Combating Power Amplifier Distortions using Neural Networks

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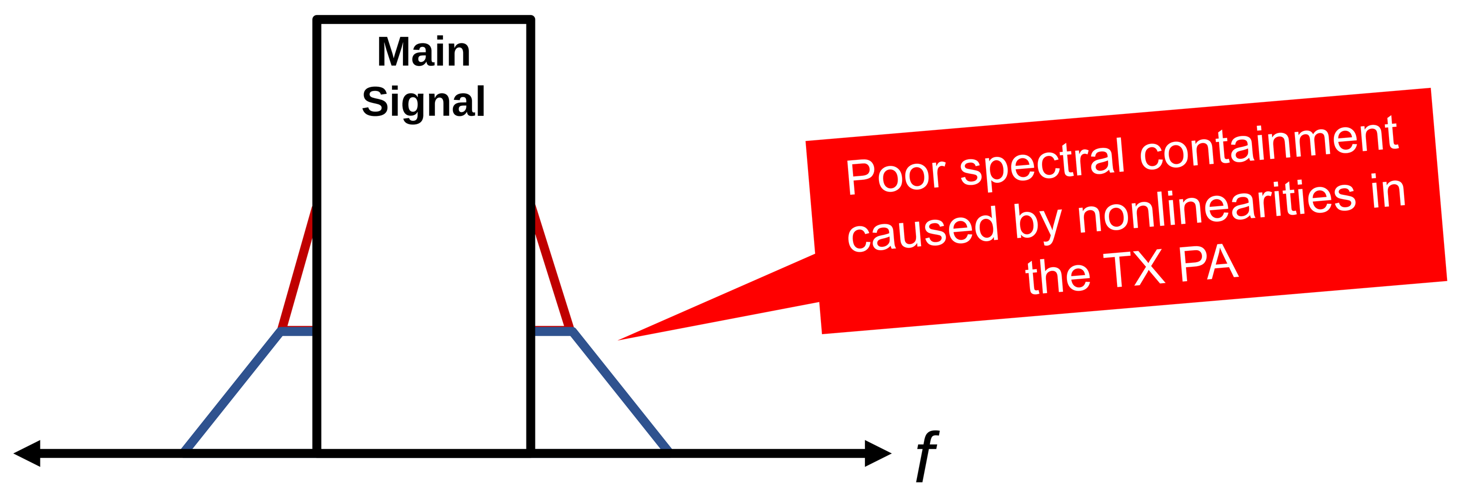
PROBLEM:

- Power amplifiers (PAs) introduce distortions which may:
  - Limit the power efficiency of mobile devices
  - Increase the error vector magnitude
  - Cause poor spectral containment
- Adjacent channel leakage is limited by the FCC and other standards bodies.



