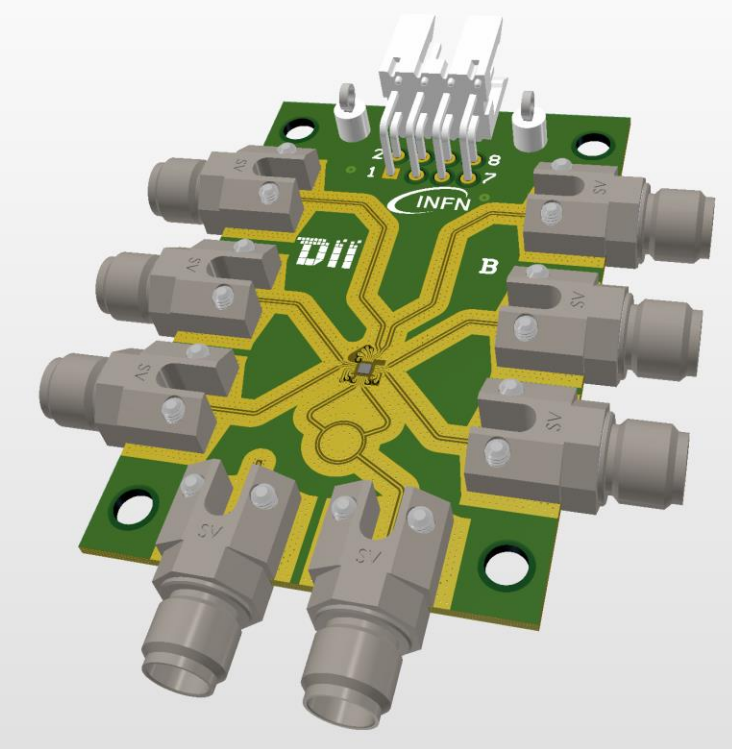
Driver in TSMC 28 nm technology for electro-optical modulators able to sustain 25 Gb/s links

Chip connected to board using wire bonding only for electrical test. The electro-optical test are scheduled for the next months

The driver is designed to work with a Ring-Resonator device at less than 1 mm. However, during the test, it was capable to drive a 50 Ω load ad a distance of about 2 m.

