

Circuitos Integrados de RF para redes sensoriais corporais (WBAN)

Fernando Rangel de Sousa

Grupo de Pesquisas em RF
Departamento de Engenharia Elétrica

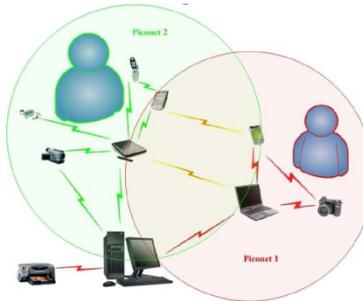


Aplicações em RF

RFD



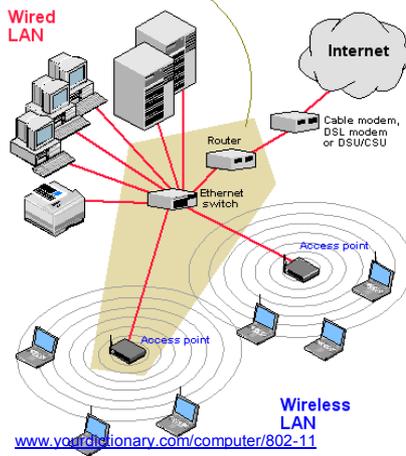
WPAN (person centered)



WLAN

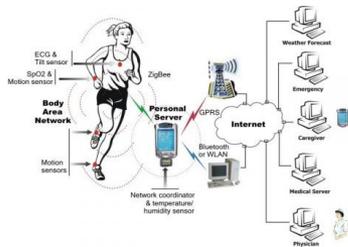
From Computer Desktop Encyclopedia © 2007 The Computer Language Co. Inc.

In a "wireless router," the router, a switch and one access point are built into one box.

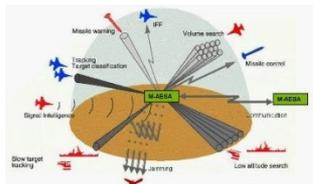


www.vocabulary.com/computer/802-11

WPAN

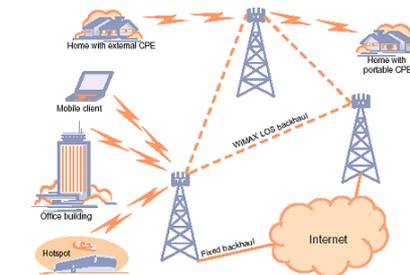


Defense



<http://www.fmv.se/WmTemplates/page.aspx?id=2160>

WMAN



http://engweb.info/courses/wdt/lecture04/WIMAX_Technology_r.html

Mobile Phone Network 2G, 3G, 4G



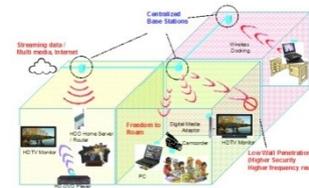
<http://giladlotan.org/thesis/methodology.html>

Space communication

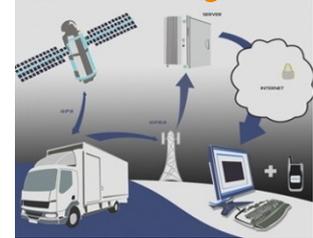


Redefining Home Networks with mmWave

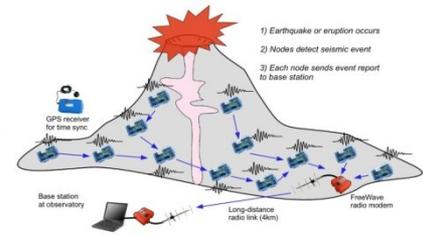
60 GHz for multimedia communications



Car tracking Self driving cars



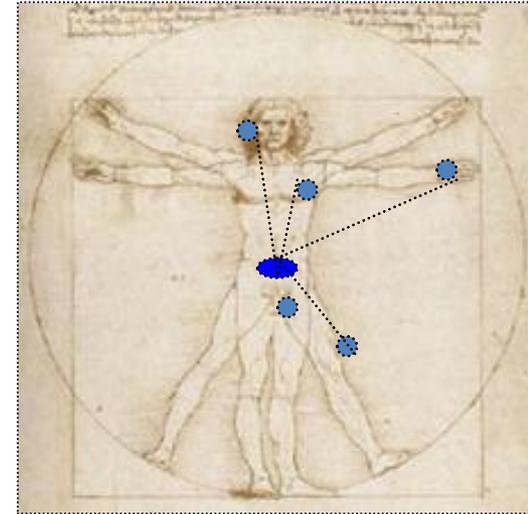
Wireless sensor networks



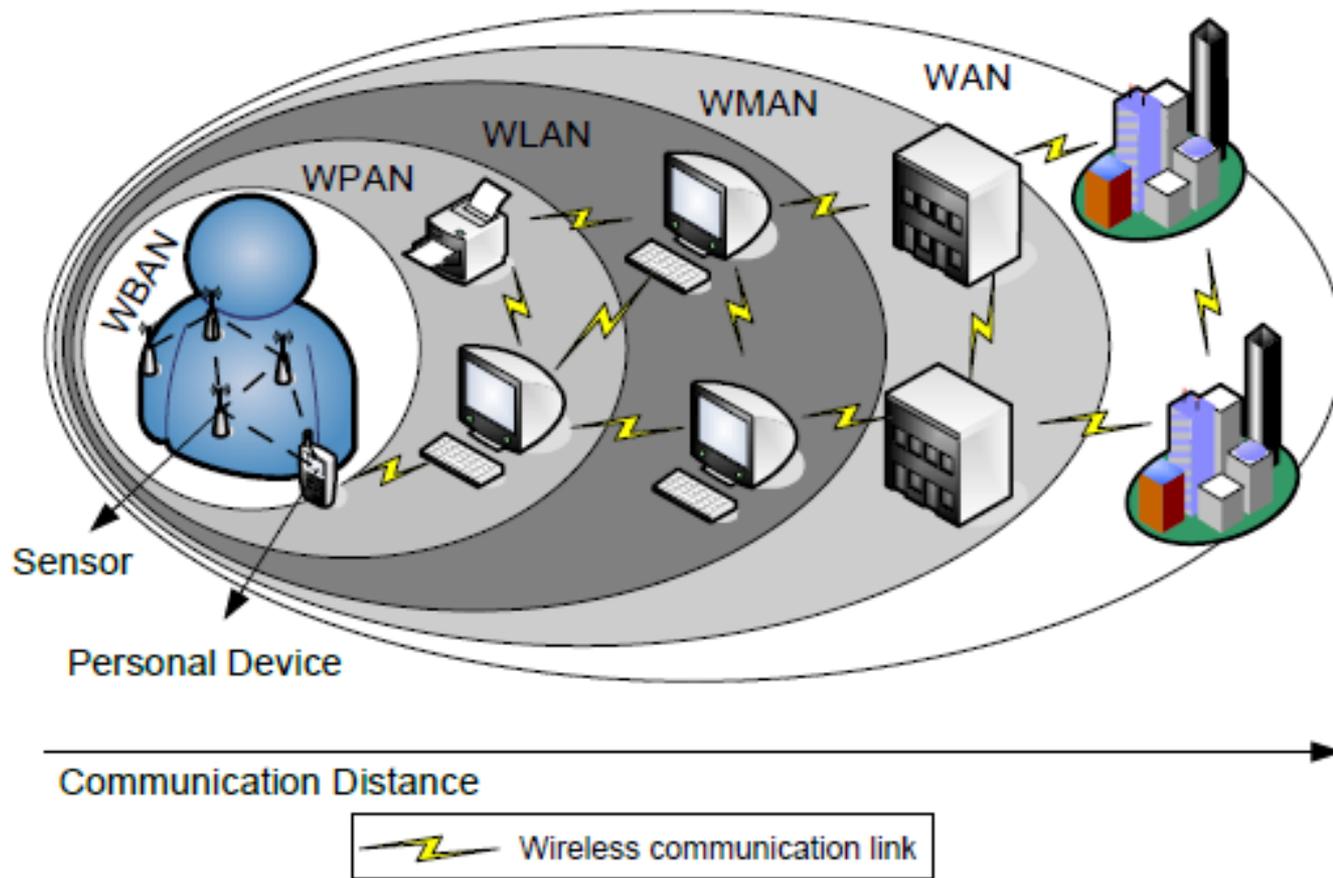
- 1) Earthquake or eruption occurs
- 2) Nodes detect seismic event
- 3) Each node sends event report to base station

O que é uma WBAN?

