Wideband Distortion Contribution Analysis of Analog Circuits with Differential Signalling

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Analog design = LTI

Design flow based on Linear System Theory

- Non-linear performance at a (too) late stage
- No indication about the source of distortion

We need to find the source of distortion

Distortion Contribution Analysis

Pinpoint the dominant source of distortion

to solve possible problems effectively

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Current solutions: Volterra theory

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Distortion Contribution Analysis

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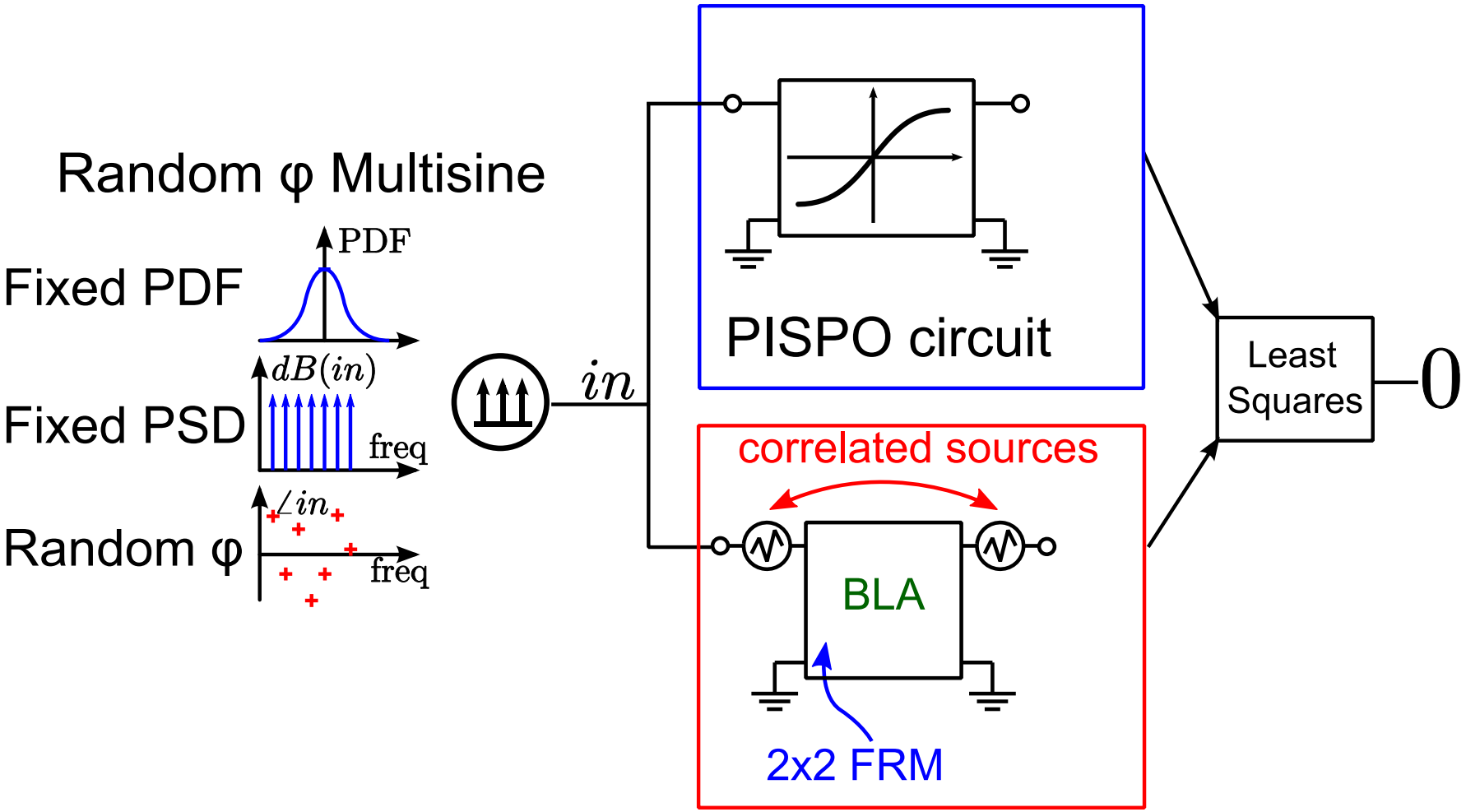
Current solutions: Volte[illegible]eory

