An RF-Powered Temperature Sensor Designed for Biomedical Applications

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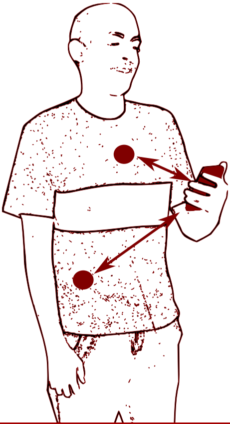
Summary

Summary

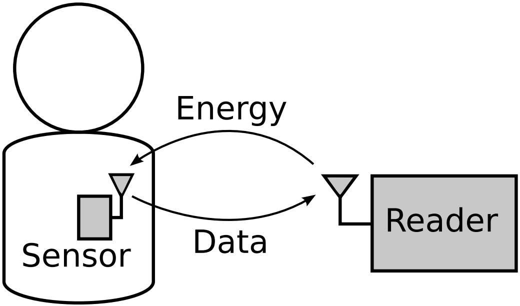
Motivation

- Continuous patient monitoring
  - Early detection of complications by continuous sensing of vital signs
  - Small wireless devices: no battery



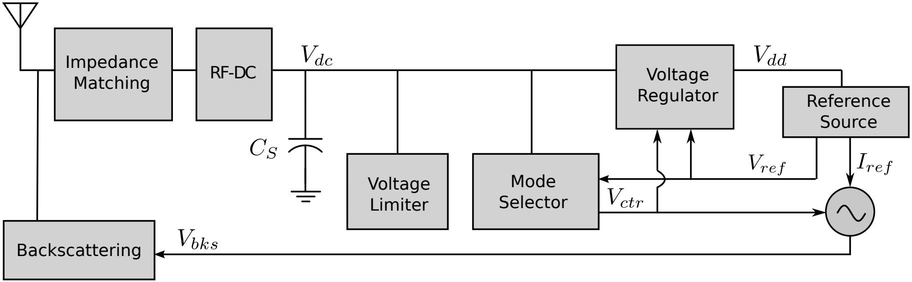
RF-Powered sensors

- Reader device: sends energy and receives data
- Sensor device: receives energy and sends data



- This work: an RF-powered temperature sensor to measure human body temperature (35 to 42 °C)