- **O lugar ideal para monitorar diferentes sinais vitais, estimular eletricamente ou injetar drogas não acontece no mesmo ponto.**
- **Uma WBAN deve:**
 - **prover links de comunicação no corpo ou em torno dele;**
 - **permitir a comunicação entre sensores, atuadores e elementos de processamento de energia e de informação.**



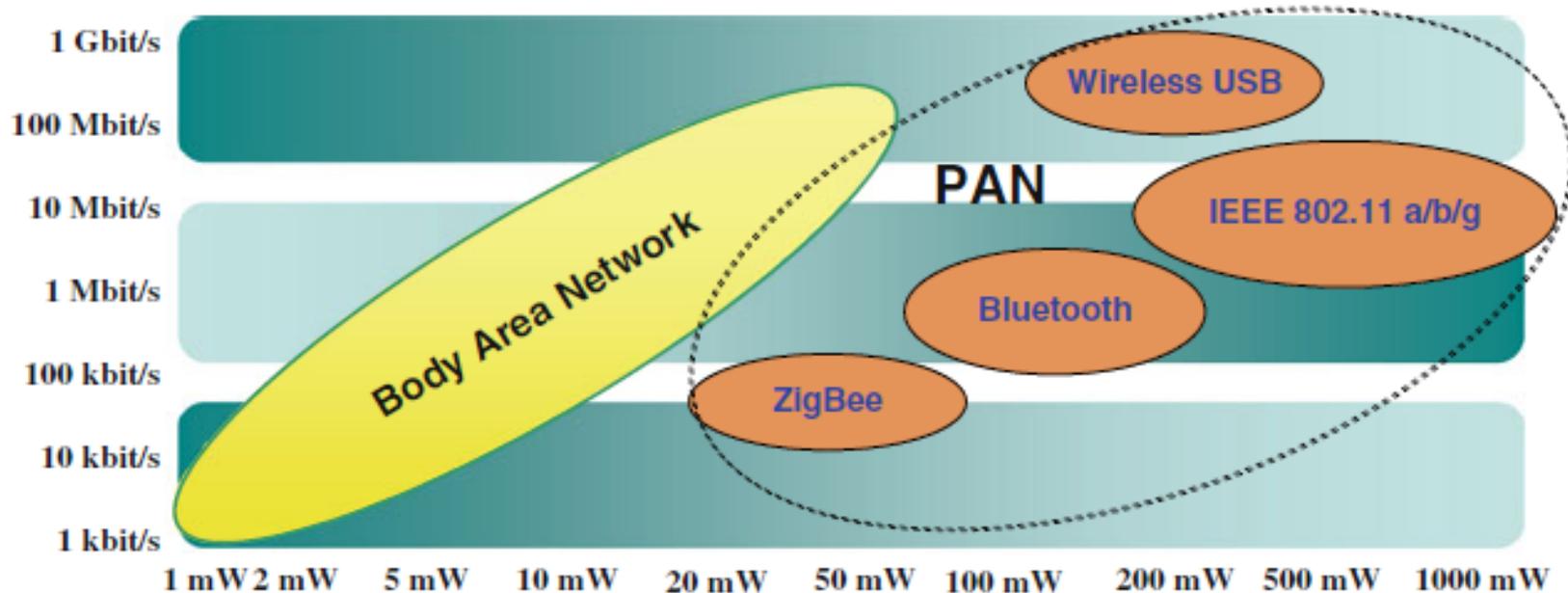
Redes IEEE 802.x



Padrão IEEE 802.15.6

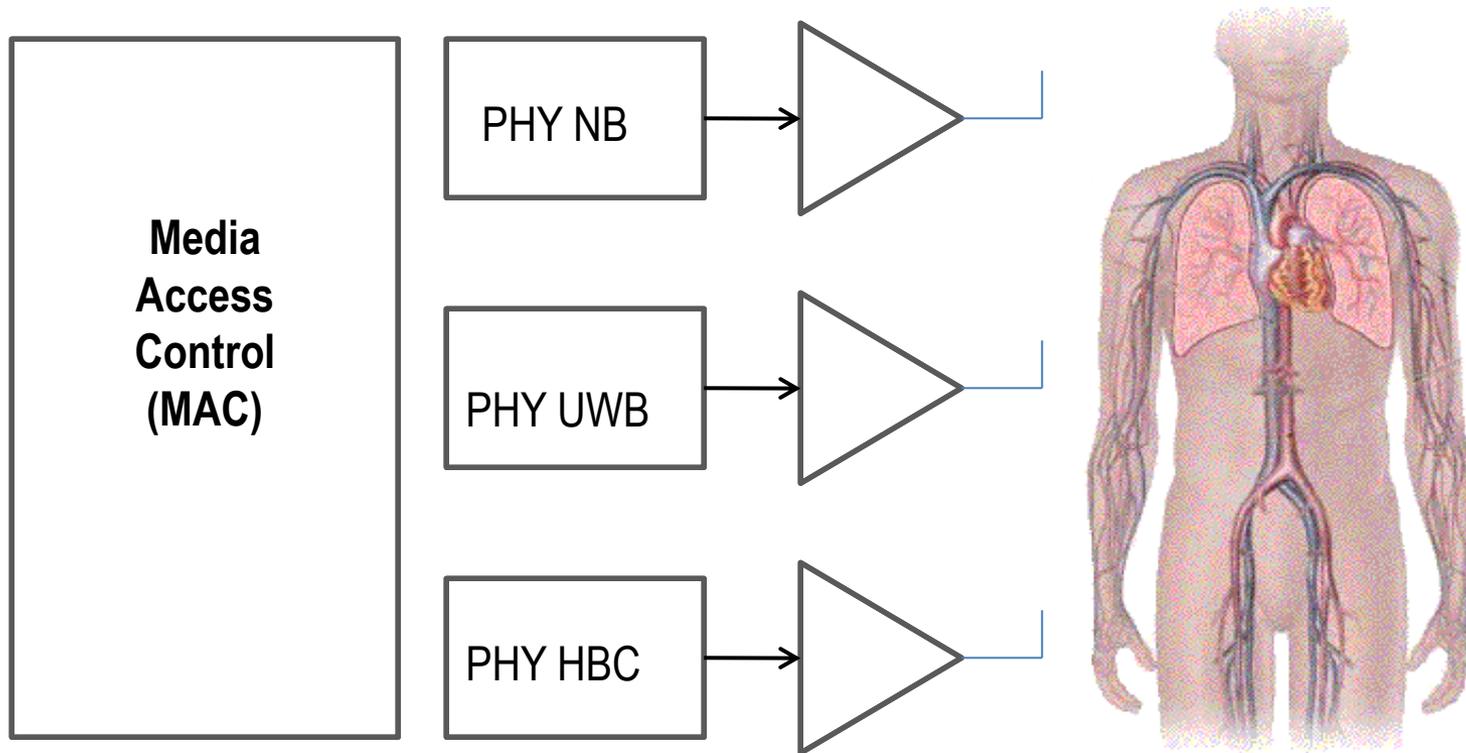
- Lançado em 2012
- **Objetiva estabelecer uma norma internacional para sistemas de comunicação sem fios com as seguintes características:**
 - baixo consumo
 - alta confiabilidade
 - operação em distâncias curtas
 - utilização nas proximidades ou no interior de **um corpo humano.**

Taxa de dados X consumo



Arquitetura 802.15.6

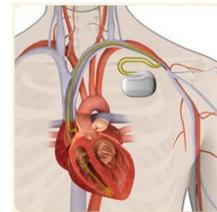
- **1 MAC**
- **3 PHY**



IEEE802.15.6 NB (Faixa-estreita)

- **Concebido para aplicações médicas:**

- **Implantáveis**
- **Vestidas**



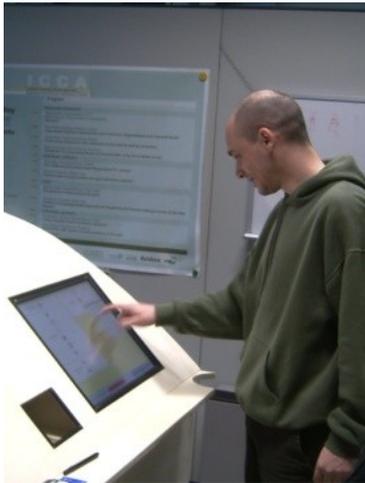
Frequency Band (MHz)	Number of Channels	Channel bandwidth
402 – 405	10	300 kHz
420 – 450	12	320 kHz
863 – 870	14	400 kHz
902 – 928	60	400 kHz
950 – 958	16	400 kHz
2360 – 2400	39	1 MHz
2400 – 2483.5	79	1 MHz

Implantable

Wearable

IEEE802.15.6 HBC

- **Human Body Communication**
 - O electrodo em contacto com o corpo é utilizado para a transmissão ou recepção de um sinal eléctrico através do corpo para um dispositivo (por exemplo, smartphone)



