319-UW659

Adaptive NFC WPT System Implementing Neural Network-Based Impedance Matching with Bypass Functionality

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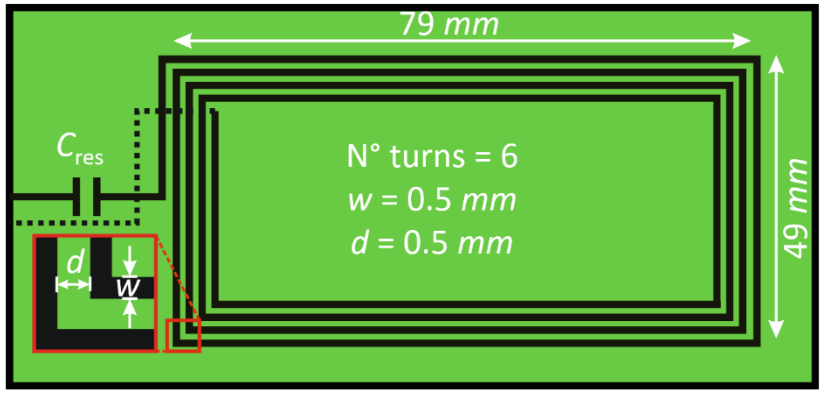
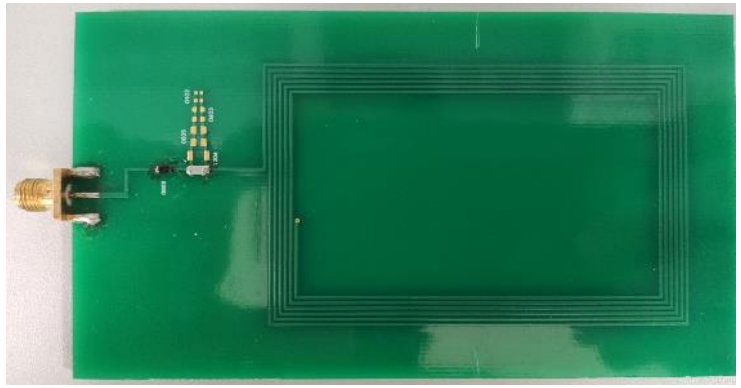
Outline

- Introduction
- Structure
- Components
  - Transmitter-Receiver Coils
  - Adaptive Matching Network
  - Artificial Neural Network
- System performance
- Conclusion

Introduction

- WPT system based on MCR at ISM band - 13.56 MHz
  - Explore NFC charging capabilities
  - Real-time optimization under varying TX-RX positions
  - Performance of ISO/ICE 14443 class 1 coils for WPT
  - Analyze advantages and disadvantages of AIMNs
  - Provide an AI enhanced solution of an RF adaptive WPT system



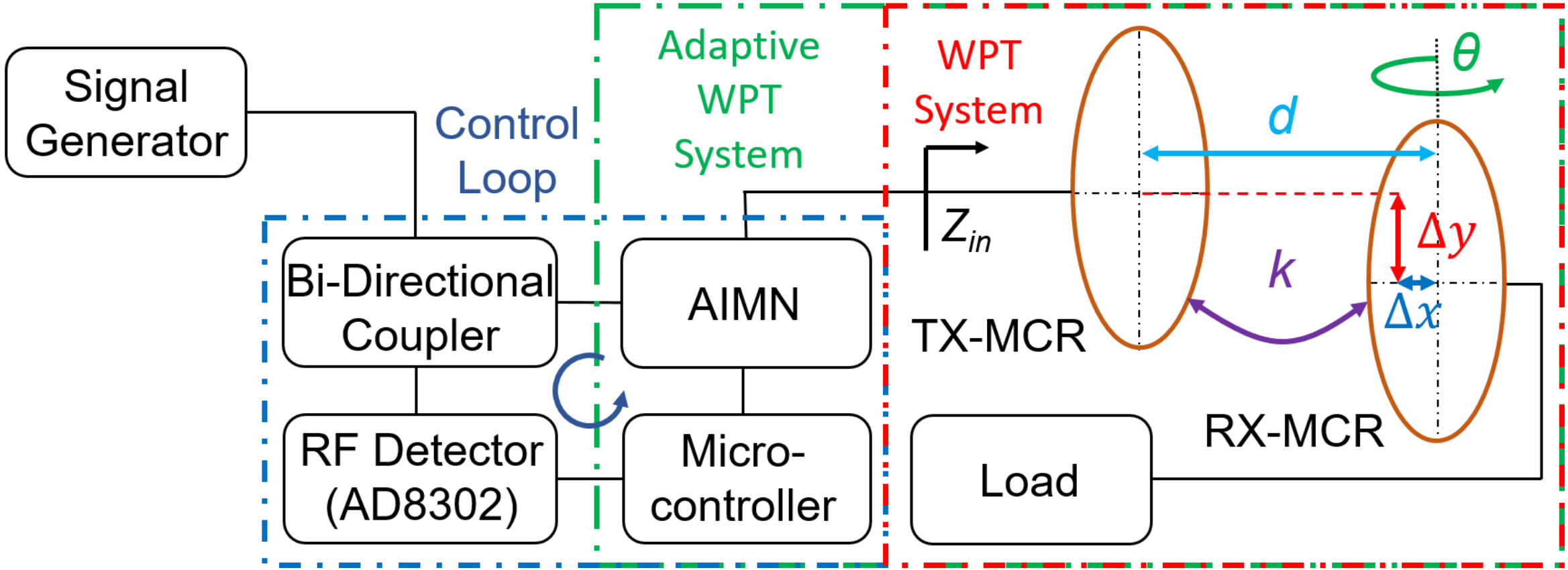


WPT: Wireless power transfer system
MCR: Magnetically coupled resonators
TX: Transmitter
RX: Receiver
AIMN: Adaptive impedance matching network
AI: Artificial intelligence
RF: Radio-Frequency
NFC: Near-field communications
ISM: Industrial, scientific, medical