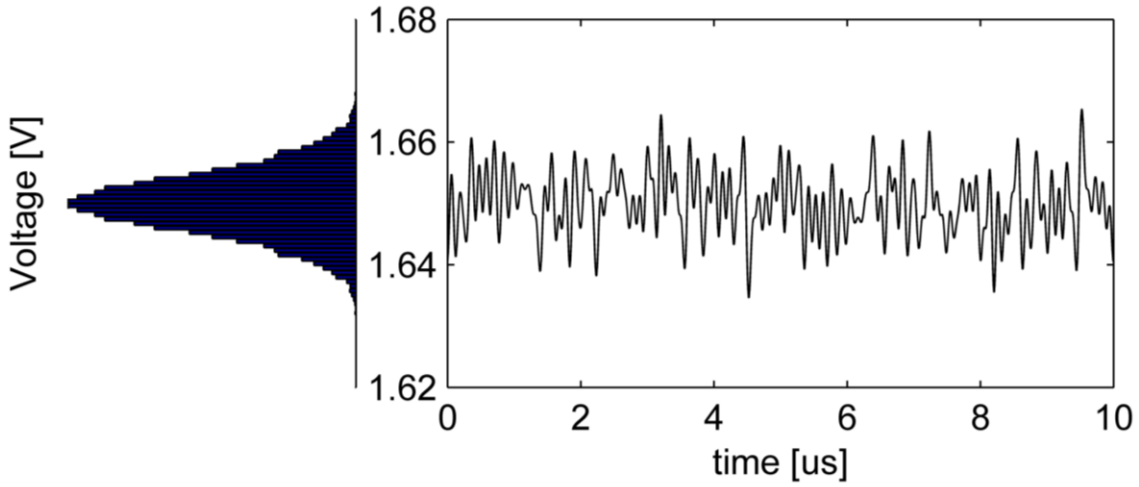
very difficult

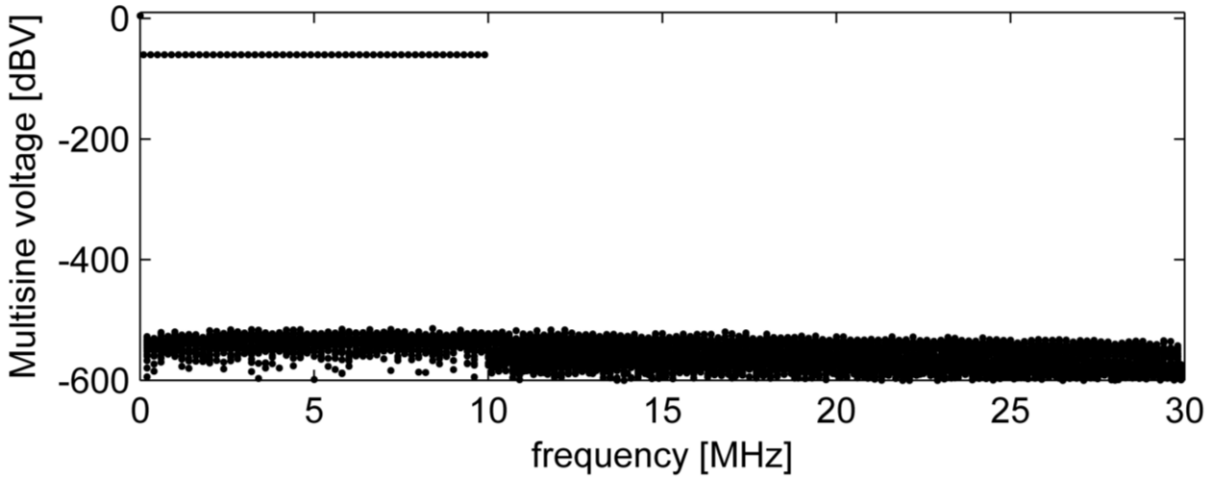
Best Linear Approximation



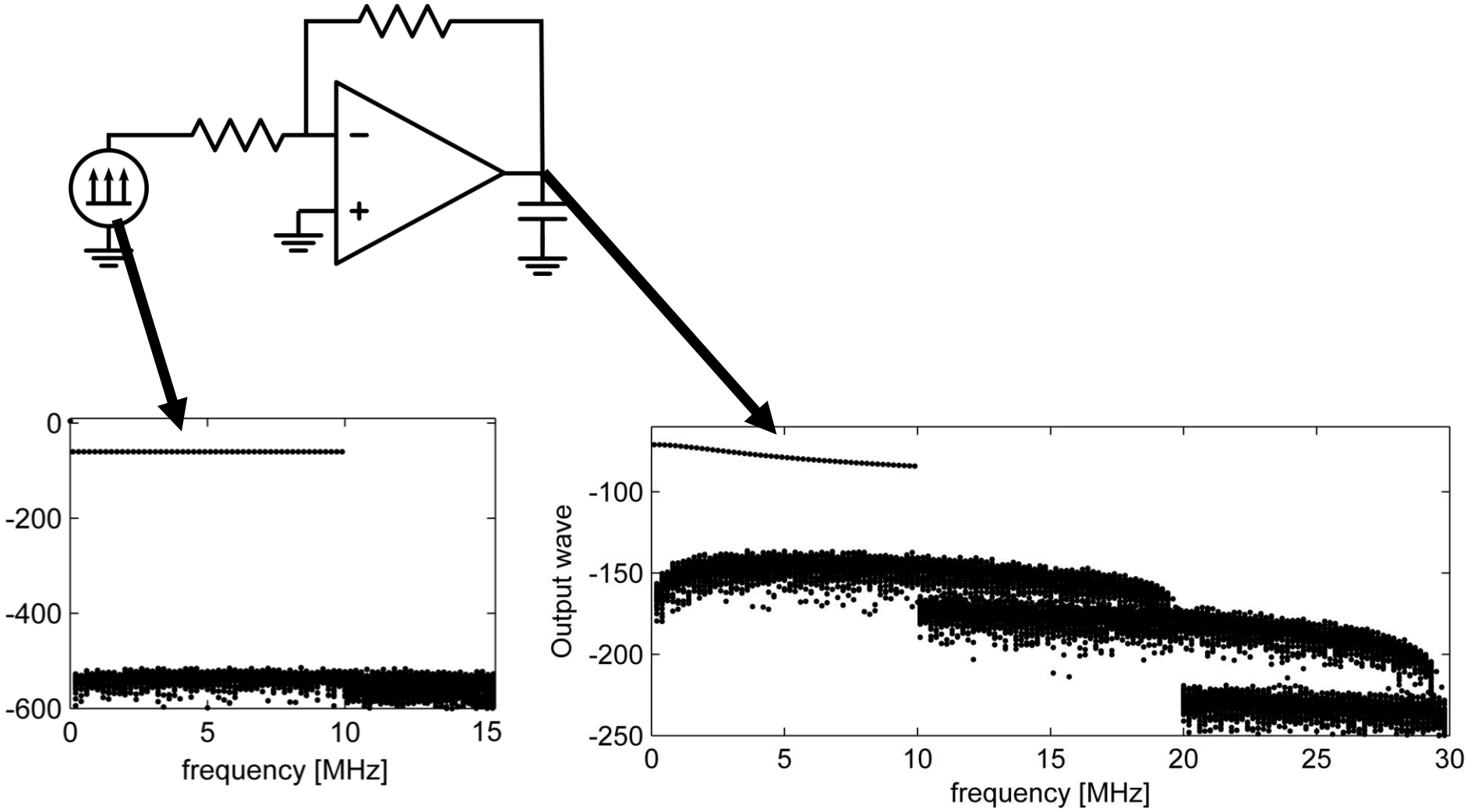
Multisines as excitation signal

