

Optimization and miniaturization of receive-only coaxial coil interfacing for MRI

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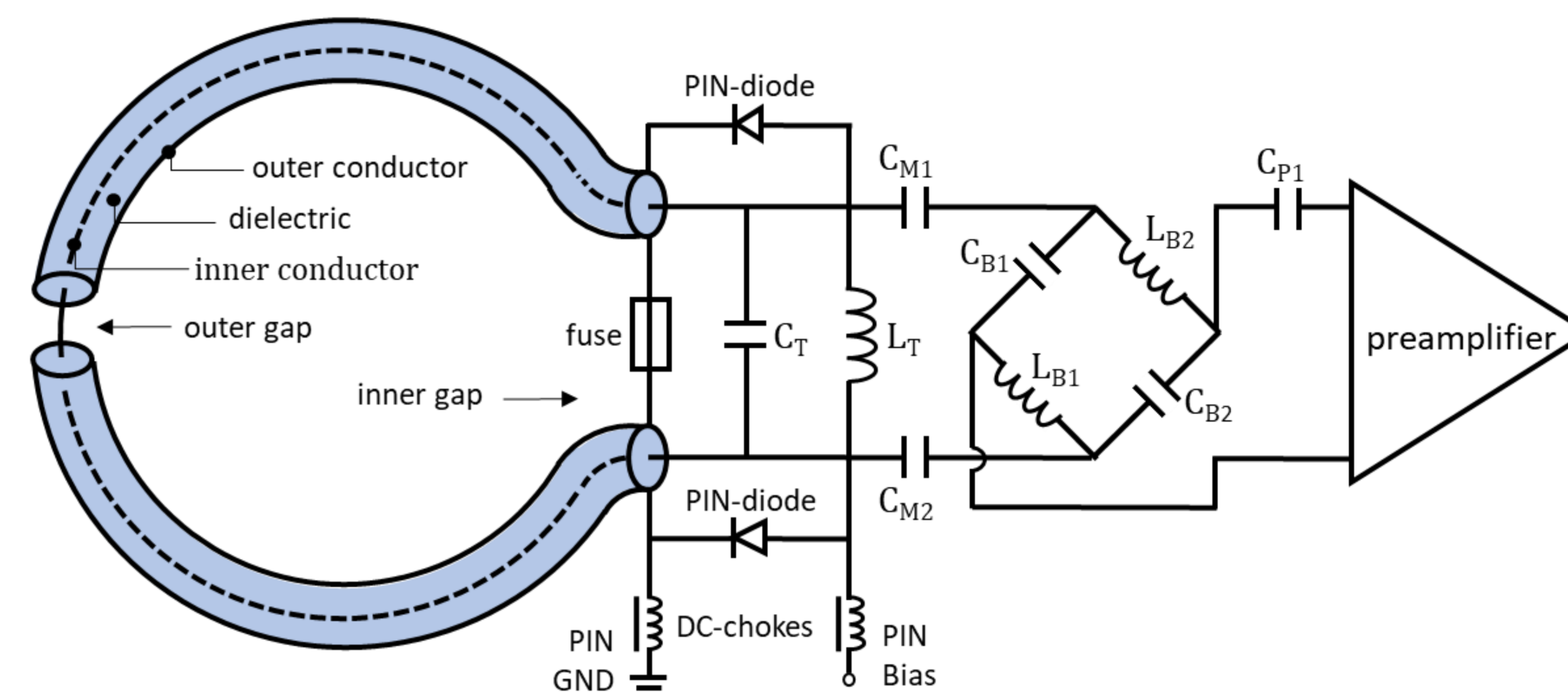
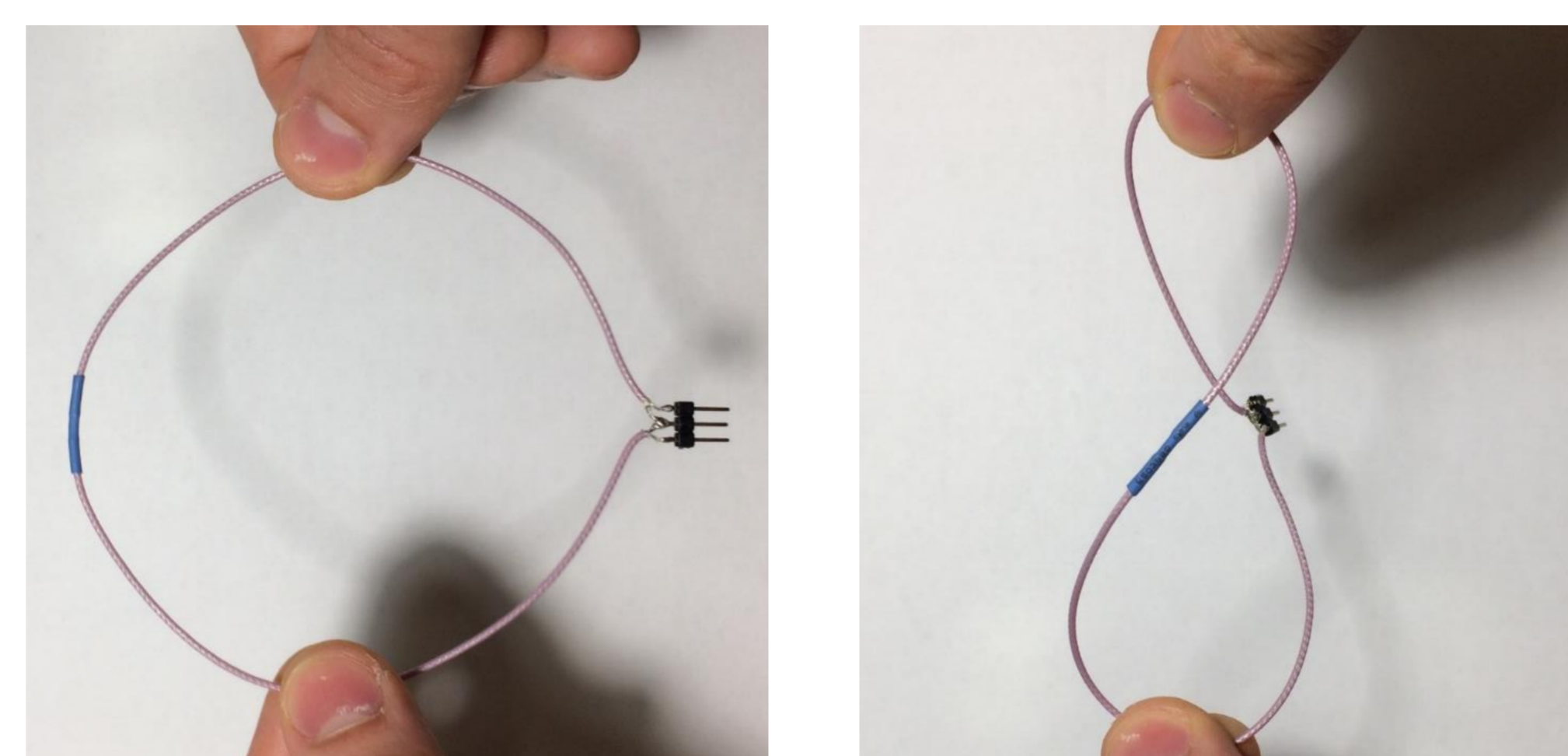
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Introduction