System Architecture

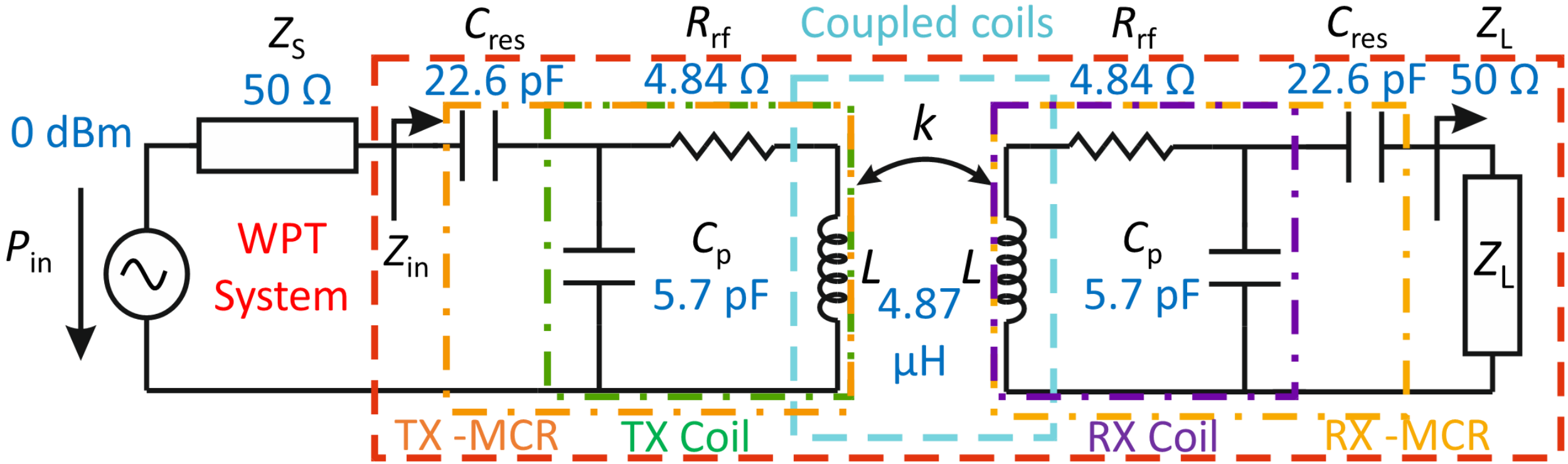
Structure of the real-time adaptive WPT system

d: Inter-coil distance
θ: Azimuthal tilt
Δx : Horizontal misalignment
Δy: Vertical misalignment
Z_{in}: Input impedance