$$u(t) = \sum_{k=1}^{N} A_k \sin(k2\pi f_0 t + \varphi_k)$$





BLA leads to easy-to-interpret models



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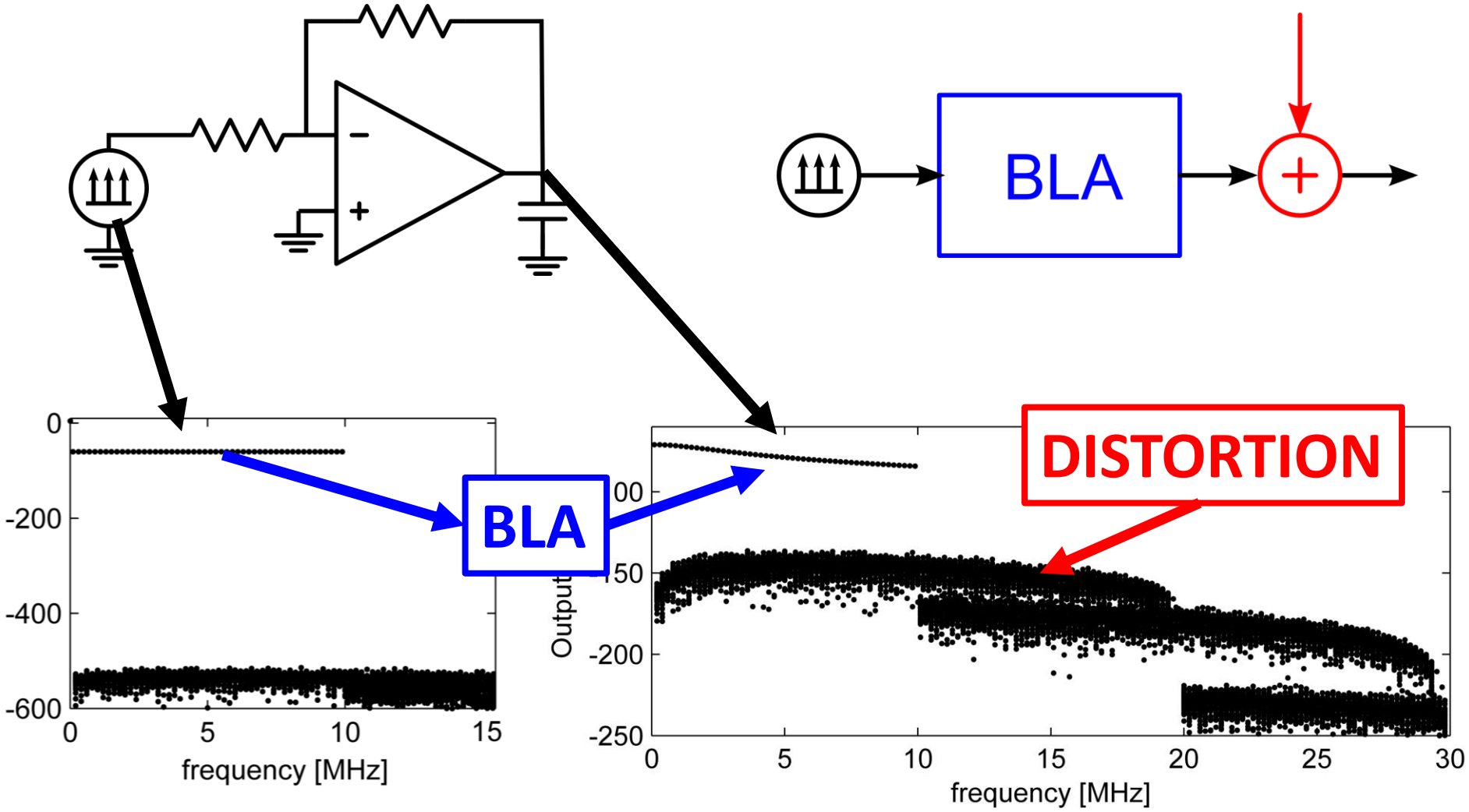