Outras aplicações HBC



Figure 1 – HBC Applications

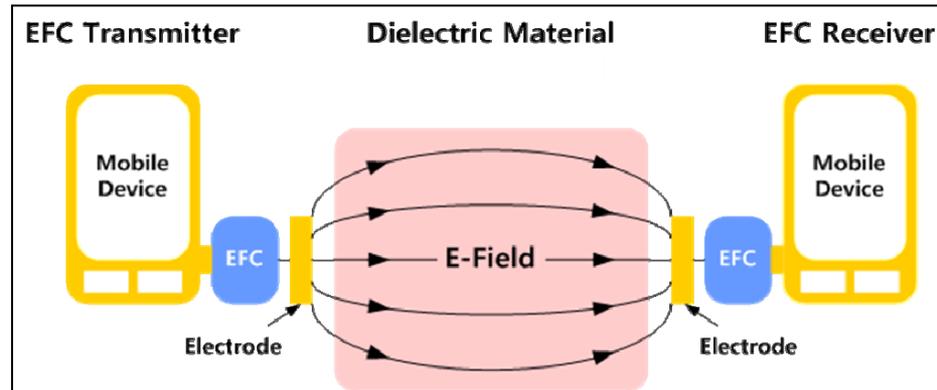
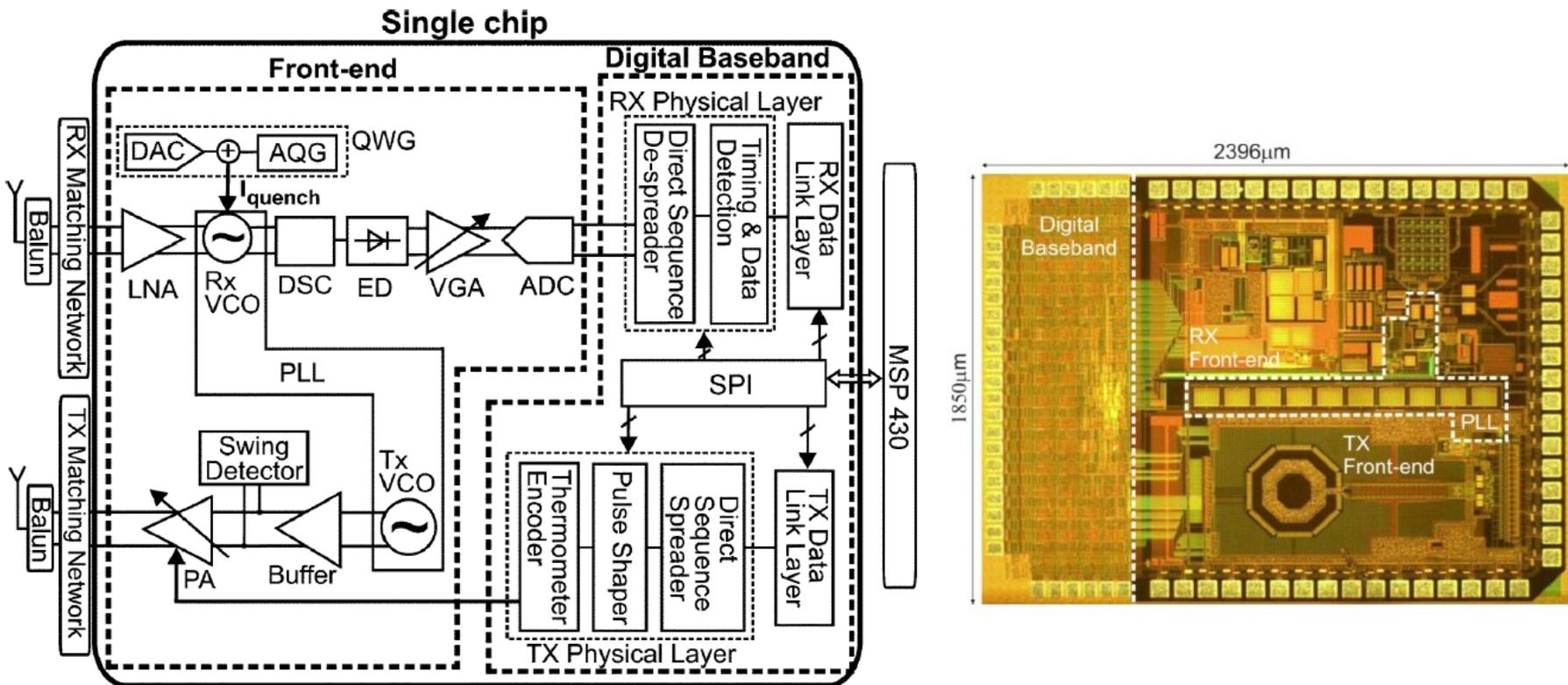


Figure 2 – EFC Concept

Sensores para aplicações WBAN

Sensor	How it works	Data rate
Accelerometer	Measures the acceleration relative to freefall in three axes	High
Gyroscope	Measures the orientation, based on the principles of angular momentum	High
ECG/EEG/EMG	Measures potential difference across electrodes put on corresponding parts of the body	High
Pulse oximetry	Measures ratio of changing absorbance of the red and infrared light passing from one side to the other of a thin part of the body's anatomy	Low
Respiration	Uses two electrodes, cathode and anode covered by a thin membrane to measure the oxygen dissolved in a liquid	Low
Carbon dioxide	Uses the infrared light and measures the absorption of the gas presented	Low
Blood pressure	Measures the systolic pressure (peak pressure) and diastolic pressure (minimum pressure)	Low
Blood sugar	Traditionally analyzes drops of blood from a finger tip, recently, uses non-invasive method including a near infrared spectroscopy, ultrasound, optical measurement at the eye, and the use of breath analysis	Low
Humidity	Measures the conductivity changes of the level of humidity	Very low
Temperature	Uses a silicon integrated circuit to detect the temperature changes by measuring the resistance	Very low

Típico transceptor WBAN



PESQUISAS EM WBAN

Grupo de Pesquisas em RF e Instrumentação sem fio

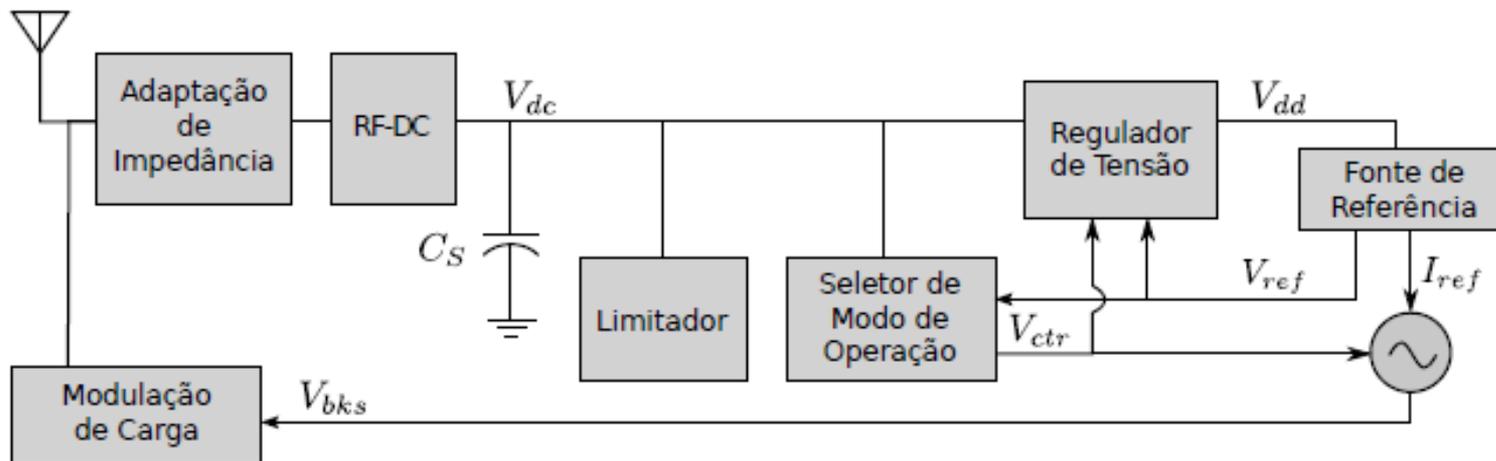
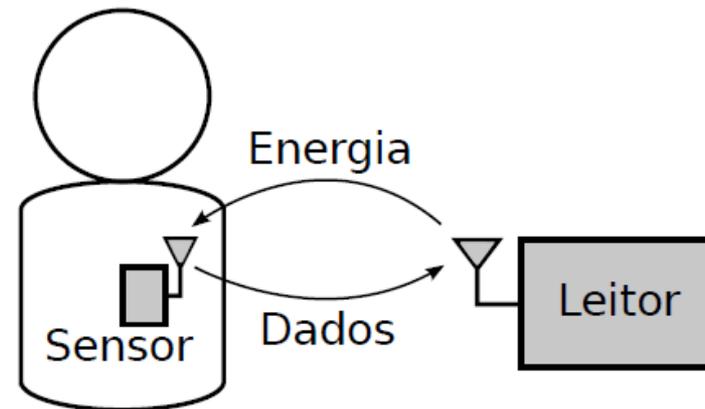
- **Linhas de Pesquisa**
 - **Circuitos de RF, RFIC, MMIC**
 - **Instrumentação sem fio**
 - **Biosensores**
 - **Bioeletrônica**