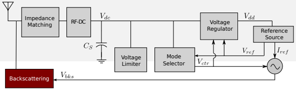
Summary

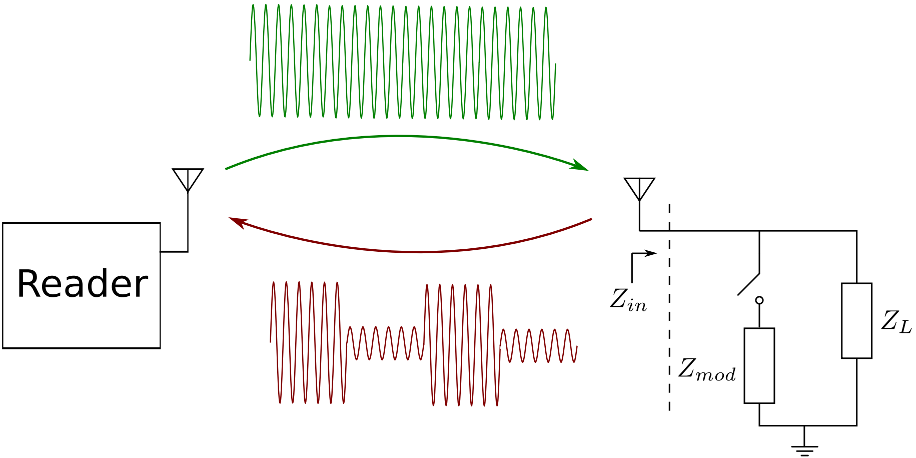


- Input signal frequency: 900 MHz
- Fabrication technology: IBM 130 nm

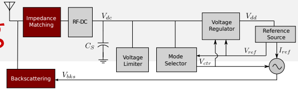
Summary

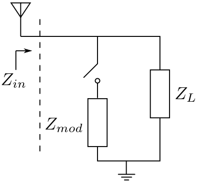
Backscattering

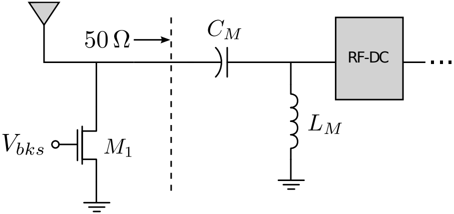


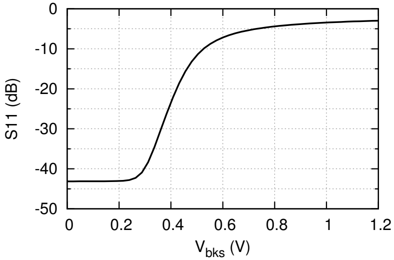


Backscattering and Impedance Matching

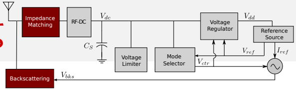


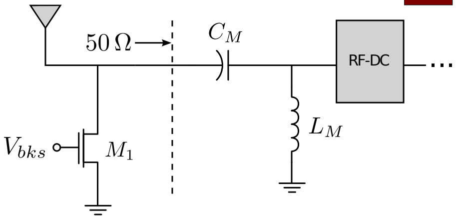


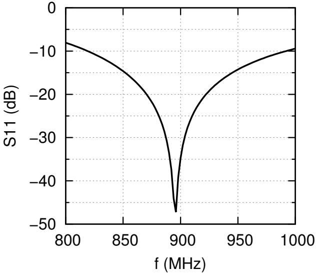


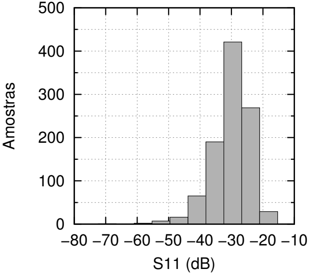


Backscattering and Impedance Matching



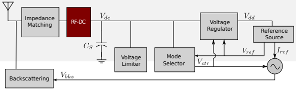


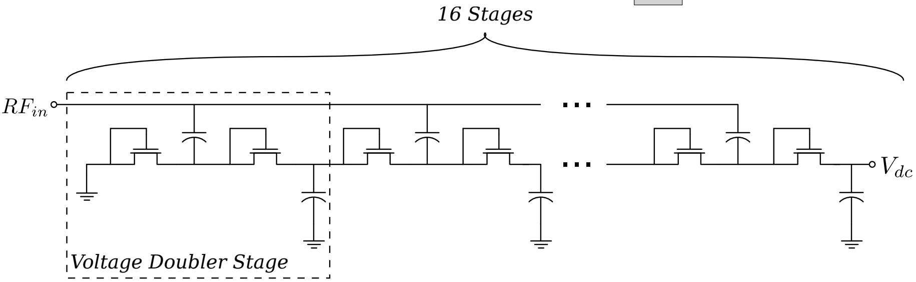




- Worst case S11 in the Monte Carlo simulation $= -15\,\mathrm{dB}$

Rectifier



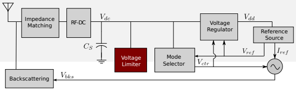


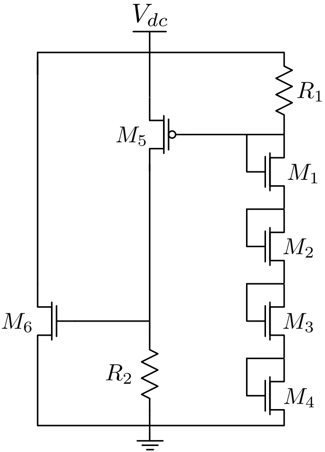
- Native transistors in diode configuration
- Output conditions: $V_{dc} = 1\,\mathrm{V}$ e $I_{dc} = 10\,\mu\mathrm{A}$
- Power convertion efficiency:

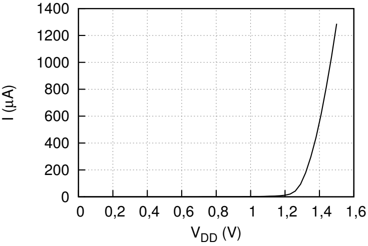
$$\mathrm{PCE} = \frac{P_{dc}}{P_{av}} = 10\%$$

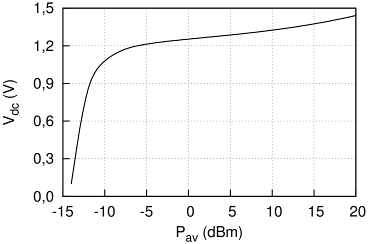
Summary

Voltage limiter

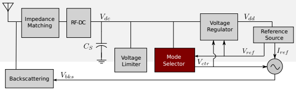


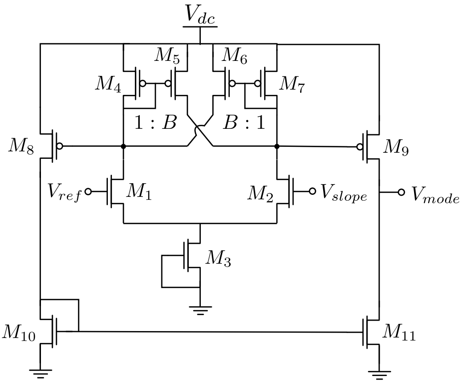


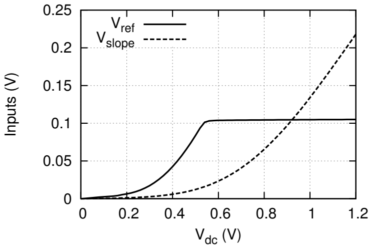


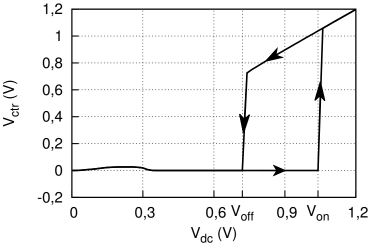


Mode Selector

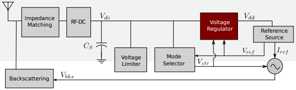


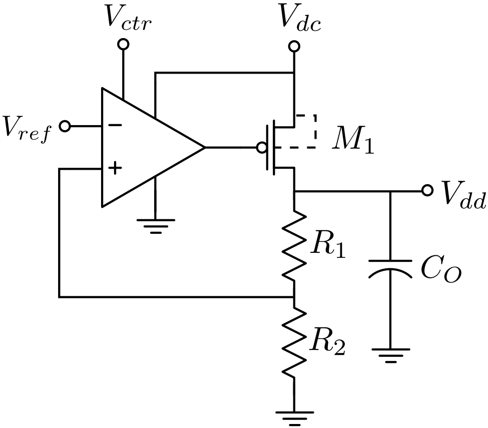




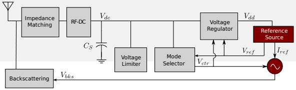


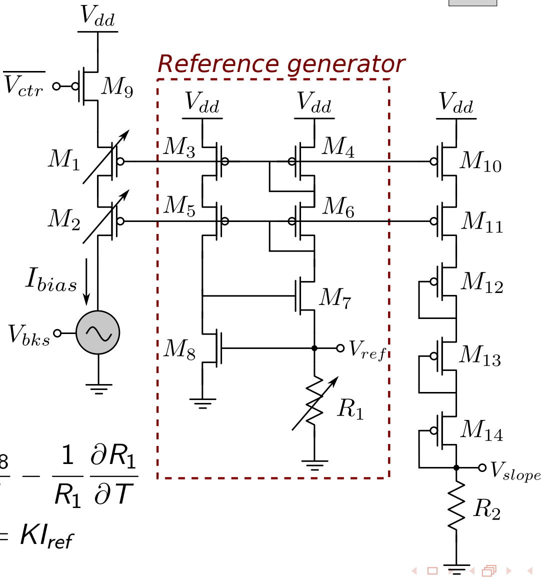
Voltage Regulator





Temperature Sensor