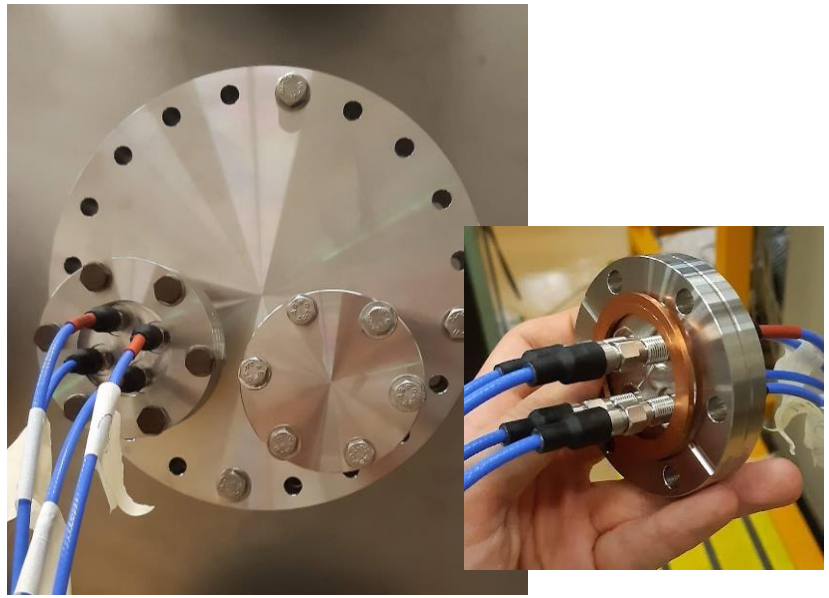
Custom devices

High-frequency High-speed testing board



Custom board hosting the chip is designed to sustain 25 Gb/s links

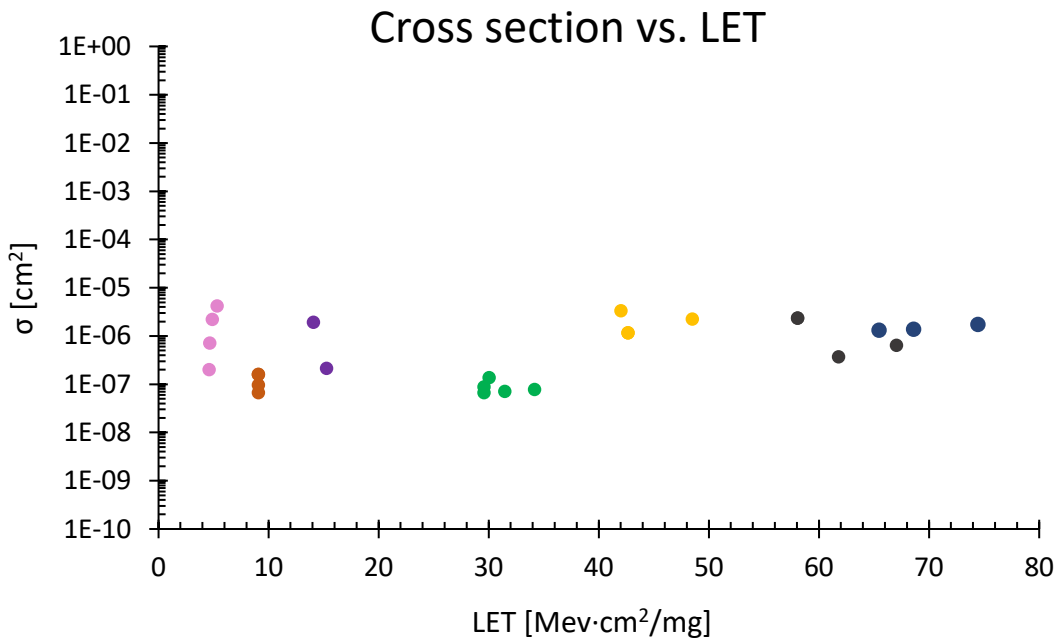
Custom Flange

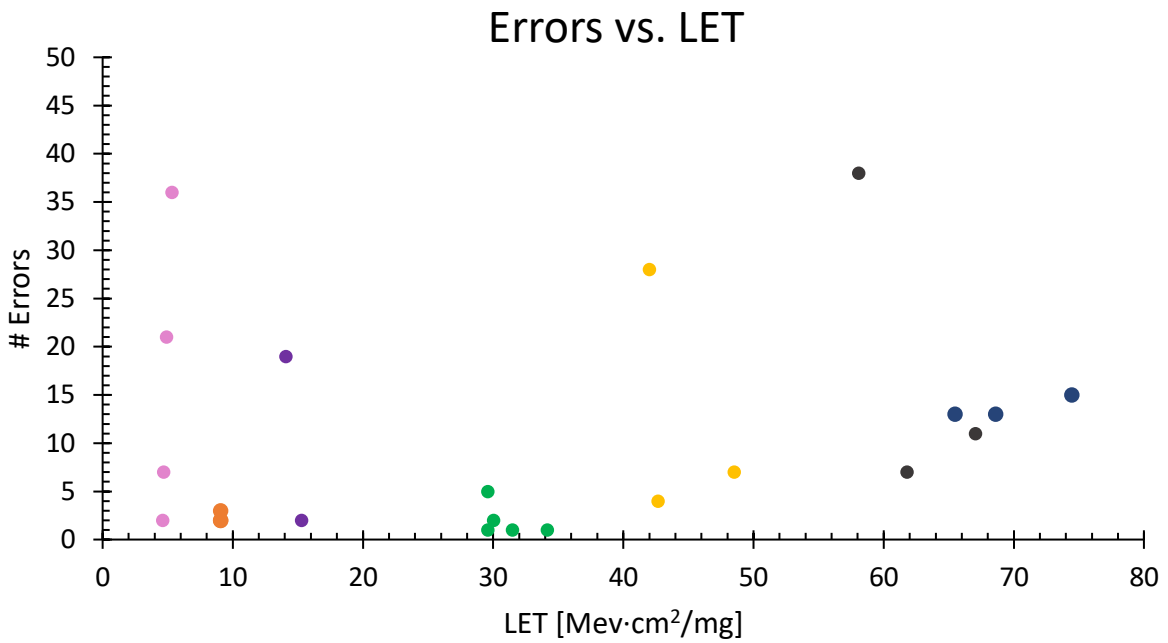


The custom flange is currently equipped with 4 SMK connector feeds able to sustain up to 40 GHz.
Optical feeds will be added for next electro-optical tests

Driver Results

The driver was tested comparing the bit sequence transmitted and that received looking for flip bits (BERT). The test was performed in the worst possible condition for the driver (well worst than that planned): link speed of 25 Gb/s over 2 m cable with some connectors in a vacuum environment.