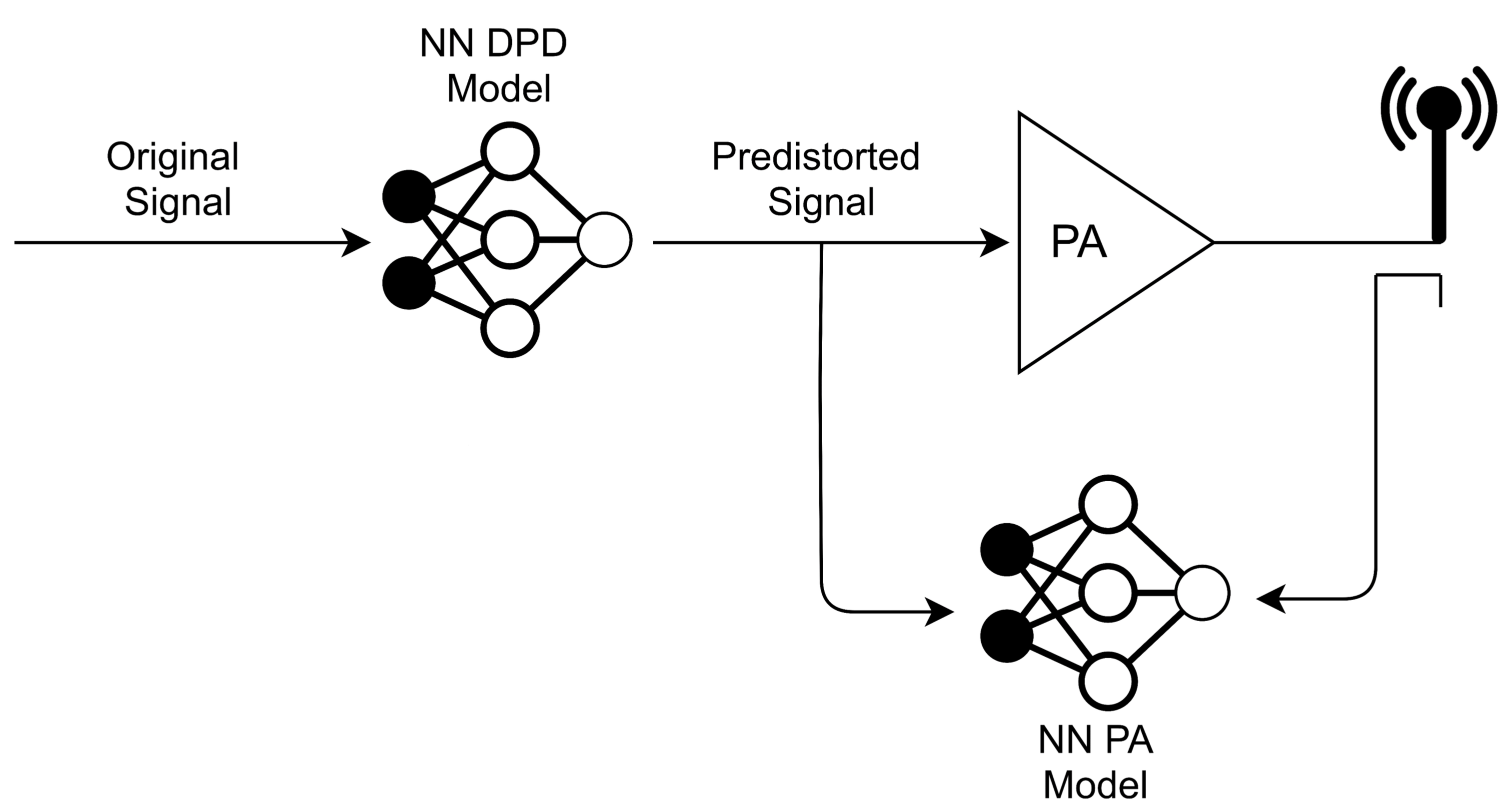
TRADITIONAL SOLUTIONS:

- Power Backoff:
  - Reduces range and power efficiency
  - Difficult for high peak-to-average power signals
- Polynomial Digital Predistortion:
  - Parallel Hammerstein polynomials *assumes polynomial behavior*
  - Indirect Learning Architecture *creates bias in the learning and is sensitive to noise*
  - The model can quickly become *computationally expensive*

NEURAL-NETWORK DPD:

- Neural Networks (NNs) can approximate any nonlinear function
- Makes fewer assumptions about the PA structure
- Can correct for more distortions not captured in traditional methods such as IQ imbalance

BLOCK DIAGRAM:



TRAINING ALGORITHM:

- Transmit through a Power Amplifier
- Create a NN model of the PA
- By backpropagating through the NN PA model, we train the NN based DPD
- Use this NN-DPD with the real PA.
- Repeat as necessary to improve performance

