IDEC Chip Design Contest

An Intra-Body Power Transfer System with Dual Maximum Resonant Power Tracking Loop Achieving Improved Power Efficiency

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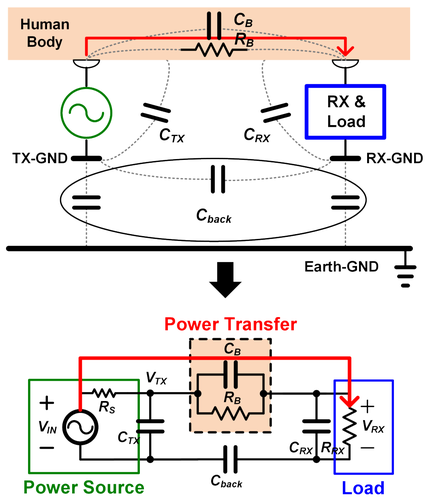
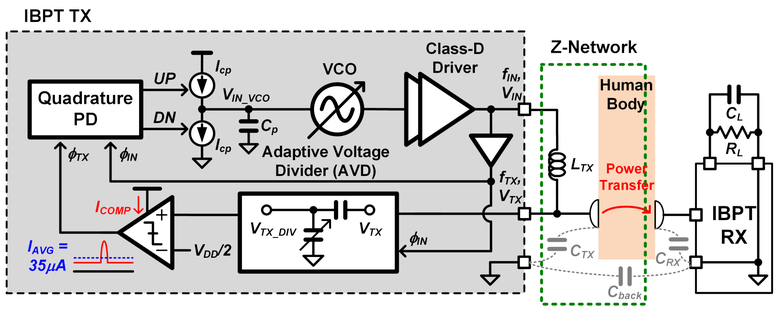
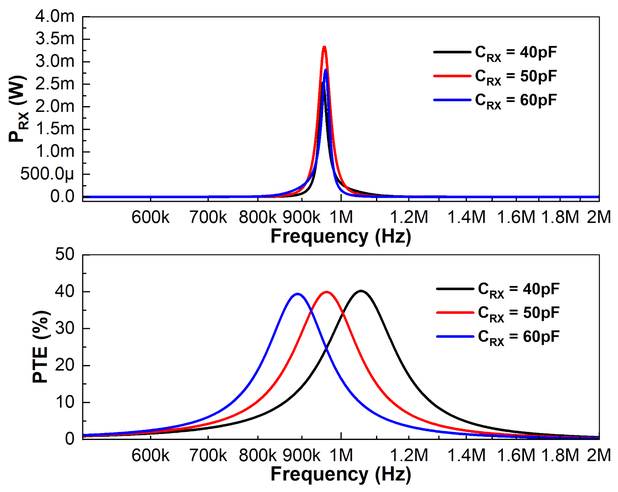
Introduction & Issues in Prior Work



- Intra-body power transfer (**IBPT**) is a novel power transfer method that conveys power through the body.
- L_{TX} and L_{RX} are added to TX and RX, respectively to implement maximum-resonant-power-tracking (**MRPT**).
- $\angle V_{TX} - \angle V_{IN} \approx -\pi/2$ at TX resonance condition.

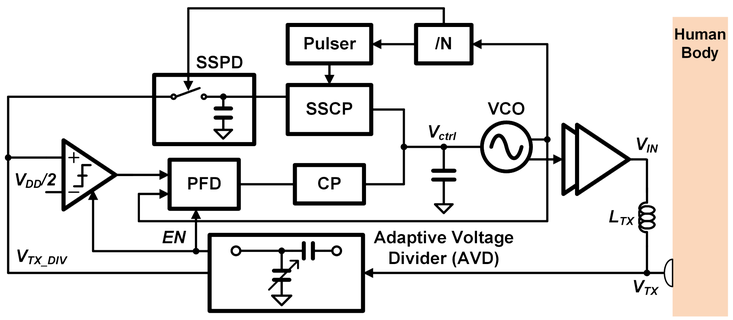


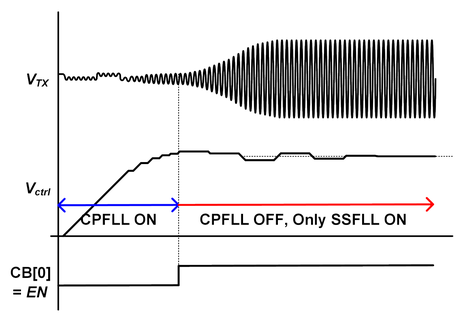


- Previous IBPT TX consumes lots of power at the comparator to minimize delay.
- Maximum power transfer frequency ≠ maximum power transfer efficiency frequency
- MRPT is required for both TX and RX. TX MRPT maximizes V_{TX}, and the RX MRPT maximizes PTE.