BLA leads to a simple DCA

BLA: Distortion = noise

Noise analysis

} DCA

Drawback: long simulation time

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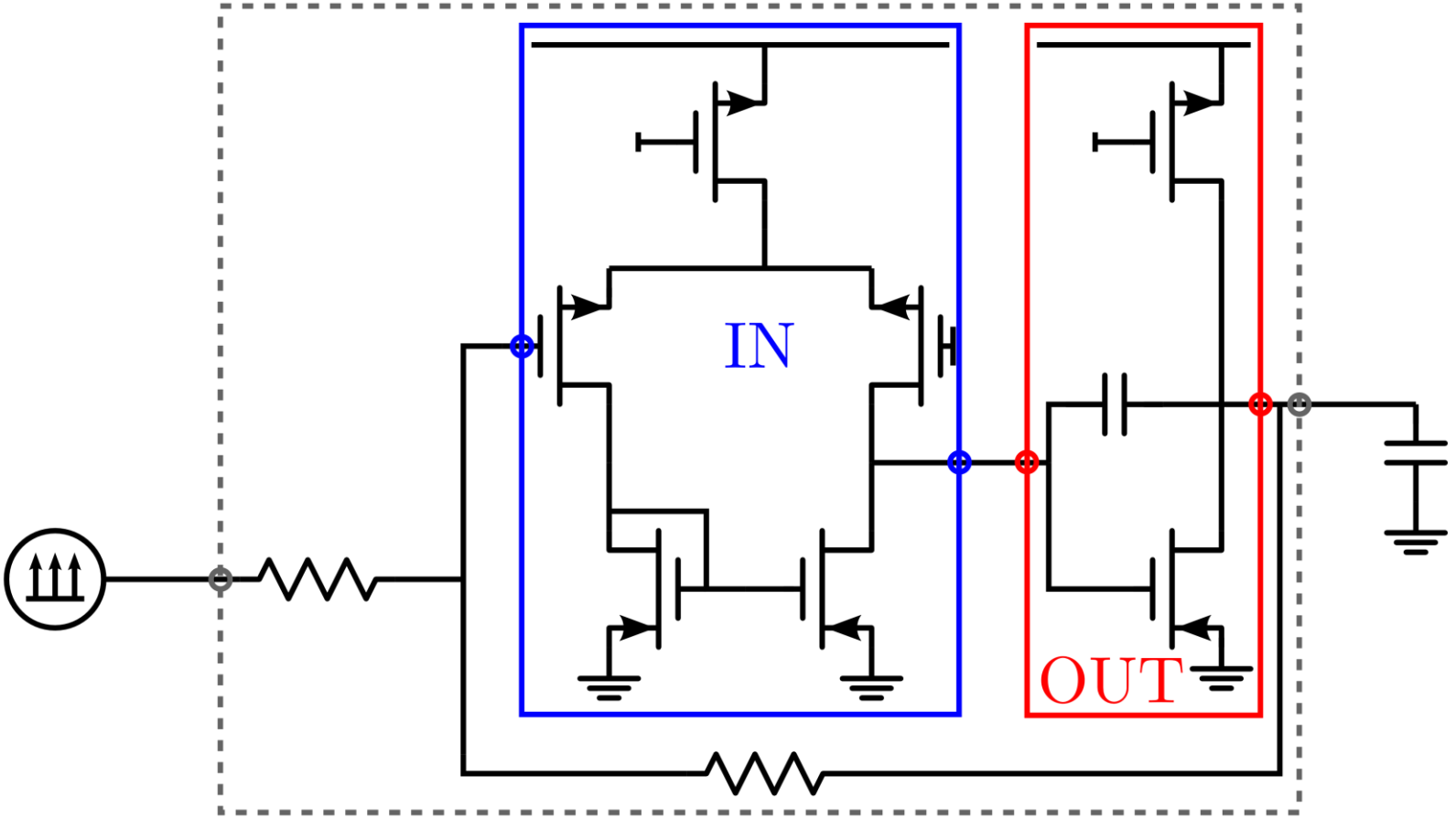
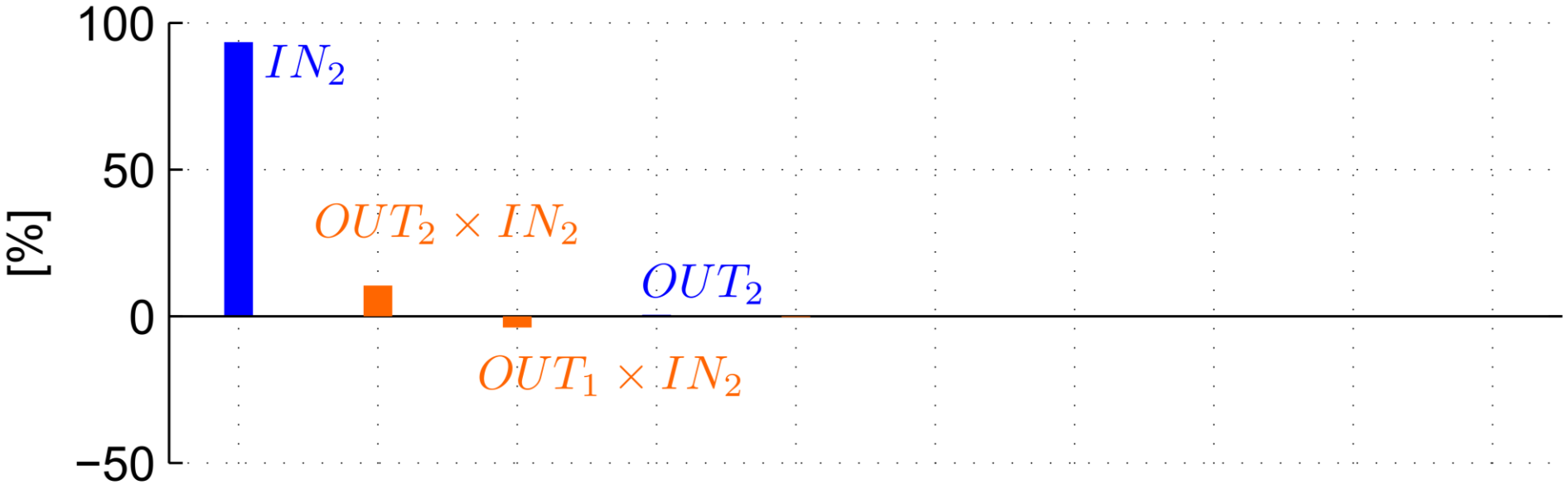
Bonus Assumption: weakly non-linear

