Simultaneous Wireless Power Transfer with Near Field Communication

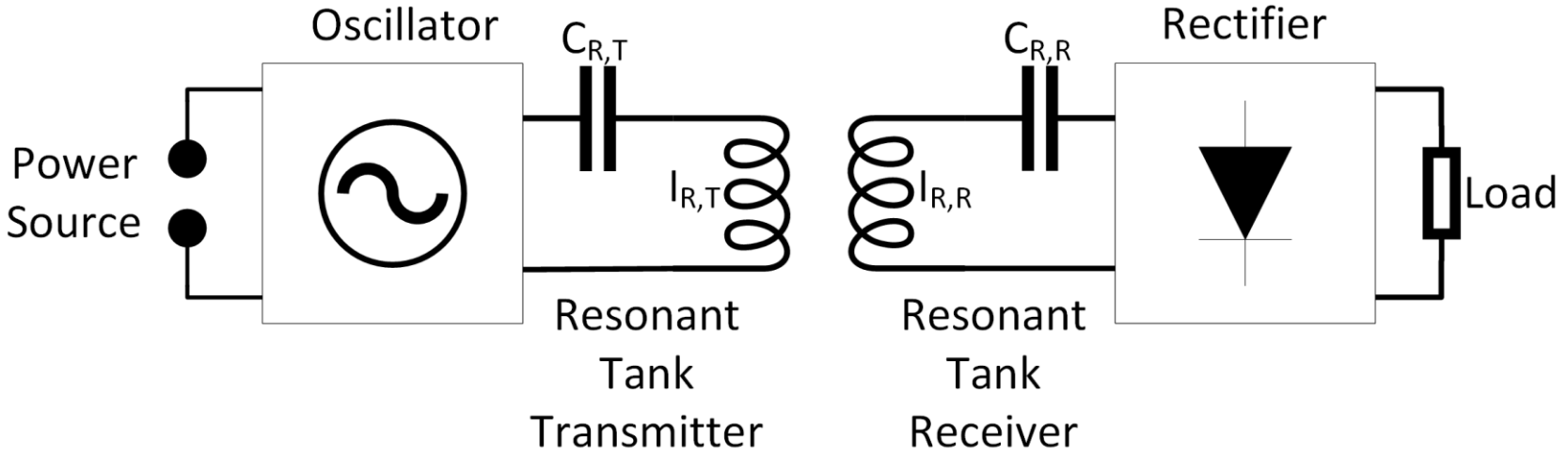
Christian Merz

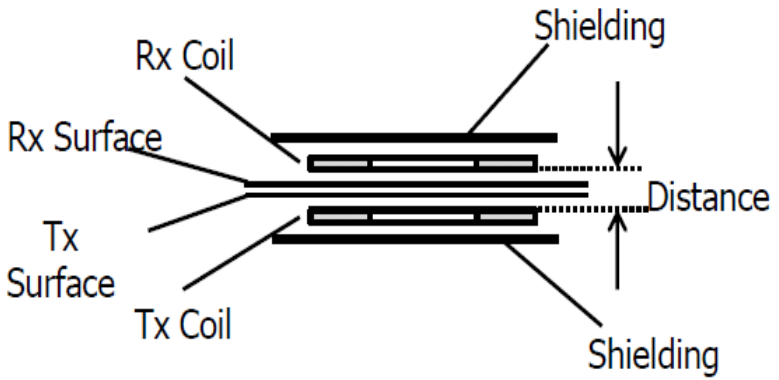
Digital Days 2021

Agenda

- Introduction into WPT/NFC
- NFC Basics
- WE WPT/NFC products and paperwork
- Simultaneous WPT/NFC System Setup
- Steps to realize simultaneous operation
- Results
- Future work

Introduction: How does Wireless Power Transfer work?





- Frequency range: 100 kHz – 200 kHz
- **Powers up to some kW**
- **Low in-band communication with data rates up to some hundred bytes**

- Magnetic field concentrated in small volume between Tx / Rx
- Power transfers via inductive coupling at short distances (mm range)
- Transmitter (Tx) and Receiver (Rx) Coils are inductively coupled

Introduction: How does Near Field Communication work?

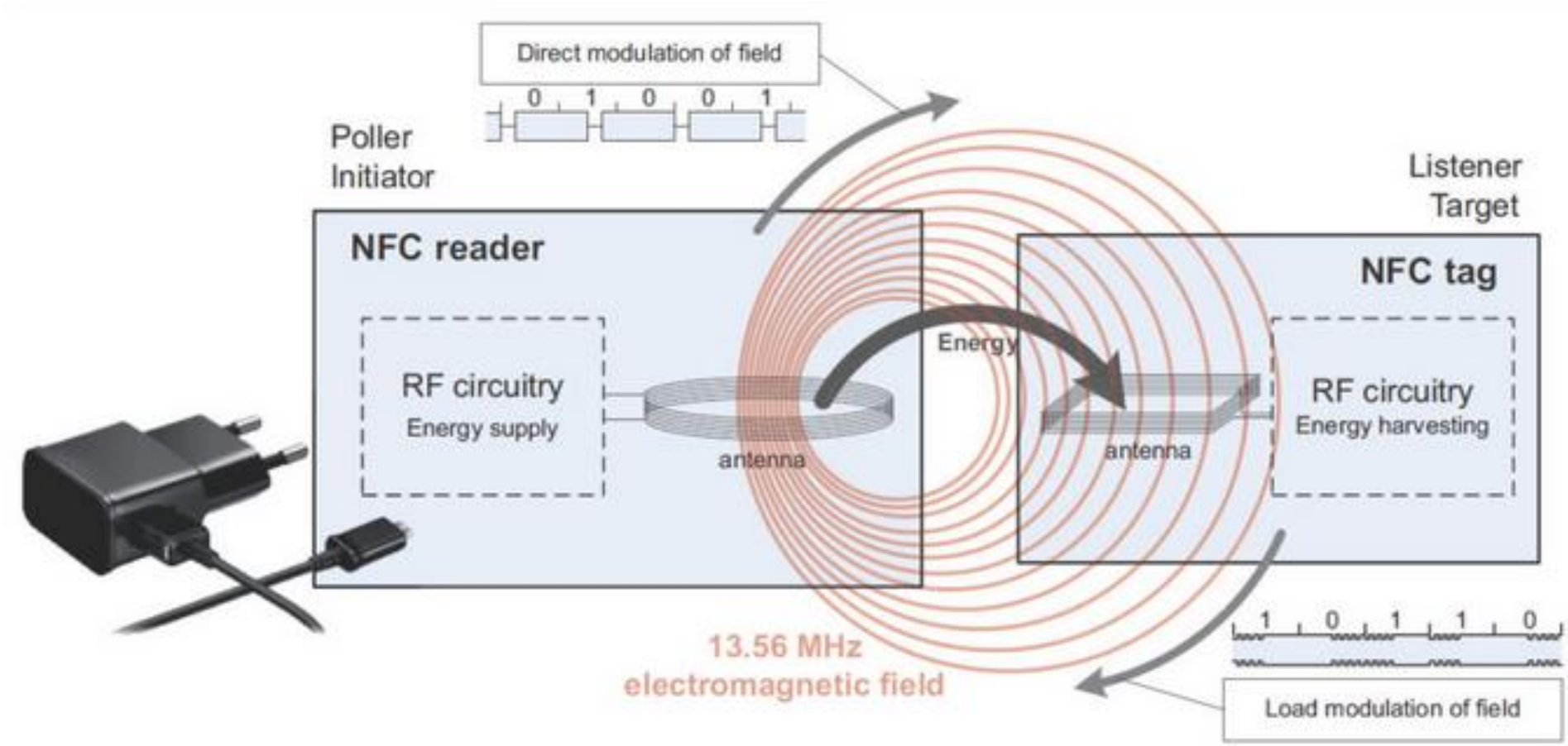


Image: st.com, TN1216, ST25 NFC Guide

Introduction: How does Near Field Communication work?

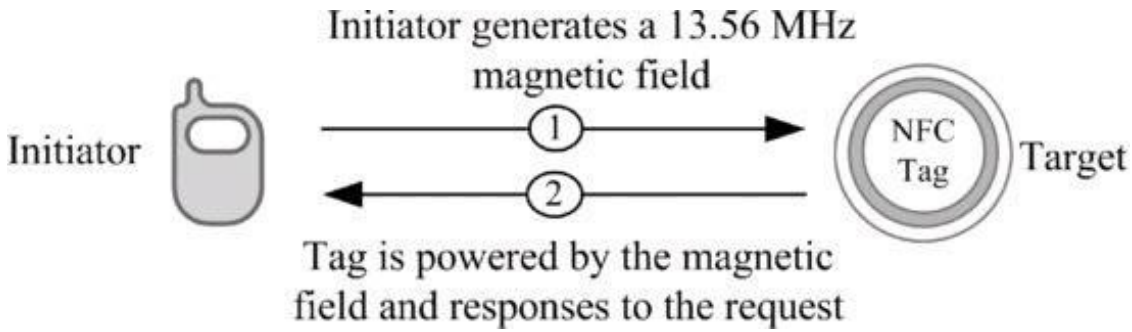
- NFC (Near Field Communication) is a **short-range** (up to some cm), **standardized, high frequency wireless communication technology**, based on RFID
- **13.56 MHz** frequency band
- Transfer **powers up to 1 W**
- Data rates from **106 kbit/s – 424 kbit/s (848 kbit/s)**
- Different operating modes (**peer-to-peer, reader/writer mode, card emulation mode**)
- **Active** or **passive communication scheme** (active: the initiator and the target generate their own field, passive: target used the generated field generated by the initiator)
- Different standards with different types

Near Field Communication operating modes

- **Reader/Writer Mode:**

The reader/writer mode is about the communication of an NFC enabled initiator (e. g. a mobile phone) with an NFC tag for the purpose of either reading or writing data from or to those tags. It internally defines two different modes: reader mode and writer mode.