Sensor de temperatura alimentado por RF



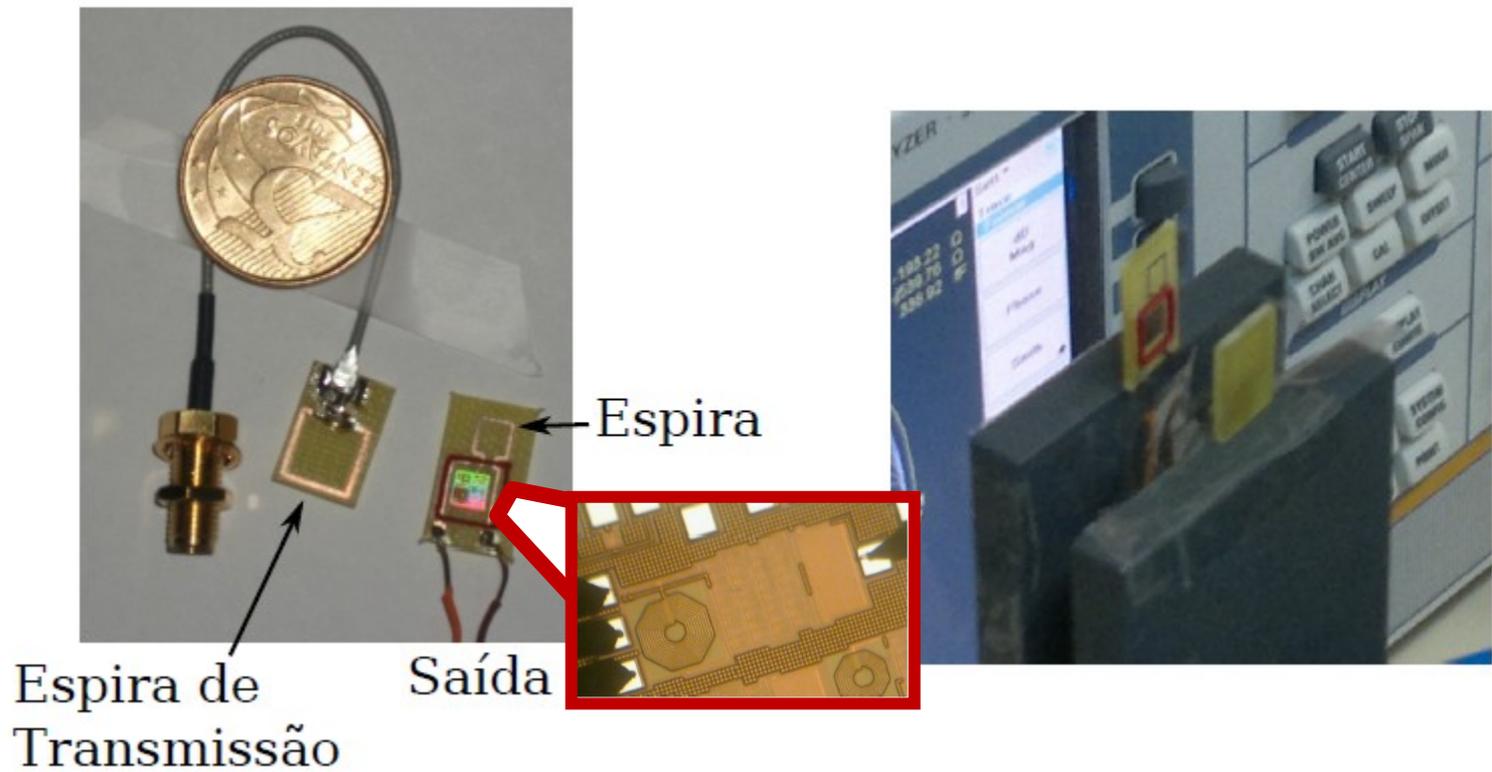
Sensor de temperatura alimentado por RF (2)

- **Arquitetura**



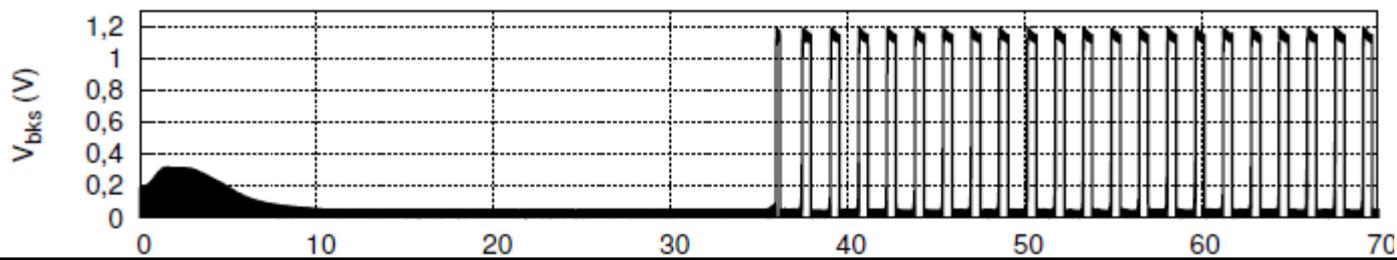
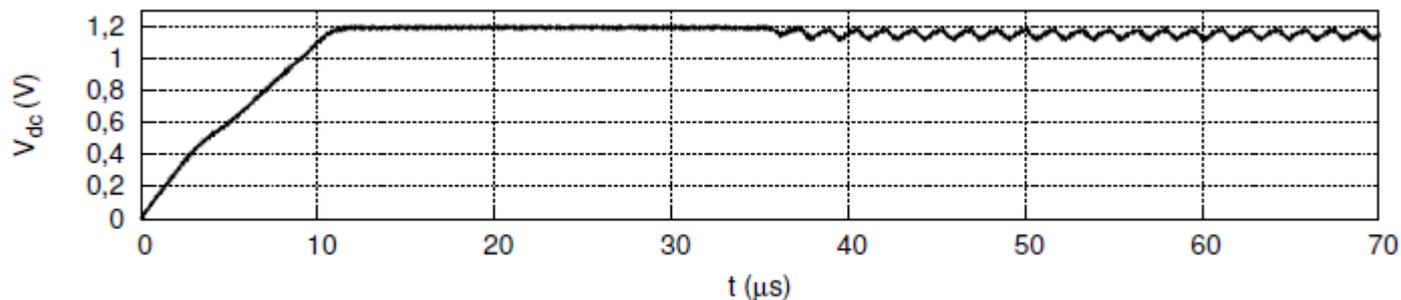
Sensor de temperatura alimentado por RF (3)

- Implementação em circuito integrado, tecnologia 180 nm.

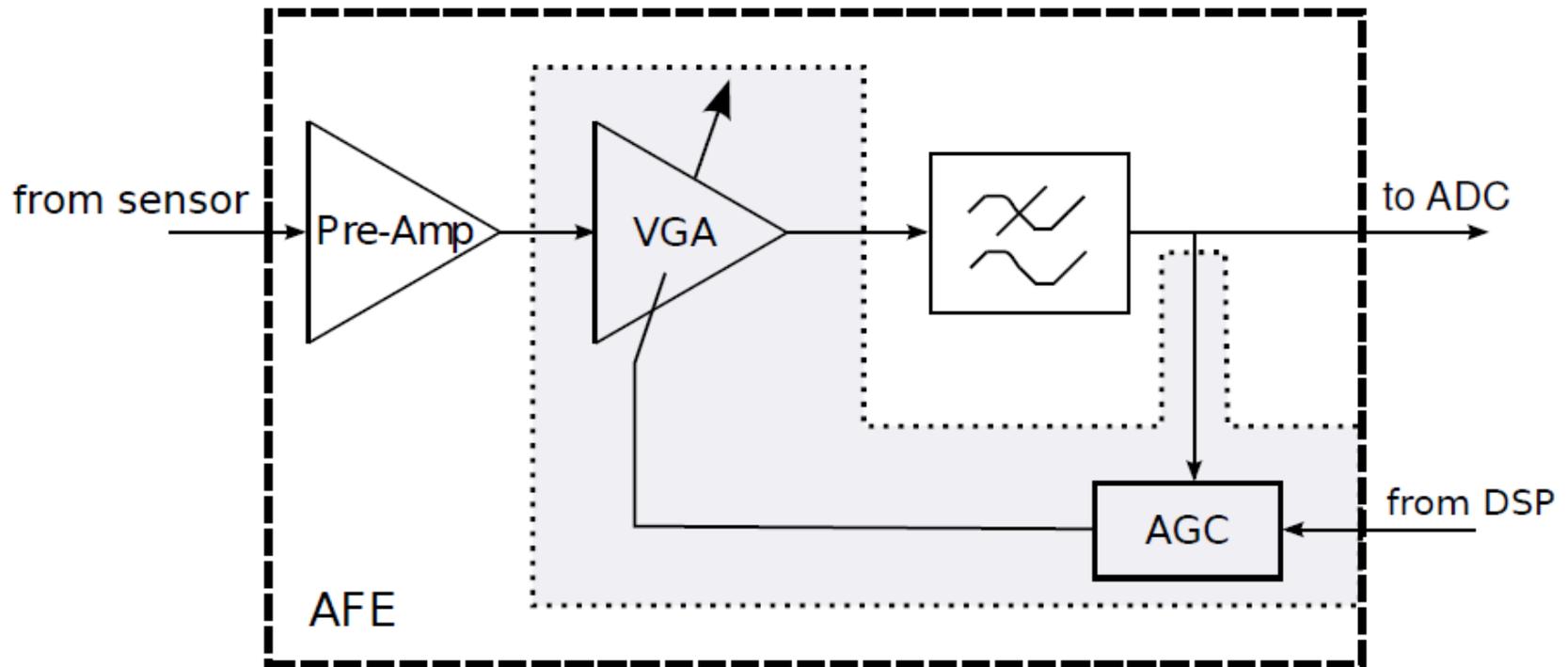


Sensor de temperatura alimentado por RF (4)

Referência	[1]	[2]	[3]	[4]	[5]	Este trabalho
Tecnologia (nm)	250	130	130	130	180	130
Frequência (MHz)	450	900	900	868	910	900
Área (mm ²)	1,2	-	0,95	3,96	1,2	0,34
Cons. <i>standby</i> (μW)	5	6	-	≈ 0,11	-	4,9
Cons. ativo (μW)	1500	9	7,9	-	7	8,5
Eficiência RF-DC (%)	-	30	7,6	35	-	10
$P_{av,min}$ (dBm)	-12,5	-12	-10,3	-	-5	-10

