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A 2.4-GHz MEMS based Sub-Sampling Receiver Front-end with Low Power Channel Filtering at RF

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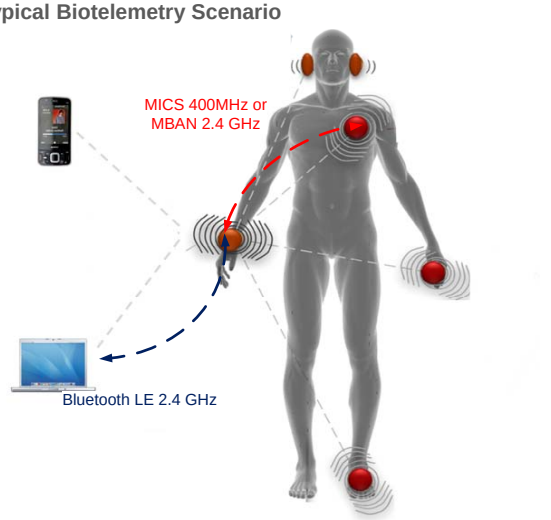
In this work, a sub sampling receiver front end at 2.4 GHz with high Q filtering to perform channel selection at RF is presented. A low power solution for channel selection directly at RF is proposed in this work using "AMF cell" with a BAW resonator load to realize a high selectivity. This work focuses on the Bluetooth LE standard, however the front-end can be used for any protocol standards for radios working at 2.4 GHz. A low power BAW based digitally controlled oscillator (DCO) is used as a reference to a LC PLL to perform channel selection. An integer divided version of the BAW DCO signal is used as reference to generate clocks for the sub-sampler to down-convert the selected channel from "super-high IF" to baseband in quadrature. The proposed architecture is designed and integrated in 0.18um CMOS process and is validated by measurements.

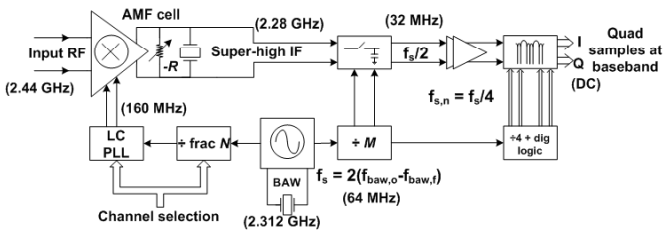
Motivation - Biotelemetry

- **A Typical Biotelemetry Scenario**

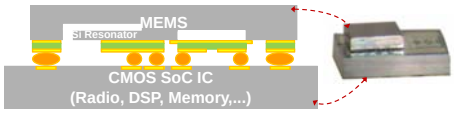


The "On-body" patch communicates with the implants on one side (MICS/MBAN standard) and with the external monitoring unit on the other (Bluetooth LE standard).

MEMS based Wireless Interface



Above is the block level view of the MEMS based RF Front End. The architecture provides a low power solution to perform channel selection right at RF. The bandwidth of the AMF cell is tunable by varying the negative transconductance across the BAW resonator.

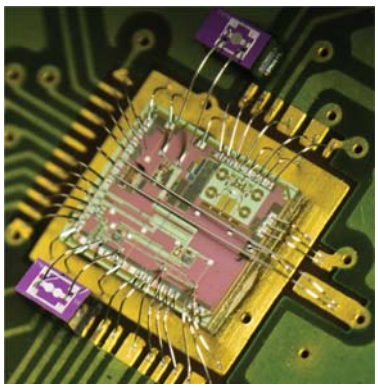


BAW resonators offer intrinsically high quality factor (*Q*) at Gigahertz frequencies which makes them quite attractive to be used in power hungry blocks of a transceiver like the VCO, LNA and PA. As shown above, a flip-chip version facilitates extreme miniaturization.

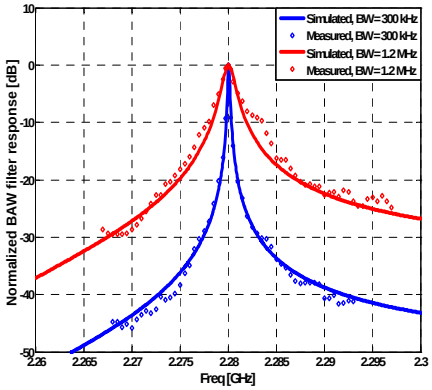
MEMS based 2.4 GHz Sub-Sampling RF Front End

- **BAW based Frequency synthesis**
  - RF Front End designed and integrated in 0.18-*μm* CMOS process.
  - BAW resonator based DCO exhibits excellent phase noise performance and provides reference clock to LC PLL for channel selection.
- **BAW based "Super-high IF" Channel Selection Filter**
  - The selected channel is down-converted (by the LC PLL) to the anti-resonant frequency of the BAW resonator used in the channel selection filter.
  - The BAW DCO signal is integer divided to provide clocks for sub-sampling mixer to down-convert the selected channel to baseband in quadrature.

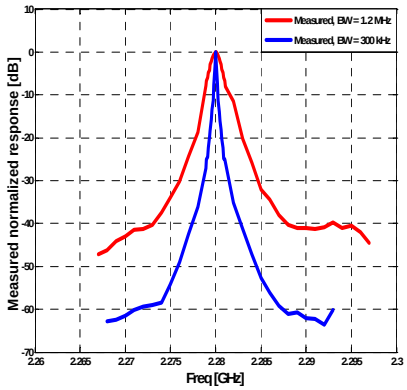
Parameter	Value
DCO Frequency	2.312-GHz
AMF Cell Peak at	2.28-GHz
Sampling Rate	64-MHz
Decimated Sampling Rate	16-MHz
I/Q Phase Difference	91.8°
Noise Figure	14.8-dB
Max Conversion Gain	44.2-dB @ 300-kHz BW
Total Power Consumption	9.94-mA from 1.8-V supply



Chip Photomicrograph



Channel Selection Filter Measured Response



Overall Measured Response of the Front-end

A.Heragu et al, "A 2.4-GHz MEMS based Sub-sampling Receiver Front End with low power channel selection filtering at RF", *to be presented at RFIC 2012, Montreal, Canada*.