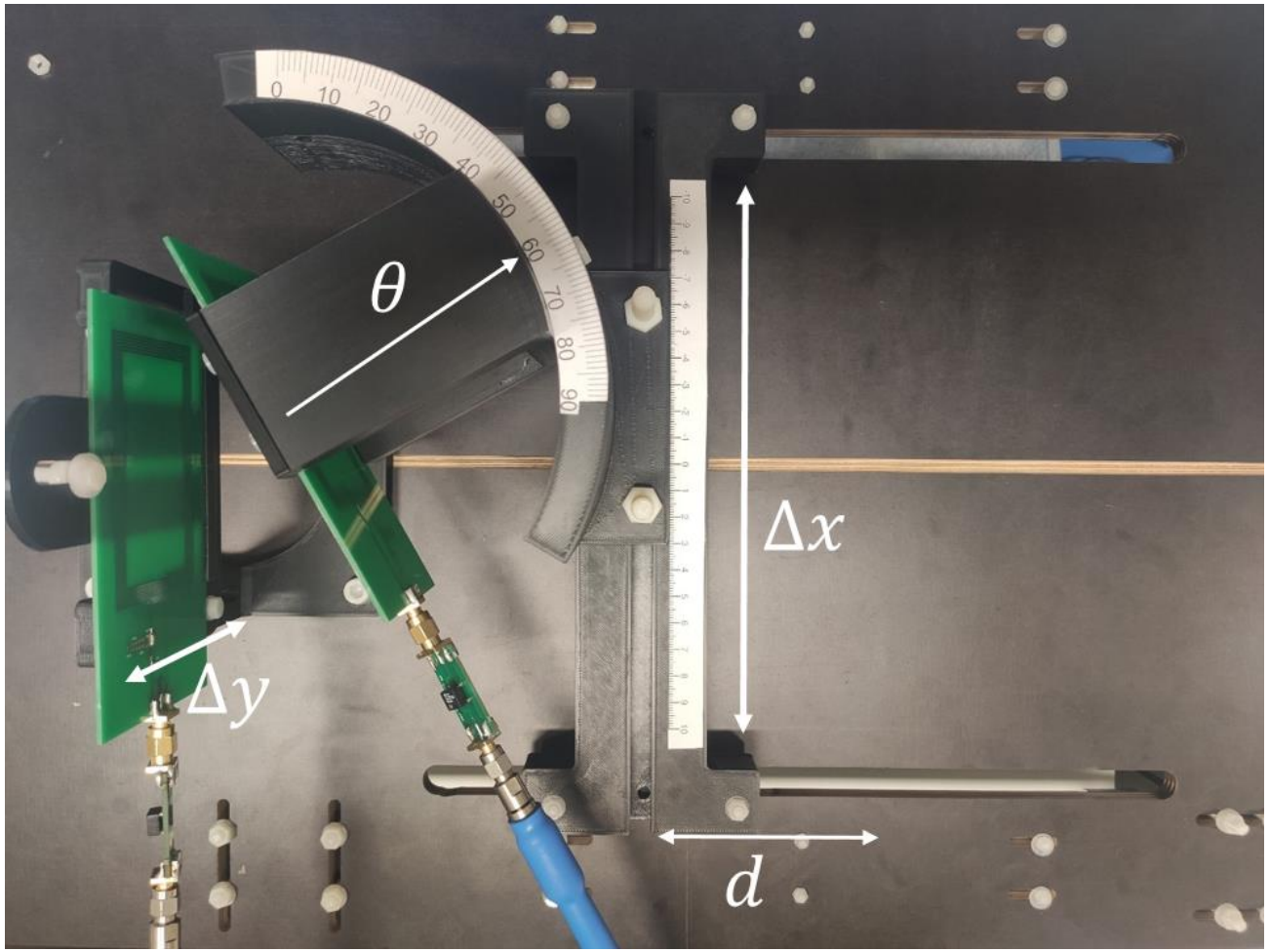
TX-RX Coils

- MCR TX-RX: Series-series (SS) resonant configuration



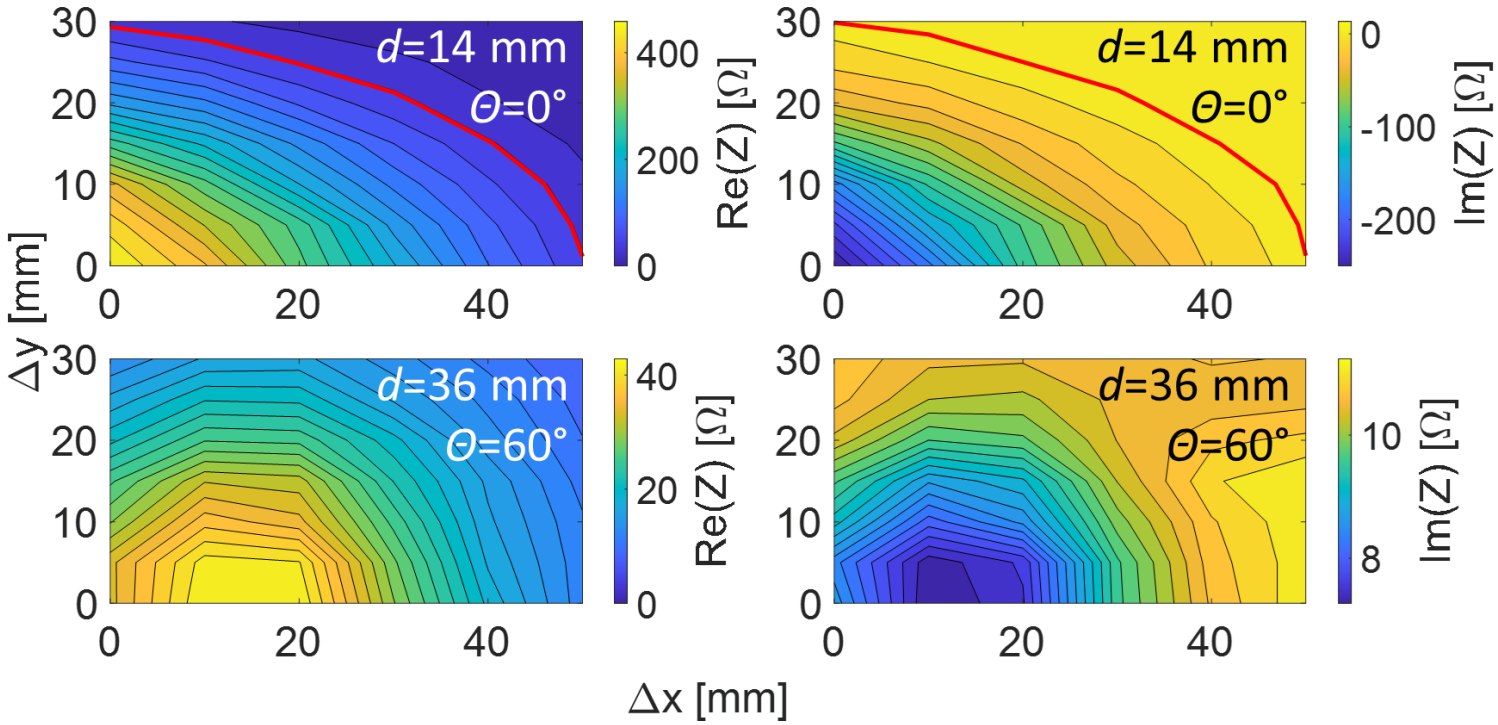
Measurement Setup

- WPT channel characterized under different TX-RX positions
- Semi-automatized process
- Scattering-parameters measured with a VNA
- Large dataset assembled
- DOI:10.21227/vtp8-x586



