Direct Learning Neural Network Digital Predistortion Using Backpropagation Through a Memory Power Amplifier Model

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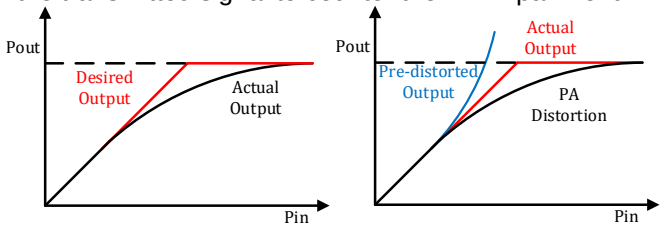
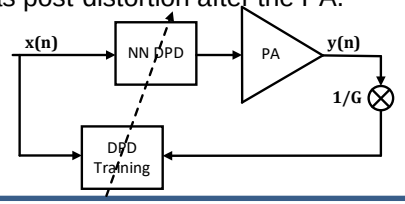
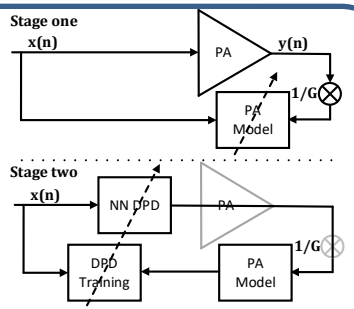
Non-linearity in power amplifier (PA) depends on the operating range. In order to improve the PA efficiency, it is necessary to work close to the supply power of the PA, which causes a higher compression and the nonlinearity increases significantly, which increases the error vector magnitude (EVM) and the adjacent channel leakage ratio (ACLR). A common approach to address the non-linear impairment is to digital pre-distortion(DPD) which distorts the transmitted signal to counter the PA impairment



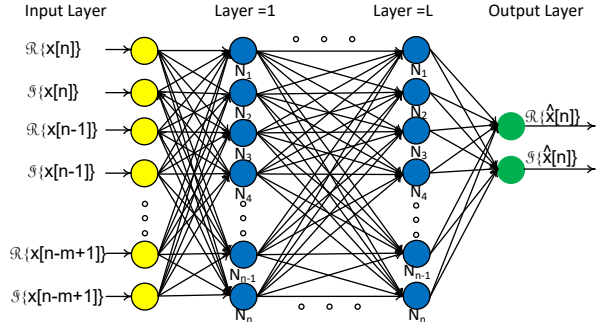
DPD solutions today use Indirect learning, where the DPD is trained as post-distortion after the PA.



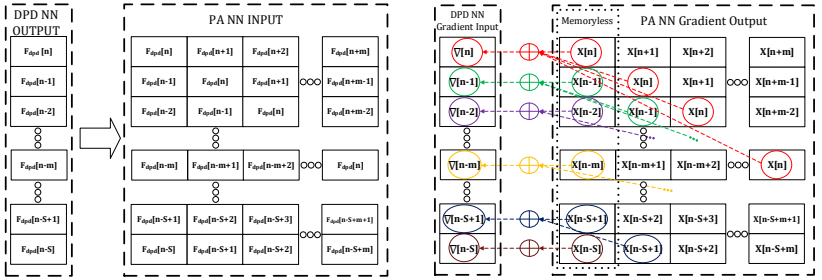
Introducing a new Novel memory direct learning method, which uses a neural network (NN) PA model to backpropagate the memory effect and train the DPD based NN as a true pre-distortion



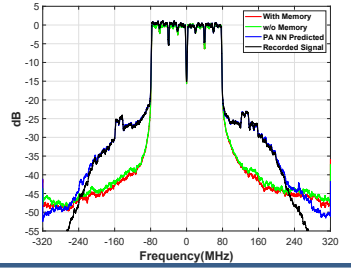
Both PA and DPD NNs are trained using a fully connected feedforward architecture. feedforward



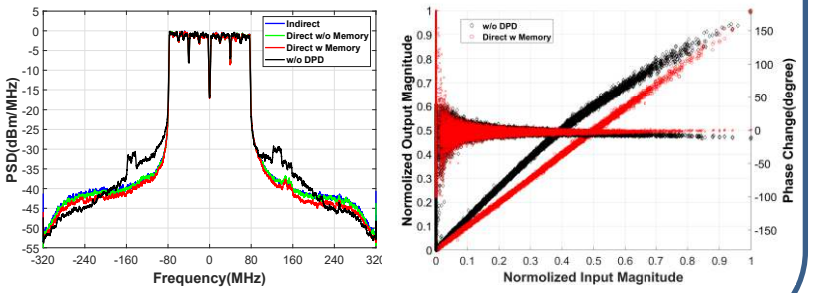
After the PA NN model is trained at the first stage, The NNs are cascaded into one NN. The cascaded NN is trained by freezing the PA model NN weights and only updating the DPD NN thus allowing it to counter the PA distortion.
The Memory backpropagation is done by summing the diagonal of the PA NN model gradient matrix that correlates to the DPD NN output.



Result in simulation using a 160 MHz 802.11ax Wifi signal. Compared to memory less backpropagation



Results on a 65 nm wideband CMOS PA with a bandwidth of 2.17 GHz between 0.33-25.GHZ, using a 160 MHz 802.11ax Wifi signal. Compared to memory less backpropagation and indirect learning



Learning Method	EVM [dB]	ACLR [dBc]	Average Power [dBm]
Simulation			
Without DPD	-22	-30.5	11.3
direct Without Memory	-34.9	-39.2	-
direct With Memory	-36.5	-40.3	-
Wideband PA			
Without DPD	-28.2	-34	8.4
indirect	-36.7	-36.1	8.4
direct Without Memory	-37.4	-36.6	8.4
direct With Memory	-39	-37.5	8.4