- **Reader mode: initiator reads data from the target**
- **Writer mode: initiator writes data to the target**



Source: E. Desai und M. G. Shajan, A Review on the Operating Modes of Near Field Communication, International Journal of Engineering and Advanced Technology (IJEAT), 2012.

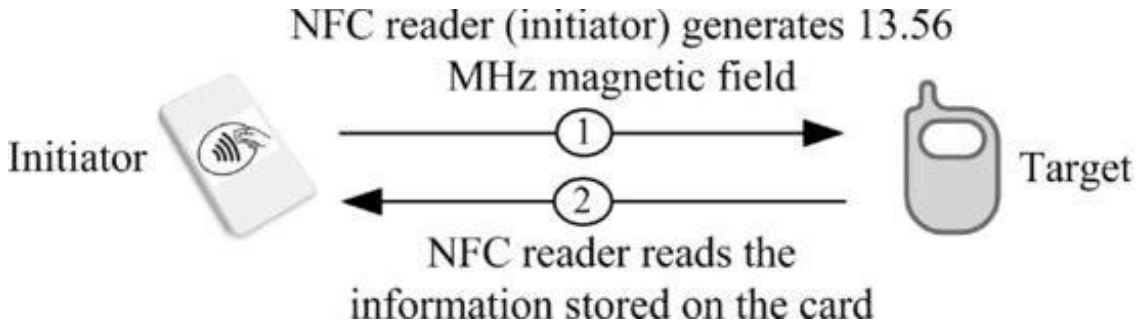
Near Field Communication operating modes

- **Peer-to-Peer Mode:**

Peer-to-peer mode enables **two NFC enabled mobile devices to exchange information** such as text messages or any other kind of data.

- **Card Emulation Mode:**

Card emulation mode provides the opportunity for an NFC enabled mobile device to **function as a contactless smart card**.

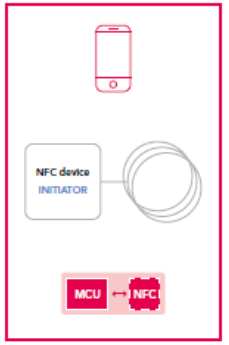


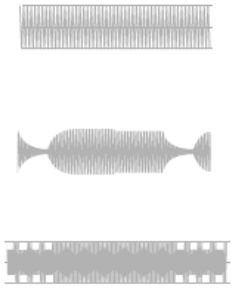
Source: E. Desai und M. G. Shajan, A Review on the Operating Modes of Near Field Communication, International Journal of Engineering and Advanced Technology (IJEAT), 2012.

Near Field Communication schemes

PASSIVE communication scheme

Read/Write, Passive Peer-to-Peer, and Card Emulation Modes





1 The initiator produces a 13.56 MHz carrier field

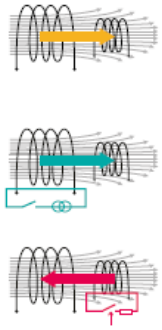
The field enables data exchanges and sends energy to the target.

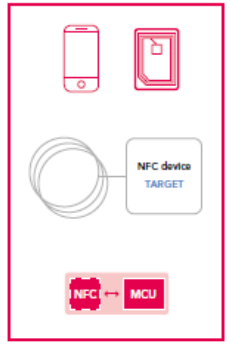
2 The initiator sends commands

The initiator transfers data by directly modulating the field.

3 The target responds

The target transfers data by load-modulating the field.

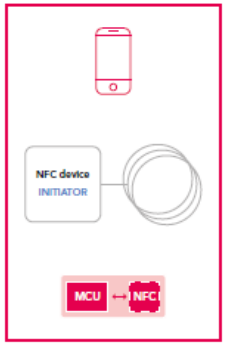


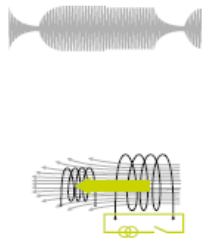


With passive communication, the target uses the RF field generated by the initiator, but with active communication, each side generates its own field. Which method you use depends on the operating mode.

ACTIVE communication scheme

Active Peer-to-Peer Mode



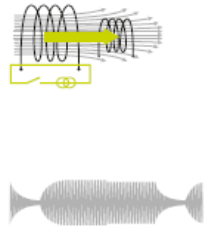


1 The initiator sends commands

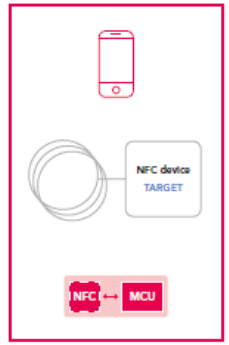
The initiator generates a 13.56 MHz carrier field, uses Amplitude Shift Key (ASK) modulation to send commands, then cuts the field.

2 The target responds

Once the initiator cuts its field, the target generates its own and uses ASK modulation to send responses.



To avoid collisions, only the sending device emits an electromagnetic field. The send/receive roles are reversed as needed to support the transaction.



Source: NXP Corporation, NFC Everywhere, Presentation, 2016

Near Field Communication applications

Source: NXP Corporation, NFC Essentials, Presentation Mobile Knowledge, 2015

Near Field Communication standards

ISO/IEC 14443A Type 1 is used by WE

	Type 1 ISO/IEC 14443A	Type 2 ISO/IEC 14443A	Type 3 JIS X 6319-4 (Felica)	Type 4 ISO/IEC 14443A/B	Type 5 ISO/IEC 15693 (18000-3)
Supported standard carrier frequency	13.56 MHz ±7 kHz	13.56 MHz ±7 kHz	13.56 MHz ±7 kHz	13.56 MHz ±7 kHz	13.56 MHz ±7 kHz
Data rate	106 kbit/s	106 kbit/s	212/424 kbit/s	106/212/ 424 kbit/s	26.48 kbit/s
Modulation (reader to tag)	ASK 100 %	ASK 100 %	ASK 10 %	Standard A + ASK 10 %	10 % or 100 % ASK
Data coding (reader to tag)	modified Miller	modified Miller	Manchester MSB first	NRZ-L (Std B)	Pulse position mod. 1 out of 256/1 out of 4
Modulation (tag to reader)	Load modulation sub-carrier (±848 kHz)	ASK 10 %	Load modulation with no sub-carrier	Standard A + Load mod. (BPSK) sub carrier (Std B)	Load modulation
Data coding (tag to reader)	Manchester	NRZ-L	Manchester	NRZ-L	Manchester
Anti-collision	No	Yes	Yes	Yes	Yes

NFC technology is based on a series of standards such as

ISO/IEC 14443
ISO/IEC 15693
ISO/IEC 18092
ECMA-340
ECMA-352

etc.

WPT/NFC Combination

WÜRTH ELEKTRONIK

WPT

Low in-band data rates of some hundred bytes

High transfer powers of some kW

NFC

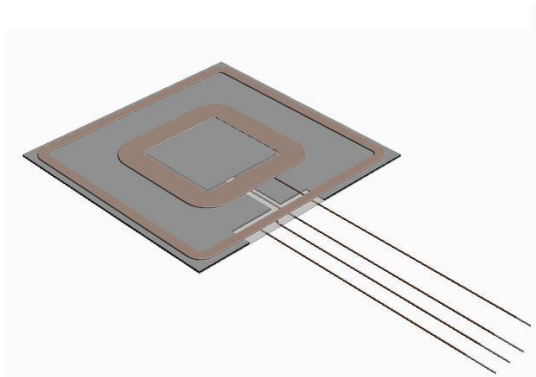
Low transfer powers up to 1 W

high data rates up to 848 kbit/s

WPT/NFC combination

WPT/NFC Combination Products

WE part number	WPT		NFC	
	L_1 [µH]	Q_1	L_2 [µH]	Q_2
760308103305	8.8	30	1.4	47
760308102306	8	19	1.4	47
760308103307	7.8	19	1.6	47
760308101312	24	125	0.7	30
760308101150	6.3	100	1.2	80



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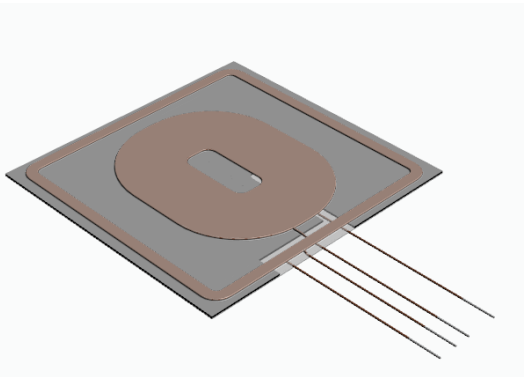

