Medical Imaging Research Laboratory

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Comparison of endoluminal receiver coils based on PIN-diode, photodiodes and MEMS switches for active detuning circuits

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Purpose

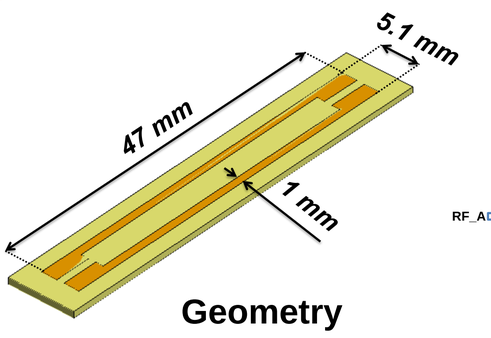
The use of endoluminal receiver coils is an attractive solution to achieve locally high spatial resolution in deep regions in the body such as colon wall [1]. During the radio frequency (RF) transmit phase, the receiver coil must be decoupled (detuned) from the transmitter coil to avoid the inhomogeneity of the RF magnetic field in proximity of the receiver coil and extra noise in the image due to the mutual inductance between coils [2].

For this purpose, several methods were proposed in literature such as active detuning based on PIN-diode or optical components [3]. Recently, Micro Electro-Mechanical System (MEMS) switches were introduced by GE Healthcare to fulfill this role [4].

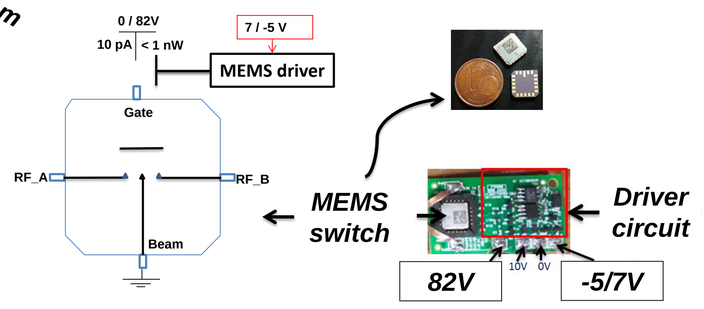
In the following study, we compare the use of controllable MEMS switch (with different locations) to the reference (parallel PIN-diode) and optical (two photodiodes in parallel to PIN-diode) coils.

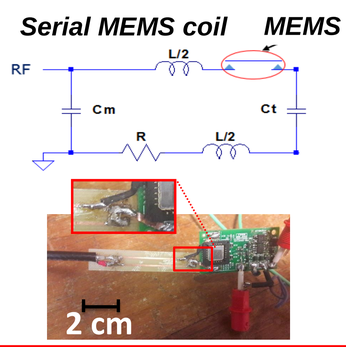
Methods & Results

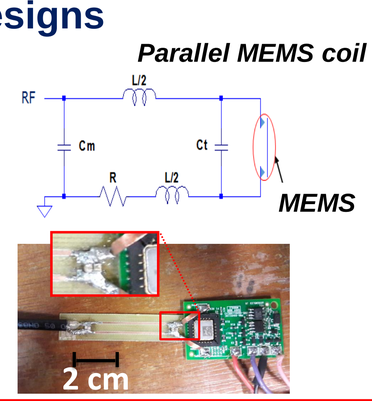
Rectangular single-loop endoluminal receiver coils designs



Geometry



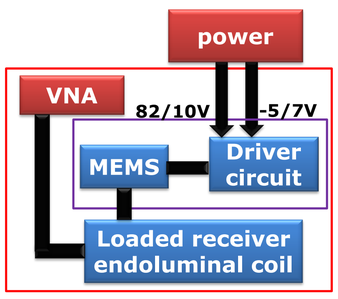




Cylindrical Phantom used
(*1.25g NiSO4x6H2O+5g NaCl per liter of distilled water*)

On bench

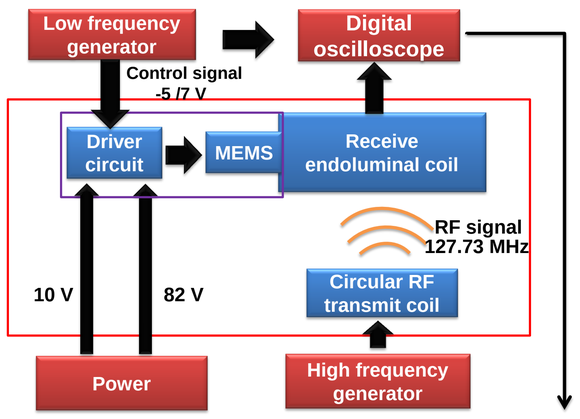
Rf characterization set-up



→ S11 frequency response

- Tuning / matching (127.73 MHz / 50 Ω)
- Quality factor Q
- Decoupling efficacy verification

