



# DIY MAGNETIC NEAR FIELD PROBE & NANOCRYSTALLINE SHIELDING

Carpov Pascual – Field Application Engineer

EXTERNAL

**WÜRTH ELEKTRONIK** MORE THAN YOU EXPECT

# AGENDA

## Contents

- **DIY Magnetic Near Field Probe (NFP)**
  - Workshop overview.
  - Theory.
  - Tools and materials.
  - Procedure.
- **Testing**
  - Setup and measurements.
  - Reduce the noise with some shielding sheets.
  - PCB Troubleshooting Tips.
- **Nanocrystalline**
  - WE-FNCS.
- **WE Shielding Portfolio**

\* Some presentation images have clickable web links



# DIY MAGNETIC NEAR FIELD PROBE (NFP)



# DIY MAGNETIC NEAR FIELD PROBE

## Workshop Overview

- Everyone can make their own DIY Near Field Probe (NFP).
- Components and tools are provided.
- We have a test setup, where participants can try their DIY NFP if it is working.
- First 5 participants who can finish and properly detect the expected noise waveform will win prizes.

# DIY MAGNETIC NEAR FIELD PROBE

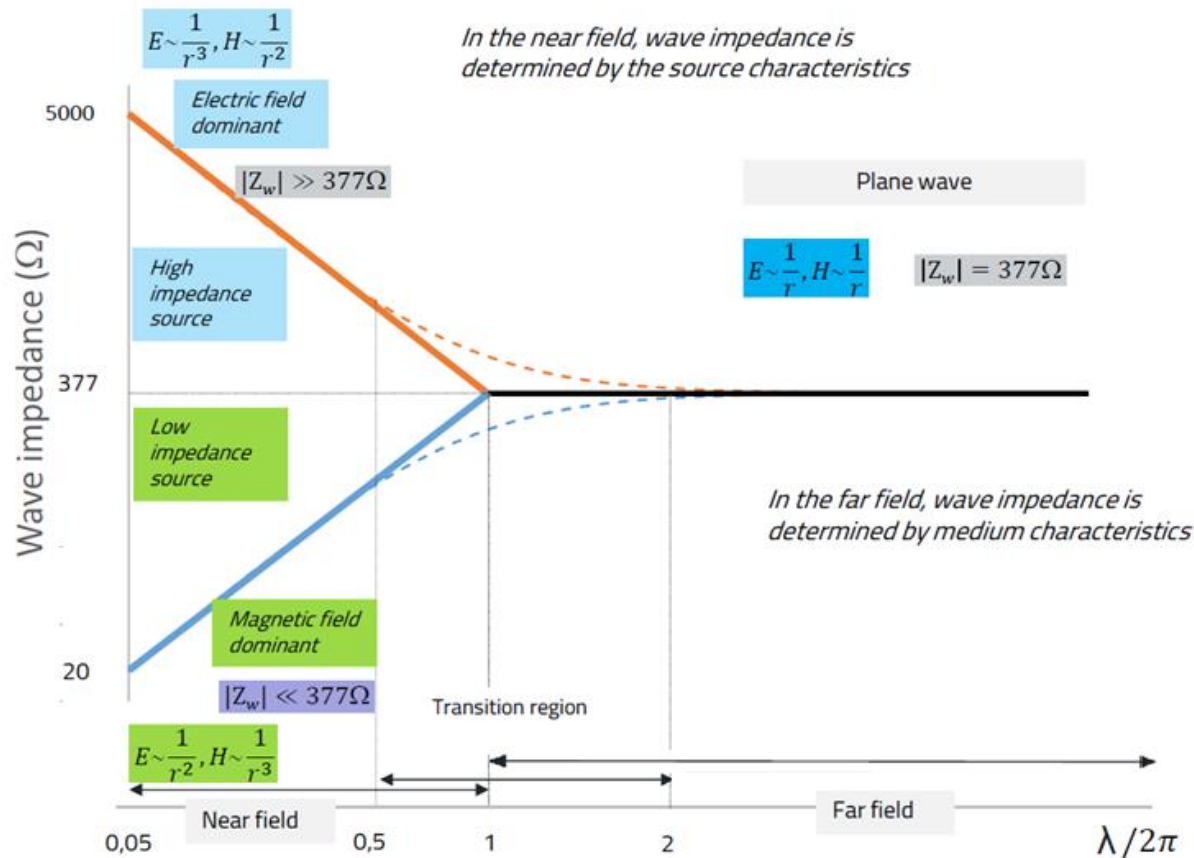
## Theory

- Near Field Probes (NFP) are used to sniff out potential EMI issue on your PCB and circuits.
- The Magnetic Near Field Probe respond primary to magnetic field as opposed to an Electric Near Field Probe, which response to electric field.
- Magnetic NFP responds to changing current which creates the magnetic field. Electric NFP responds to switching voltages which creates electric field.
- The magnetic NFP will be shielded by the outer coaxial cable metal covering to minimize picking up of electric field.
- Magnetic NFP is sensitive to the orientation of how the loop is placed in reference to the plane. It responds to the current in the same plane as the loop.