Test cases:

- Eight ion species (O, F, Si, Cl, Ni, Br, Ag, I)
- Four inclination angles between the flux direction and chip surface

Test Conclusions

- The 28 nm driver shown to operate in worst condition (2 m cable and 50 Ω load) at 25 Gb/s.
- Because of the low error rate detected during tests run for tens minutes (time limited by schedule), statistical analysis of the data is not possible. However, in the worst case a cross-section less than $4 \cdot 10^{-6}$ could be considered.
- The chip hosts also custom ESD protections that could be sensitive to latchup problems. However, no latchup events occurred in whole chip during the tests.

Future works

- Deeper data analysis.
- Expose both chips to X-ray to study their behavior for high cumulated dose (TID).
- Perform Electro-optical measurement of the driver also when exposed to heavy ions.

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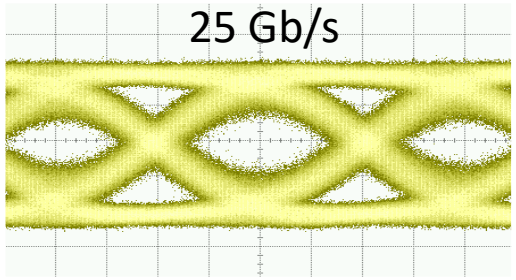
Problem

- Could we improve the driver performances?

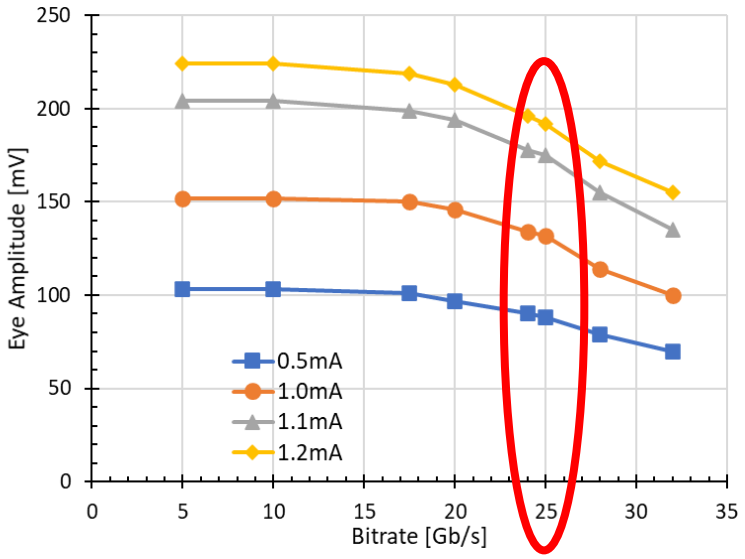


- CERN is moving on 28nm 9M stack (no library inductors)

