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Introduction

- Inband full-duplex means that transmission and reception occur \textit{simultaneously} and on the \textit{same frequency band}
  - Spectral efficiency is theoretically doubled
Introduction (cont.)

- The downside is the ensuing self-interference (SI)
- **Self-interference cancellation is crucial**
- In this work, we explore the boundaries of **digital SI cancellation**
Self-interference cancellation

- Passive isolation provided by a circulator
- The first *active SI cancellation stage* is typically right before the receiver chain
  - *RF cancellation*
- Protects the more delicate RX components from the powerful SI
Self-interference cancellation

- The rest of the SI is taken care of in the digital domain
  - Digital cancellation
- The original transmit data samples are used to regenerate the SI
- In this work, we determine the boundaries of digital SI modeling
  - Computational complexity is not considered
Existing digital cancellers

- Predominantly, the existing digital cancellers use two models:
  - Linear model
  - Memory polynomial (MP)-based nonlinear model
- The latter captures the nonlinearity of most power amplifiers (PAs)
Proposed Volterra-based digital canceller

• What if there is memory before the PA or other sources of nonlinearities?
  – Or the transmit power is very high, requiring even more accurate SI modeling?
• Then, we can use the Volterra series to model the SI
Proposed Volterra-based digital canceller

• Using the Volterra series, we can model the SI as

\[ y_{SI}[n] = \sum_{p=1}^{P} \sum_{m_1=-M_{1,p}}^{M_{2,p}} \sum_{m_2=m_1}^{M_{2,p}} \cdots \sum_{m_{(p+1)/2}=m_{(p-1)/2}}^{M_{2,p}} \sum_{m_{(p+3)/2}=-M_{1,p}}^{M_{2,p}} \cdots \sum_{m_p=m_{p-1}}^{M_{2,p}} \gamma_{p,m_1,\ldots,m_p} \varphi_{p,m_1,\ldots,m_p}[n] \]

• where the basis function is

\[ \varphi_{p,m_1,\ldots,m_p}[n] = \prod_{j=1}^{(p+1)/2} x[n - Lm_j] \prod_{k=(p+3)/2}^{p} x^*[n - Lm_k] \]

• This is the \( P \)th-order Volterra series for the transmit signal \( x[n] \), with both pre-cursor \( (M_{1,p}) \) and post-cursor memory taps \( (M_{2,p}) \)
Measurement evaluations

• We evaluate the Volterra-based digital canceller using the latest version of our full-duplex prototype
  – Shared TX/RX antenna
  – Three-tap self-adaptive RF canceller
  – Supports transmit powers up to 33 dBm
• The unknown coefficients of the signal model are estimated with least squares
The proposed digital canceller is compared to two alternatives: a linear canceller and a nonlinear MP-based canceller.
Measurement results

- The Volterra-based modeling clearly improves the digital cancellation performance
- The total amount of cancellation is **109 dB**
  - Highest reported cancellation performance for such a high transmit power

![Graph showing PSD (dBm/100 kHz) vs Frequency (MHz)]
Measurement results

- The improvement provided by Volterra-based modeling is clear with the higher transmit powers.
Conclusion and next steps

• Volterra-based modeling in the digital canceller clearly improves the cancellation performance
• The obtained cancellation results are the best currently available in the literature
• As future work, we intend to decrease the complexity of the Volterra-based canceller
Thank you!

• Questions or comments?