Reseach Activities LRF@UFSC

Fernando Rangel de Sousa

Visiting Professor at LIP6 - Sorbonne
Full Professor at LRF/EEL – UFSC

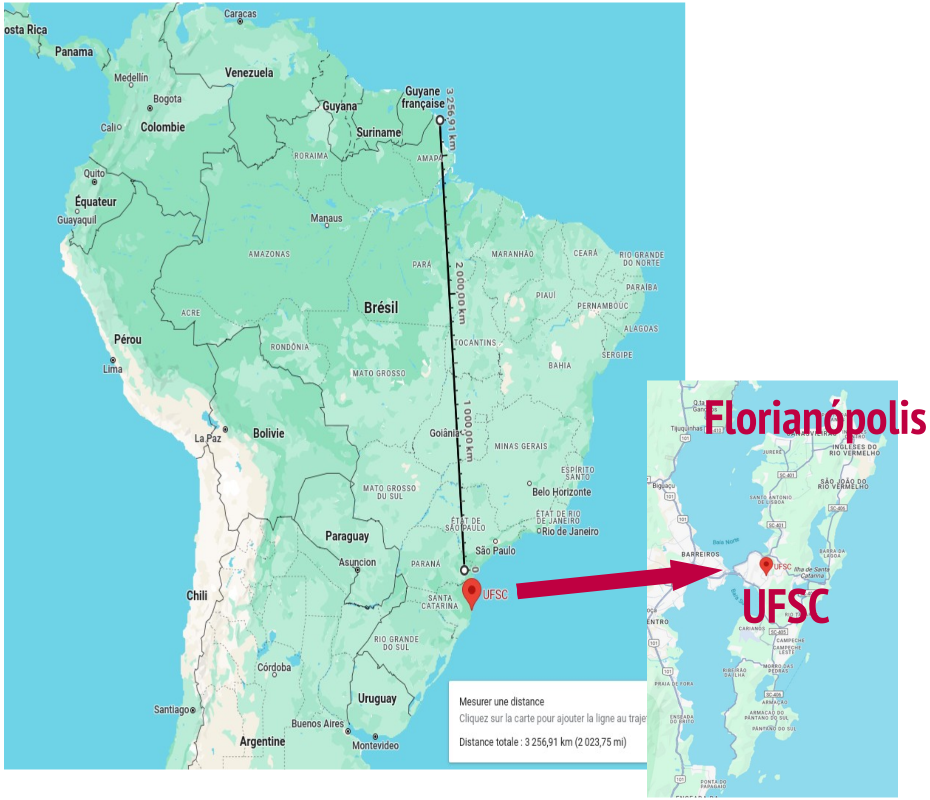
January 2024

Outline

- Overview of UFSC
- Research Activities at LRF
- Discussion

12th
Latin America Rankings
2023

UFSC-Florianópolis



Some numbers (2022)

- 21 000 undergraduate (87 courses)
- 5000 MSc students
- 3800 PhD students

Technology Center

- 13 Engineering Courses + 2 Computer Science
- 10 Departments
- 390 professors (all levels)

Electrical & Electronic Department (EEL)

- 2 undergraduate courses
  - Electrical Engineering (1966): 500 students
  - Electronic Engineering (2010): 300 students
    - Electronic Systems (digital and analog), Communications, Biomedical
- 1 Graduate Program (7/7 at CAPES ranking)
  - Energy
  - Information

Research

- Electromagnetism and Electromagnetic Devices
- Electrical Power Systems
- Power Electronics
- Communications and Signal Processing
- Electronic Systems
- Biomedical engineering

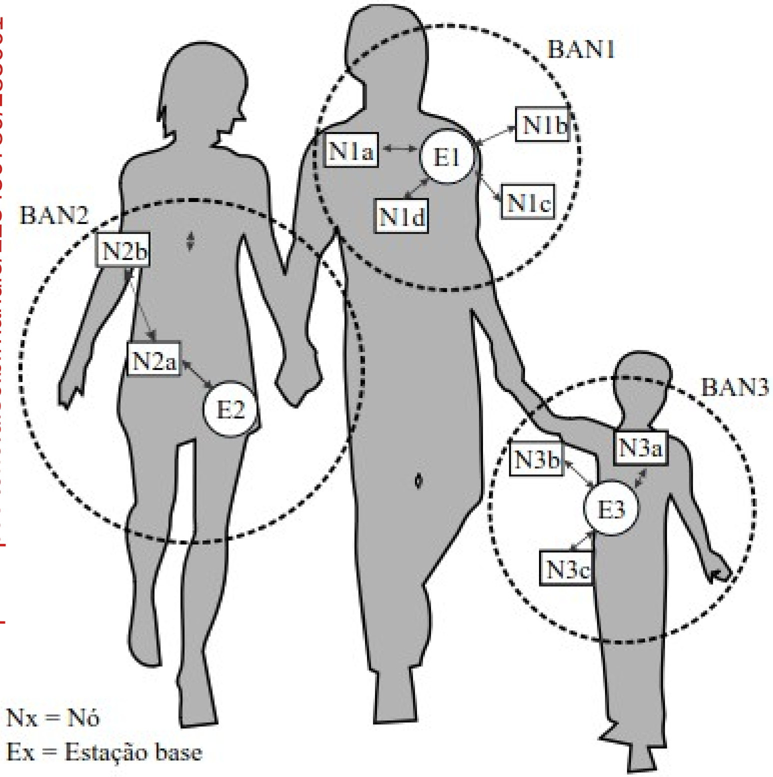
Research at LRF

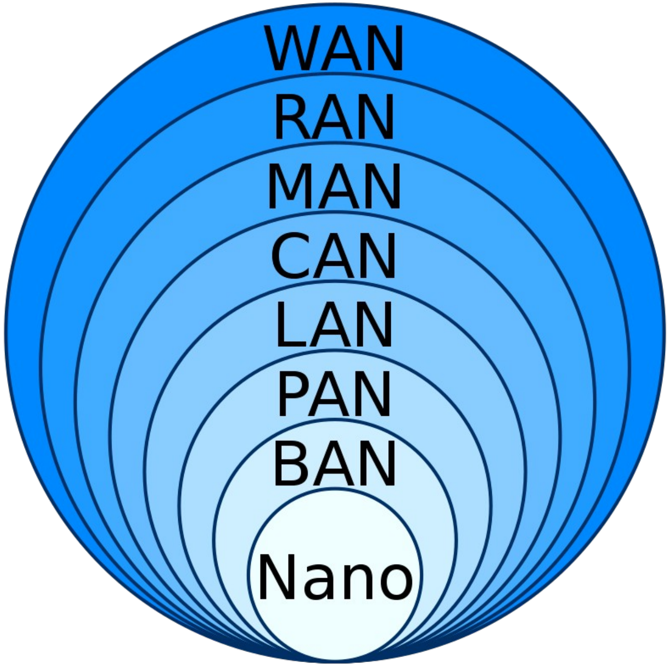
- Development of sensors, circuits and systems for applications requiring measurement.
- Emphasis on wireless or contactless solutions
- Design CMOS integrated circuits for miniaturization and low power consumption

Overview of the LRF Research Activities

Wireless Body Area Network

https://repositorio.ufsc.br/handle/123456789/185001





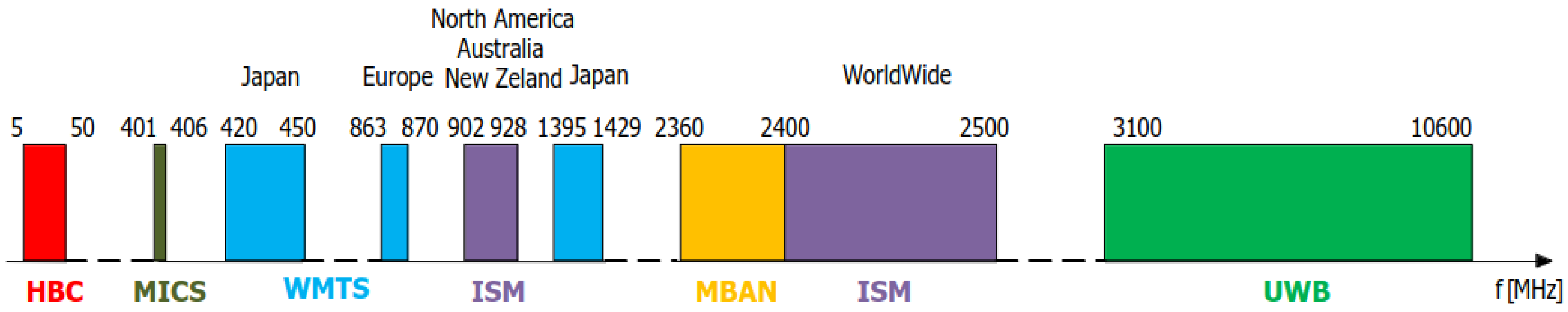
Michel Bakni, CC BY-SA 4.0

WBAN Characteristics

IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 16, NO. 3, THIRD QUARTER 2014

Wireless Body Area Networks: A Survey

Samaneh Movassaghi, *Student Member, IEEE,* Mehran Abolhasan, *Senior Member, IEEE,*
Justin Lipman, *Member, IEEE,* David Smith, *Member, IEEE,* and Abbas Jamalipour, *Fellow, IEEE*