# DIY MAGNETIC NEAR FIELD PROBE

## Theory

- As the name implies, the Magnetic Near Field Probe works in the near field as opposed to the far field.



$$\text{Wave Impedance} = Z_W = \frac{E}{H}$$

$$\text{Far Field} = \sqrt{(\mu_0/\epsilon_0)} = 377\Omega$$

$\mu_0 \approx 12.566 \times 10^{-7}$  H/m is the magnetic constant, also known as the permeability of free space,  
 $\epsilon_0 \approx 8.854 \times 10^{-12}$  F/m is the electric constant, also known as the permittivity of free space,

### Near Field:

Source Impedance:

$Z_W > 377\Omega$  -> Large voltage changes, small current change  
 -> Pick up by electric near field probe

$Z_W < 377\Omega$  -> Large current changes, small voltage changes  
 -> Pick up by magnetic near field probe

<https://interferencetechnology.com/classical-shielding-theory-vs-near-field-measurements/>

# DIY MAGNETIC NEAR FIELD PROBE

## Materials

- SMA straight plug coaxial cable – [65503503530507](#) or alike
- Heat shrink tube - [71204811](#) to cover exposed conductive areas.
- Optional materials:
  - Cable ferrite – WE-SAFB series like [74270023](#)
  - Heat shrink tube with bigger diameter like [71232011](#)
  - PVC insulating tape



# DIY MAGNETIC NEAR FIELD PROBE

## Tools



# DIY MAGNETIC NEAR FIELD PROBE

## Tools



Solder Iron/Gun

Solder wire

# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Get the SMA cable connector and cut it having **at least 13-15 cm**. Only one side is needed.



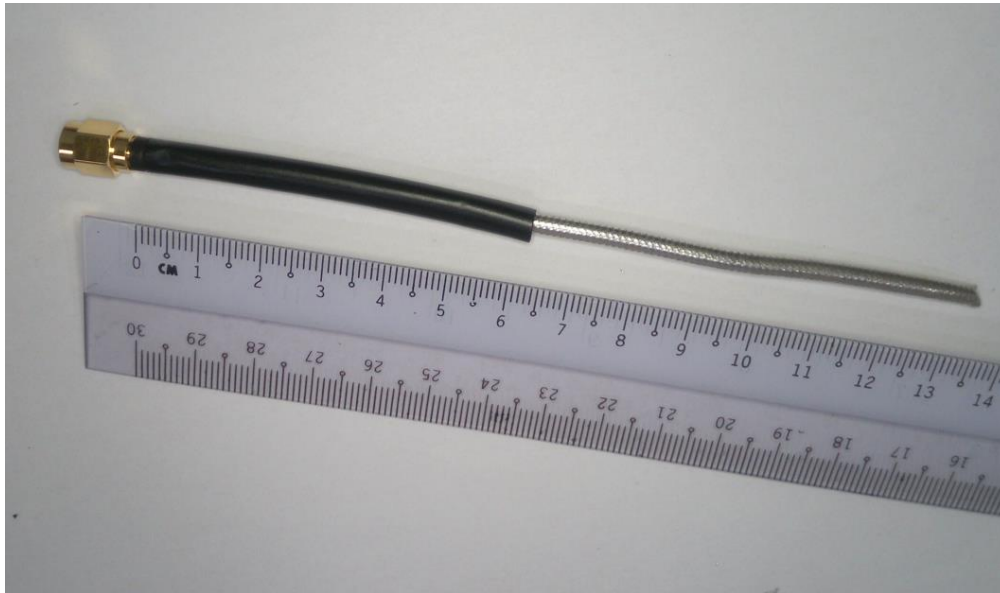
Cut around 6cm of Heat Shrink tube (71204811)