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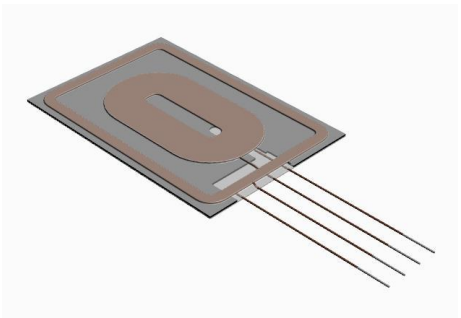

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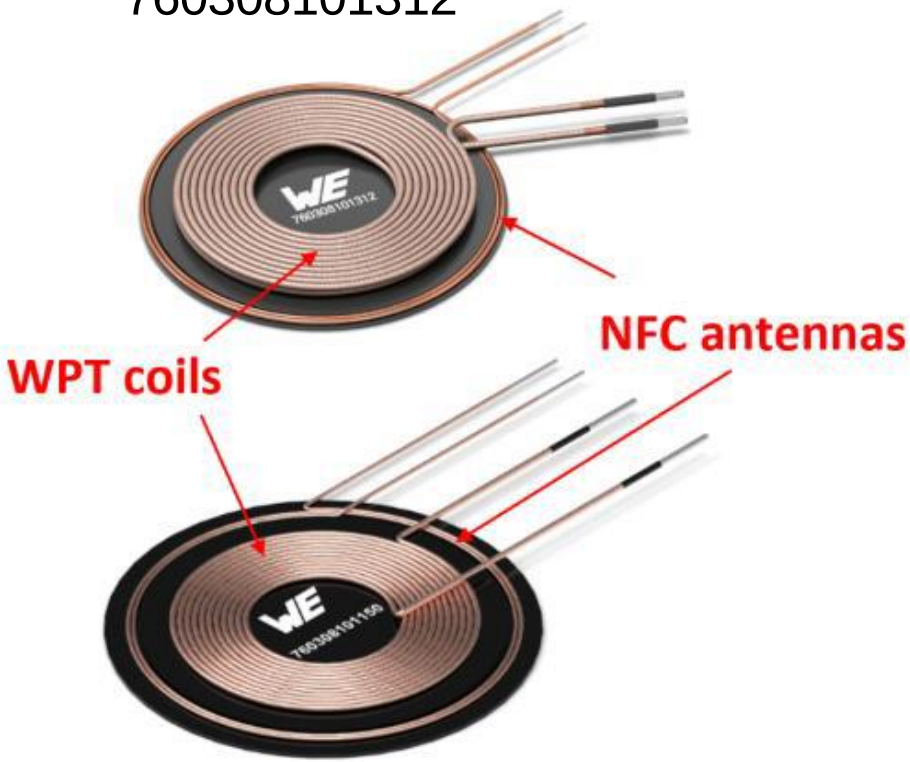

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WPT/NFC Combination Paperwork

3 Papers and 1 Appnote about WPT/NFC by now

Design and Optimization of a Combined Wireless Power Transfer and Near Field Communication System,
Embedded World Conference 2020

Impedance Matching for Near Field Communication Applications,
Würth Elektronik Application Note 84, 2020.

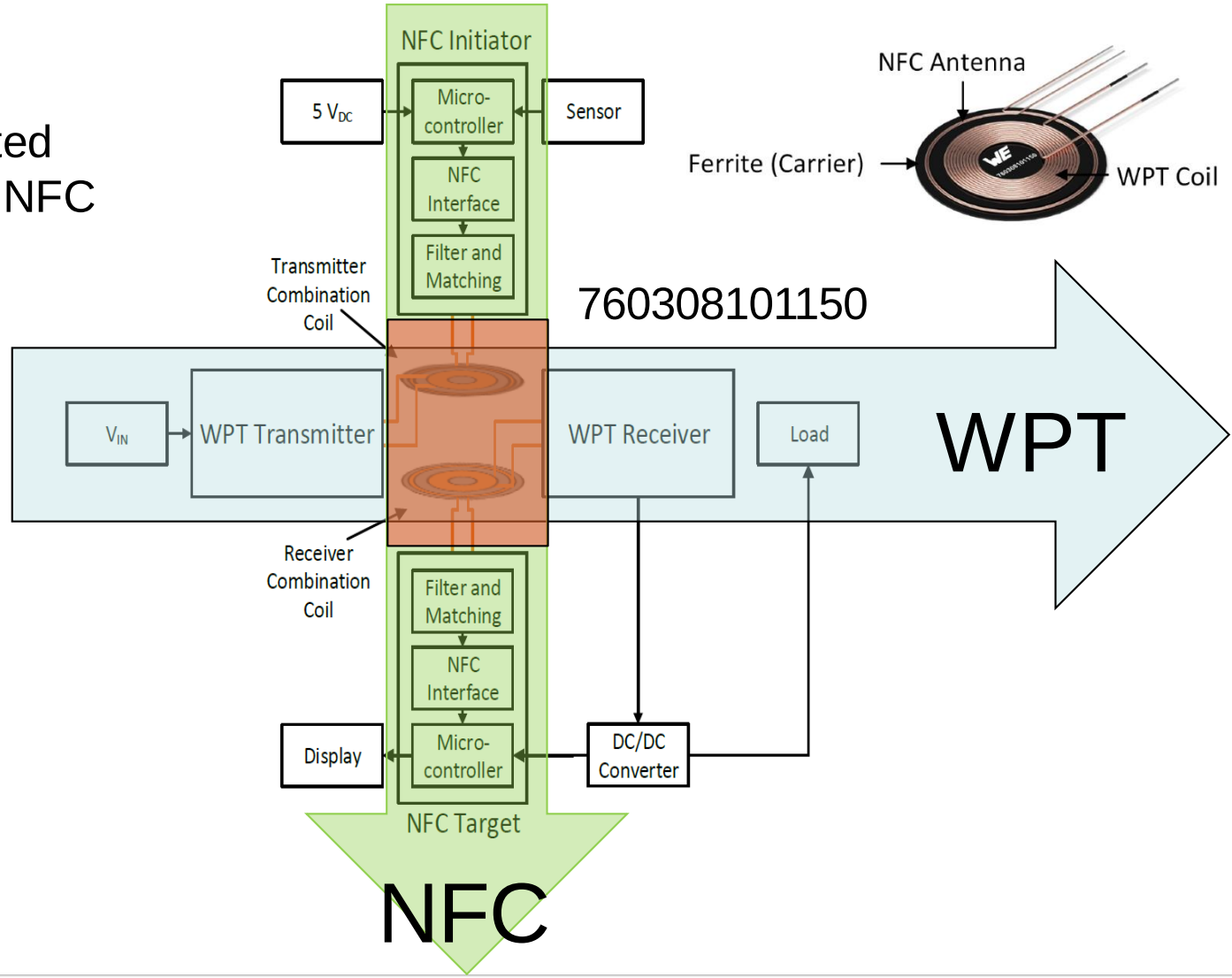
Circuit and Antenna Design of a Simultaneous Wireless Power Transfer and Near Field Communication System,
Embedded World Conference 2021

Design and Optimization of Simultaneous Wireless Power Transfer and Near Field Communication Systems,
PCIM Conference 2021

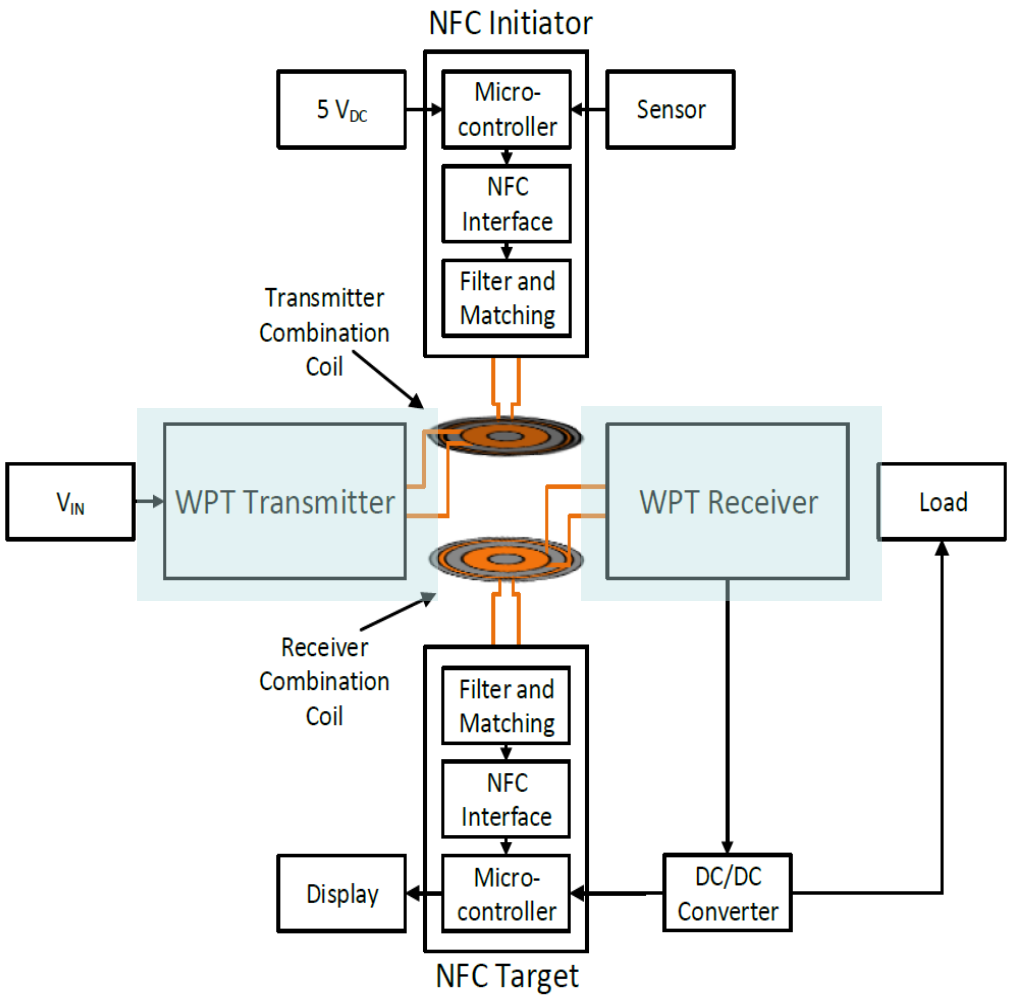
WPT/NFC Combination System Setup

State of the art WPT/NFC systems use „slotted NFC“, where the WPT is switched off during NFC is active