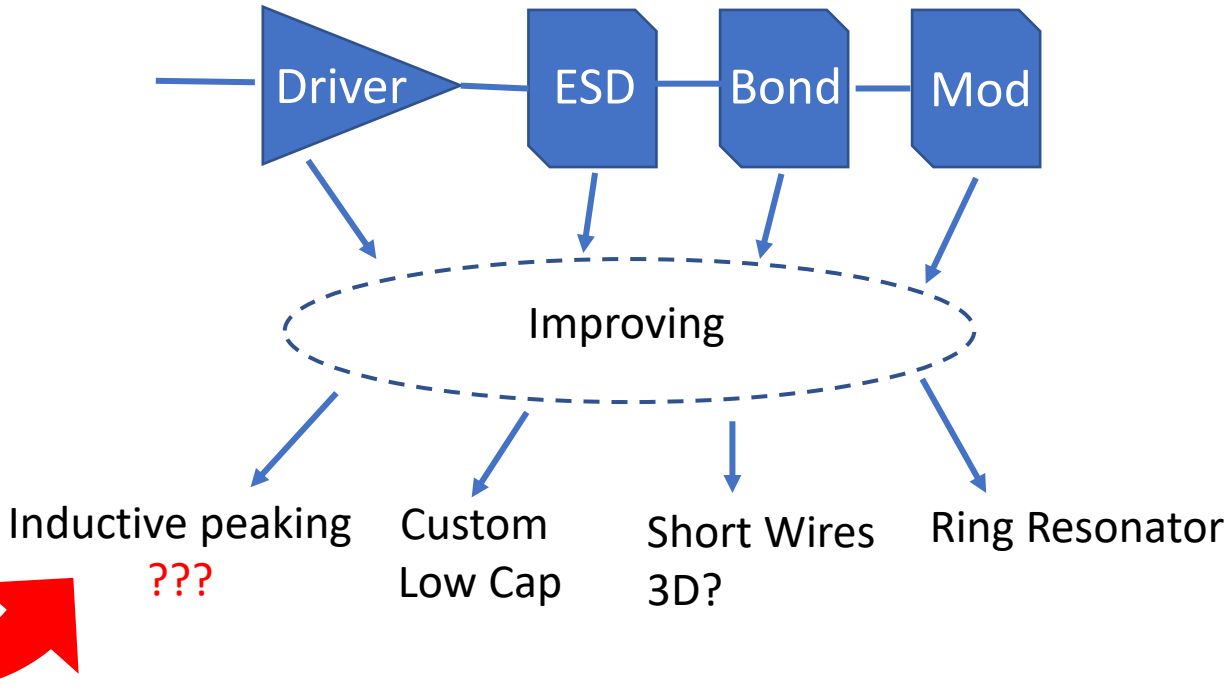
28 HPC+ (use MMWAVE PDK)	7M	lp7m_4x1y1z_alrdl	/
	8M	lp8m_5x2r_alrdl	lp8m_5x1z1u_ut-alrdl
		lp8m_5x2r_ut-alrdl	
	9M	/	lp9m_5x1y1z1u_ut-alrdl

What can we do?

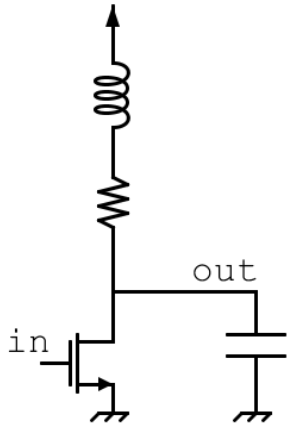
HPC driver results



How can we improve the driver bandwidth?
Which is the main limitation of driver bandwidth?

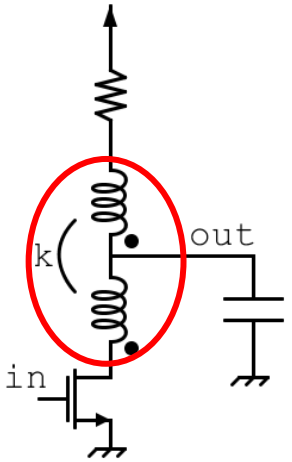


Other bandwidth extension techs



Inductive peaking

BWER ≈ 1.72

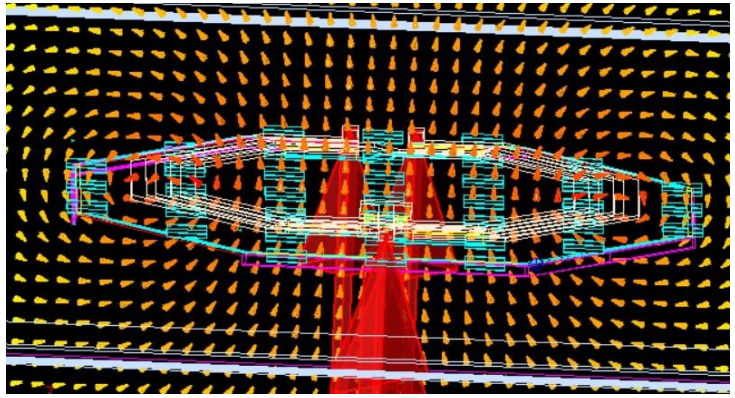


T-coil peaking

BWER ≈ 4.1

Custom design of T-coil transformer:

- First simulations of TSMC library inductors did not match the tech results (10% discrepancy in L and 55% discrepancy in Q)
- Now simulations match technology devices (less 10% discrepancy to be refined)
- Many TSMC inductors show a resonant frequency below 10-20 GHz
- Work in progress…