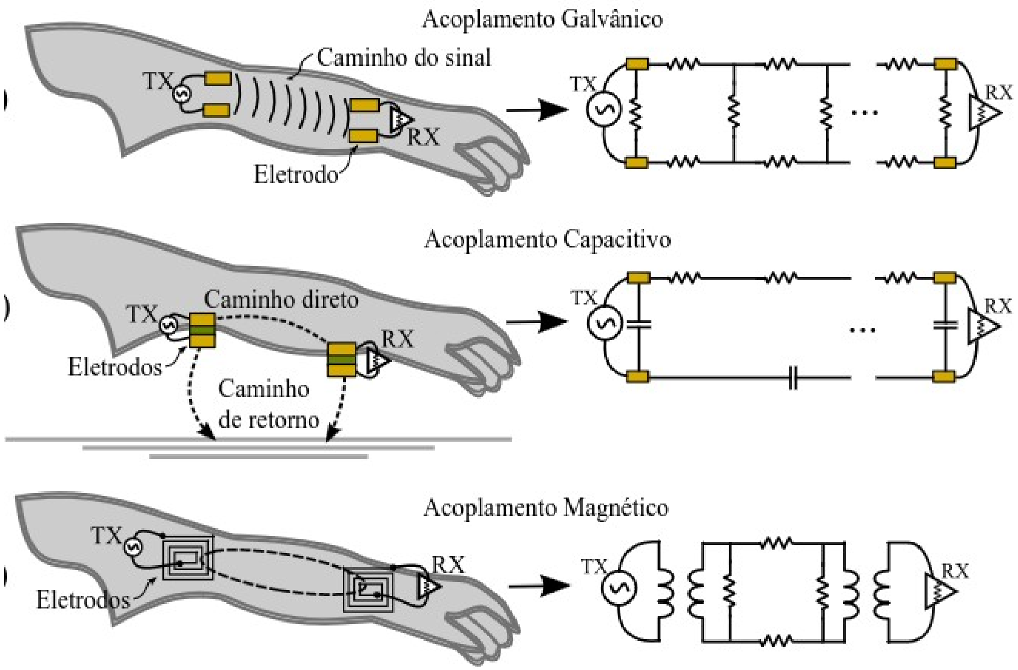


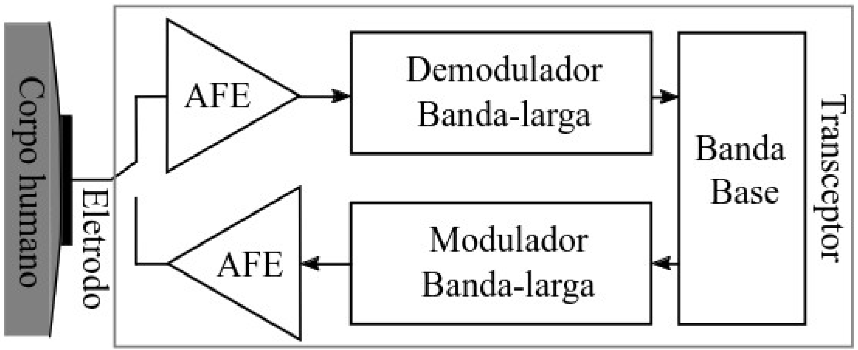
IEEE 802.15.6

Human-Body Communication	
Frequency	Bandwidth
16 MHz	4 MHz
27 MHz	4 MHz
Narrowband Communication	
Frequency	Bandwidth
402-405 MHz	300 kHz
420-450 MHz	300 kHz
863-870 MHz	400 kHz
902-928 MHz	500 kHz
956-956 MHz	400kHz
2360-2400 MHz	1 MHz
2400-2438.5 MHz	1 MHz
UWB Communication	
Frequency	Bandwidth
3.2-4.7 GHz	499 MHz
6.2- 10.3 GHz	499 MHz

Application Type	Sensor Node	Data Rate	Duty Cycle (per device) % per time	Power Consumption	QoS (Sensitive to Latency)	Privacy
In-Body Application	Glucose sensor	Few Kbps	$< 1\%$	Extremely low	Yes	High
	Pacemaker	Few Kbps	$< 1\%$	low	Yes	High
	Endoscope Capsule	$>$ 2 Mbps	$< 50\%$	low	Yes	Medium
On-Body Medical Application	ECG	3 Kbps	$< 10\%$	Low	Yes	High
	SpO2	32 Kbps	$< 1\%$	low	Yes	High
	Blood Pressure	$<$ 10 bps	$< 1\%$	High	Yes	Medium
On-Body Non-Medical Application	Music for Headsets	1.4 Mbps	High	Relatively High	Yes	Low
	Forgotten Things Monitor	256 Kbps	Medium	Low	No	Low
	Social Networking	$<$ 200 Kbps	$< 1\%$	Low	No	High

Human Body Communications

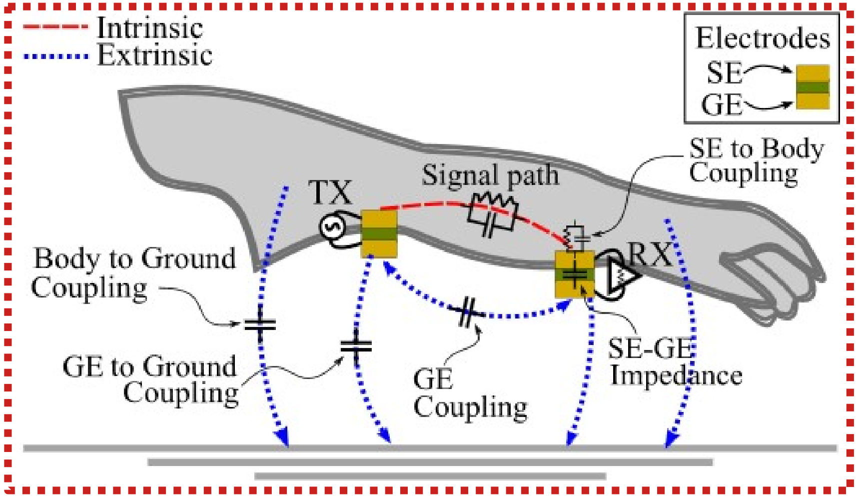


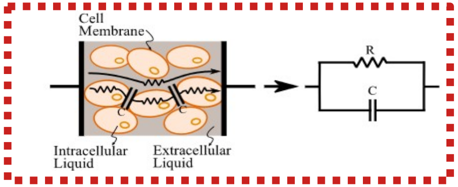


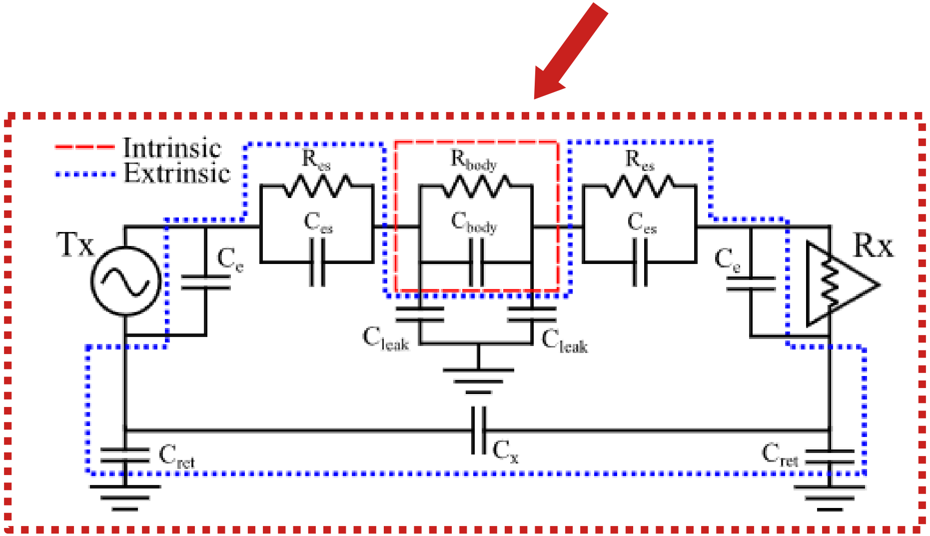
IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 64, NO. 10, OCTOBER 2015

Characterization and Modeling of the Capacitive HBC Channel

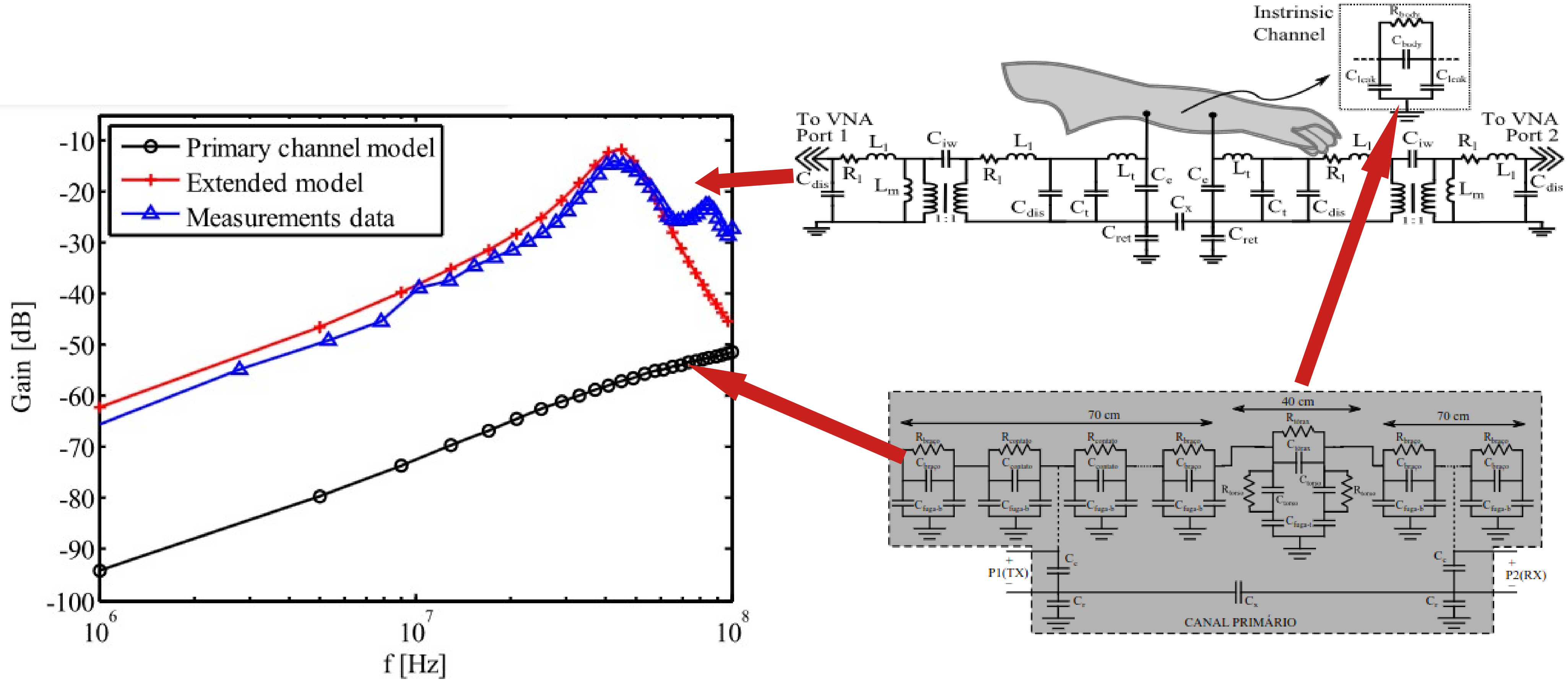
Maicon D. Pereira, *Member, IEEE,* Germán A. Alvarez-Botero, *Member, IEEE,* and Fernando Rangel de Sousa, *Senior Member, IEEE*