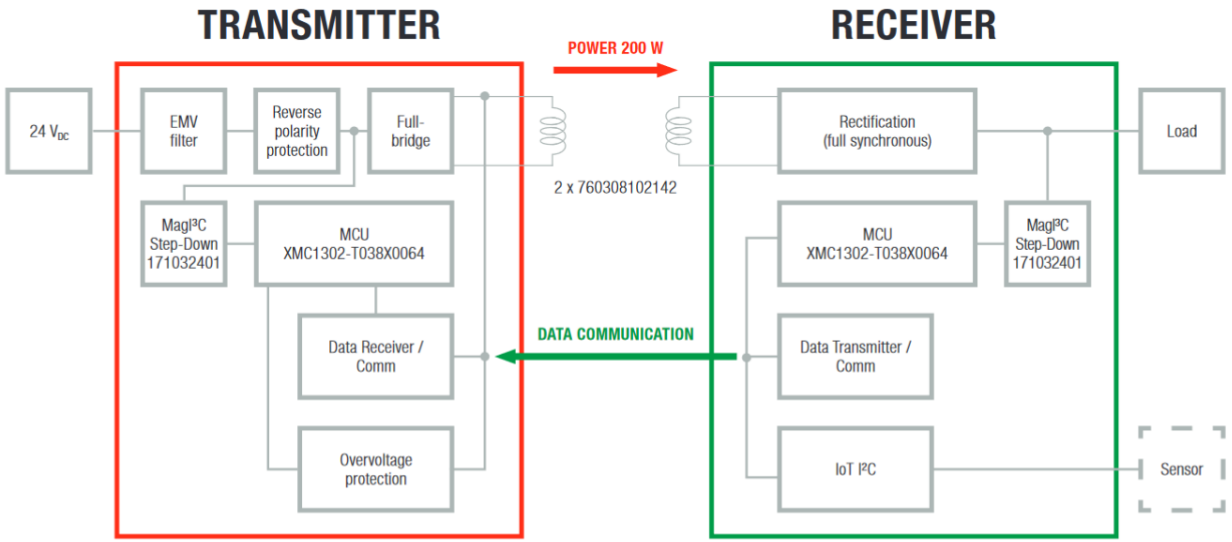
At **simultaneous** WPT/NFC systems, the WPT and NFC **operate at the same time**

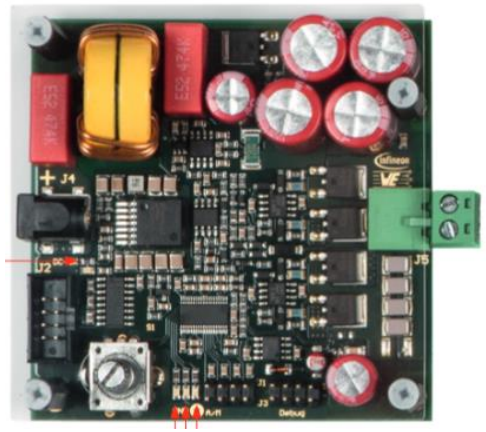


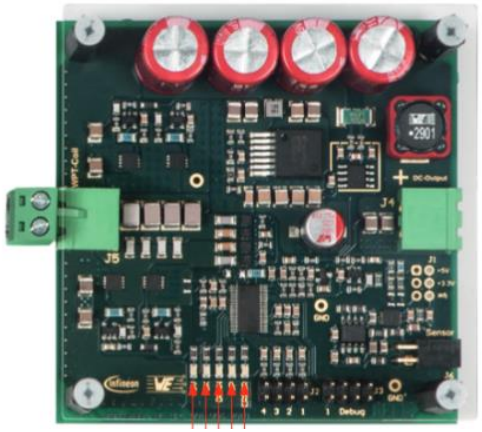
WPT/NFC Combination System Setup



WE 200 WPT Development Kit (760308EMP)







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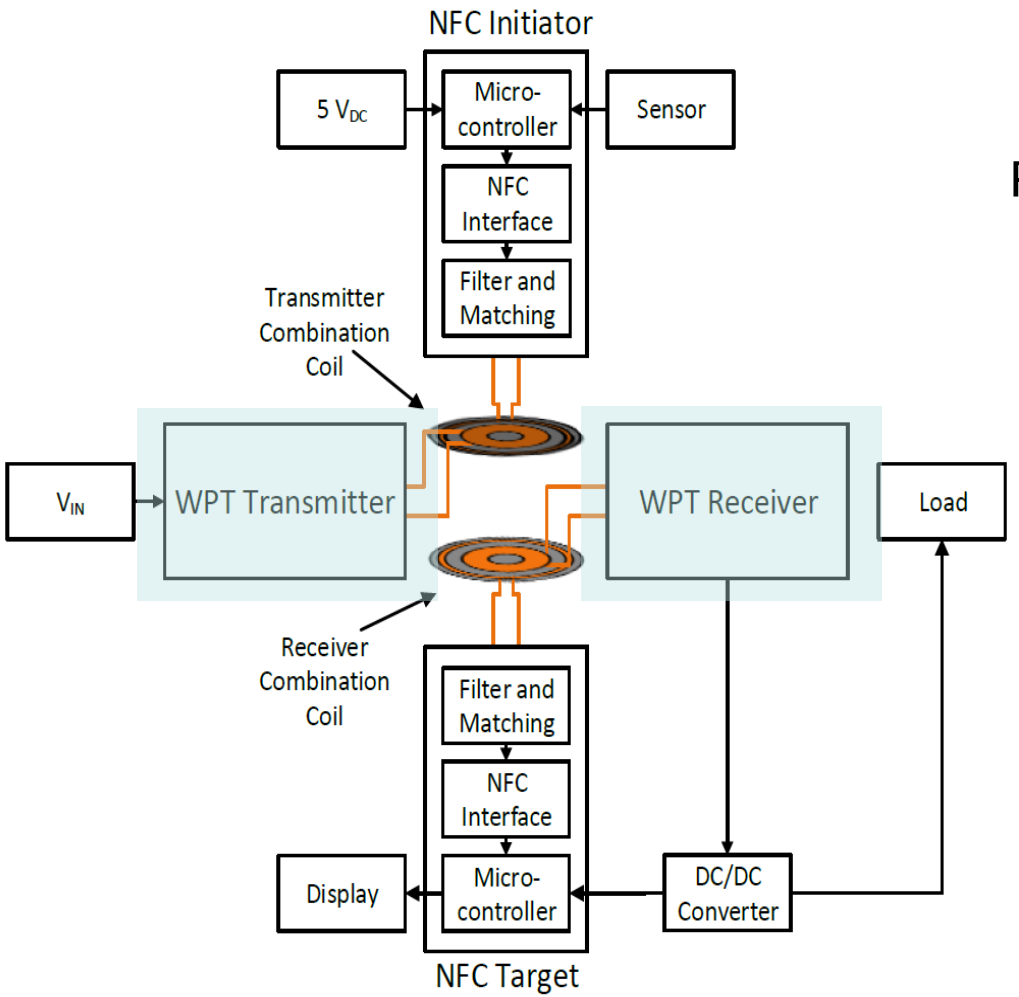
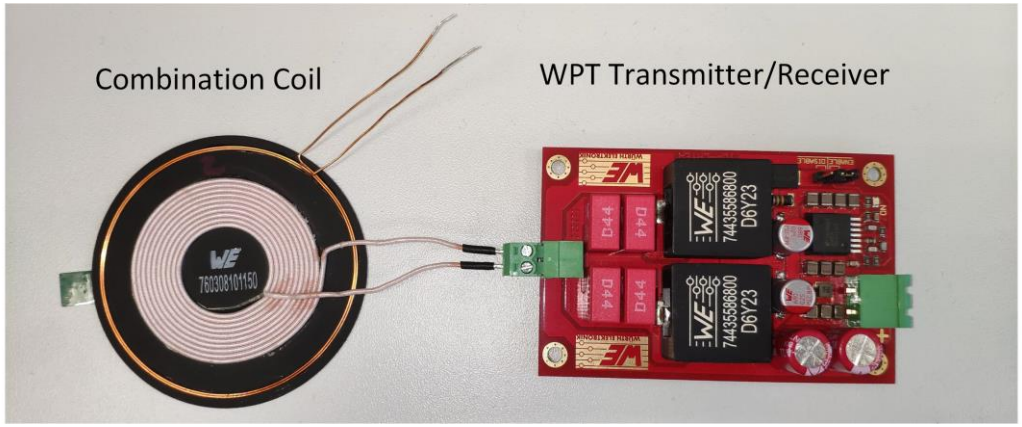
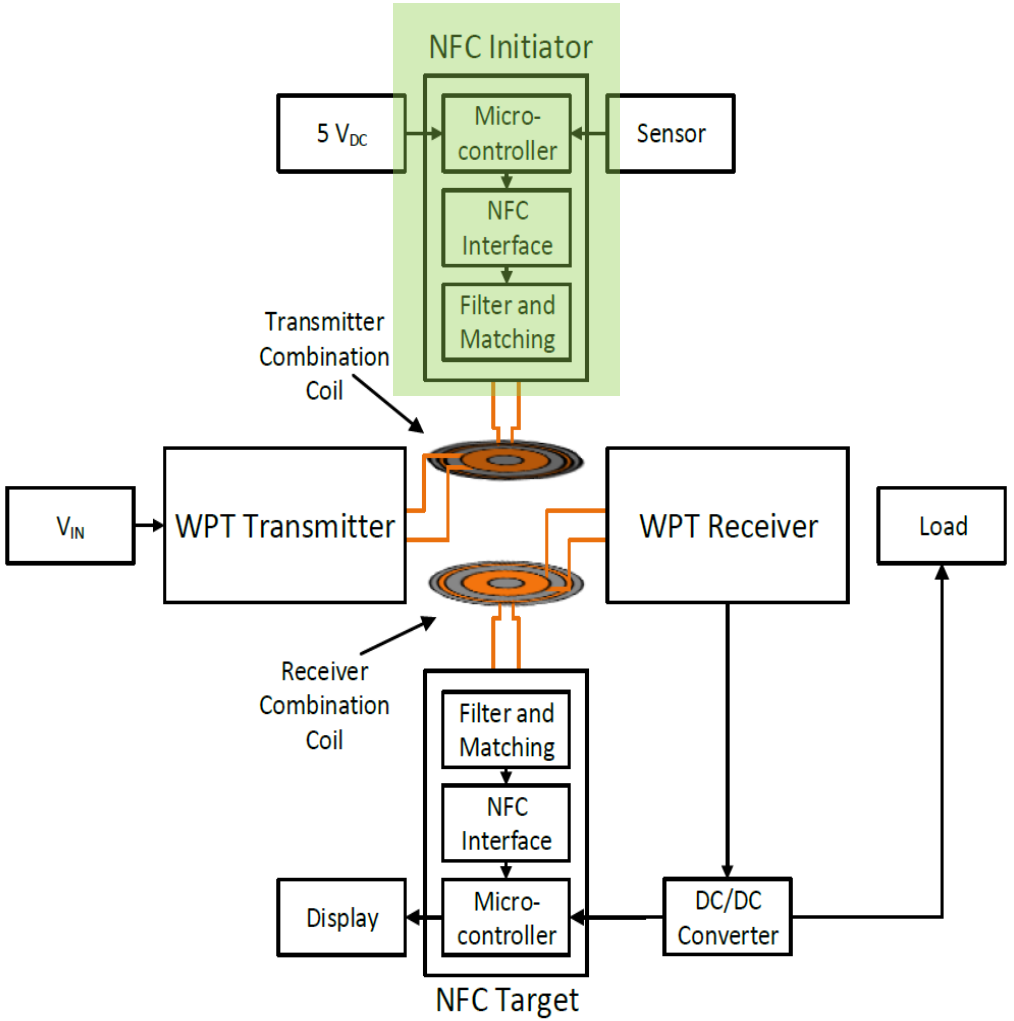