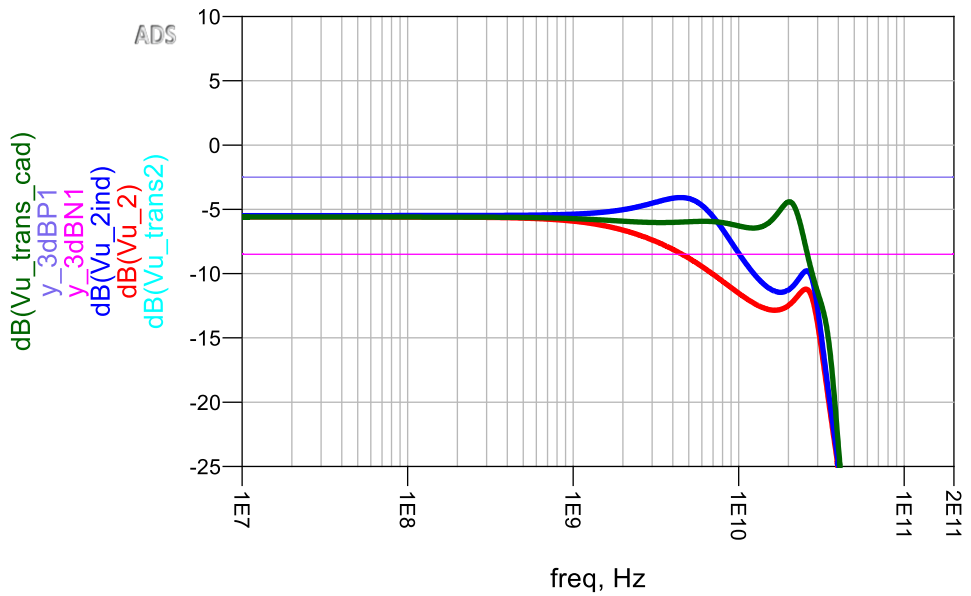


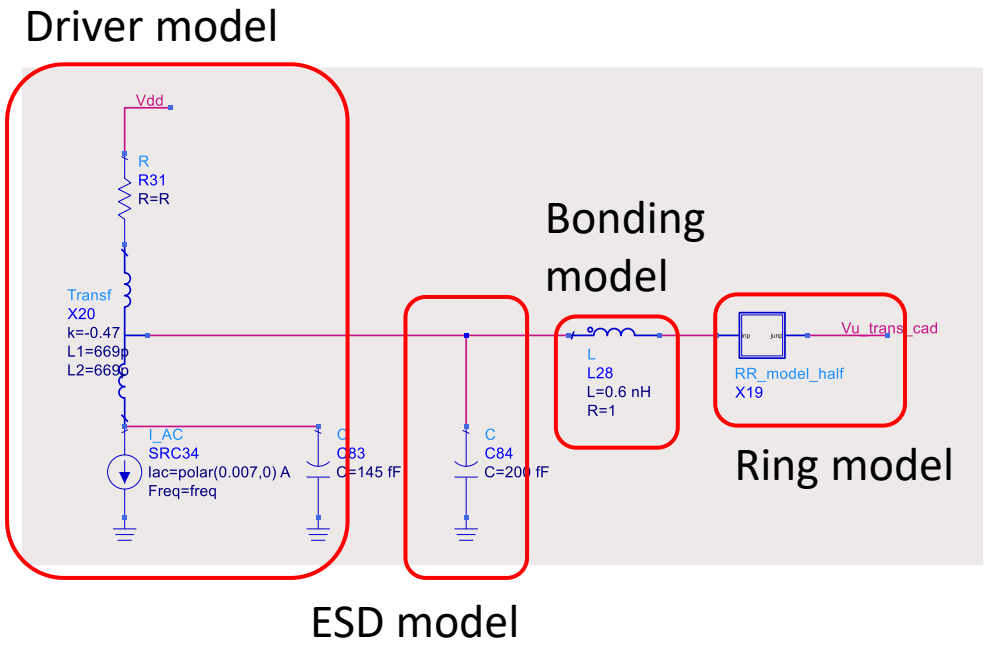
BWER: Bandwidth Extension Ratio

Which T-Coil?