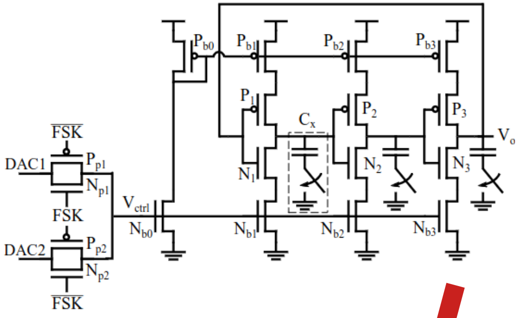


HBC Channel

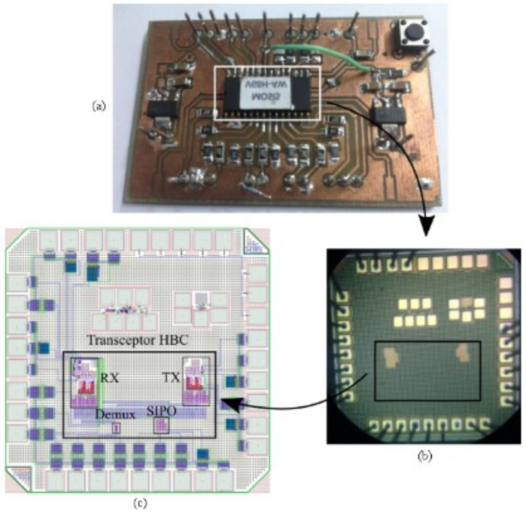


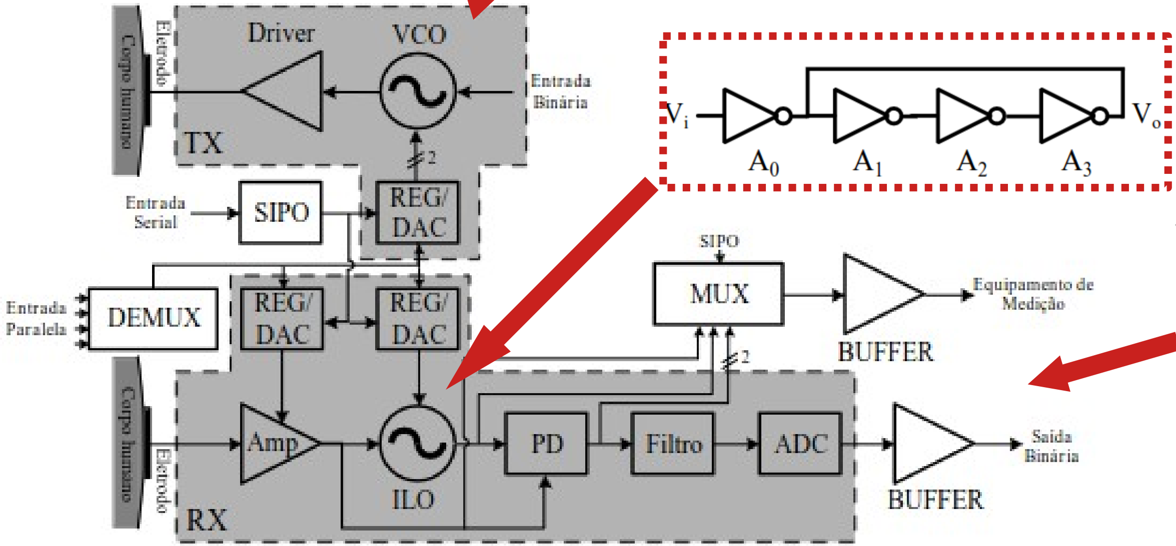
Primary channel model
Extended model
Measurements data
Gain [dB]
f [Hz]
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
10^6
10^7
10^8
Instrinsic Channel
To VNA Port 1
To VNA Port 2
1 : 1
70 cm
40 cm
P1(TX)
P2(RX)
CANAL PRIMÁRIO

HBC Transceiver



Modulação	BFSK
Frequência de operação	10-100 MHz
Taxa de dados	2 Mbps
Amplitude de saída - V_o	1,2 V
Potência consumida - P_{tx}	3,4-8,7 mW
Arquitetura	Modulação direta
En/bit	1,7-4,35 nJ/bit
Tensão de alimentação	1,2 V
Banda total	90 MHz
Tecnologia	CMOS 130 nm
Componentes externos	não
Impedância de saída	116 Ω



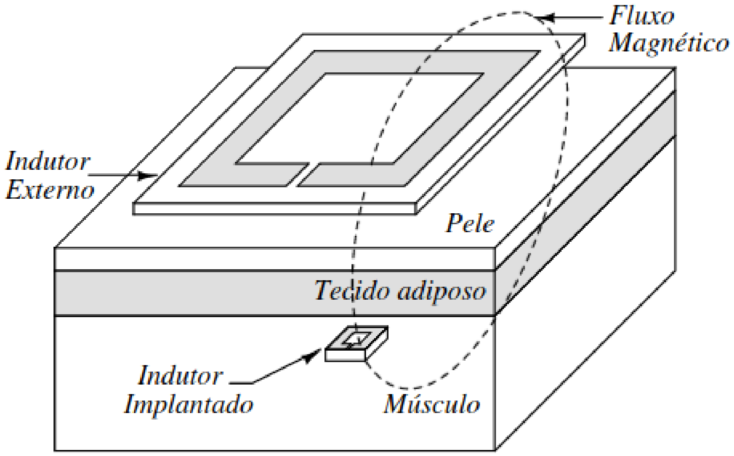


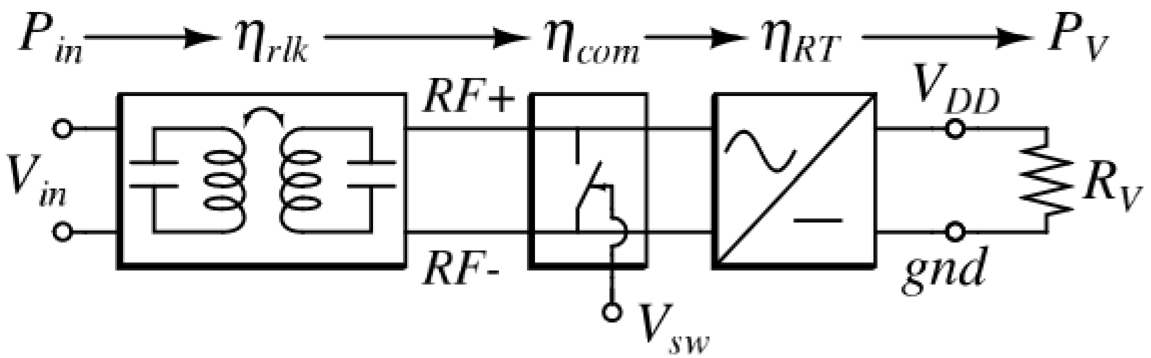
Modulação	BFSK
Frequência	10-100 MHz
Sensibilidade	698 μV@B5
Taxa de dados	2 Mbps
Amplitude de saída V_o (BB)	1,2 V
Potência consumida P_{rx}	0,417-0,620 mW
Arquitetura	Demod. ILO+PD
En/bit	208,6-310,3 pJ/bit
Tensão de alimentação	1,2 V
Banda total	90 MHz
Tecnologia	CMOS 130 nm
Componentes externos	não
Impedância de entrada	1,4 kΩ

Achieving Optimal Efficiency in Energy Transfer to a CMOS Fully Integrated Wireless Power Receiver

Fabian L. Cabrera and Fernando Rangel de Sousa, *Senior Member, IEEE*

The transition from idea to reality depends on addressing problems which remain unsolved. As stated in the visionary paper by Mark Weiser [3], *"the most profound technologies are those that disappear"*, however, the physical size as well as the cables used to deliver energy to current IoT-enabled devices are not compatible with the ongoing paradigm shift.