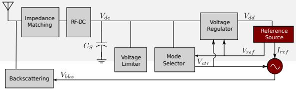


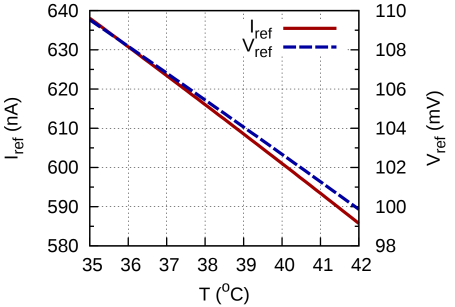


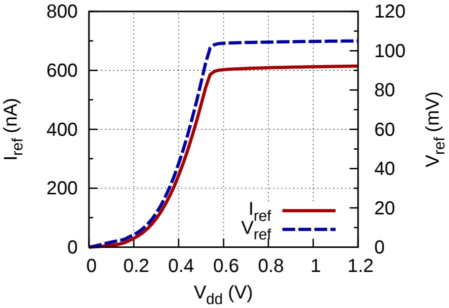
$$TC_I \simeq \frac{1}{V_{t8}} \frac{\partial V_{t8}}{\partial T} - \frac{1}{R_1} \frac{\partial R_1}{\partial T}$$

$$f \propto I_{bias} = K I_{ref}$$

Temperature Sensor



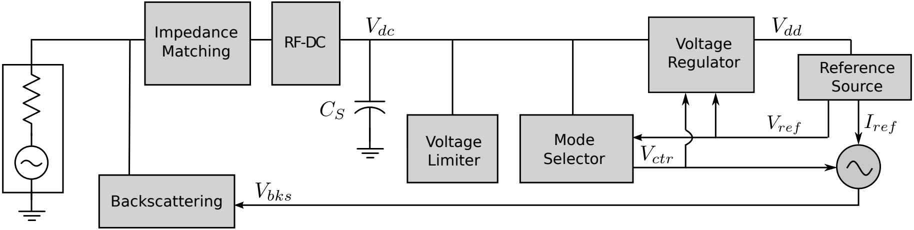




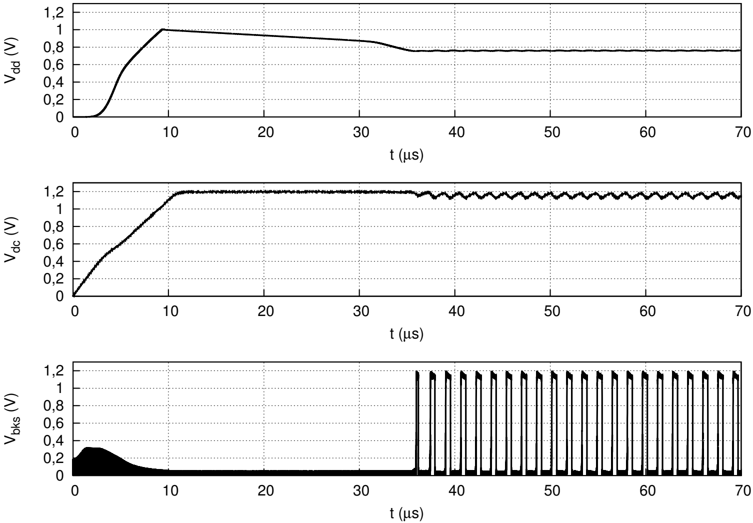
- $TC_I = -1.22\,\%/^{\mathrm{o}}\mathrm{C},\ I_{ref} = 613\,\mathrm{nA}$
- Calibration method to achieve less than $0.2\,^{\mathrm{o}}\mathrm{C}$ measurement error