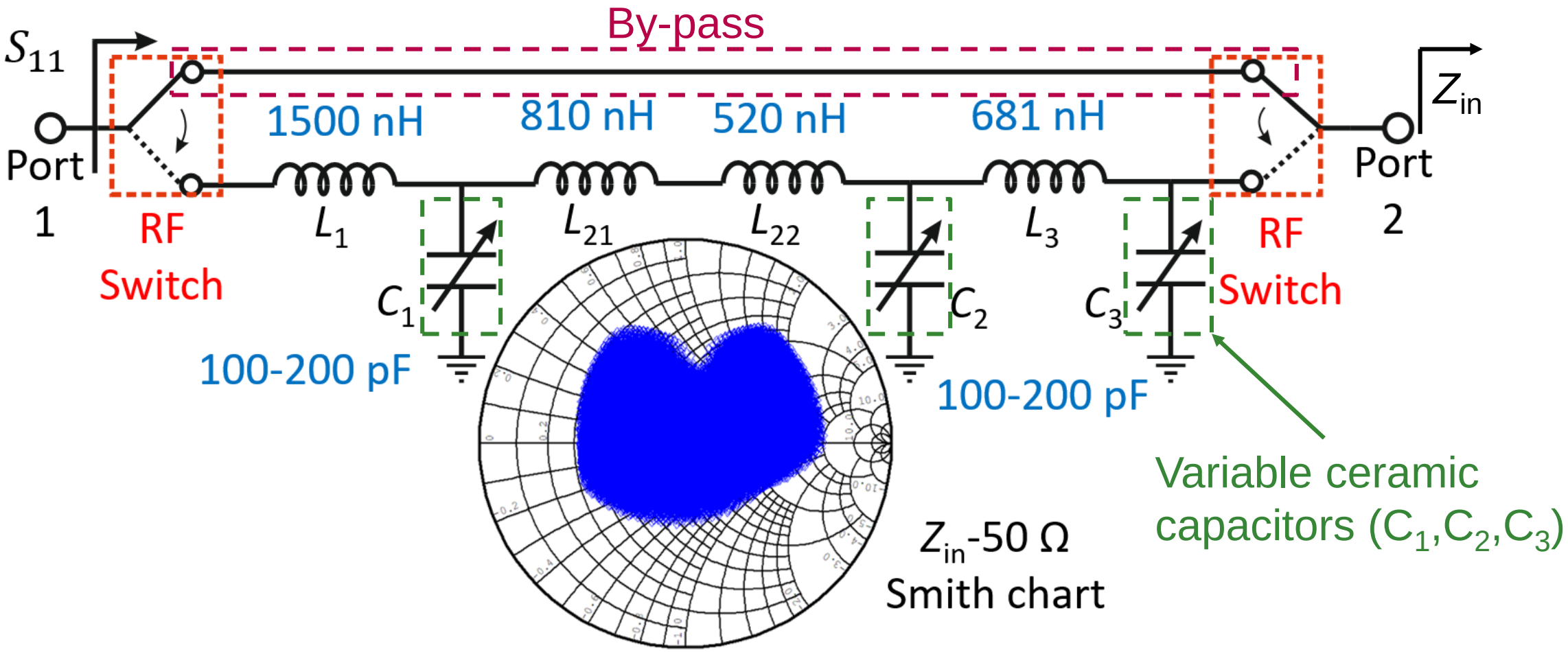
Channel Dataset - Z_{in}

- Different coupling regimes determined by Z_{in}
  - Overcoupling
  - Undercoupling
  - Critical coupling
- Red trace indicates critical coupling region