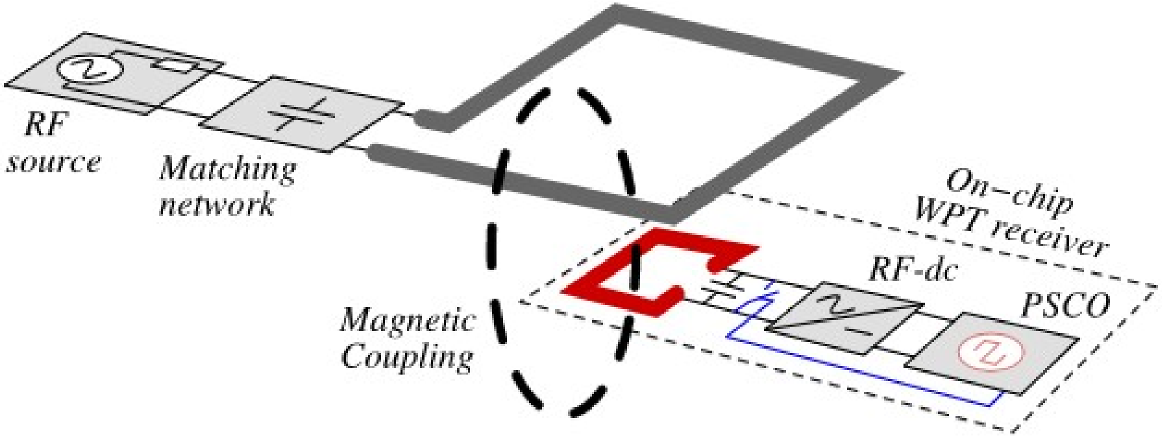


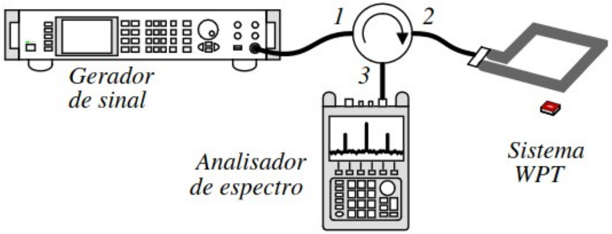


Part	Receiver				Transmitter	
Objectives	η_{com}	Q_{2r}	η_{RT}	p	k	Q_{1r}
Design variables	• Fixed value: 0.5	• Integrated inductor • Frequency (f)	• Rectifier • Load (R_V) • Power (P_V)		• Primary inductor	

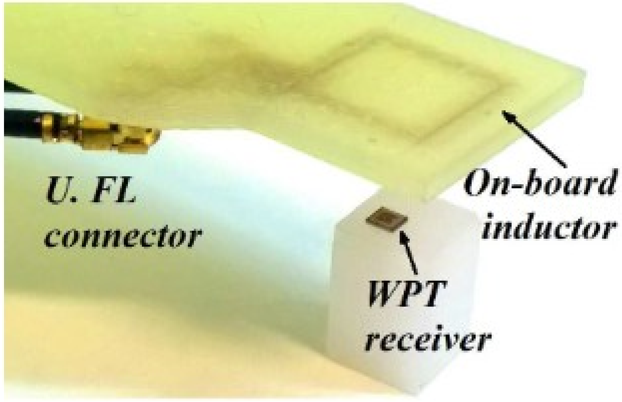
$$\eta_T = \frac{\eta_{com}\eta_{RT}}{\frac{1}{k^2 Q_{1r} Q_{2r}}\left(p + 2 + \frac{1}{p}\right) + p + 1}$$

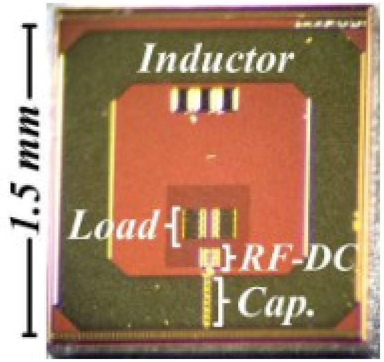
WPT CMOS (Receiver)





$$FoM = \frac{\eta_{rlk} \times d^3}{A_{Rx}^{3/2}}$$

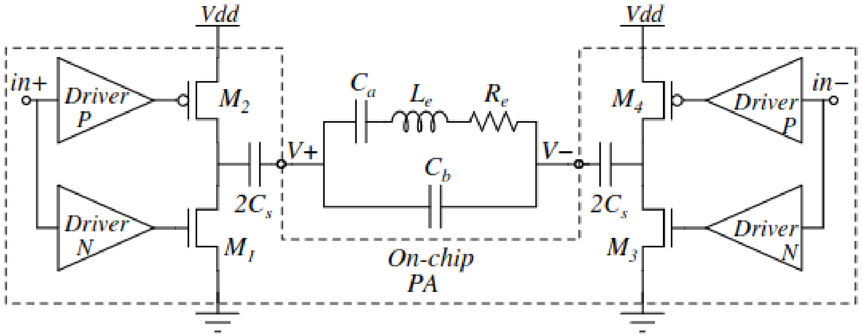




	Area (mm^2)	Receiver technology	Q_2 (max.)	f (MHz)	η_{rlk} (%)	d (mm)	FoM
This work	2.3	CMOS 180 nm	21	986	7.26*	5	269
					0.93*	10	276
					0.29*	15	290
[15]	4.8	CMOS 130 nm	11	187	1.42**	10	159
[17]	20.3	High resistivity substrate and post-processing	20	7	4.3**	12	82
[13]	0.4	CMOS 180 nm	–	900	0.16	2	6
[11]	0.5	CMOS 130 nm post-processing	3	2450	0.02	0.5	0.01

A 25-dBm 1-GHz Power Amplifier Integrated in CMOS 180nm for Wireless Power Transferring

Fabian L. Cabrera, and F. Rangel de Sousa
Radiofrequency Laboratory
Federal University of Santa Catarina
Florianópolis-SC, 88040-900, Brazil.
fabian.l.c@ieee.org, rangel@ieee.org



Ref.	f_o [MHz]	$P_{Rs(1)}$ [dBm]	η [%]	Area [mm^2]	Tech. [nm]	Class	Inductors
[7]	800	30.4	40.7	5	180	E	On-chip transformer
[3]	900	29.5	41	4	250	E	Bondwires
[2]	900	24.4	55	1.2	45	D	External
This work	990	25.1	58	1.5	180	D	No
[8]	820	29	70.7	0.5	180	E	External

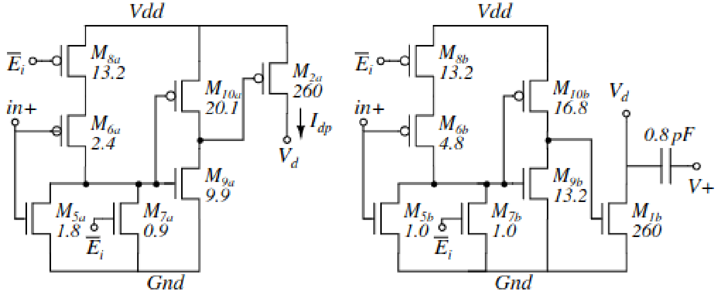


Figure 7: PA unit cell: (a) PMOS part. (b) NMOS part.

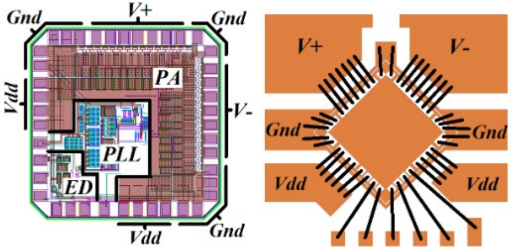
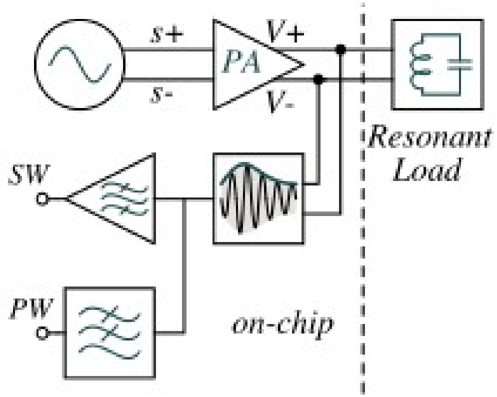


Figure 8: (a) Layout 1.5 mm × 1.5 mm. (b) PCB bonding diagram.

Test strategy for a 25-dBm 1-GHz CMOS power amplifier in a wireless power transfer context

Fabian L. Cabrera and F. Rangel de Sousa



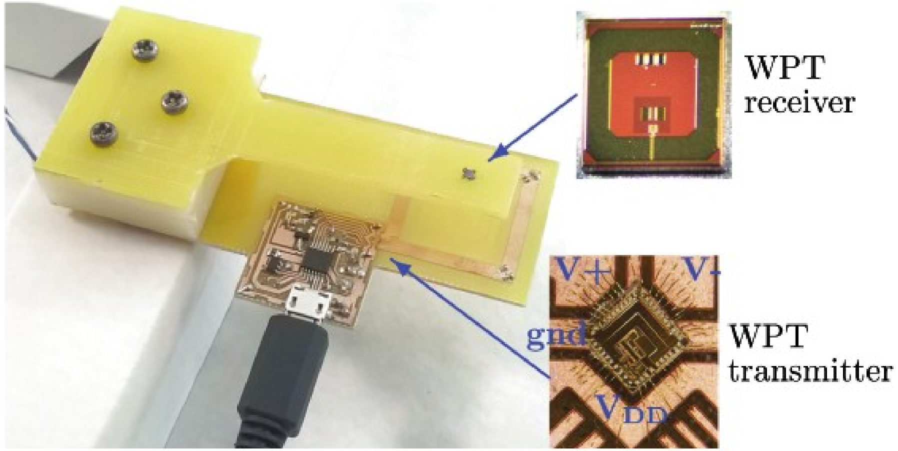
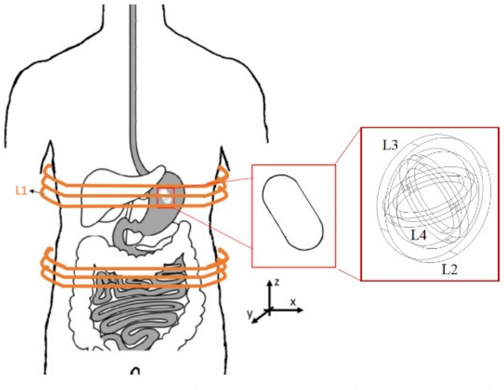
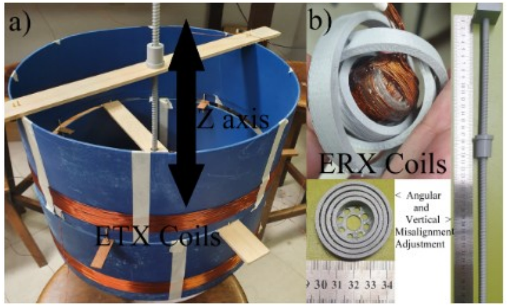