Royer converter on the transmitter and receiver side

For more information see WE Appnote 32



WPT/NFC Combination System Setup



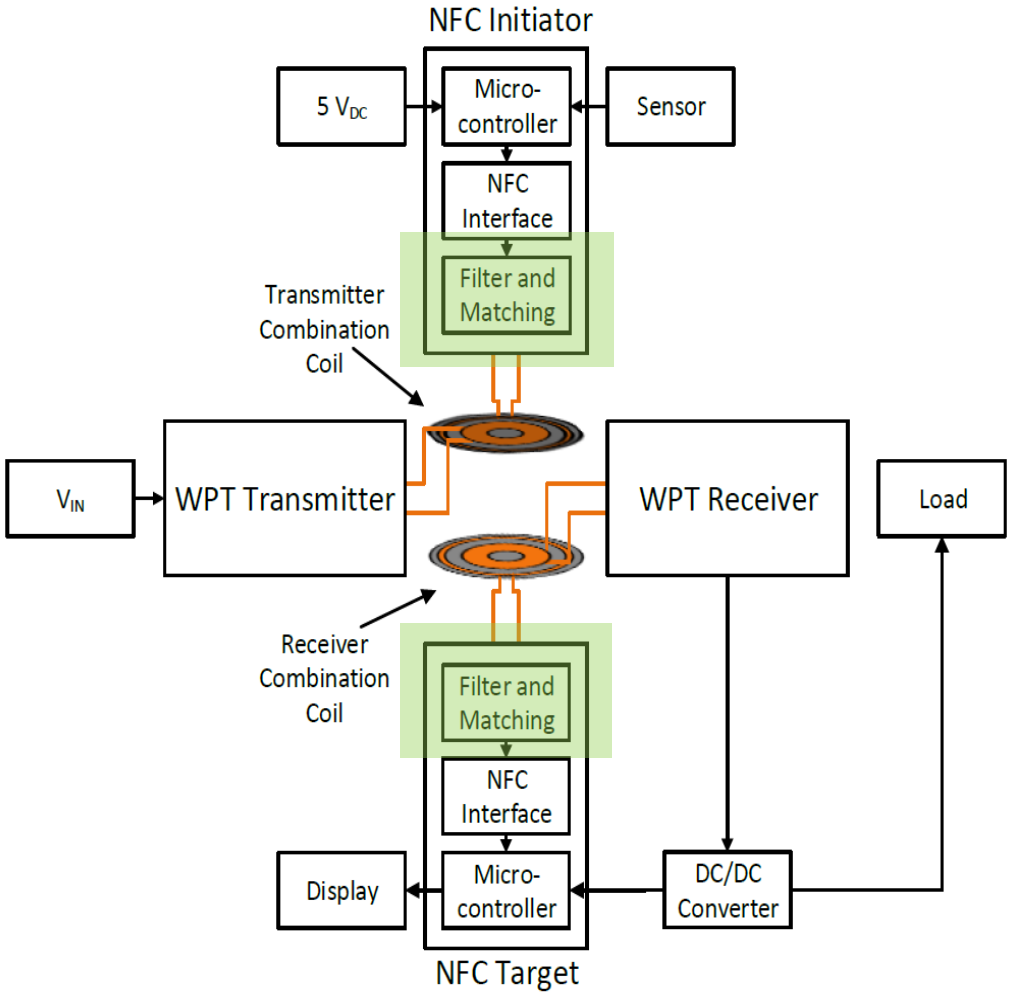
NFC Initiator is based on an Arduino Platform from Adafruit

Microcontroller Board: Arduino Mega 2560 with the microcontroller ATMega2560 from Atmel

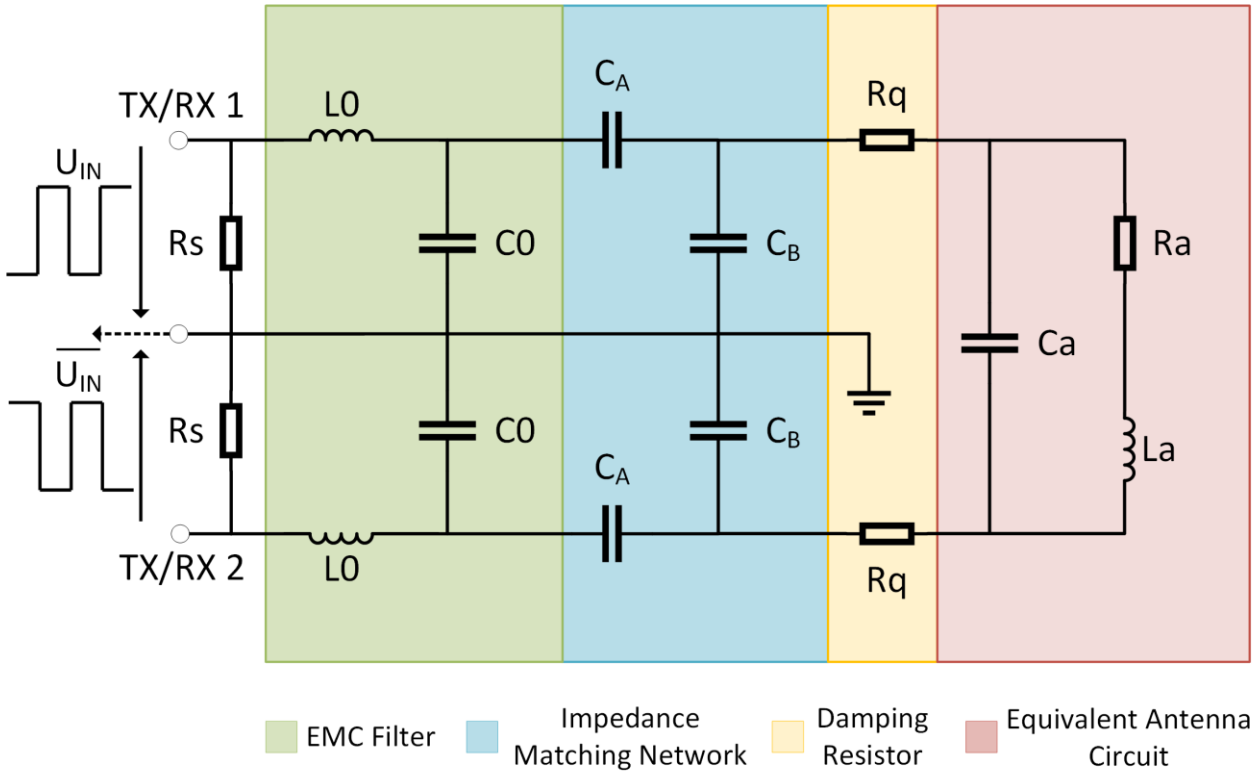
NFC Interface: Adafruit PN532 NFC/RFID shield, based on the PN532 chip set from NXP