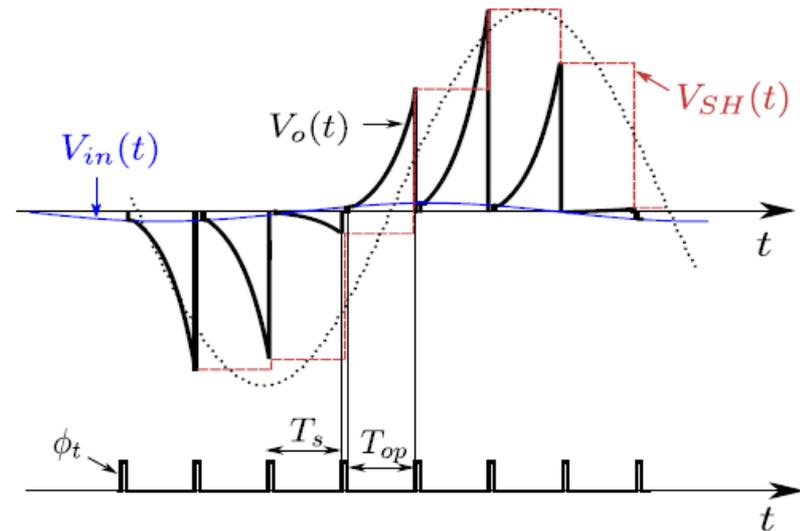
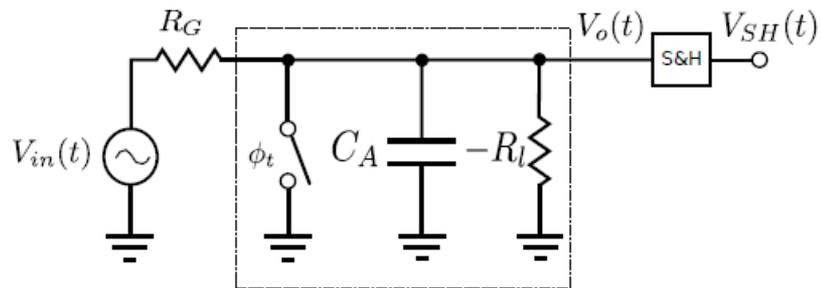


VGA superregenerativo



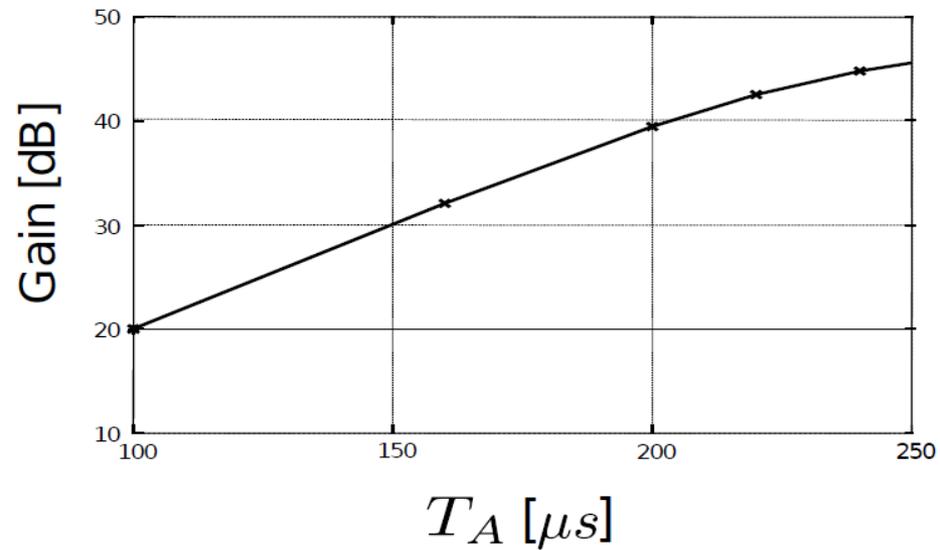
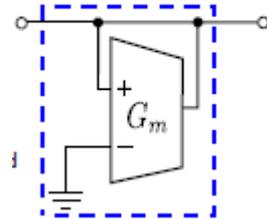
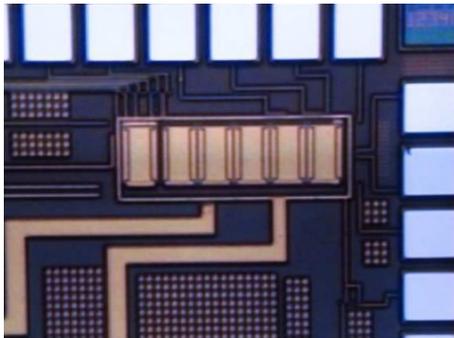
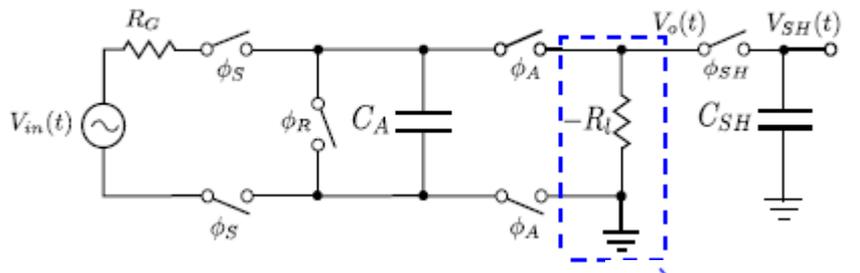
VGA Superregenerativo

- **Princípio de operação**



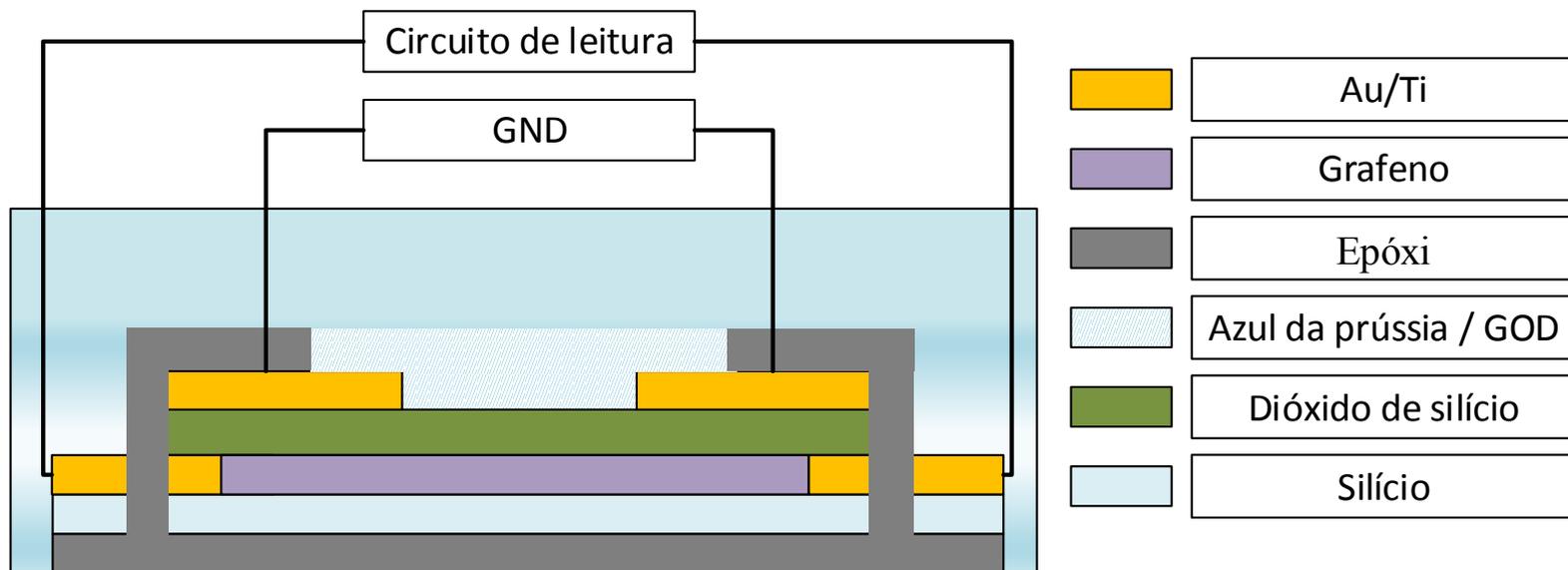
VGA Superregenerativo

- Implementação em tecnologia integrada de 180 nm



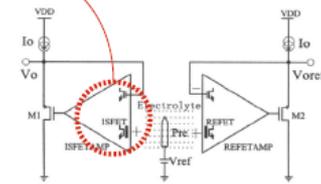
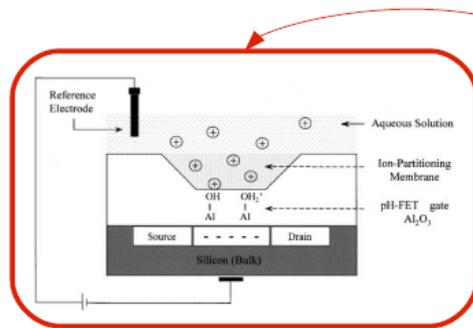
Sensor de glicose implantado

- **Sensor ISFET (parceria com a UNICAMP e com DEF/UFSC)**

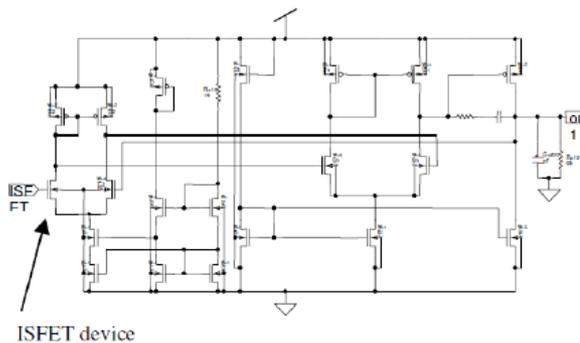
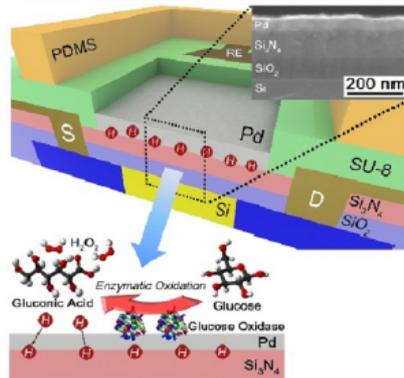