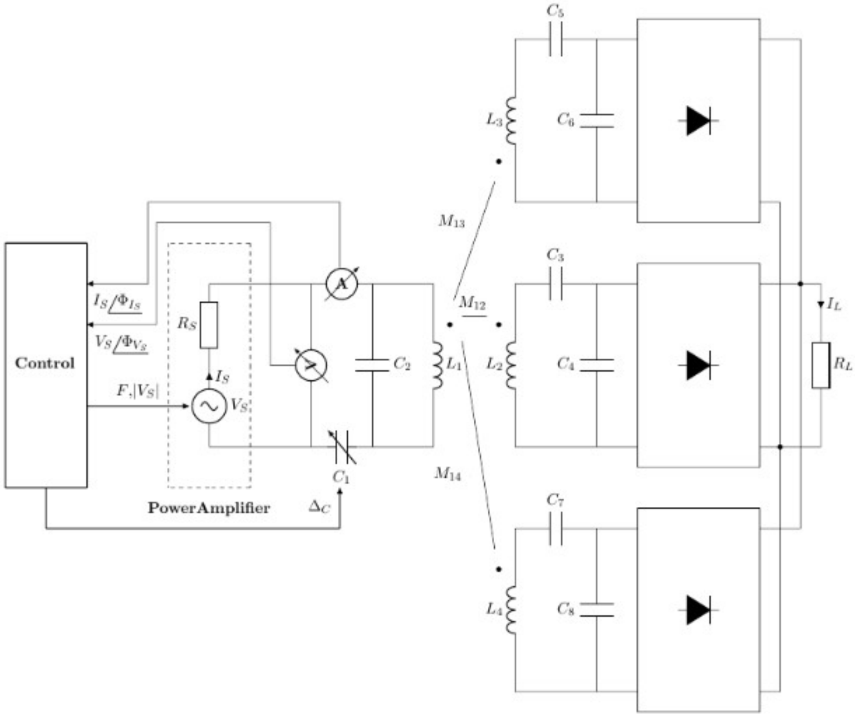
Table 1. Comparison of CMOS power amplifiers.

Ref.	[1]	[2]	[3]	[4]	[5]	[6]	This work
f_o (MHz)	978	900	880	800	920	820	986
Class	A	D	C	G	–	E	D
$P_{Rs(1)}$ (dBm)	24	24.4	27	23.5	27.7	29	24.2
η (%)	10	55*	47.4	42.7	44.3	70.7	48.1
Area (mm^2)	3.5	1.2	1.3	1.2	0.8	0.48	1.5
CMOS (nm)	180	45	180	55	55	180	180
Load (Ω)	50	50	50	50	50	50	1.8+ j58
OMN inductors†	Int.	Ext.	Ext.	Ext.	Ext.	Ext.	None

WPT for endoscopic Capsule







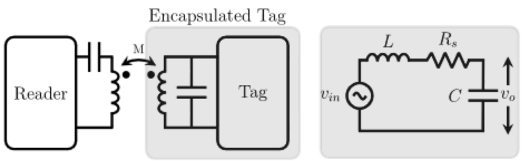
Article

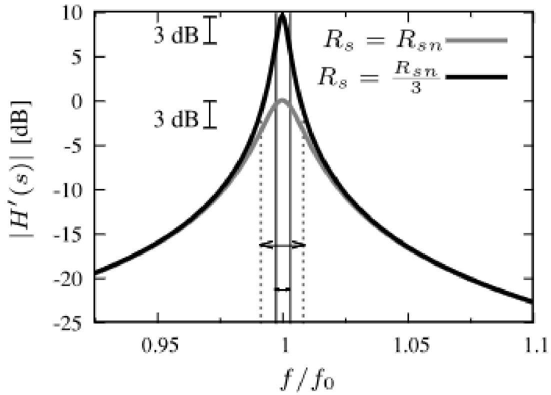
Tracking and Dynamic Tuning of a Wireless Powered Endoscopic Capsule †

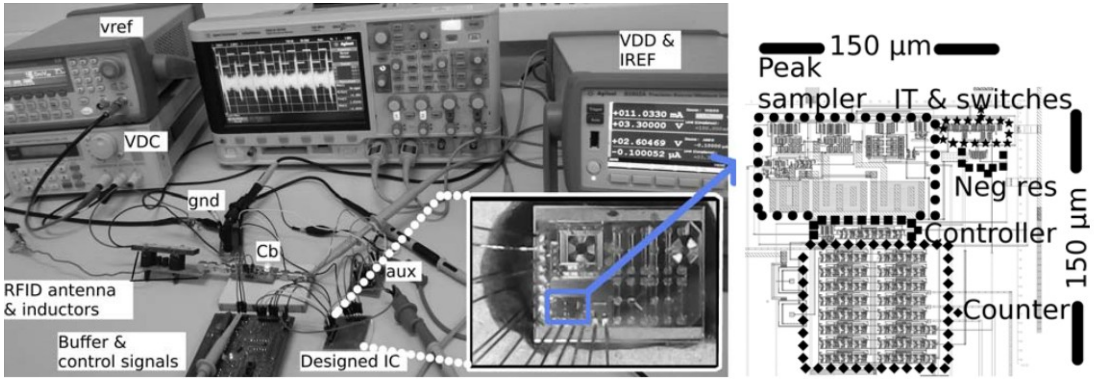
Lucas Murliky [1,*], Gustavo Oliveira [1], Fernando Rangel de Sousa [2] and Valner João Brusamarello [1,*]

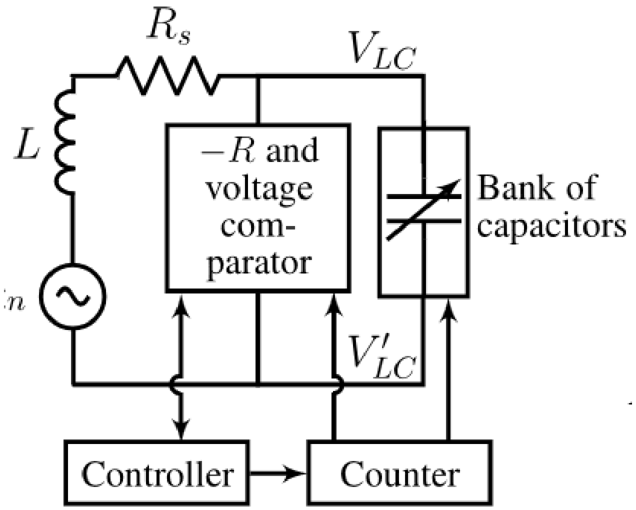
On-Chip Automatic LC Tuner for RFID Tags Based on Negative Resistances

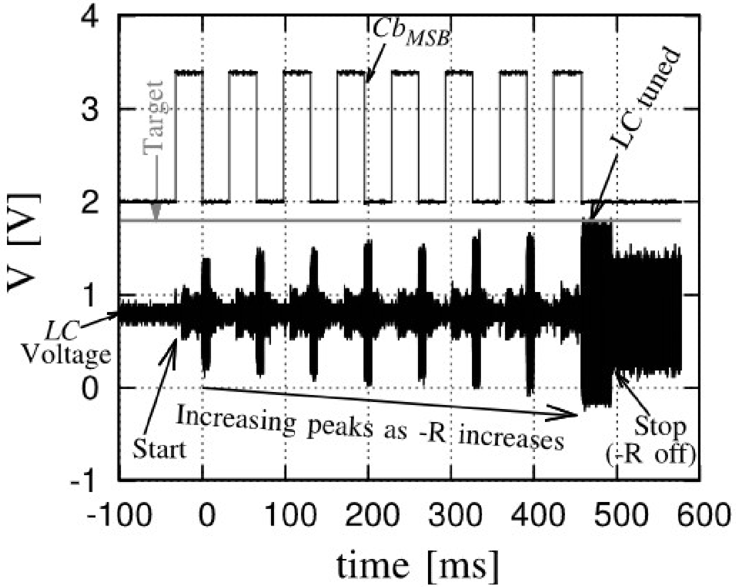
Paulo M. M. Silva, Fernando Rangel de Sousa, *Senior Member, IEEE*, and Calvin Plett, *Senior Member, IEEE*