Overall System

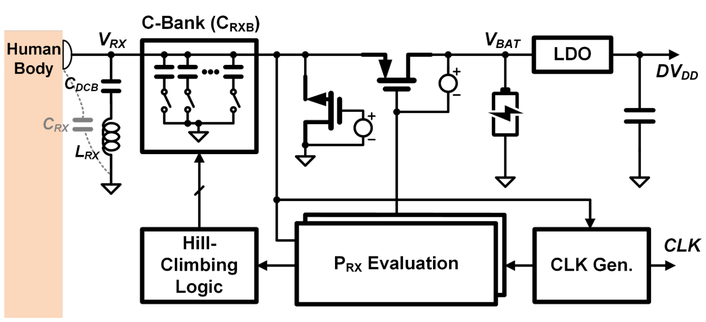
IBPT TX

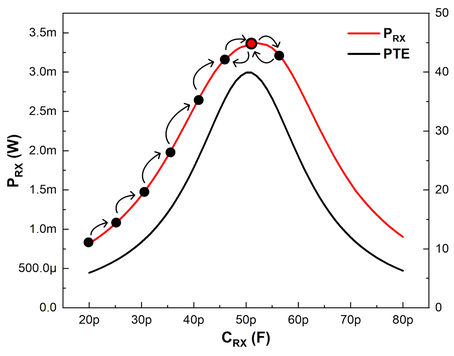




- TX employs a FLL-based MRPT loop that locks at the frequency, where ϕ_Δ is $\pi/2$. ($\phi_\Delta = \angle V_{IN} - \angle V_{TX} = \phi_{IN} - \phi_{TX}$)
- Charge pump (CP) FLL + sub-sampling (SS) FLL.
- Power consuming CPFLL helps fast and stable start-up.
- C-bank control bit at adaptive voltage divider (AVD) is used as enable (EN) for CPFLL.

IBPT RX

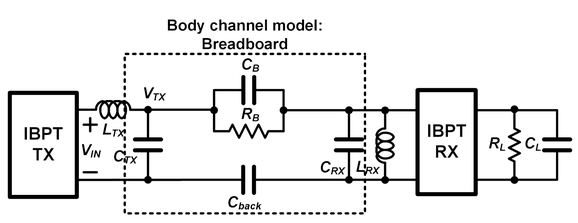


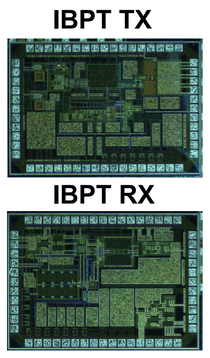


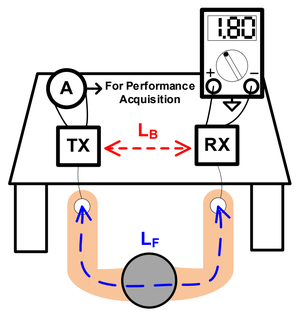
- Battery load target.
- L_{RX} resonates with $C_{RX}||C_{RXB}$
- Hill-climbing algorithm controlling C_{RXB} can find maximum P_{RX} & PTE condition.

Measurement Results

Measurement Setup & Chip Micrograph

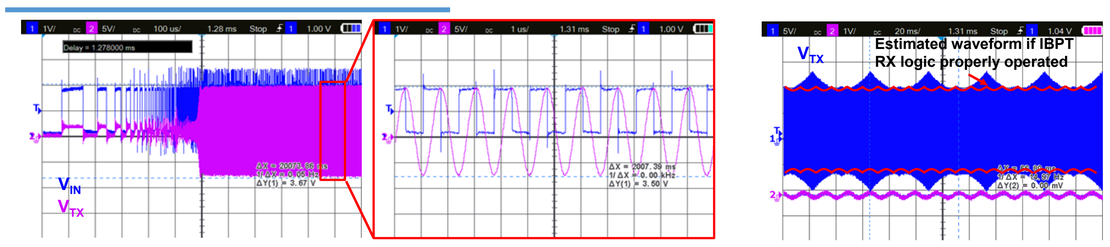


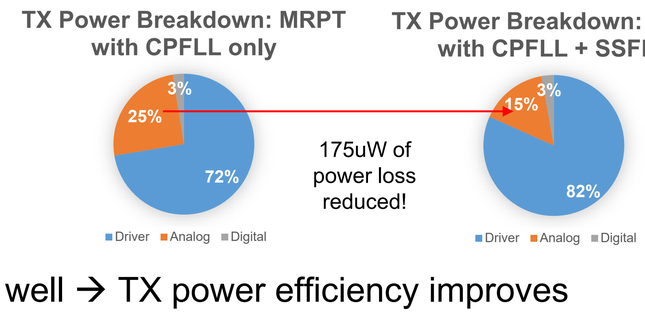




- To verify TRX operation, body channel model is implemented on the breadboard and measured.

Measurement Results





- TX operates well → TX power efficiency improves
- RX does not operates well → Logic cannot find the optimum C_{RX}, but oscillates.
- Potential issues in P_{RX} Evaluation block at IBPT RX: leakage current makes an error while comparing V_{NOW} and V_{PAST}.

Summary & Conclusion

- Power loss at TX significantly reduced due to using temporarily-on CPFLL and always-on SSFLL.
- Hill-climbing algorithm controlling C_{RXB} was implemented, but did not operated well because of leakage current.
- Proposed IBPT system can make both maximum power and efficiency by implementing dual MRPT both at TX and RX.

Acknowledgement

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