⇒ BLA = small-signal behaviour

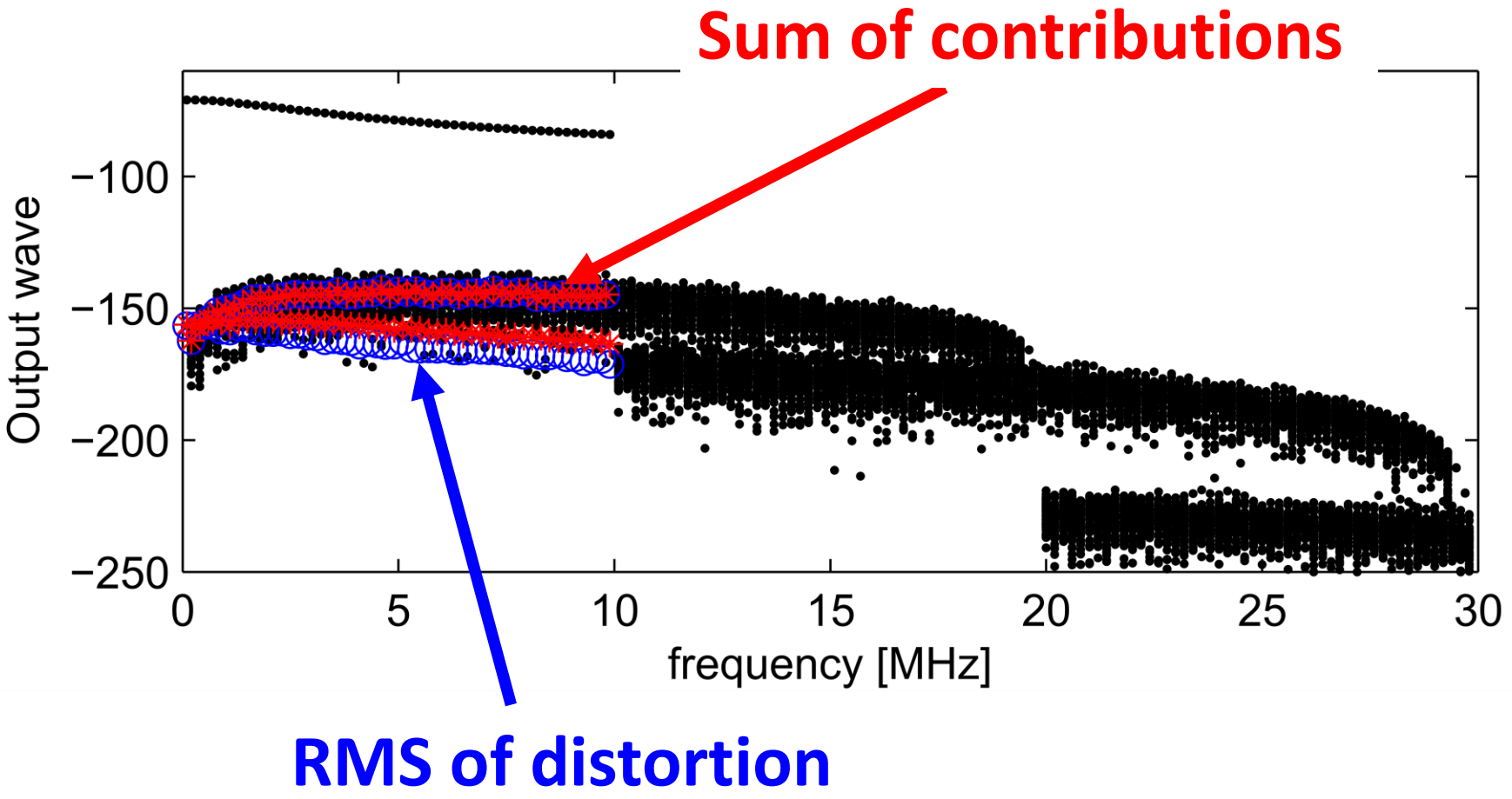
Example: Miller op-amp



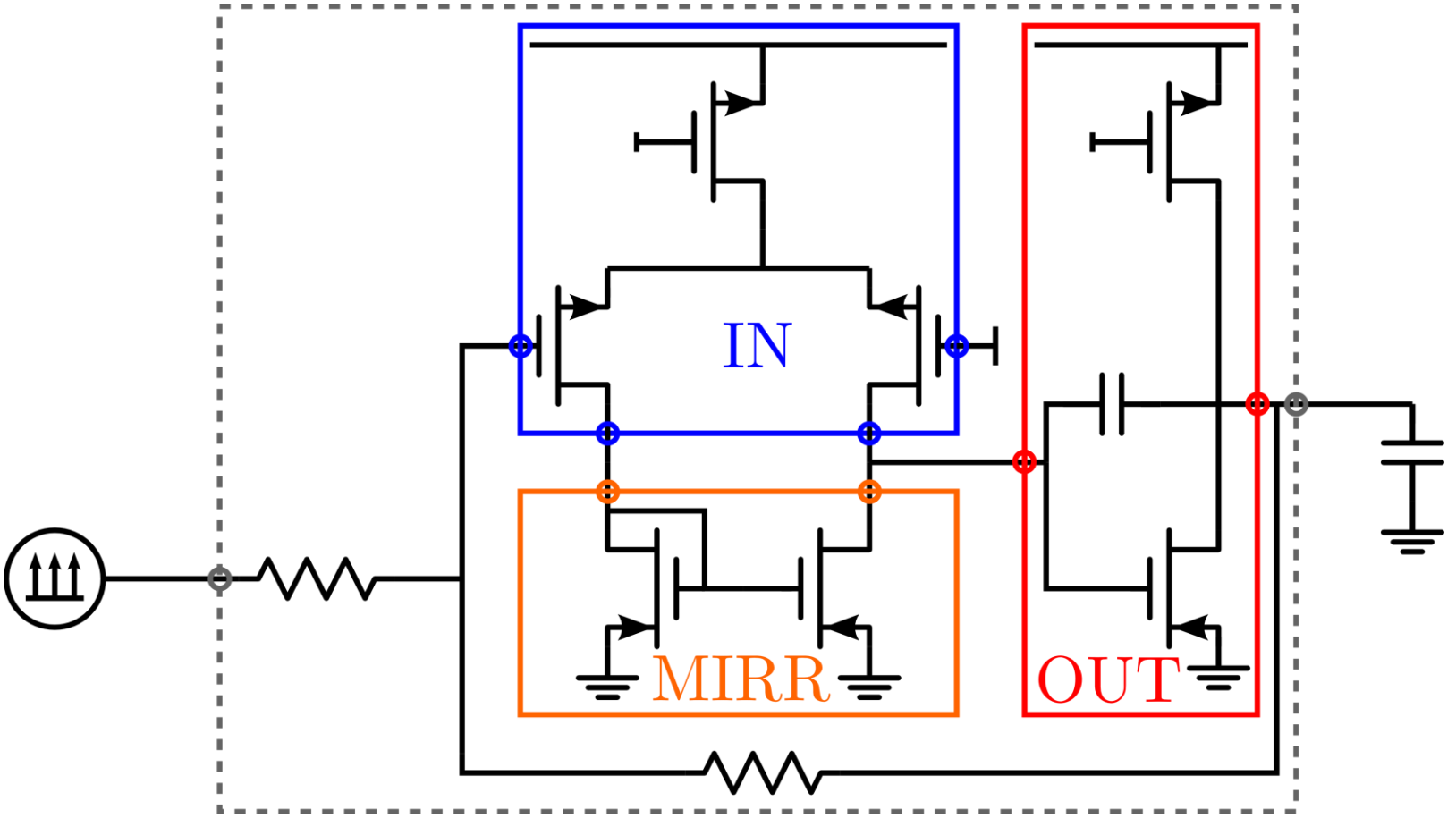
The input is dominant source



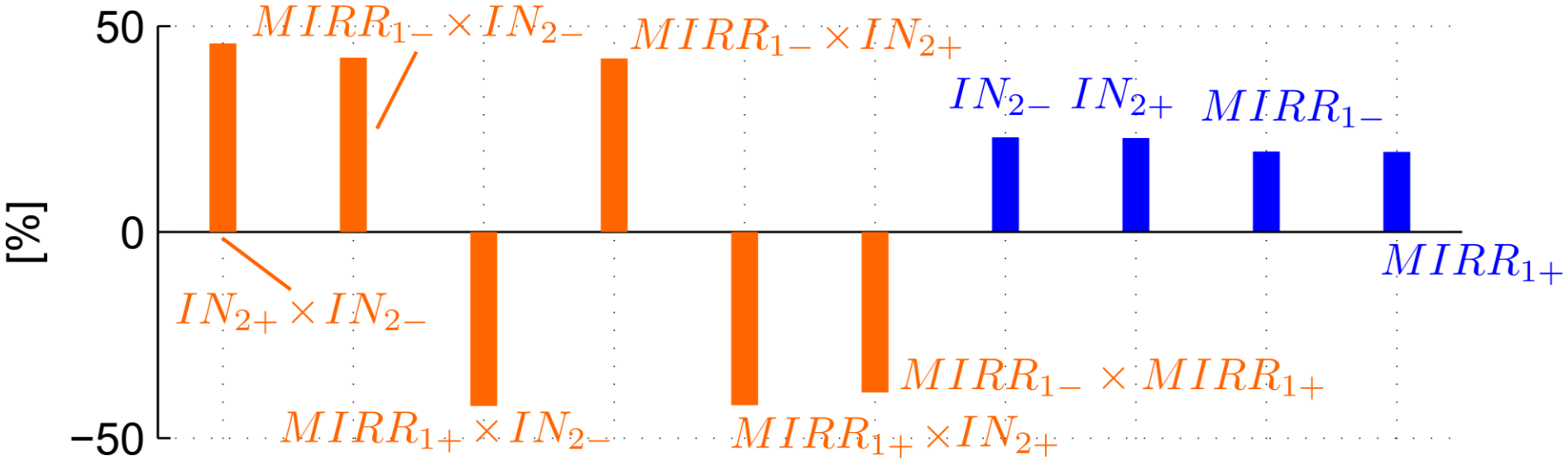
Weakly NL assumption is valid

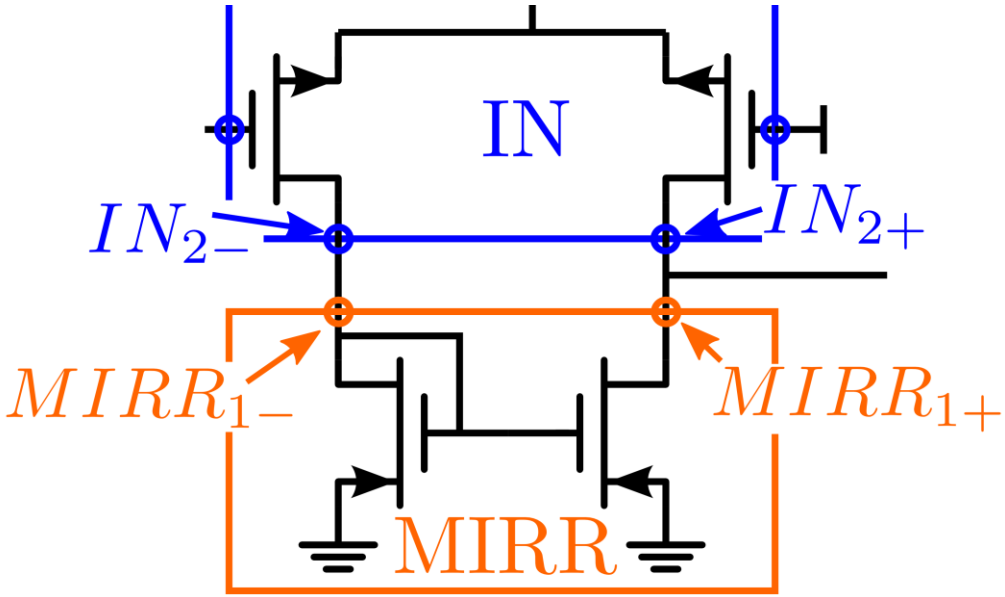