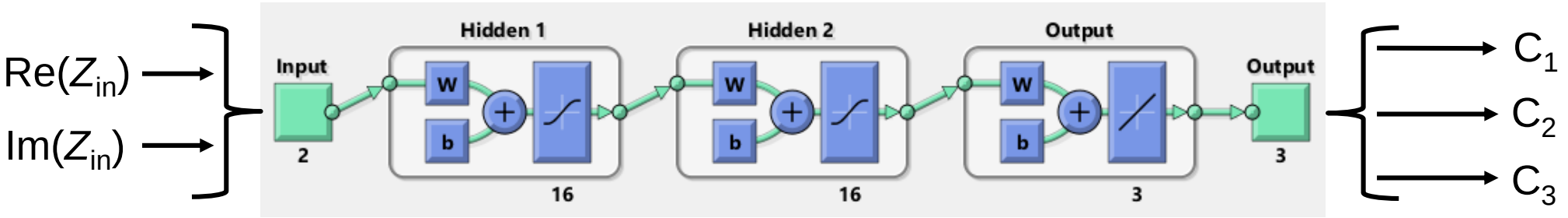
Adaptive Matching Network

- AMN designed to perform matching of Z_{in} to 50 Ω at 13.56 MHz



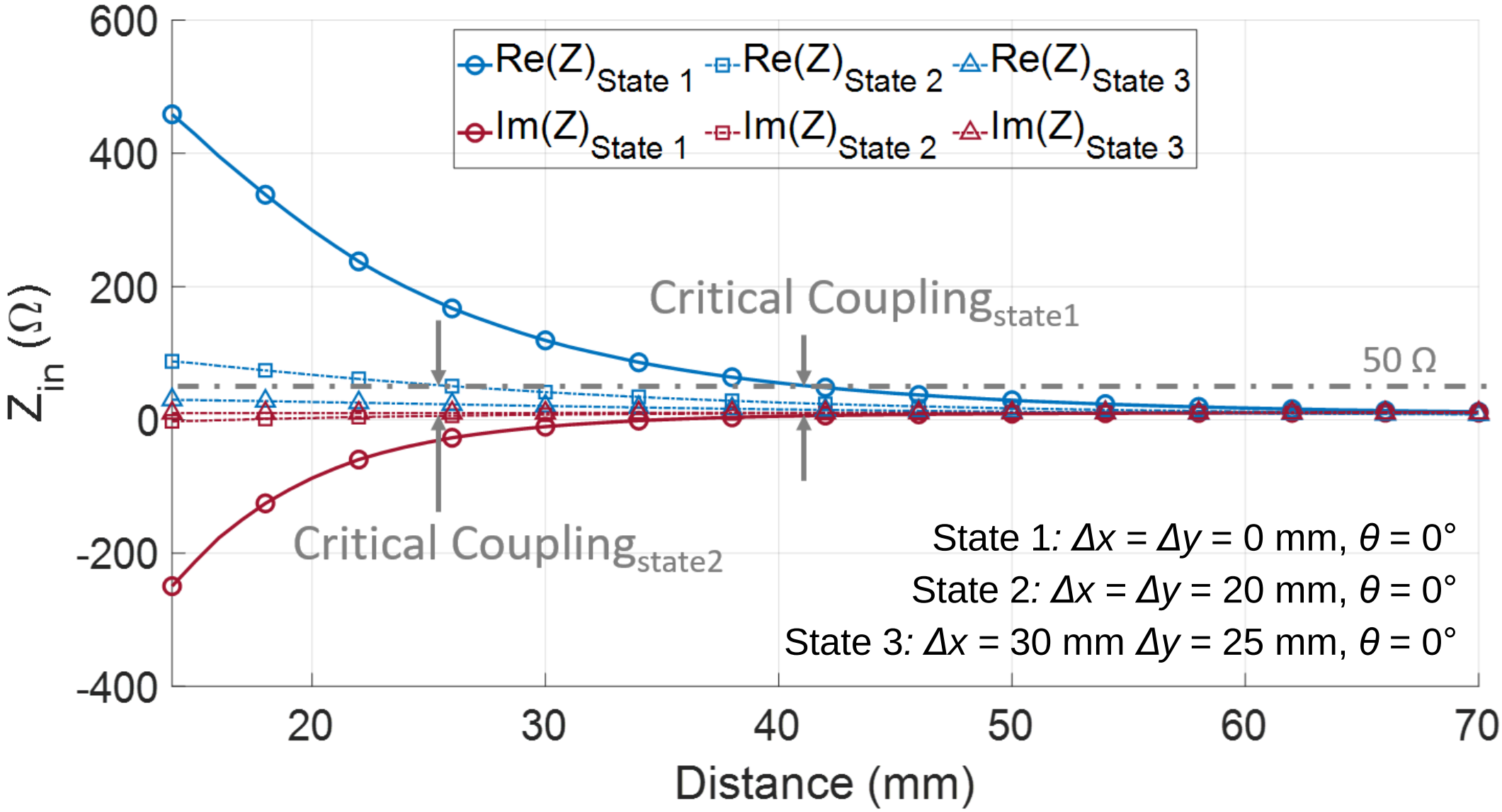
Artificial Neural Network

- Neural network with backpropagation using Matlab's toolbox



- General dataset created for training-validation
  - $Re(Z_{in})$ = [5-900] Ω; $Im(Z_{in})$ = [-100-100] Ω; 8200 data points
  - AWR controlled through Matlab: AWR optimizer determines C_1, C_2, C_3
  - 70% Training, 30% Validation
- Measured S-parameters ⟶ Z_{in} used to test the network
- Training and validation MSE ~ 5%. Test MSE ~ 10%