Coupling/decoupling set-up



- Switching delays measurements

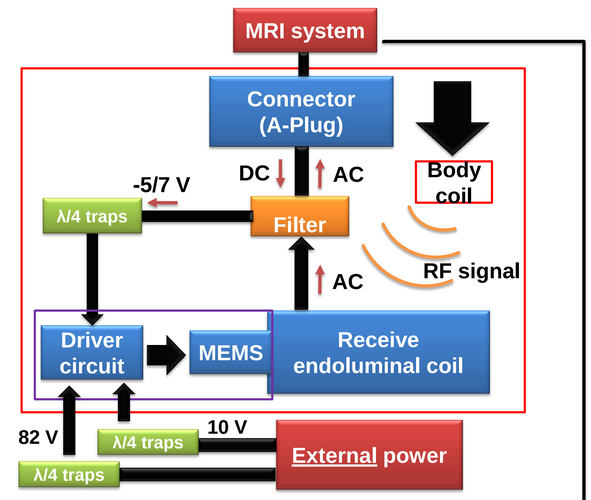
Bench results

Measured parameters	Reference coil (PIN-diode)	Optical coil (Photodiodes / PIN-diode)	Serial MEMS coil	Parallel MEMS coil
Loaded quality factor Q	53.00	55.00	53.87	80.00
Reflection coefficient at the resonance frequency f0 (dB)	- 42.96	- 39.33	- 50.92	-23.50
Decoupling coefficient at f0 (dB)	- 0.66	- 0.70	---- *	- 0.20
Switching delay to couple (µs)	0.75	13.6	6.22	3.00
Switching delay to decouple (µs)	0.25	1.70	1.32	7.20

* In decoupling mode, the loop is open and not resonating (best case)

Imaging

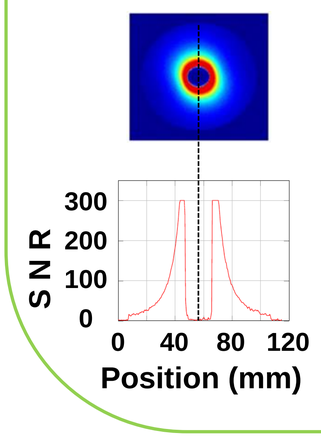
Imaging set-up: 3.0T MRI



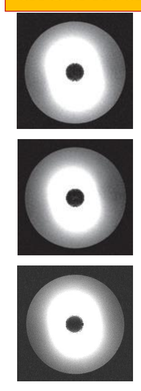
- Image quality: SNR

Imaging results

SNR of Parallel MEMS coil

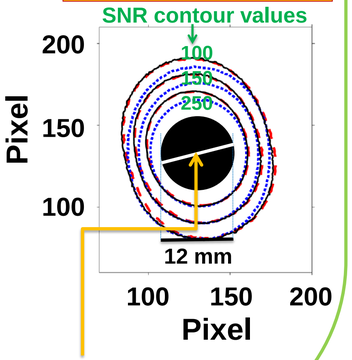


Intensity distribution



Reference coil
Optical coil
Parallel MEMS coil

SNR iso-contours



The coil orientation inside the cylindrical phantom along the B0 field

Discussion

All coils

Verified impedance matching

Ensured decoupling efficacy
(Close to the 0 dB)

Switching delays

Controllable MEMS less faster than PIN-diode due to the driver circuit but its speed is enough (< 8 µs)

Quality factor Q

High Q-value for the Parallel MEMS coil
(receive mode => open MEMS ⇔ Additional capacitor of about 2 pF)

Q-value degradation for the other coils
(parasitic resistance effect)

Control the loop

Serial MEMS coil has the possibility to open/close the loop

The other coils do not have this possibility

SNR

High SNR very close to the coil
(Endoluminal coil is close to the region of interest)

SNR iso-contours of MEMS coil do not exactly overlap that of reference and optical coils
(due to the electromagnetic coupling with external cables used to power the driver MEMS circuit)

Conclusion & Perspective

- **Good performances of MEMS-based circuits compared to other methods**
- **Parallel MEMS can be used for active decoupling (25% gain of Q-value)**
- **Serial MEMS may be relevant to be used for reconfigurable multiple-geometry coil**

References:

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