Filter and Matching is described in WE Appnote 84

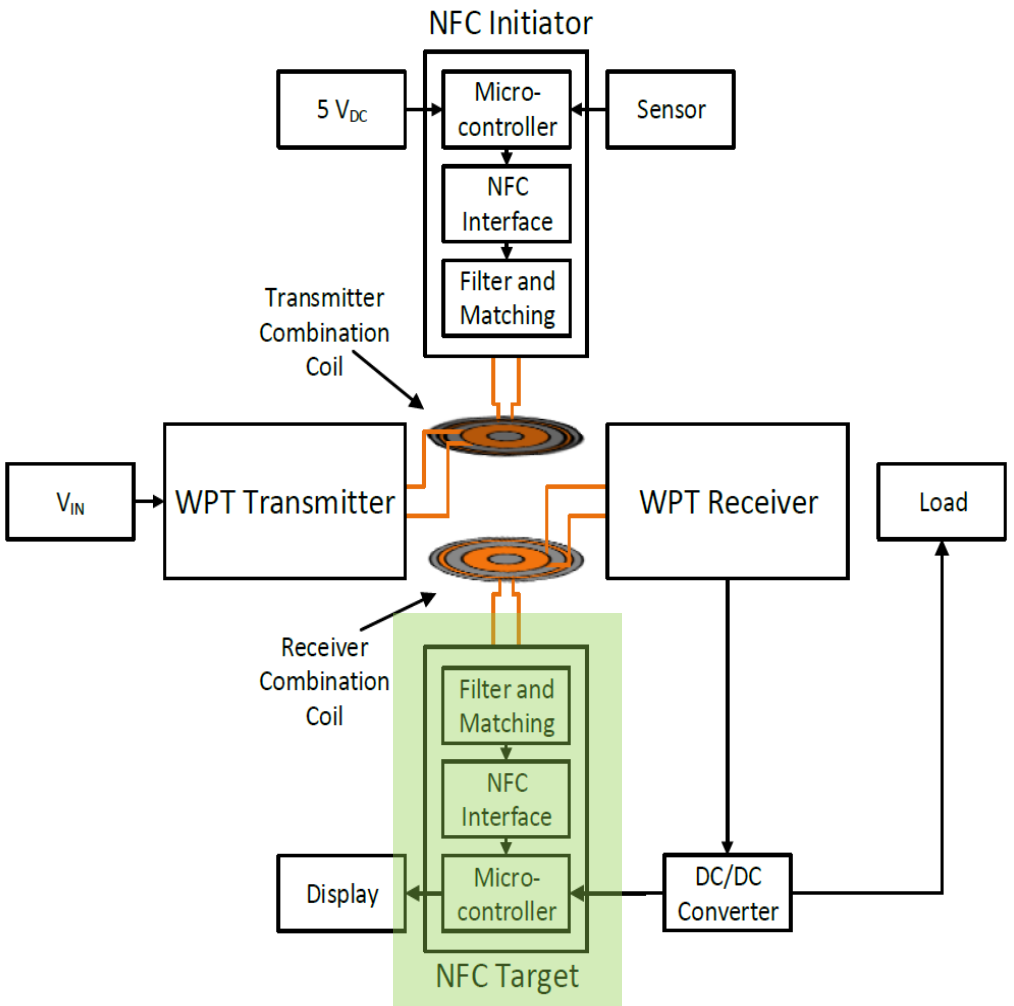
WPT/NFC Combination System Setup



Filter and Matching circuit (WE Appnote 84)



WPT/NFC Combination System Setup

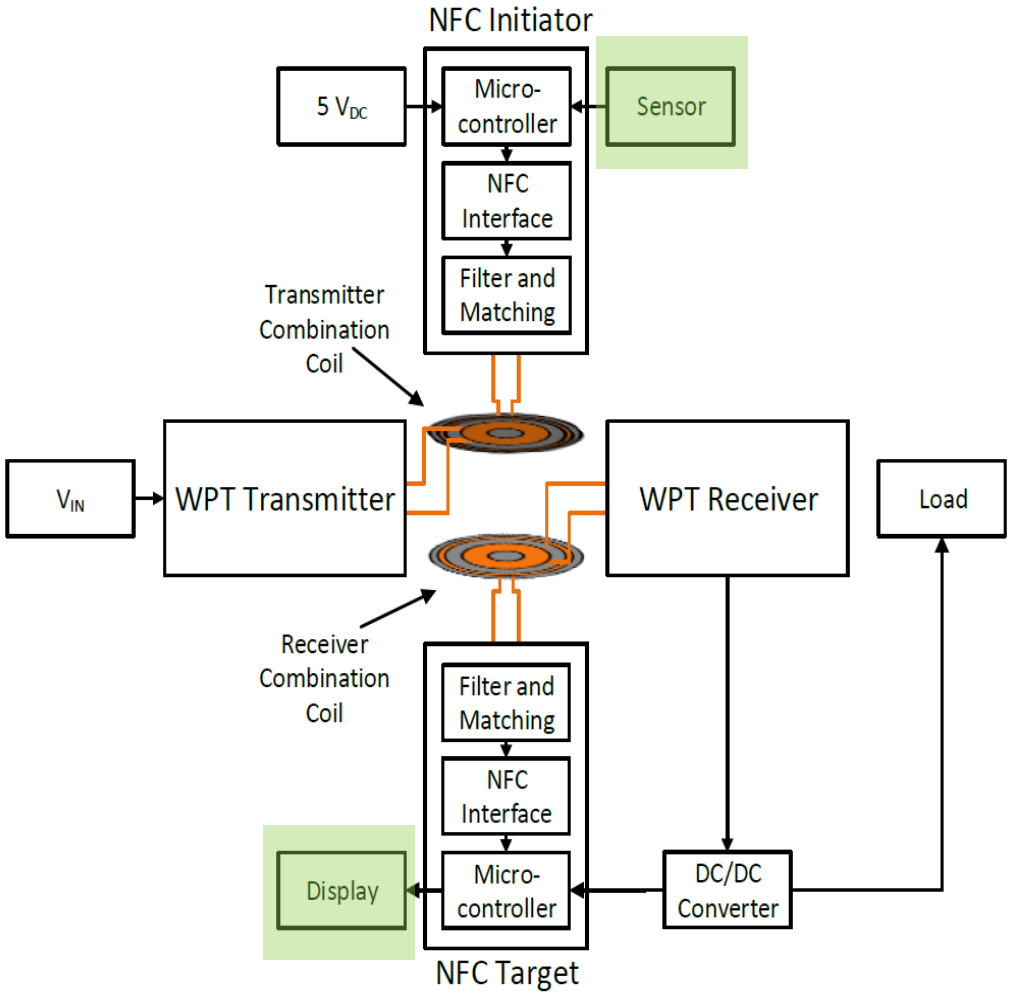


NFC Target is also based on an Arduino Platform from Adafruit

Microcontroller Board: Arduino Uno Rev. 3 with the microcontroller ATmega328P from Atmel

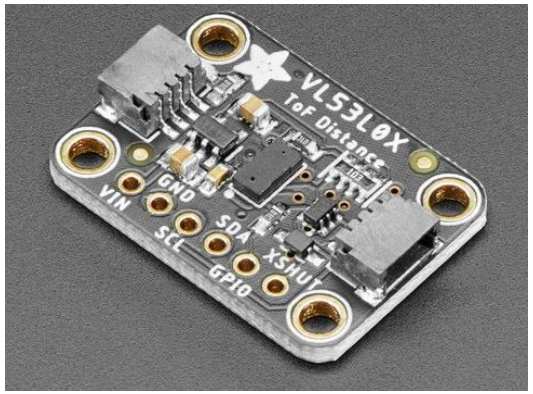
NFC Interface, Filter and Matching is the same like on the initiator side

WPT/NFC Combination System Setup



Sensor: Adafruit VL53L0X time of flight (TOF) distance sensor, uses I2C and measures how long the light has taken to bounce back to the sensor