System performance

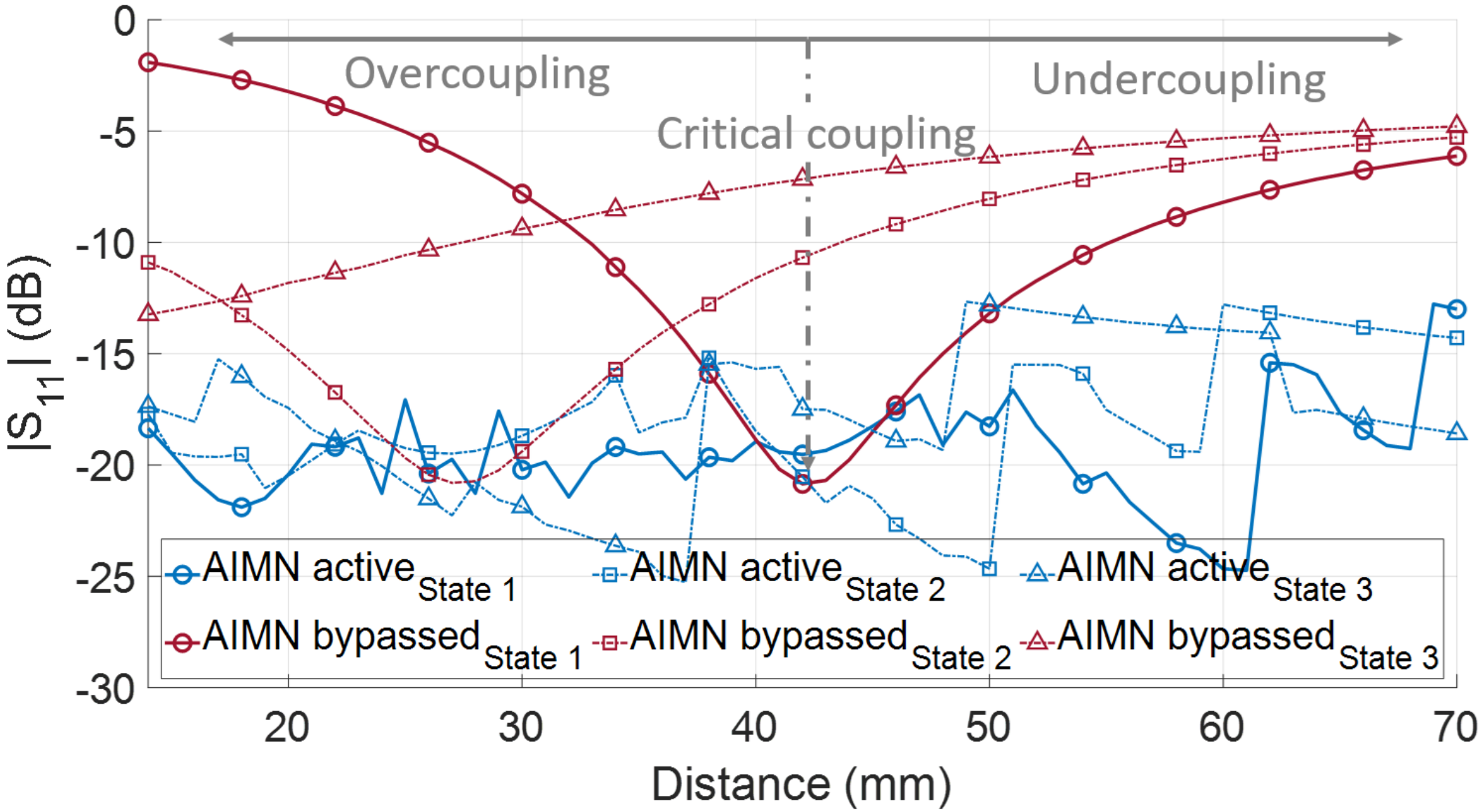


State 1: $\Delta x = \Delta y = 0$ mm, $\theta = 0°$

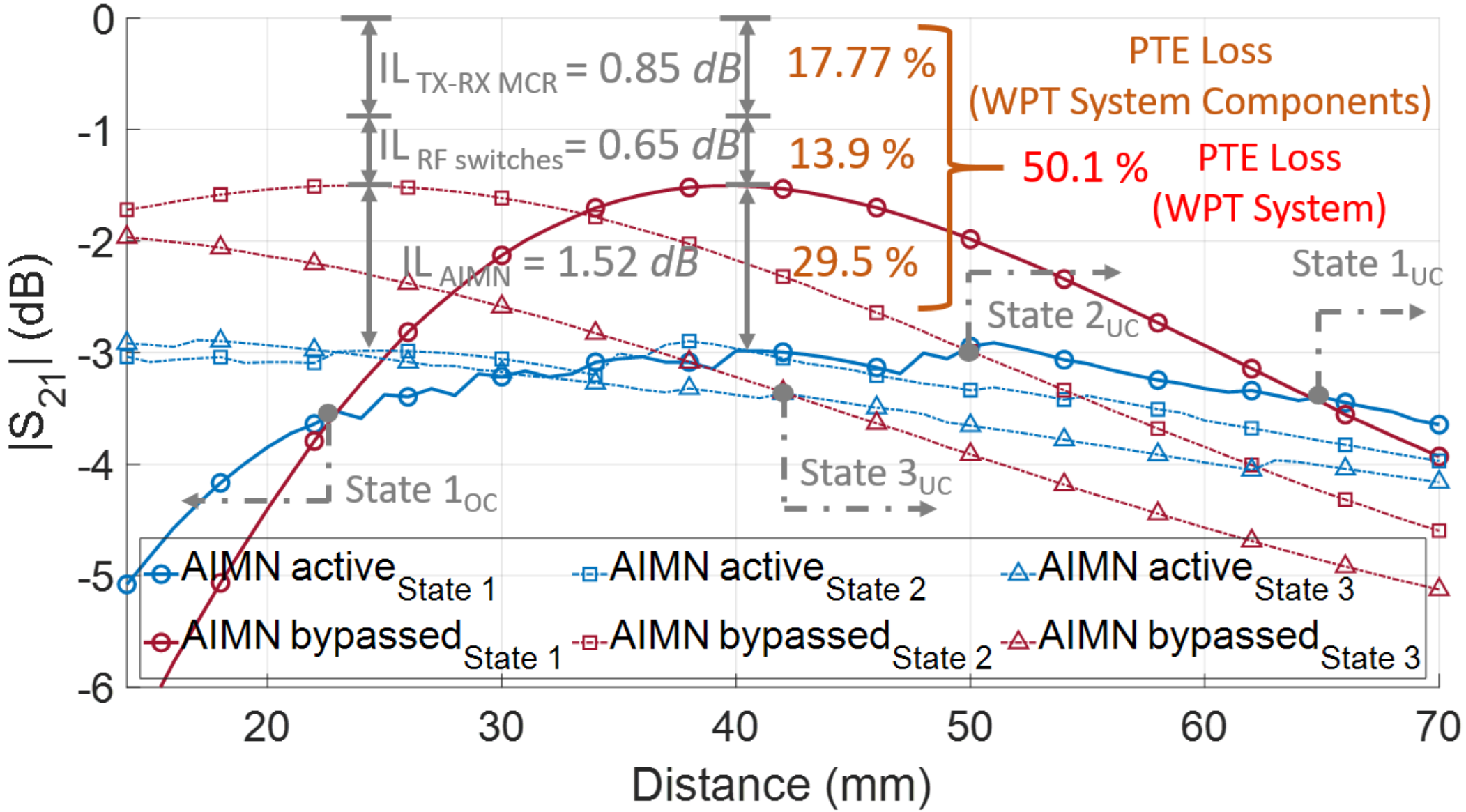
State 2: $\Delta x = \Delta y = 20$ mm, $\theta = 0°$