Sensor de glicose implantado

- Modelagem do ISFET e desenvolvimento de condicionador de sinais



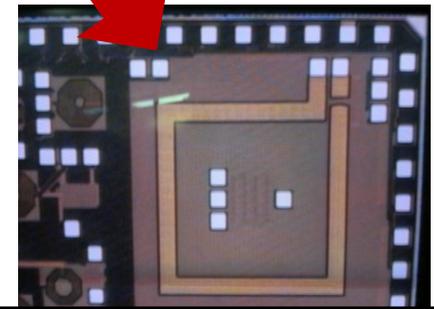
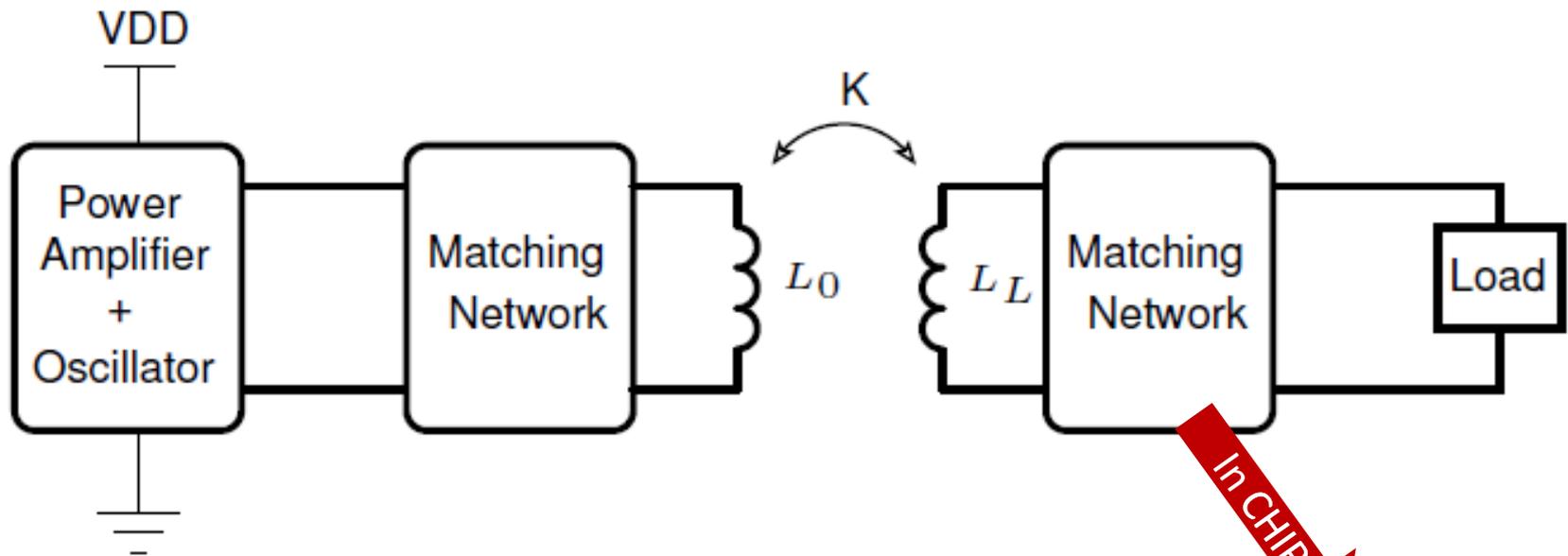
Block diagram of the differential sensing measurement circuit



ISFET device

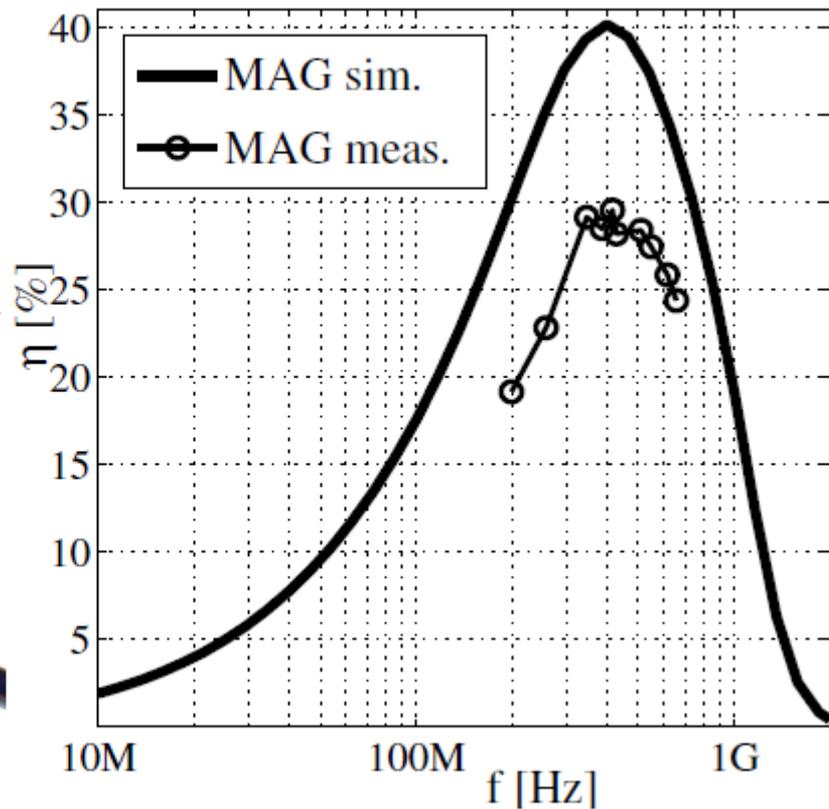
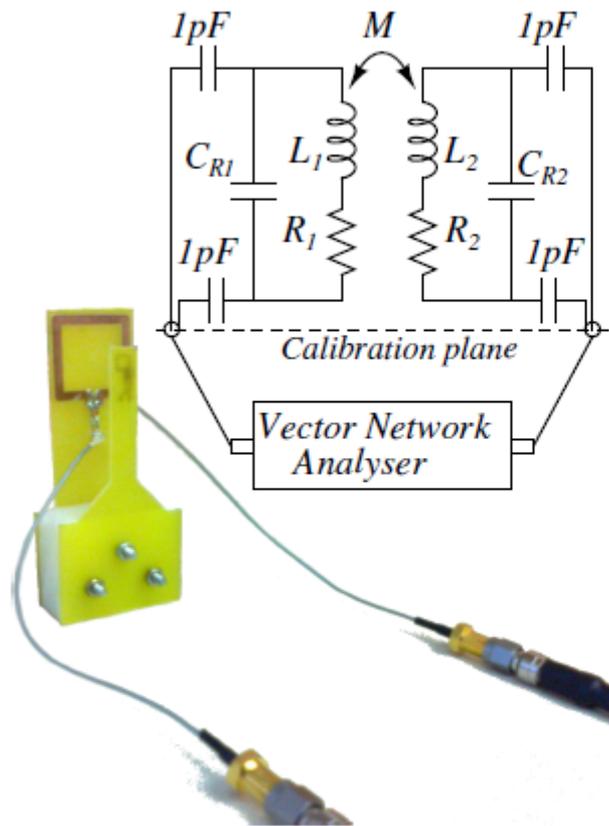
Sensor de glicose implantado