Going deeper

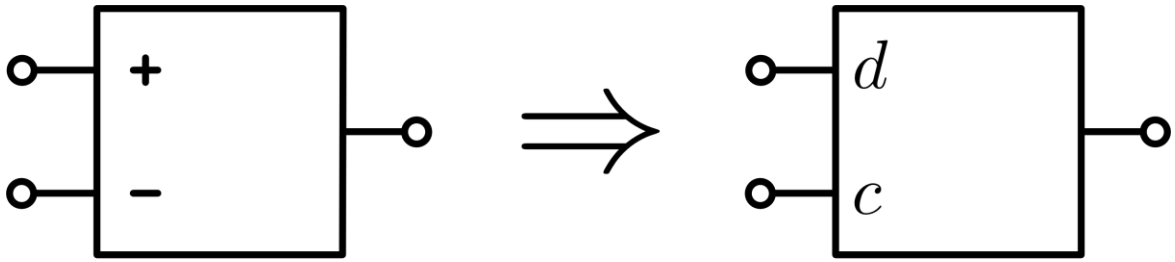


Results become difficult to interpret





Mixed-mode S-parameters



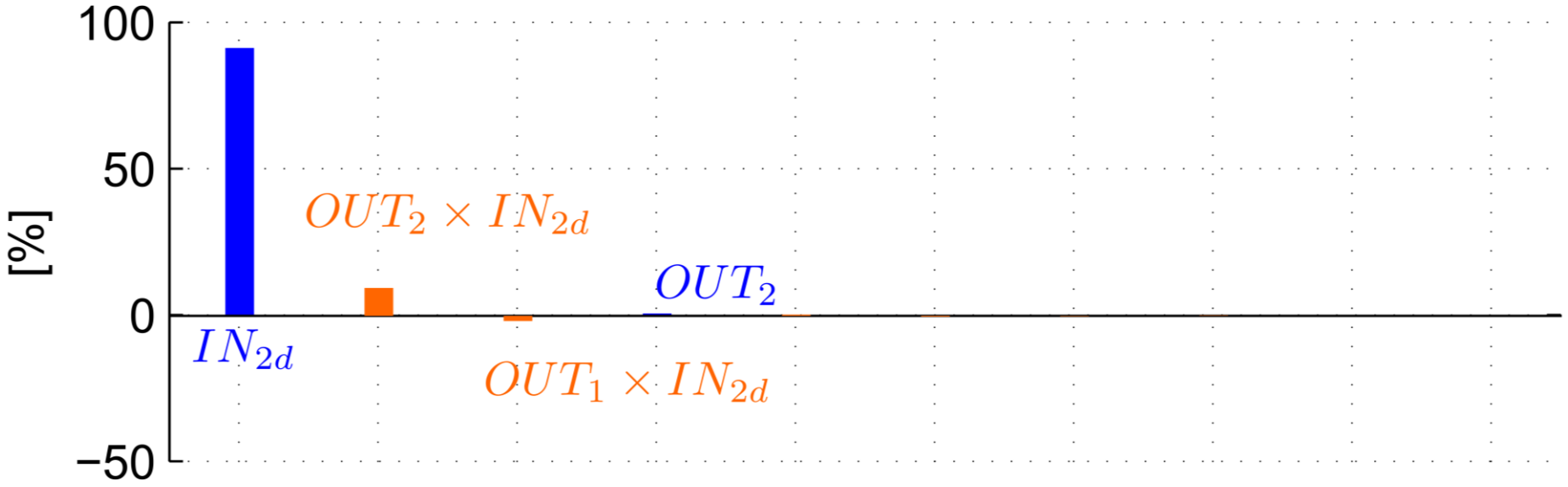
$$V_d = V_+ - V_- \qquad V_c = \frac{V_+ + V_-}{2}$$