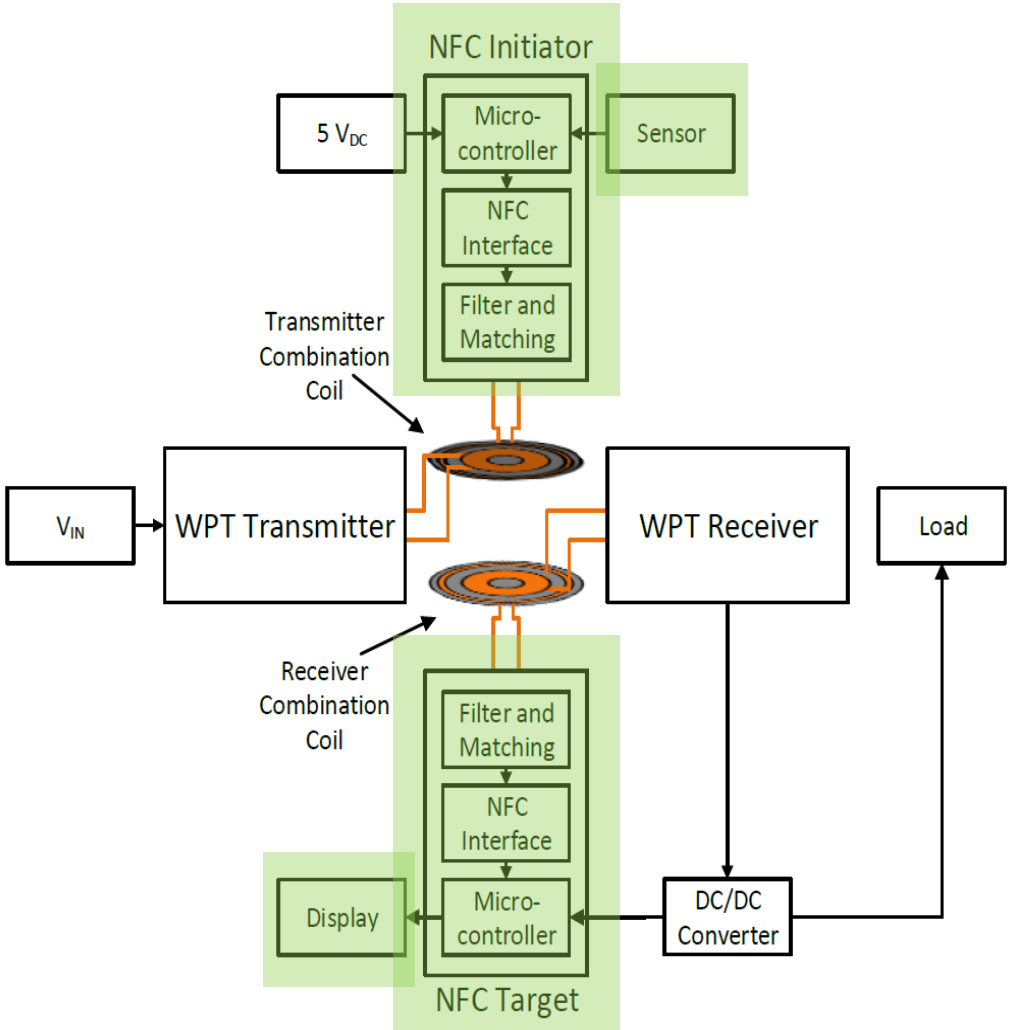
Display: RGB LCD shield kit display from Adafruit, also uses I2C



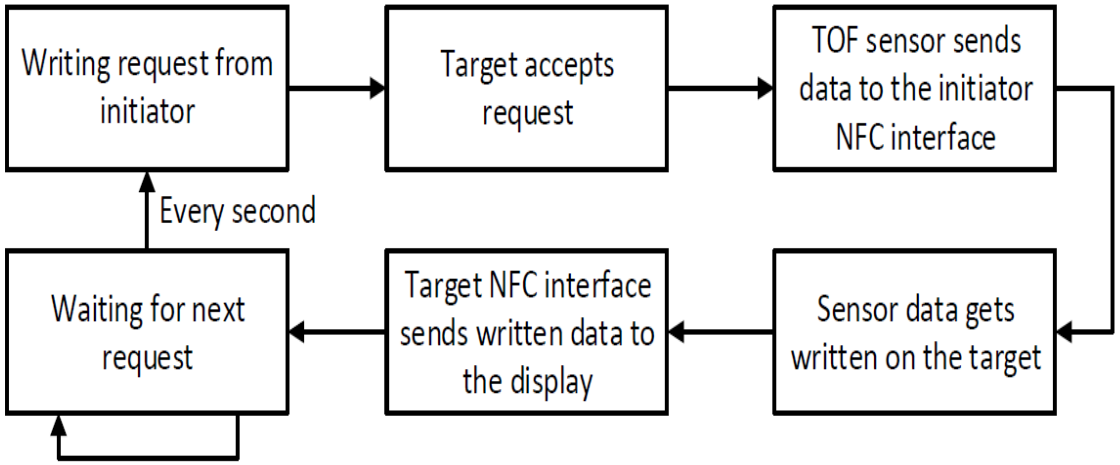
https://learn.adafruit.com/adafruit-vl53l0x-micro-lidar-distance-sensor-breakout