State 3: $\Delta x = 30$ mm $\Delta y = 25$ mm, $\theta = 0°$

System performance - S_{11}



System performance - S_{21}



Conclusions

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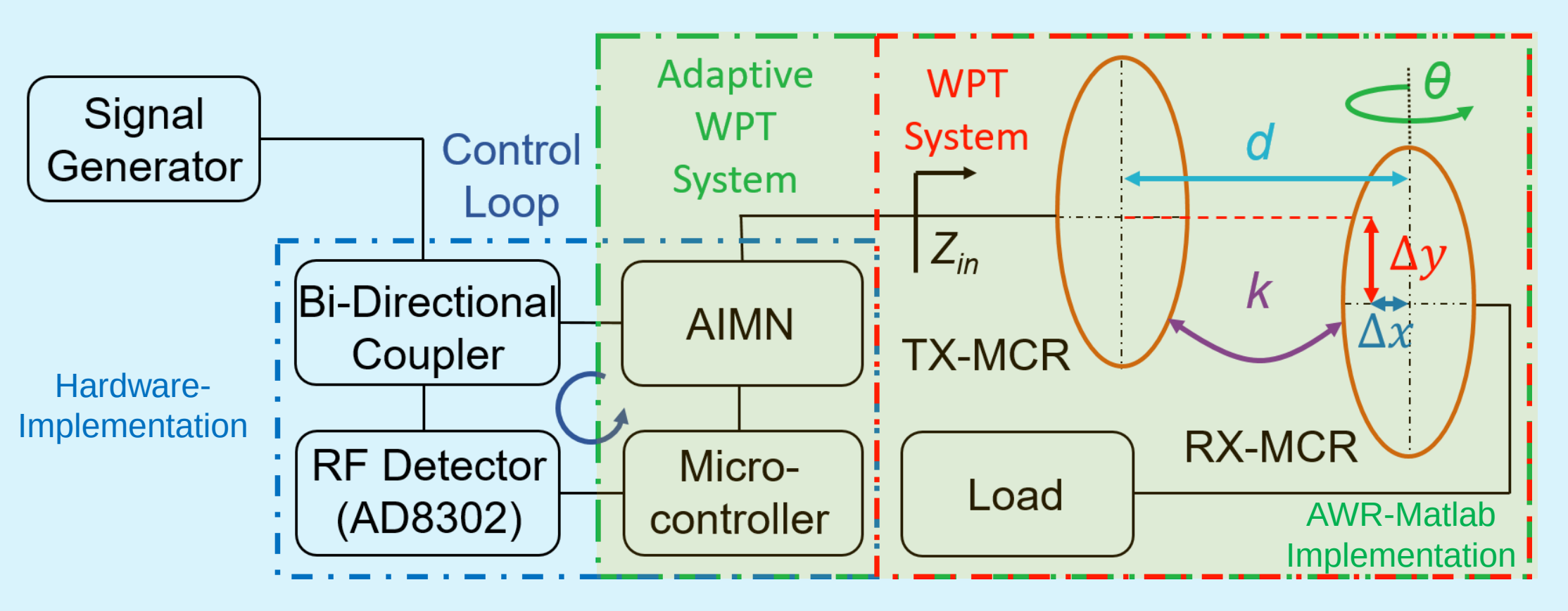
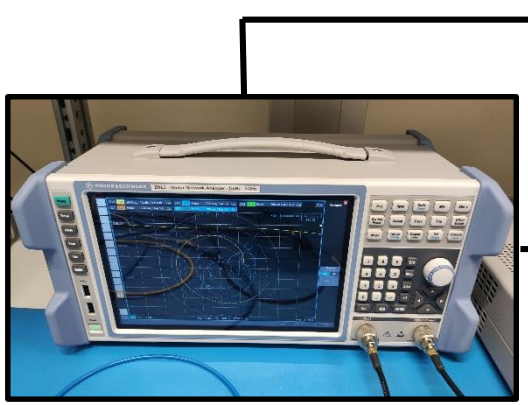
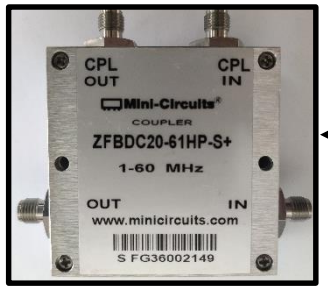
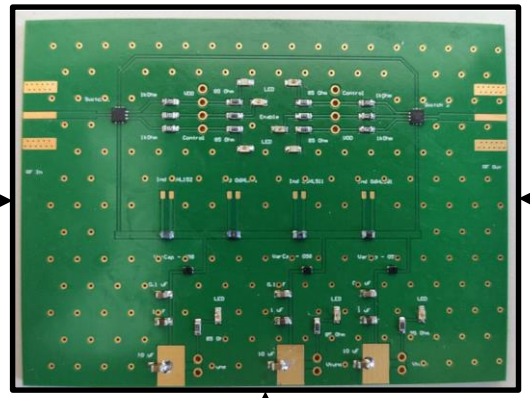