$$I_d = \frac{I_+ - I_-}{2} \qquad I_c = I_+ - I_-$$

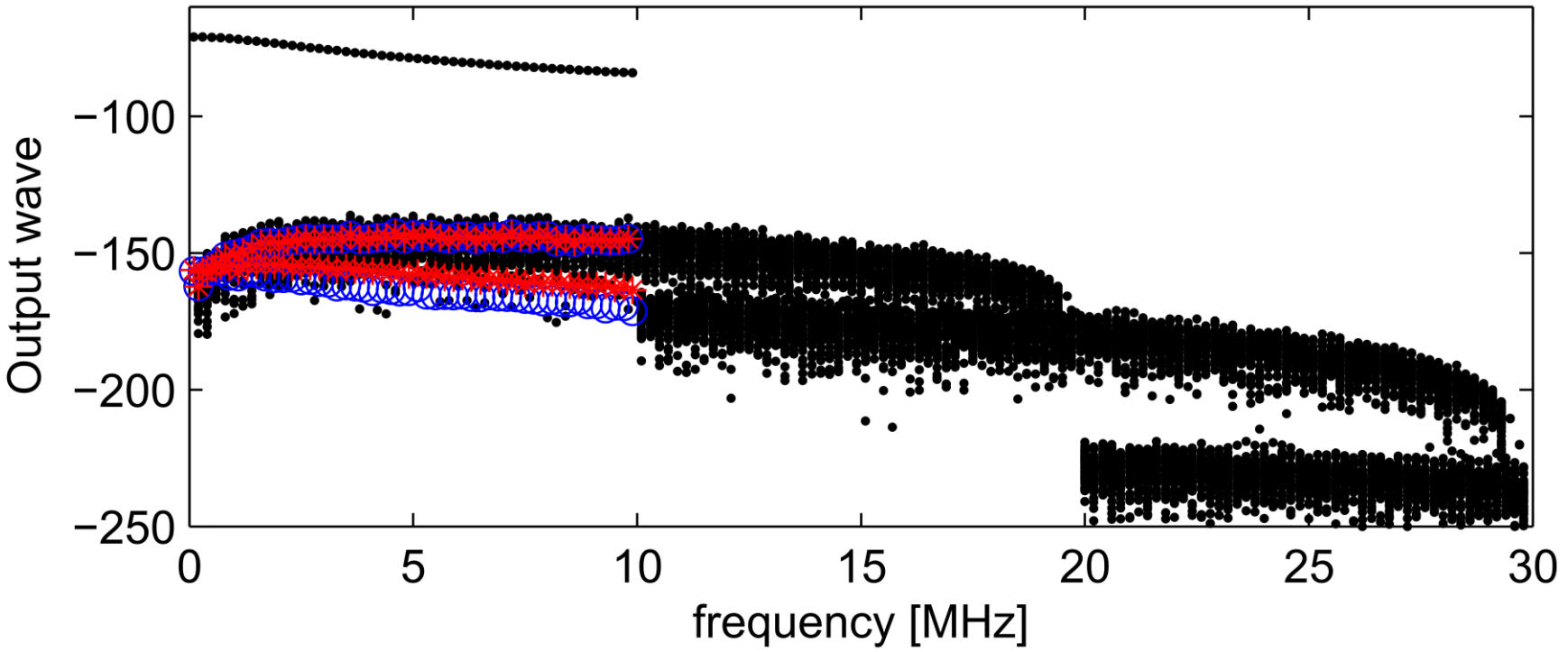
A. Ferrero and M. Pirola “Generalized Mixed-Mode S-parameters”
IEEE Tran. On Microwave Theory and Techniques, vol. 54 No. 1, Jan. 2006

No fundamental change to DCA required

Using mixed-mode make it all clear



And the error is the same



Conclusions

DCA can be used to find source of distortion

Weakly NL assumption valid

Extension with mixed-mode S-parameters

allows easier interpretation of results

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