- Coaxial coils^{1,2,3} made from thin coaxial cable.
- One gap cut in the inner and outer conductor: three separate currents → self-resonant coil.
- 8 cm coil ↔ resonance frequency ≈ 123 MHz.
- Interface: miniaturization and optimization necessary for ideal coil performance and design.



Methods

Optimize interfacing:

- Vary $L_T = 27$ nH ($C_T = 53.5$ pF) to $L_T = 360$ nH (no C_T), two measurement series ($C_{M1} \neq C_{M2}$, $C_{M1} = C_{M2}$).
- Miniaturized components: self-wound toroid inductors, small non-magnetic preamplifiers.
- Network analyzer: matching $S_{11} < -15$ dB; S_{21} : Q_U , Q_L .
- MRI: Siemens Prisma Fit 3 Tesla, SNR-maps (2D GRE).

Results

Optimize interfacing:

Interface components				Q_U	Q_L	Qratio	SNR	ΔC_M
L_T [nH]	C_T [pF]	C_{M1} [pF]	C_{M2} [pF]	(S_{21})	(S_{21})	(S_{21})		[pF]
27	53.5	27	6.5	64	48	1.3	420	-21
47	28.5	10	5.6	108	66	1.6	684	-4
68	18.5	12	6.5	104	52	2.0	655	-6
82	16.5	7.5	6.5	102	48	2.1	752	-1
110	9.8	10	6.5	96	40	2.4	684	-4
160	6.5	15	4.75	76	32	2.4	633	-10
300	2.1	15	4.75	66	26	2.5	545	-10

Interface components			Q_U	Q_L	Qratio	SNR
L_T [nH]	C_T [pF]	$C_{M1}=C_{M2}$ [pF]	(S_{21})	(S_{21})	(S_{21})	
27	53.5	10	74	54	1.4	589
47	28.5	7.5	112	66	1.7	768
68	18.5	6.8	120	58	2.1	738
82	16.5	6.8	108	52	2.1	781
110	9.8	6.1	122	48	2.5	807
160	6.5	6.1	106	38	2.8	885
360	0	5.6	98	30	3.3	985

best performance:
 $L_T = 360$ nH, no C_T ,
 $C_{M1} = C_{M2} = 5.6$ pF.

Safety: fuse at inner gap

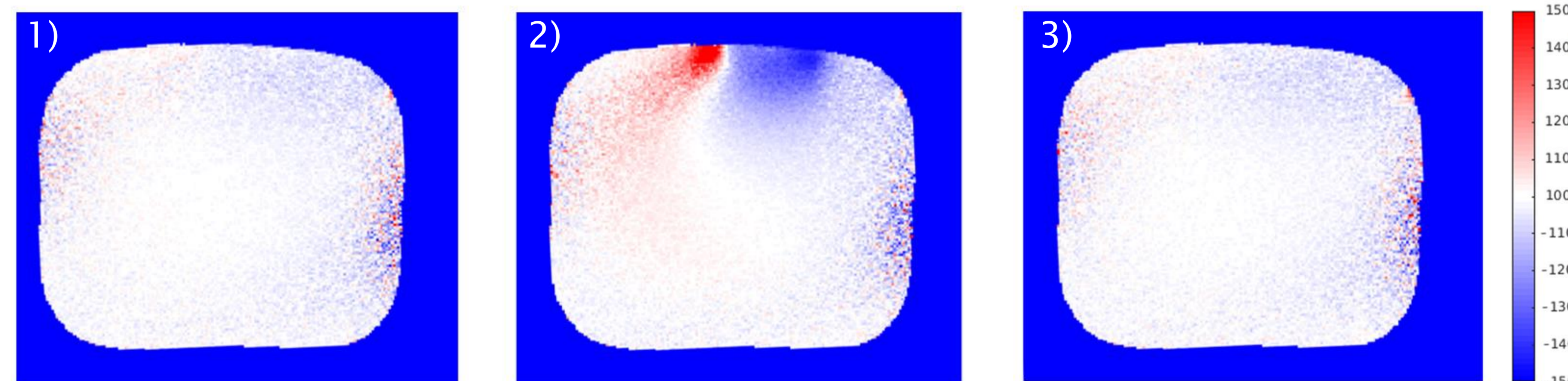
Flip-angle maps (satTFL method⁴):

- 1) functioning interface with detuning
- 2) intentionally malfunctioning detuning
- 3) intentionally blown fuse and no detuning.

Balun

- Reduce current flow: transform preamplifier impedance to a short at coil port.
- Convert balanced signal to unbalanced signal.

Safety: fuse



Balun:

Increased Q (>20%) and SNR (>11%).

References

¹ LL Libby, Proc. I.R.E Waves and Electrons: Sept. 1946.
² HJ Zabel et al., Radiology 165: 857-859, 1986.

³ B Zhang et al., Nat. Biomed. Engin. 2: 570-577, 2018.
⁴ S Chung, et al., Magn. Reson. Med. 64: 439-446, 2010.

Acknowledgement

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