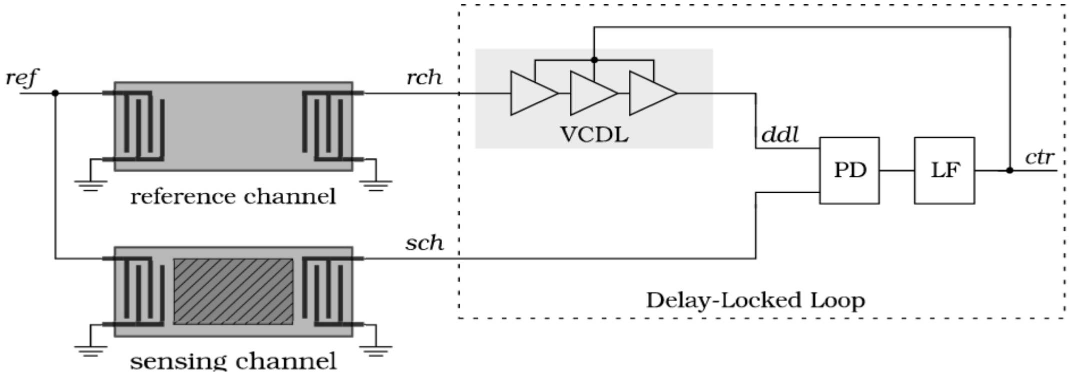


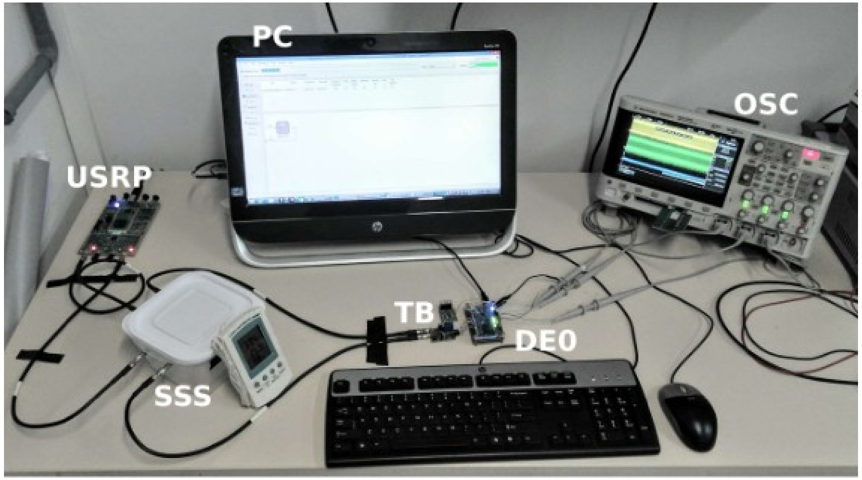


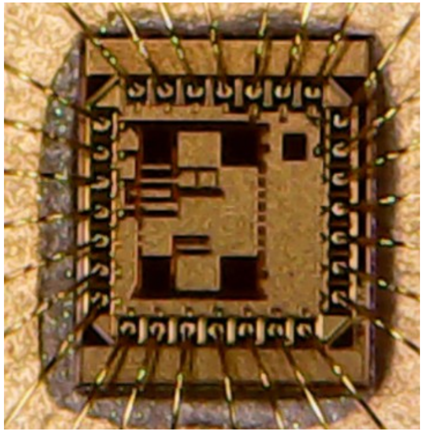


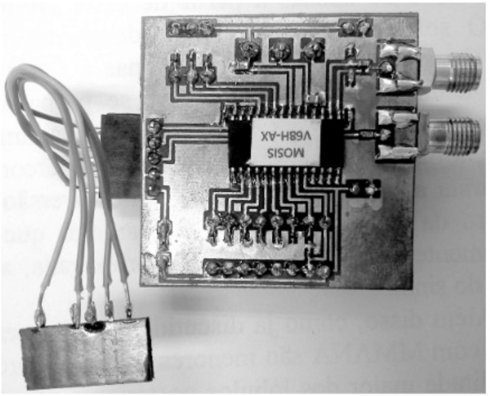
ANALYSIS AND DESIGN OF A CMOS DLL-BASED CONDITIONER FOR A SAW-DL RELATIVE HUMIDITY SENSOR

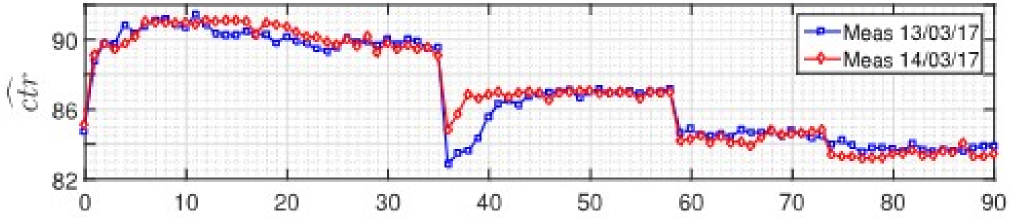
Rodrigo Eduardo Rottava





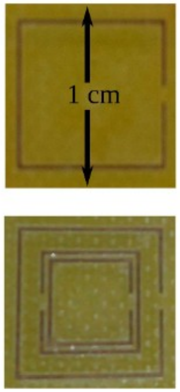






Miniaturized Chipless Sensor With Magnetically Coupled Transducer for Improved RCS

Roddy A. Romero Antayhua, *Student Member, IEEE*, Carlos Renato Rambo, *Member, IEEE*, and Fernando Rangel de Sousa, *Senior Member, IEEE*



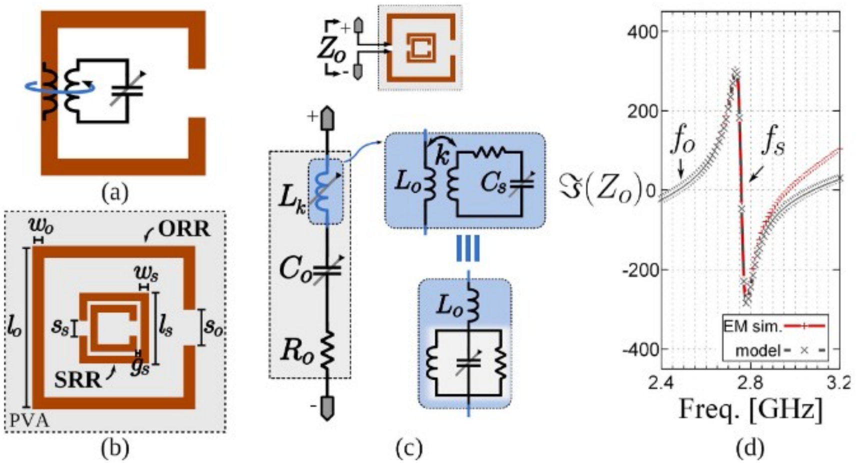
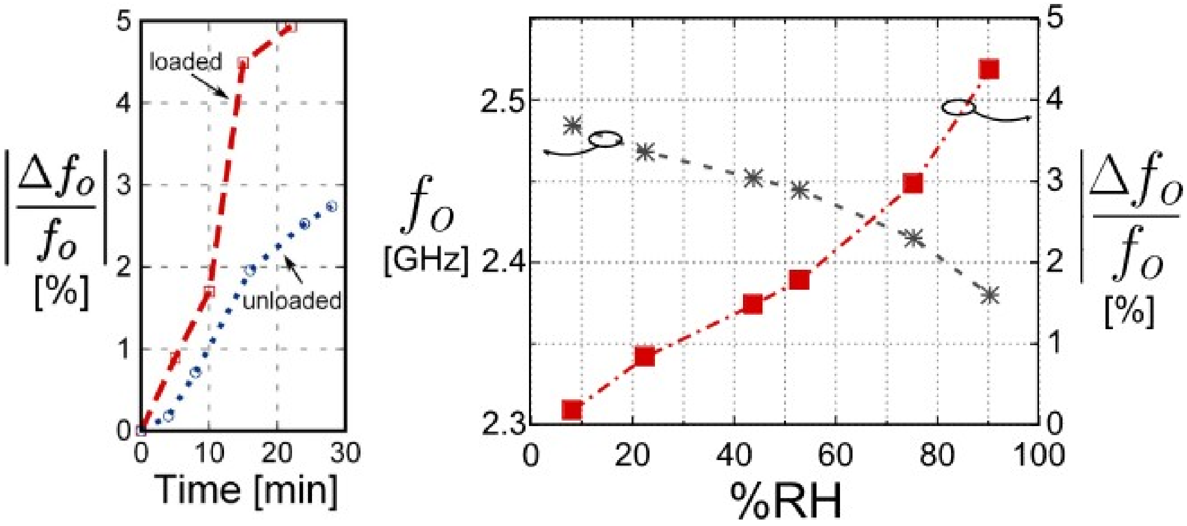


Fig. 2. ORR with magnetically coupled transducer (a) concept and (b) layout. (c) Electrical model for the equivalent impedance and (d) its validation with EM simulation.

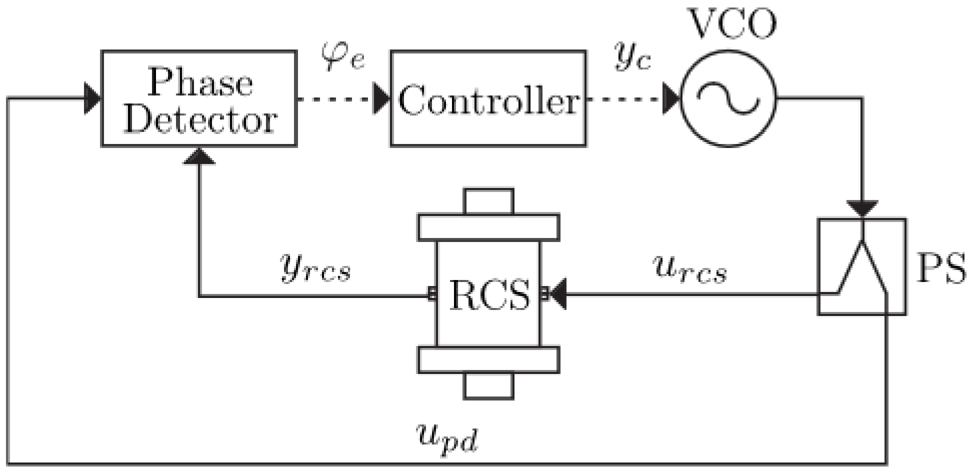


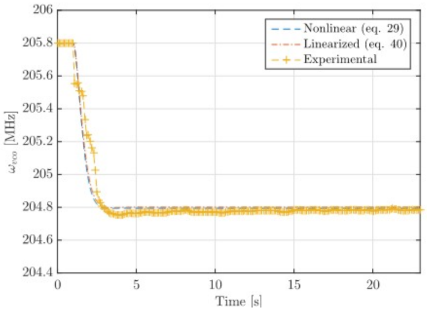
(a) (b)

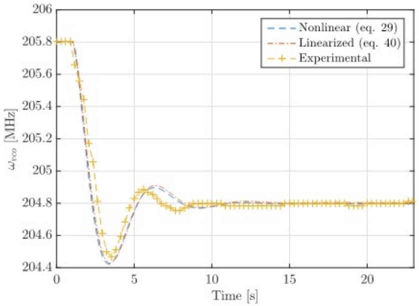
IEEE SENSORS JOURNAL, VOL. 19, NO. 17, SEPTEMBER 1, 2019

Modeling and Analysis of a PLL-Based Resonant Frequency Tracking System Using a Resonant Cavity Sensor