- Alimentação por RF



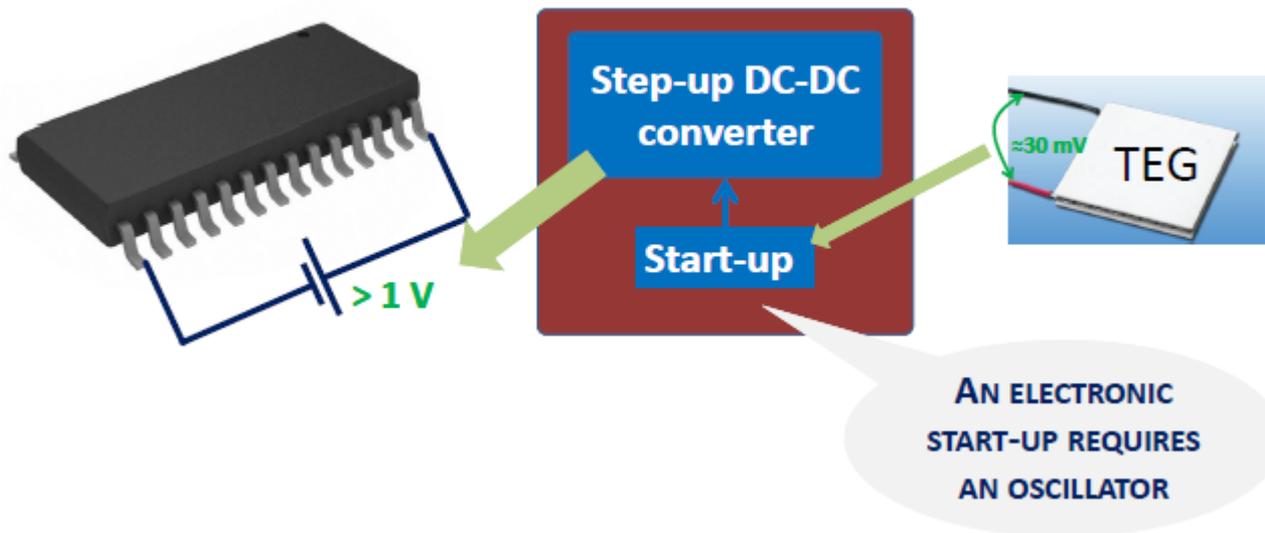
Sensor de glicose implantado

- Otimização de eficiência



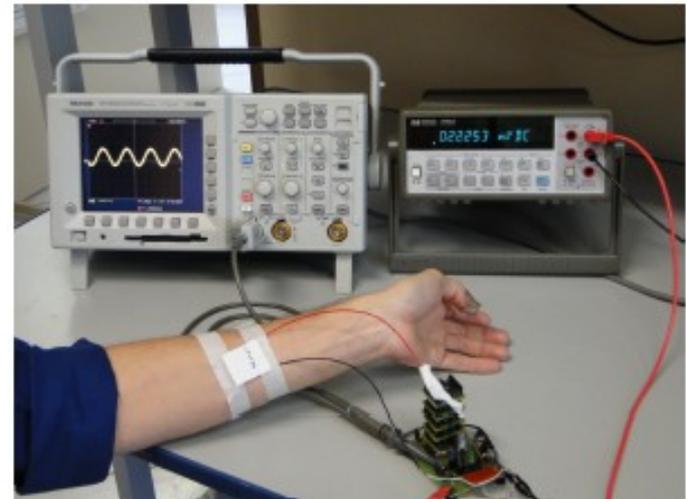
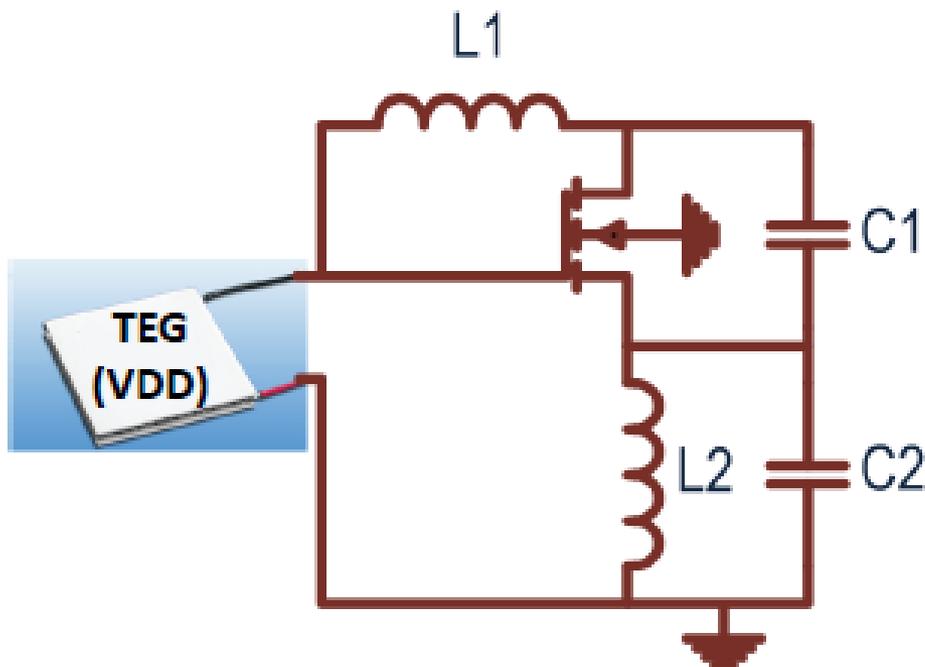
Colheita de energia

- Para alimentar sistemas implantados, uma alternativa é o gradiente de temperatura entre corpo e ambiente



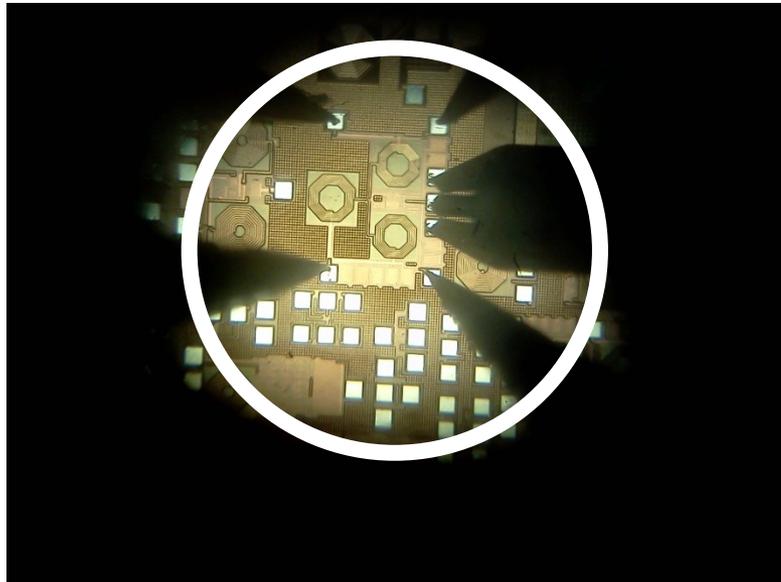
Oscilador alimentado por TEG

- **Circuito opera a partir de 20 mV, gerando um sinal senoidal de 100 kHz**

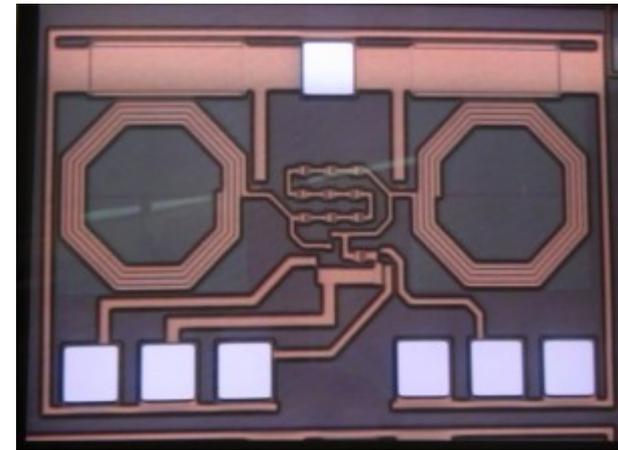
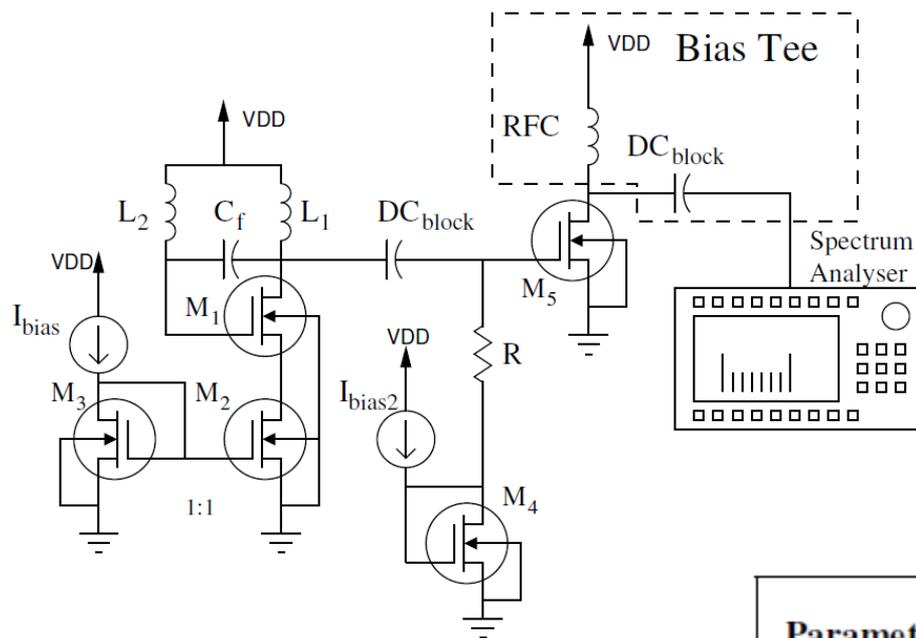