Summary

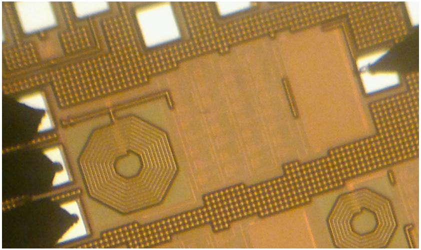
Simulation

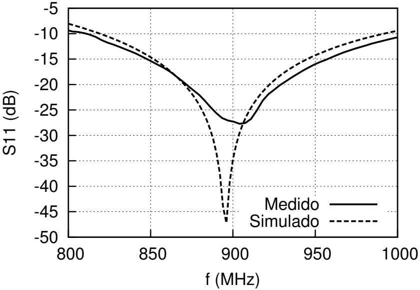

Impedance
Matching
RF-DC
V_{dc}
C_S
Voltage
Limiter
Mode
Selector
Voltage
Regulator
V_{dd}
Reference
Source
V_{ref}
I_{ref}
V_{ctr}
Backscattering
V_{bks}

Simulation



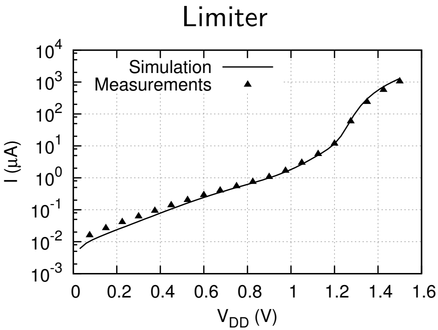
Measurement Results - Rectifier

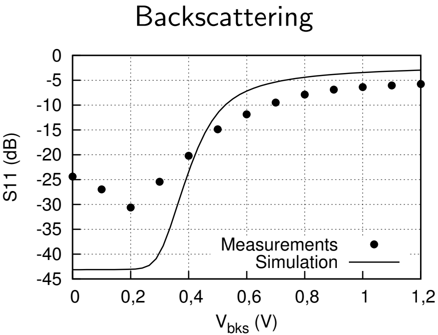




- PCE $= 10\%$ for $P_{av} = -10\,\mathrm{dBm}$, $V_{dc} = 1\,\mathrm{V}$ and $I_{dc} = 10\,\mu\mathrm{A}$

Measurement Results - Limiter and Backscattering





Summary

Comparison

- An RF-powered temperature sensor (35 to 42 $^{\circ}\mathrm{C}$) that has measurement error $< 0.2\,^{\circ}\mathrm{C}$ was designed and partially tested

Reference	[1]	[2]	[3]	[4]	[5]	This work
Technology (nm)	250	130	130	130	180	130
Frequency (MHz)	450	900	900	868	910	900
Area (mm^2)	1.2	-	0.95	3.96	1.2	0.34
Standby power ($\mu\mathrm{W}$)	5	6	-	≈ 0.11	-	4.9
Active power ($\mu\mathrm{W}$)	1500	9	7.9	-	7	8.5
PCE (%)	-	30	7.6	35	-	10
$P_{av,min}$ (dBm)	-12.5	-12	-10.3	-	-5	-10

[1] KOCER, F.; FLYNN, M. *An rf-powered, wireless cmos temperature sensor*. **Sensors Journal, IEEE, 2006**.
[2] YEAGER, D. et al. *A 9 μA, Addressable Gen2 Sensor Tag for Bio-signal Acquisition*. **Solid-State Circuits, IEEE Journal of, 2010**.
[3] REINISCH, H. et al. *A multifrequency passive sensing tag with on-chip temperature sensor and off-chip sensor interface using epc hf and uhf rfid technology*. **Solid-State Circuits, IEEE Journal of, 2011**.
[4] VAZ, A. et al. *Full passive uhf tag with a temperature sensor suitable for human body temperature monitoring*. **Circuits and Systems II: Express Briefs, IEEE Transactions on, 2010**.
[5] QIAN, J. et al. *A passive UHF tag for RFID-based train axle temperature measurement system*. In: **Custom Integrated Circuits Conference (CICC), 2011 IEEE, 2011**.

Thank you!

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