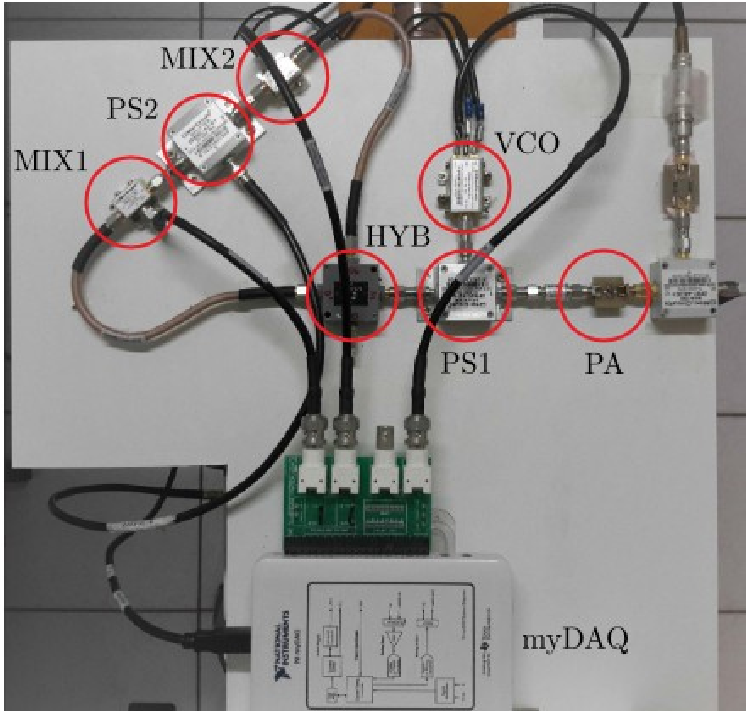
Heron Eduardo de Lima Ávila, Gustavo Artur de Andrade, Fernando Rangel de Sousa, *Senior Member, IEEE*, and Daniel J. Pagano, *Member, IEEE*



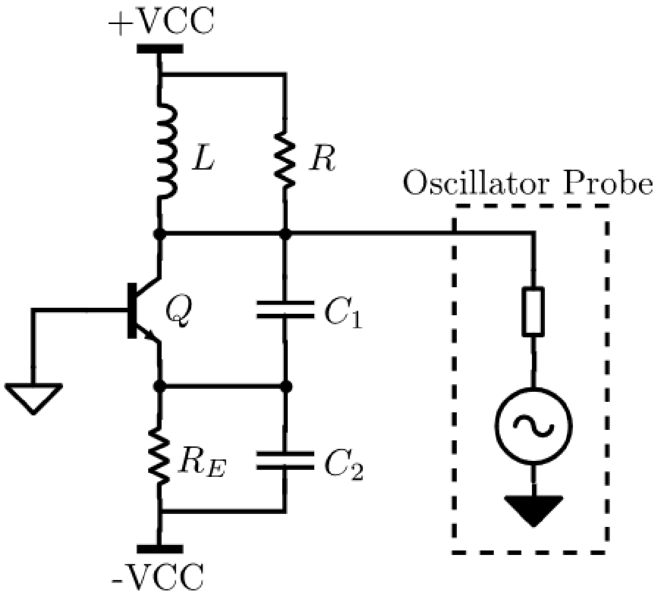


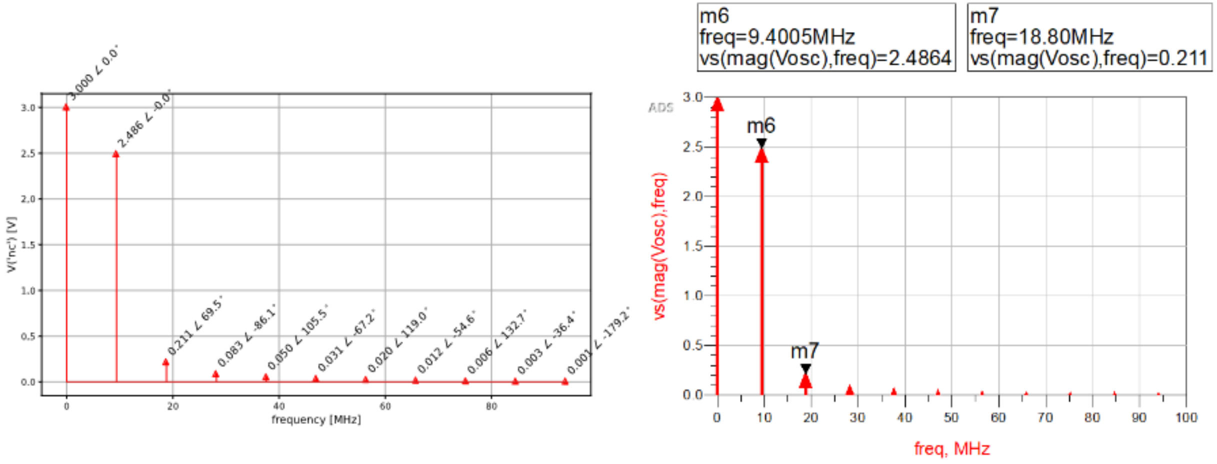


(a) (b)



PyHBSIM - the Steady-State Simulation of Autonomous Circuits using the Harmonic Balance Method





a) YalRF

b) ADS

https://pyhbsim.ufsc.br

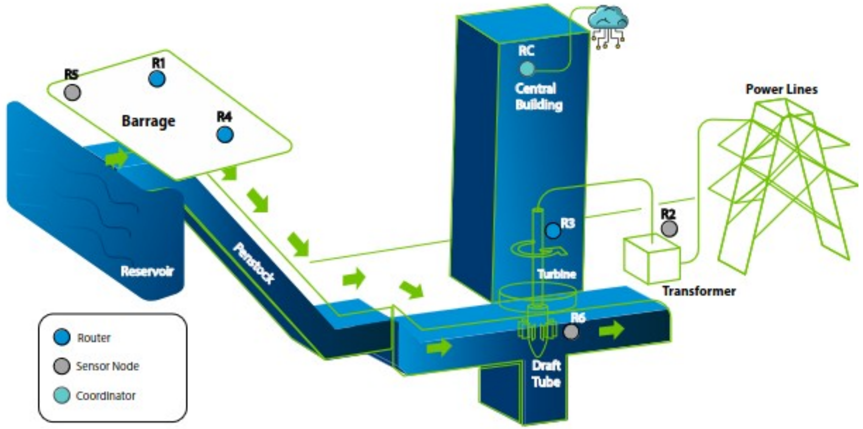
sensors

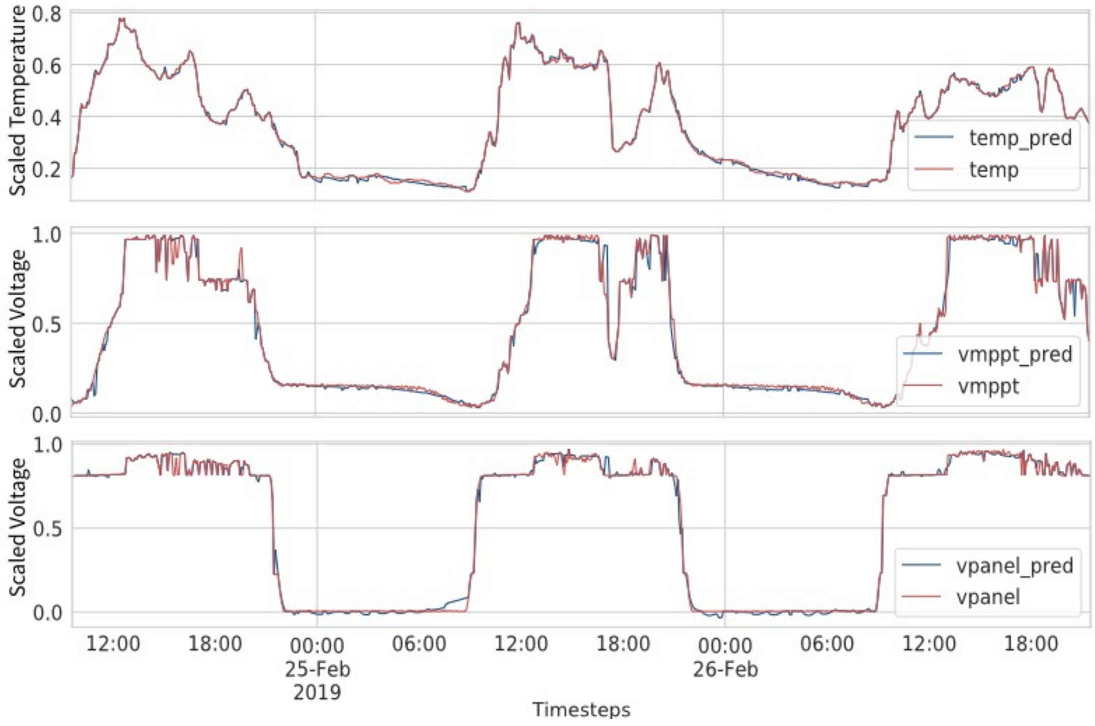
MDPI

Article

Evaluation of Deep Learning Methods in a Dual Prediction Scheme to Reduce Transmission Data in a WSN

Carlos R. Morales [1], Fernando Rangel de Sousa [1,*], Valner Brusamarello [2] and Nestor C. Fernandes [3]





Five-Port Receiver (1.8-5.5 GHz)