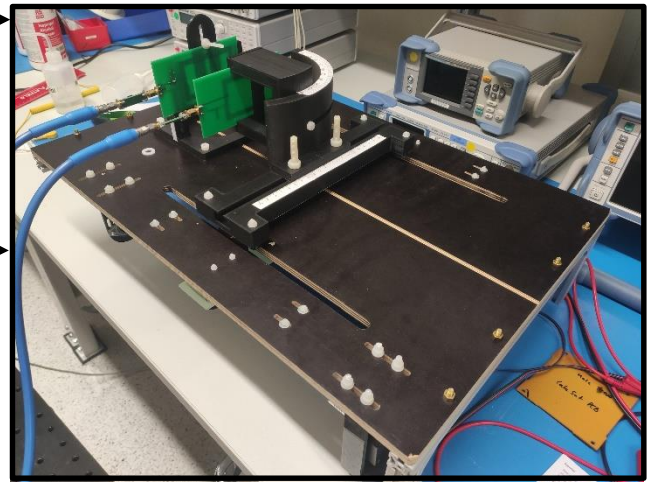
Outlook

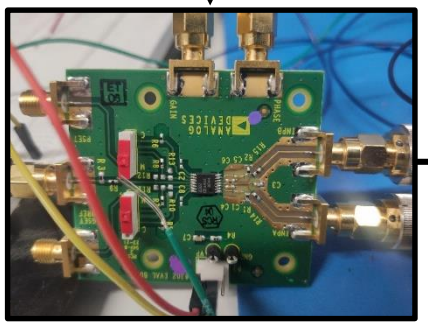
- Hardware implementation of the prototype

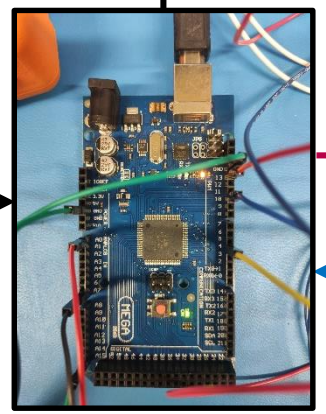


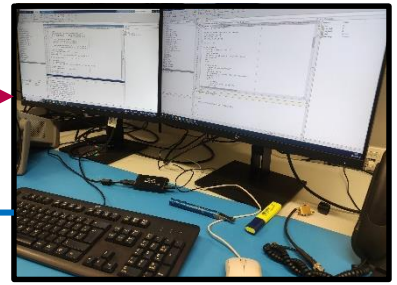












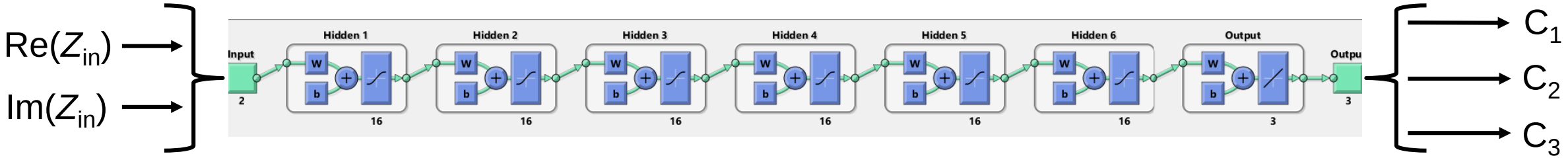
Thanks for your attention!

Virtual adaptive WPT environment

- Matlab controls AWR to implement a virtual environment of the adaptive WPT system:
  - Coil measurements $\rightarrow Z_{in}$ loaded in Matlab and passed to AWR
  - EM simulated AMN implemented in AWR
  - Neural network outputs performed in matlab
  - Impedance detection and AMN control performed in Matlab
  - S_{11} and S_{21} of the adaptive WPT system determined in AWR
  - Switching between bypass and AMN performed by Matlab

Artificial Neural Network

- Neural Network with backpropagation using Matlab's Toolbox



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