Osciladores integrados

- **Opera a partir de 60 mV em 2 GHz.**

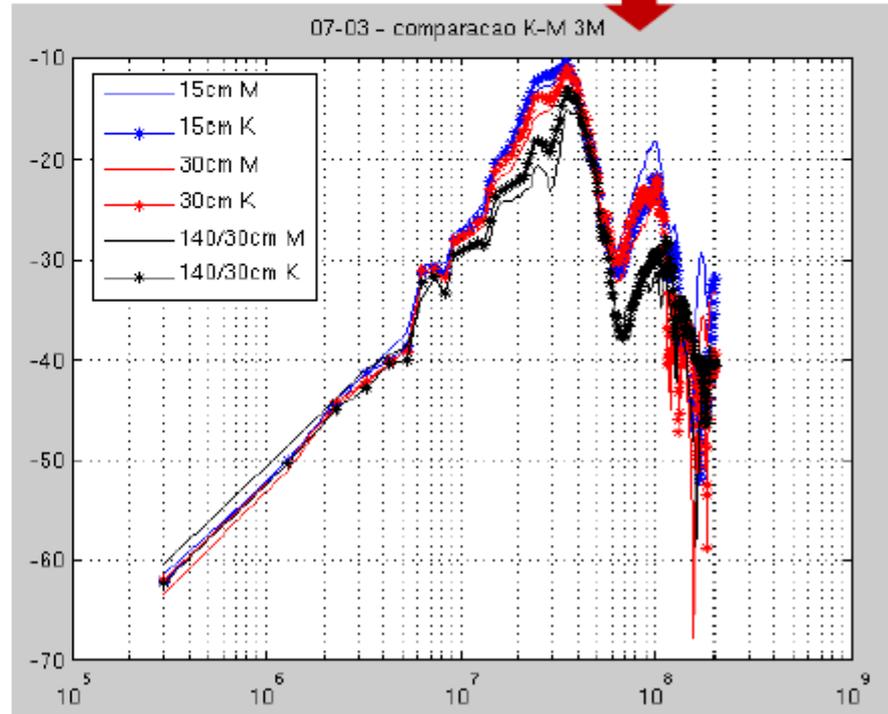
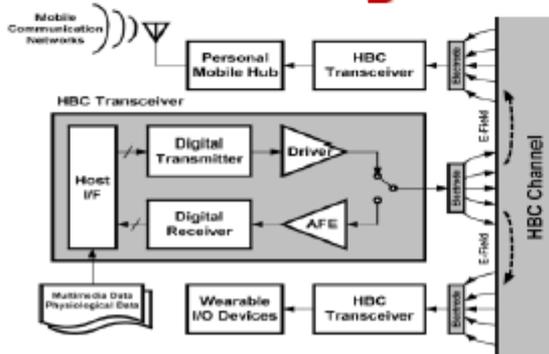
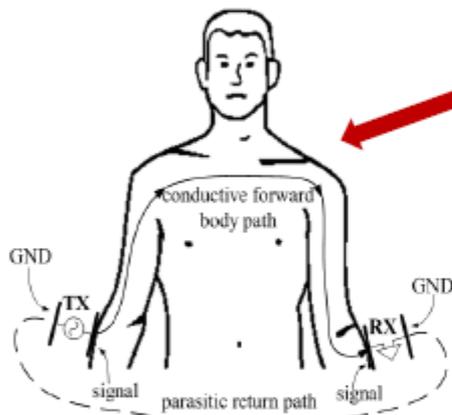


Oscilador Hartley de ultra baixo consumo



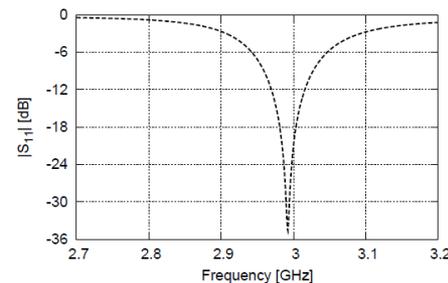
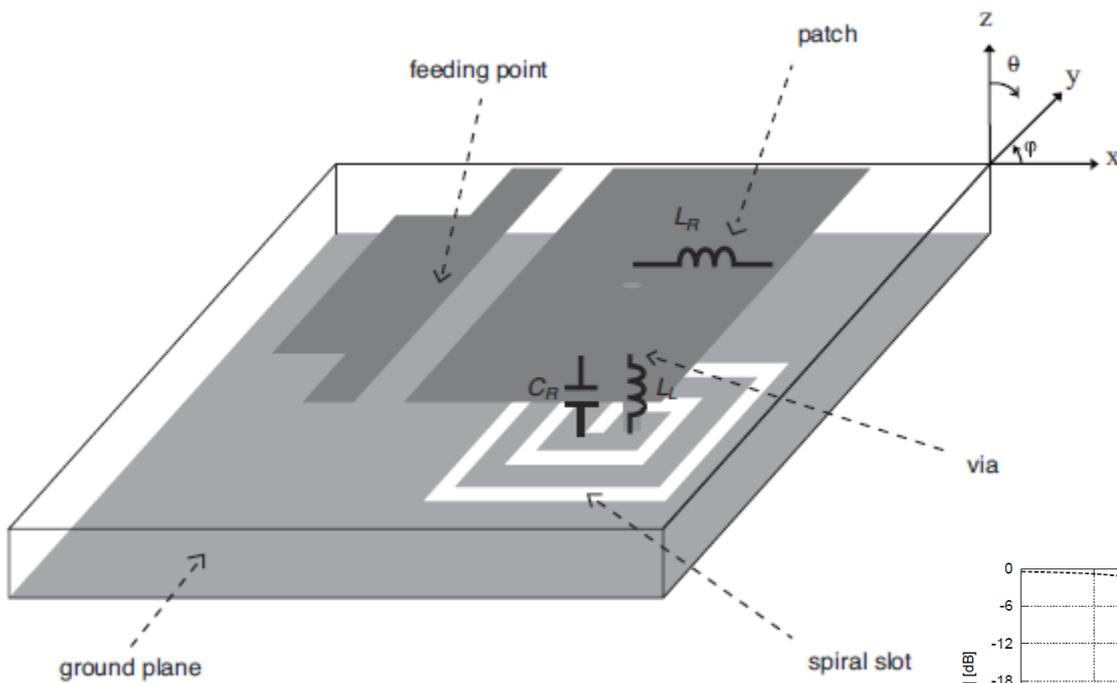
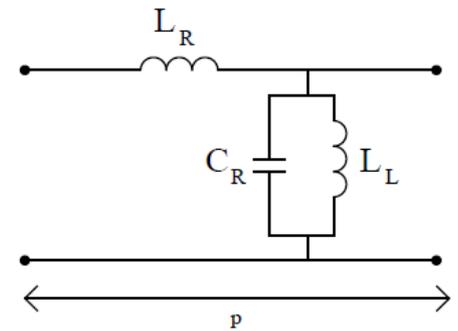
Parameters	FoM (dBc/Hz)	f_o (MHz)	P_{DC} (μ W)	L(1 MHz) (dBc/Hz)
Mean	184.5	2322	88.26	-106.7
Sigma	1.33	13.25	4.064	1.389
Max	188.3	2350	99.46	-103.4
Min	181.3	2274	78.19	-110.5

Transceptor HBC



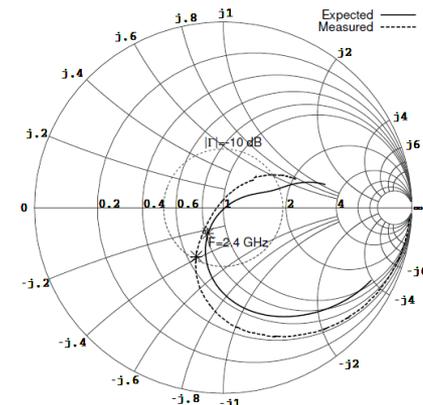
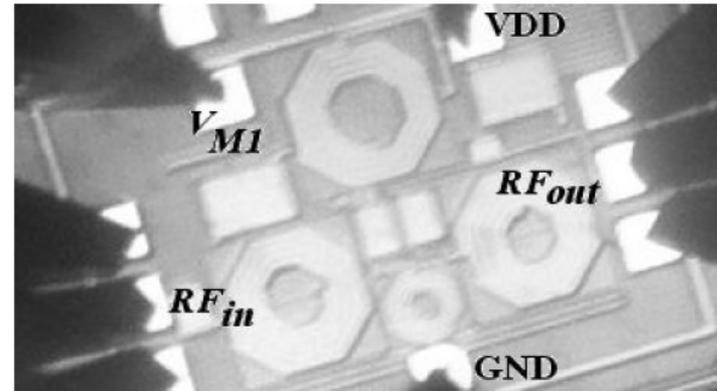
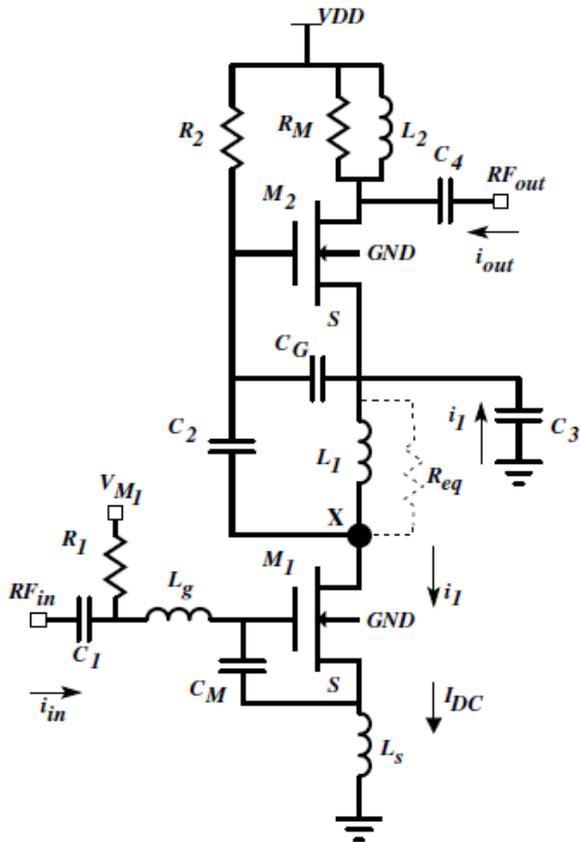
Antenas miniaturizadas

- Antena baseada em ressonância de ordem ZERO



Amplificador de baixo ruído

- **LNA com reuso de corrente**



Equipe

- **6 doutorandos: Fabian, Maicon, Paulo, Arturo, Heron, Roddy**



- **5 mestrandos :Gustavo Carlyle, Ronaldo, Mateus, Fabrício**



- **5 alunos de IC: Kaleo, Luccas, Lucas, Luiza, Aron**



• **Muito Obrigado**