Thèse

présentée pour obtenir le grade de Docteur de

l'Ecole Nationale Supérieure des Télécommunications de Paris

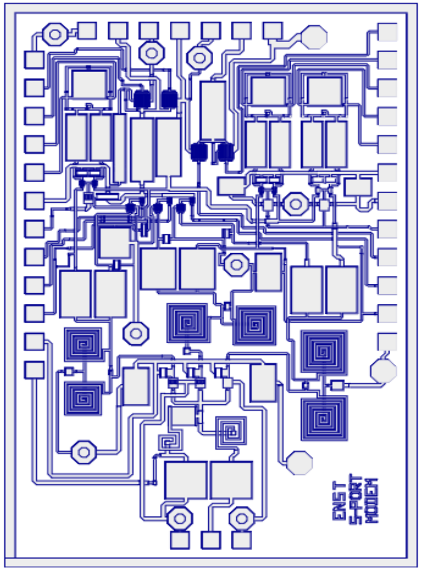
Spécialité: **Électronique et Communications**

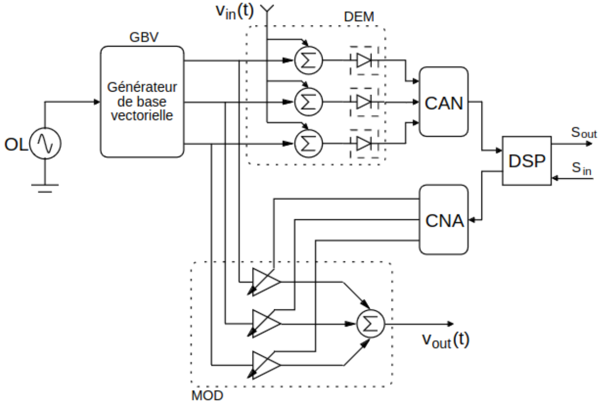
Fernando Rangel de Sousa

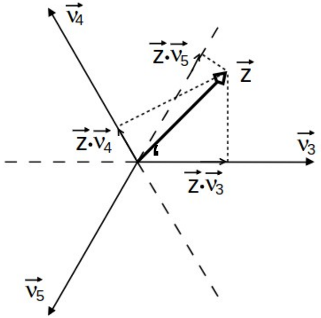
Application du corrélateur « Five-Port » aux PLLs, à la récupération de porteuse et à un MODEM de télécommunications dans la bande 1,8 - 5,5 GHz

Soutenue le 18 octobre 2004 devant le jury composé de:

Raymond QUÉRÉ	Université de Limoges	Président
Vicent GIORDANO	Institut FEMTO-ST	Rapporteur
Serge TOUTAIN	Université de Nantes	Rapporteur
Robert WEIGEL	Université de Erlangen (Alemagne)	Examinateur
Raimundo C. S. FREIRE	UFCG (Brésil)	Examintaeur
Eric BERGEAULT	ENST Paris	Examinateur
Francisco M. DE ASSIS	UFCG (Brésil)	Examinateur
Bernard HUYART	ENST Paris	Directeur de thèse

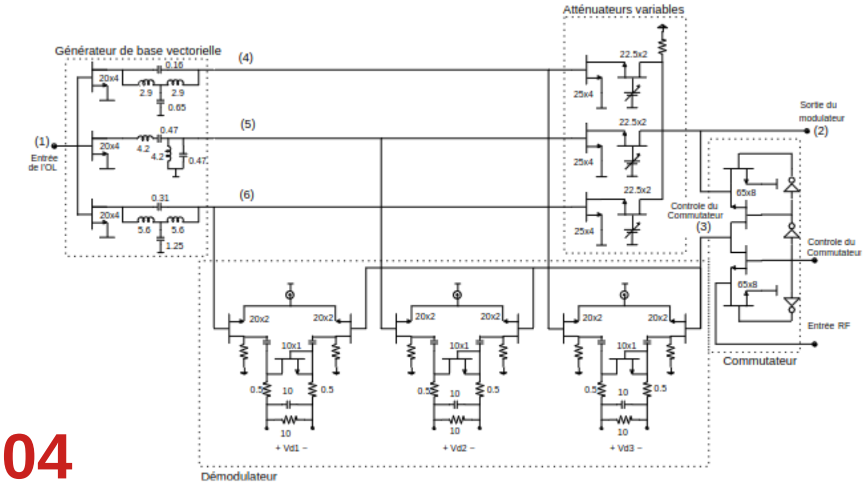


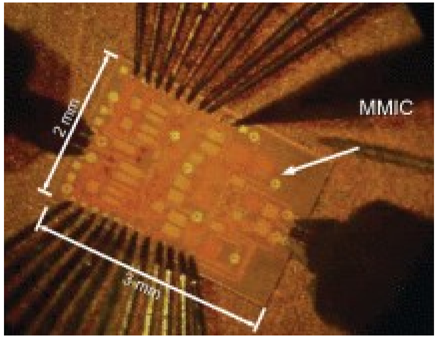




$$z_I(t) = \check{v}_3(t)r_I + \check{v}_4(t)s_I + \check{v}_5(t)t_I$$

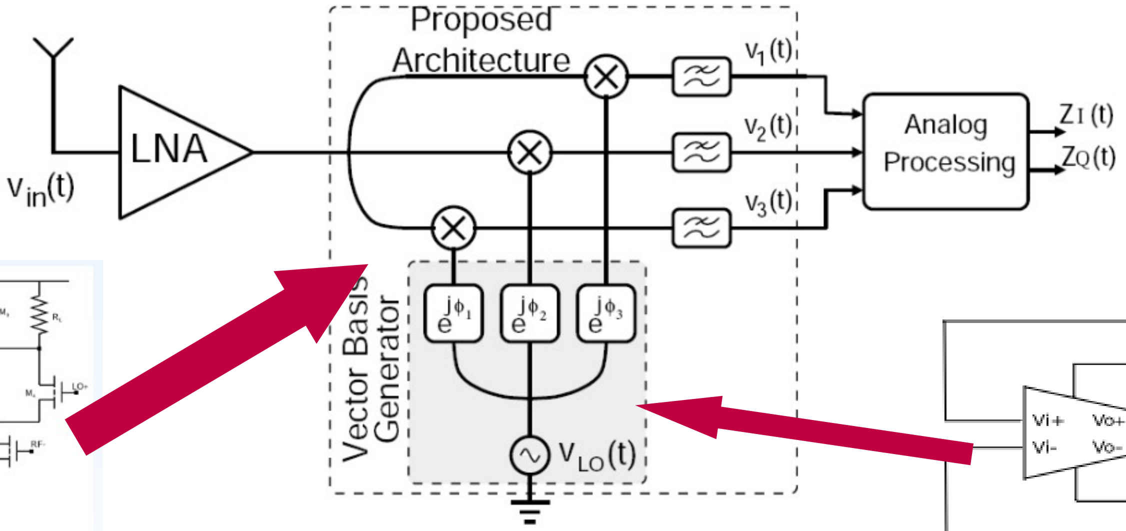
$$z_Q(t) = \hat{v}_3(t)r_Q + \hat{v}_4(t)s_Q + \hat{v}_5(t)t_Q$$

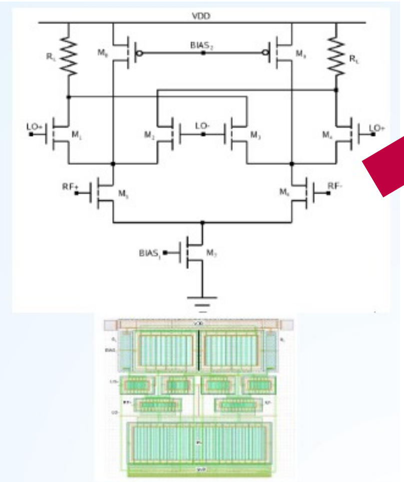


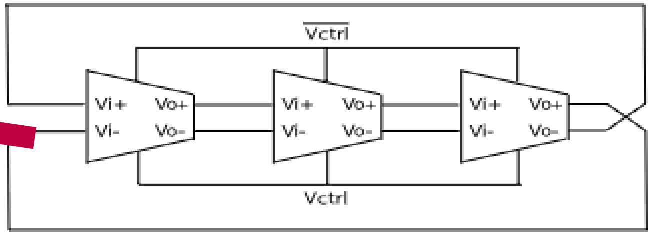


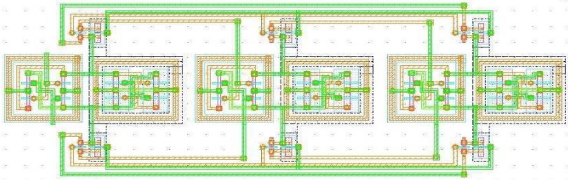
2004

3-mixers RF Receiver









2008

Teaching Actvities

- IoT: Circuits, Systems and Aplications
- RF Circuits

Collaboration possibilities

- **BRAFITEC Network (12 undergraduate students/year, 2023-2026)**
  - Polytech Montpellier (Projeto RAISON)
  - Polytech Marseille(Projeto RAISON)
  - École Nationale Supérieure de Chimie de Montpellier – ENSCM (Projeto RAISON)
  - Institut National Polytechnique de Toulouse – (Projeto SITESA)
  - Bordeaux INP – (Projeto SITESA)
  - Grenoble INP – PHELMA (Projetos RAISON e SITESA)
  - Grenoble INP- ENSE3 (Projeto SITESA)
  - Grenoble INP – ESISAR (Projetos SITESA e FUTURE)
  - Polytech Grenoble (Projetos SITESA e FUTURE)
  - ISIMA – Institut Supérieur d’informatique, de Modélisation et de leurs Applications (Projeto FUTURE)
  - Polytech Clermont (Projeto FUTURE)

Collaboration possibilities

- **CAPES-COFECUB (graduate level network)**
  - Calls every year
  - Hard competition with Humanities people

Collaboration needs

- Internationalization
- Mobility
- Infrastructure share
- Opportunities for state-of-the art problems
- Technology access

Florianopolis is cool

Thank you

http://lrf.ufsc.br

Fernando.rangel@lip6.fr
rangel@ieee.org