https://learn.adafruit.com/rgb-lcd-shield

WPT/NFC Combination System Setup

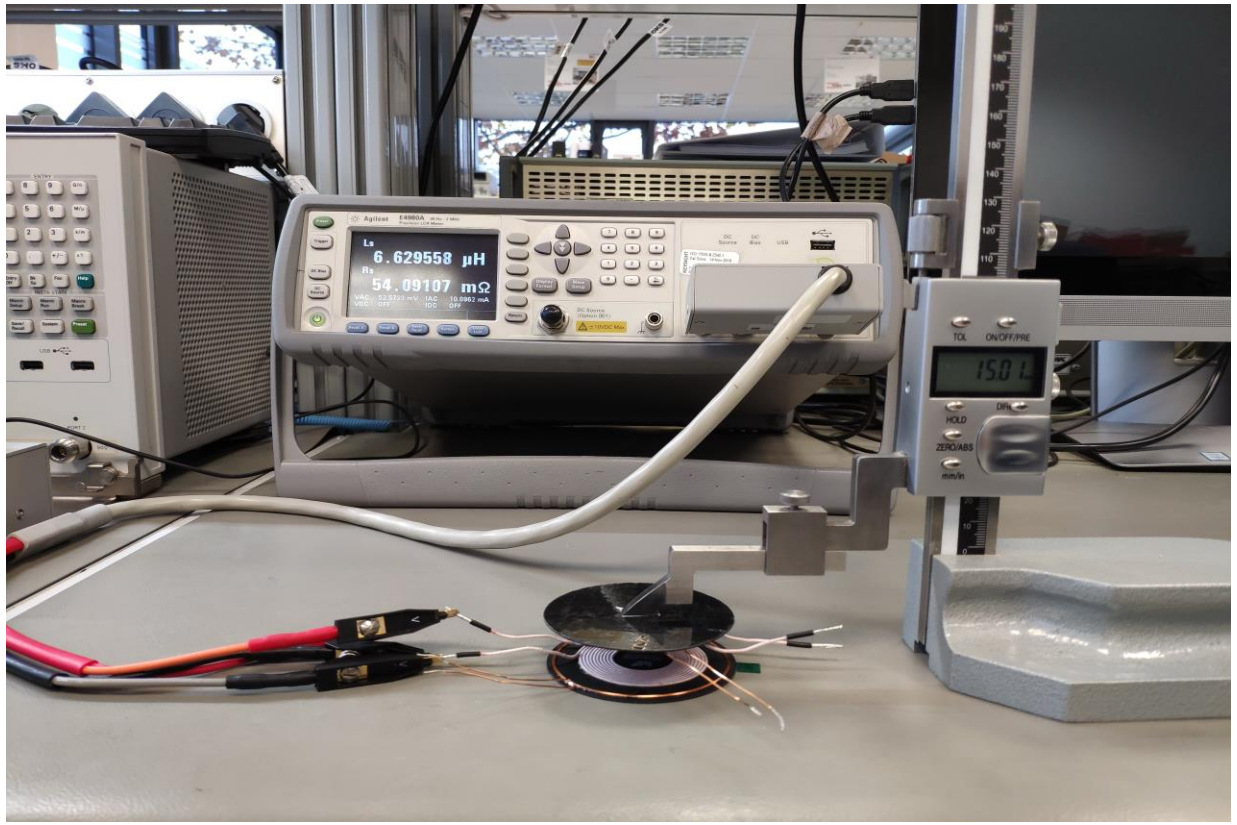


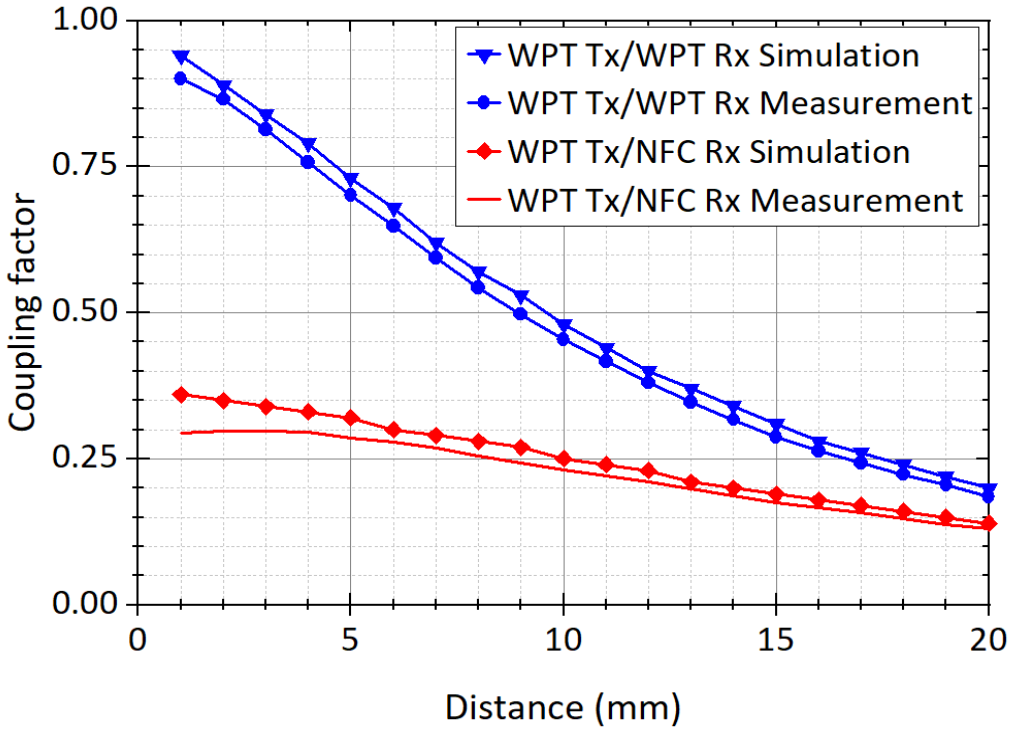
NFC Software Workflow



Steps to realize simultaneous WPT/NFC operation up to 190 W

1. Definition of an operation point or operation range (e. g. 1 cm distance)
2. Measurement of the coupling factor between the WPT coils





Steps to realize simultaneous WPT/NFC operation up to 190 W

3. Operating point determination, so that a sinusoidal signal is achieved for the WPT

$$k = \sqrt{1 - \frac{L_1'}{L_1}}$$

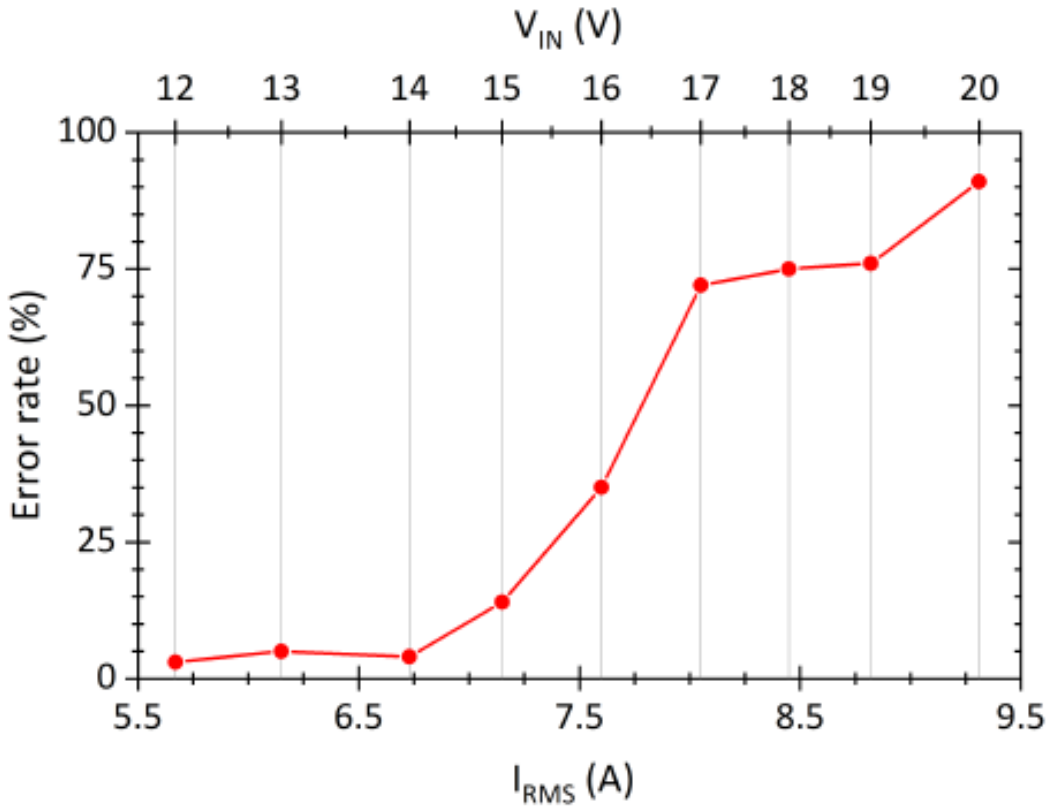
$$R_L = \frac{\pi^2}{8} k \omega_0 L_0$$

RL is the load of the WPT system, L0 is the inductance of the receiver coil,

ω0 is the angular operating frequency and k is the coupling factor between the WPT coils

Steps to realize simultaneous WPT/NFC operation up to 190 W

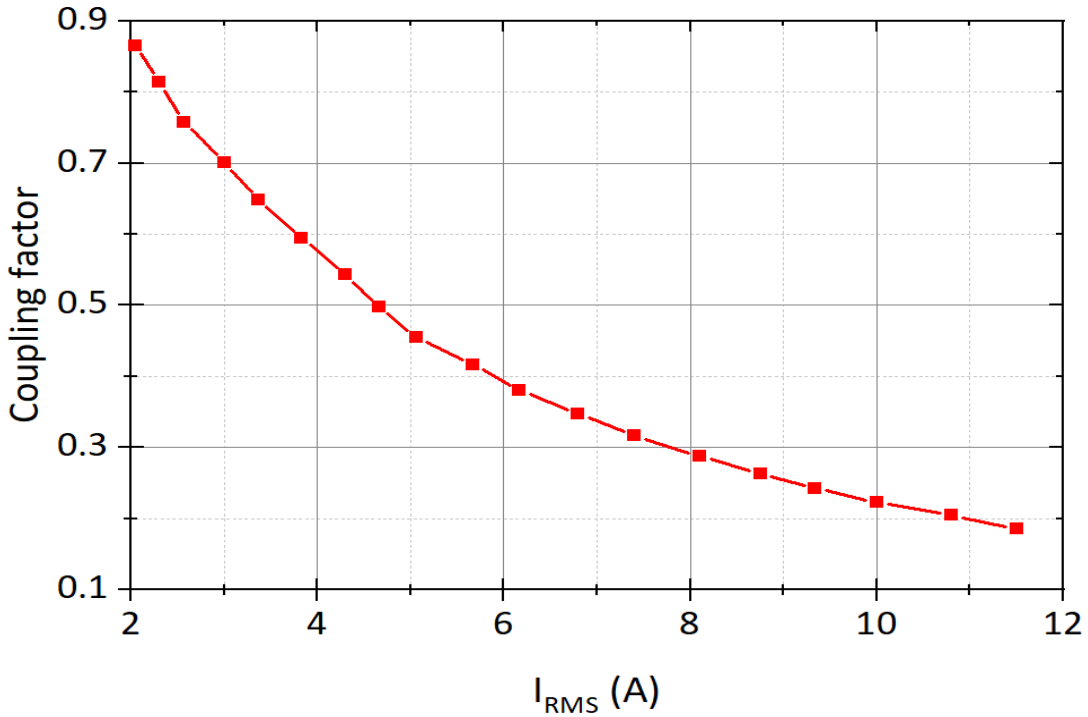
4. Measurement of the highest possible WPT coil current without influence on the NFC frequency band



NFC error rates for different RMS currents in the Tx WPT coil.

Steps to realize simultaneous WPT/NFC operation up to 190 W

5. Approximation for the required coupling factor between the WPT coils and the NFC antennas using cross multiplication based on the inversely proportional behavior



Example:

$$k = \frac{6.7\ A}{10\ A} \cdot 0.42 = 0.28$$

Measured coupling between the WPT coils at the Tx and Rx side in dependence of the Tx RMS current with V_{in} = 12 V.

Steps to realize simultaneous WPT/NFC operation up to 190 W

6. Determination of the necessary WPT coil geometry, to reach a defined inductance and coupling factor, e. g. by simulation with Ansys Maxwell

Example for a high power coil:

around 6 µH, 4 turns, 2.6 mm litz wire

NFC antenna identical to the part 760308101150

Inner diameter 92 mm, outer diameter 113 mm

Ferrite 150*150 mm, 1 mm thickness

Results

WPT type	Used combination coil on Tx and Rx side	DC-to-DC efficiency	Power
200 W Kit	760308101150	72 %	54 W
	High Power Coil	80 %	190 W
Royer converter	760308101150	75 %	160 W
NFC data rate: 106 kbit/s, distance: 1 cm, error rate: < 5 %, Reflection coefficient: -35 dB			

Next Steps

- Increase of the NFC data rate to 424 kbit/s
- Continue research to improve the WPT/NFC system (Higher efficiencies, higher distances, higher power levels etc.)
- New publications and appnotes
- Addon NFC board for the 200 W Development Kit

Questions?

contact: christian.merz@we-online.de