A 2.75mW wideband correlation-based transceiver for body-coupled communication

Citation for published version (APA):

DOI:
10.1109/ISSCC.2009.4977379

Document status and date:
Published: 01/01/2009

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher’s website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
depends also on the polarity of the incoming voltage transition (Fig. 11.5.3), and template signals are adjusted. Since the polarity of the phase control a VCO that clocks the timing controller so that the phases of the clamp period. M20-23 select the polarity of the output according to the detected data. The data and phase correlators are folded cascade $G_v$-$C$ integrators and the multiplication is performed by inverting the current flow at their output by switching M12-15 in accordance with the data or synchronization templates. The RC at the input of the correlator realizes a differential high-pass filter at 1MHz for further suppression of low frequency interference. The VCO is a five-stage ring oscillator with 33 to 35MHz tuning range. Its frequency is divided by five in the timing controller such that the system bit-rate is 8.5Mb/s at the VCO center frequency. LF is passive RC and together with the data comparator is implemented on the test board.

Separate ICs for the RX/TX circuits and the VCO have been designed in 130nm CMOS (Figure 11.5.7). The measured BER of the data correlator path alone against interference is shown in Fig. 11.5.5, where FM interference of 100kHz bandwidth is swept from 250kHz to 100MHz. A BER of less than $10^{-3}$ is measured for 450µV RX signal (6dB attenuated 1.2V digital signal) with -74dBm interference for all frequencies (in compliance to Fig. 11.5.1). The BER is still below $10^{-3}$ for -68dBm interference with frequencies below 5MHz and above 20MHz, where higher interference levels are most likely to arise [4]. The highest sensitivity to interference is observed in the 5 to 20MHz band as the correlation time is close to the interference period. Higher interference suppression in this band can be achieved by increasing the correlation time using error correction codes. Figure 11.5.5 shows that the jitter of the synchronization loop during the synchronization sequence at 8.5Mb/s is 14.8ns without interference and 22.4ns with a -68dBm, 15MHz, interference. An evaluation of different interference scenarios is ongoing. Figure 11.5.6 summarizes the overall performance.

In this work 1.2V digital signals for TX are used, an RX band of 1 to 30MHz is chosen and a new robust BCC architecture is proposed that altogether provide reliable performance in the presence of interference. The measured BER and jitter show that performance competitive to the cognitive FSK approach [4] can be achieved with a simpler implementation. The energy consumption at 8.5Mb/s is 0.32mJ/b, lower than [4] (0.37mJ/b), and the core area is 0.19mm$^2$.

Acknowledgments:
The authors would like to thank their Philips Research colleagues N. Bird, T. Schenk, P. Rutten, L. Tan, S. Corroy, H. Balduz, K. Klabunde and N. Mazioum for the useful discussions and for the work done on channel characterization.

References:
Measurements performed with active probe with 1MΩ input impedance. Power levels referred to 50Ω.

Figure 11.5.1: Body-couple communication concept and body-channel measurements: propagation losses and interference power.

Figure 11.5.2: Architecture of transceiver for body coupled communication.

Figure 11.5.3: Functional and measured waveforms.

Figure 11.5.4: Schematics of the low noise amplifier, pulse amplitude modulator and correlator.

Figure 11.5.5: BER measurements of data detection path alone and jitter measurements during synchronization sequence.

Figure 11.5.6: Summary of design parameters and performance.
Figure 11.5.7: Micrographs of 1×1 mm² RX/TX chip (280x600µm² core area) and 550x650µm² VCO chip (90x100µm² core area).