Tree grade of freedom in T-Coil:

- Inductance L1
- Inductance L2
- Coupling factor k





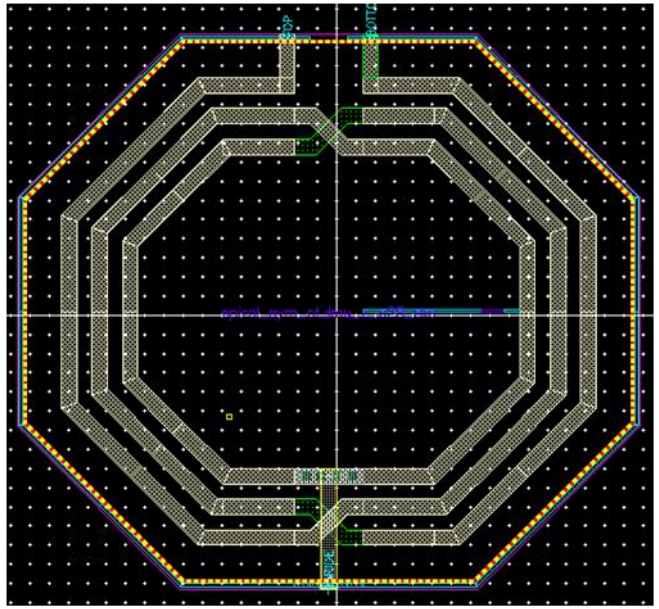
No inductor

Inductor Peaking

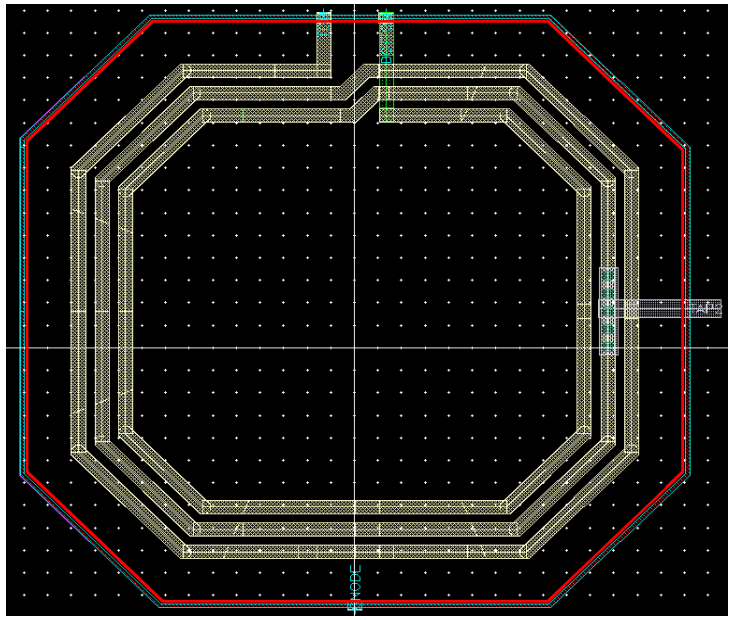
T-Coil

Are we able to design that T-coil?