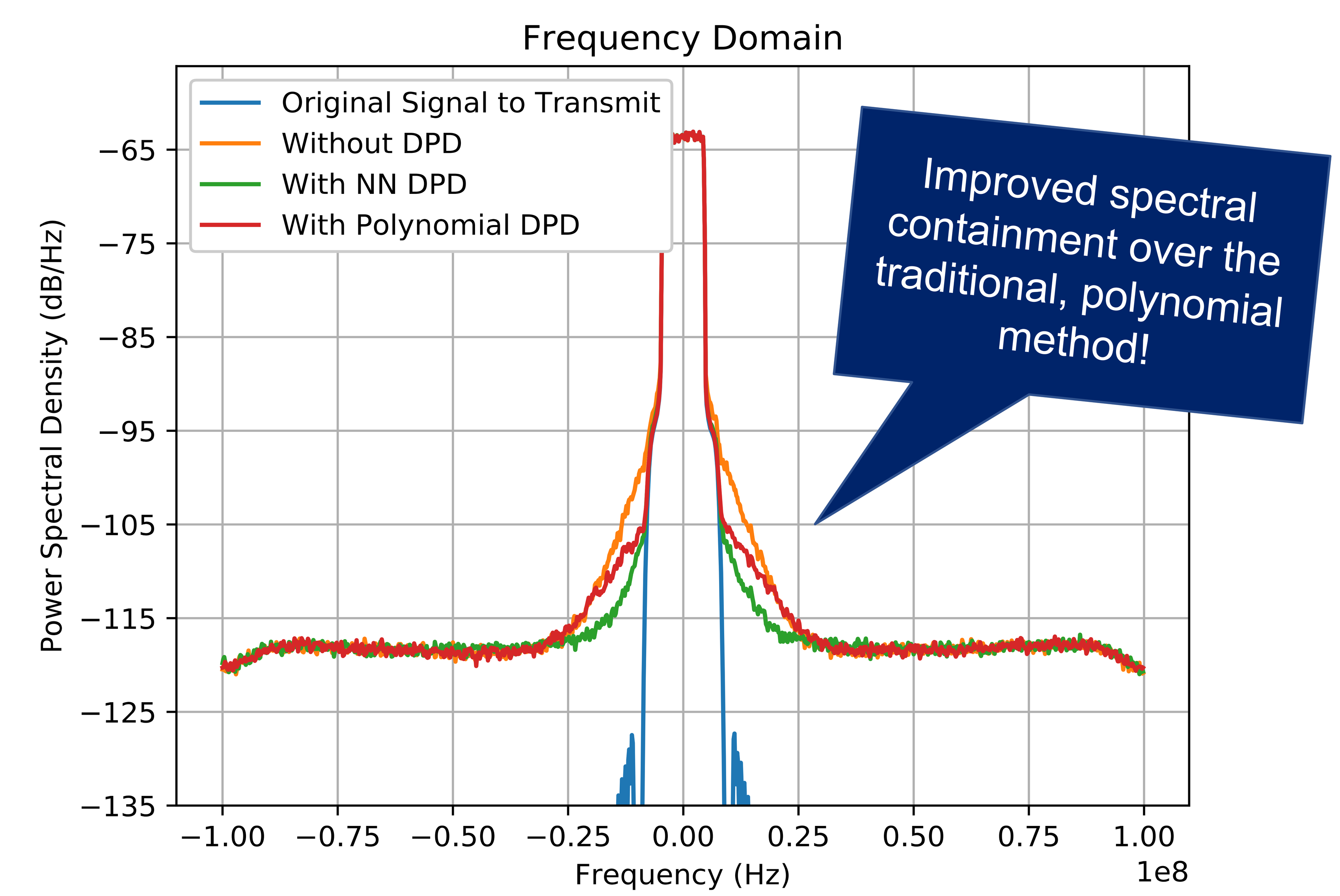
COMPLEXITY COMPARISON:

	NN DPD	Poly DPD
Multiplies	*4n+(k-1)n*	*2m+2pm+p+3*
Adds	*4n+n²(k-1)*	*2n+2pm+1*

- *n:* neurons, *k:* layers
- *p:* polynomial order, *m:* memory depth
- For similarly performing 10 neurons/1 hidden layer and 7th order, 4 memory taps polynomial, *we cut multiplies by 45%!*
- Possibility to further reduce complexity with different NN architectures.

RESULTS:

- 10 MHz, LTE signal
- RFWebLab PA at Chalmers University
- NN has:
  - 1 hidden layer
  - Leaky, ReLu activation functions
  - 20 neurons
- Polynomial is 7th order with 4 memory taps
- The spectral leakage around the main carrier is reduced.



FUTURE WORK:

- Explore new NN architectures to account for memory effects (RNNs, LSTMs)
- Evaluate training complexity
- Study performance/complexity tradeoffs
- Improve training speed
- Evaluate on a mobile GPU

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