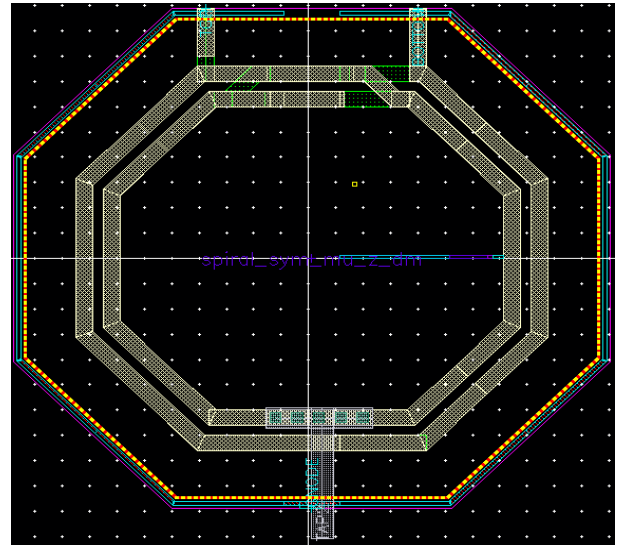
Symmetrical T-coil



Symmetrical T-coil, square shape



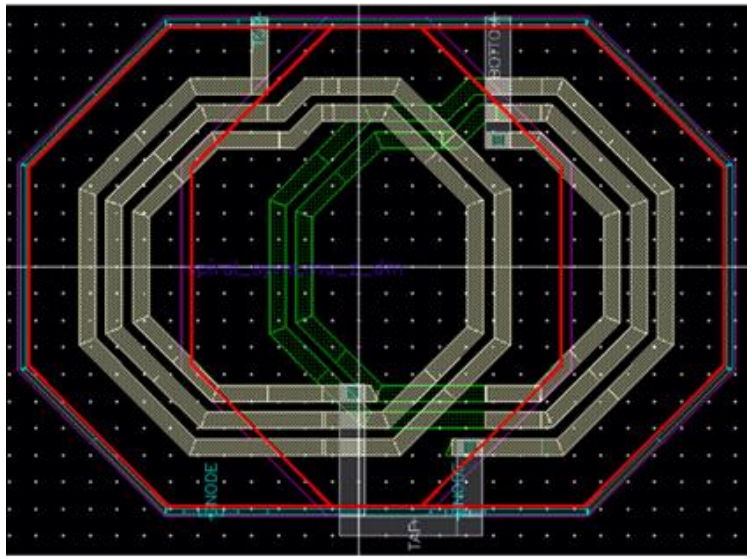
Stacked Symmetrical T-coil

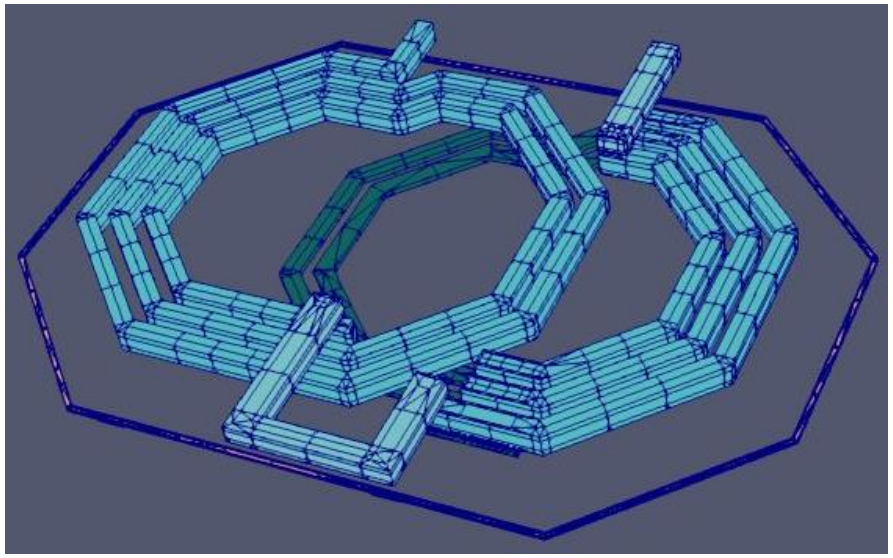


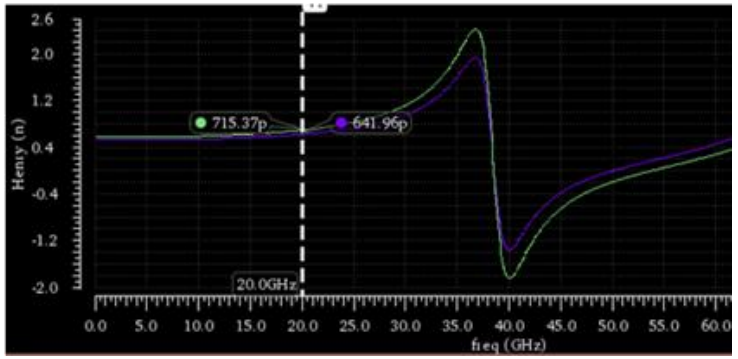
Different shape, different area, different performances but coupling factor too high for the model

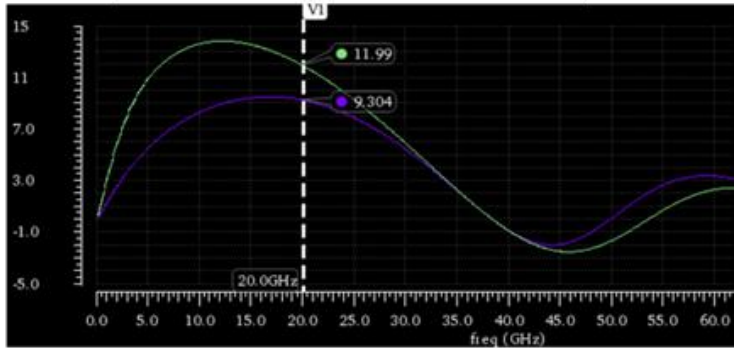
Note: Top metal M9 (I changed the color)

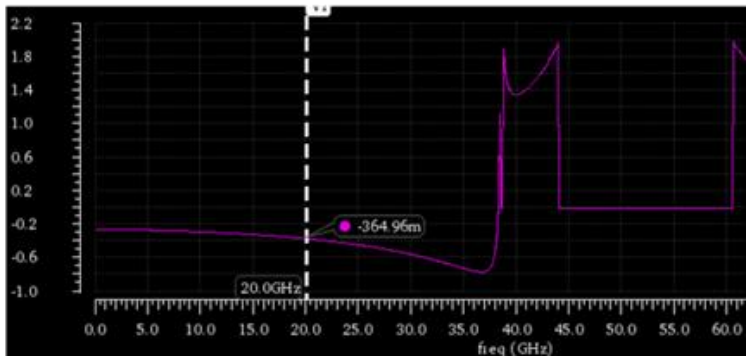
Solution for RR-driver model



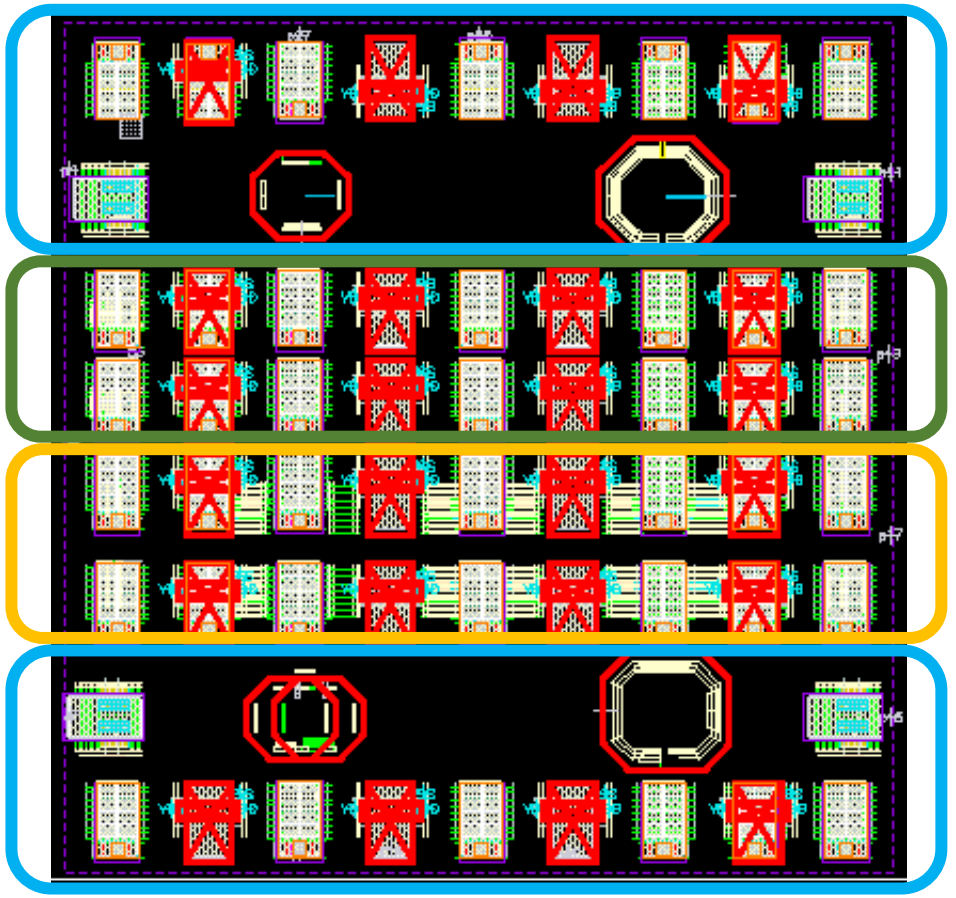








Chip Submission



Inductor test

Some MOSFET test

ESD High-speed test

Inductor test

Thanks for your attention