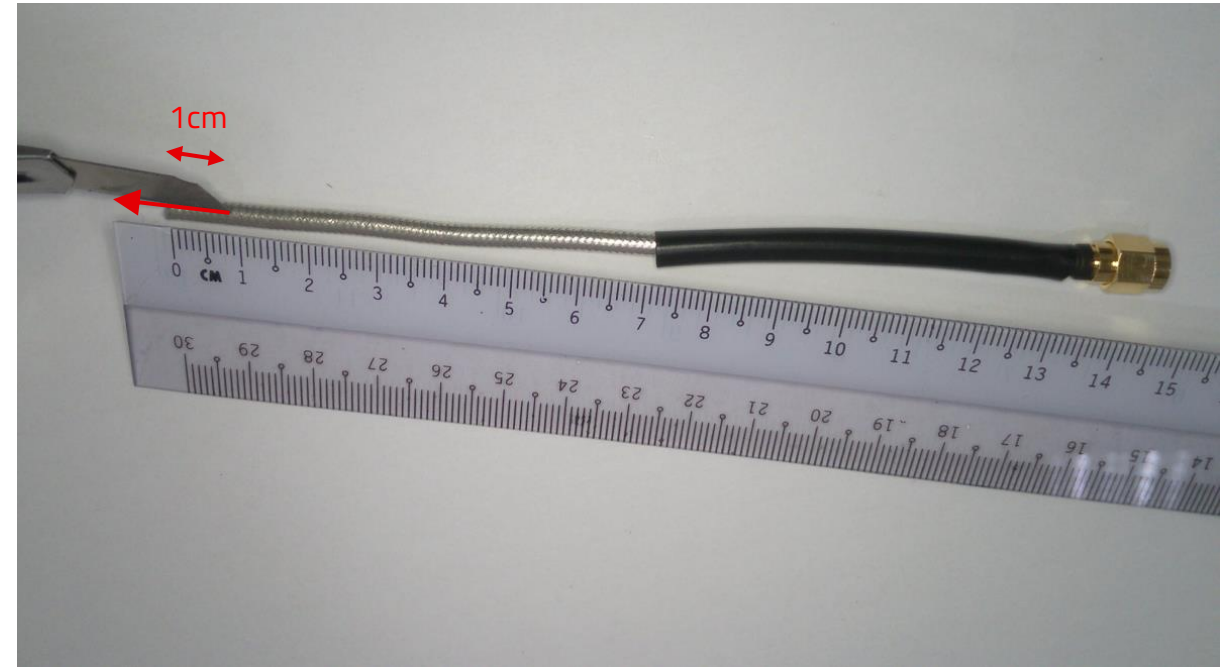
# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Put the 6cm heat shrink tube (71204811) through the cable as shown below.



Cut around 1 cm along the outer shielding at the cable tip at both side.

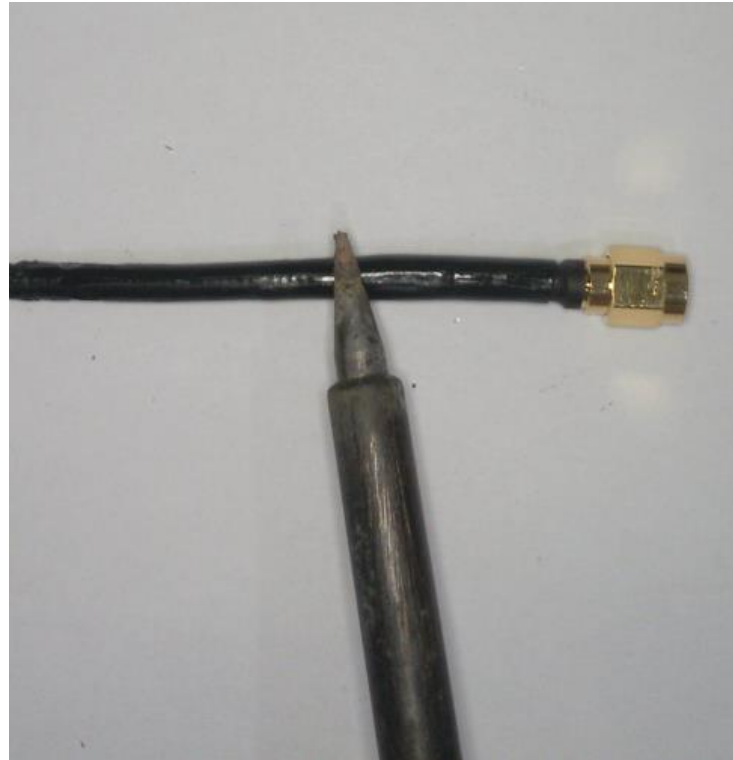


Note: Do not cut too deep into the plastic insulation. Just cut enough to peel back the outer metal shielding.

# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Shrink down the heat shrink tube with a solder iron.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Slip in the 3 cable ferrites as shown below



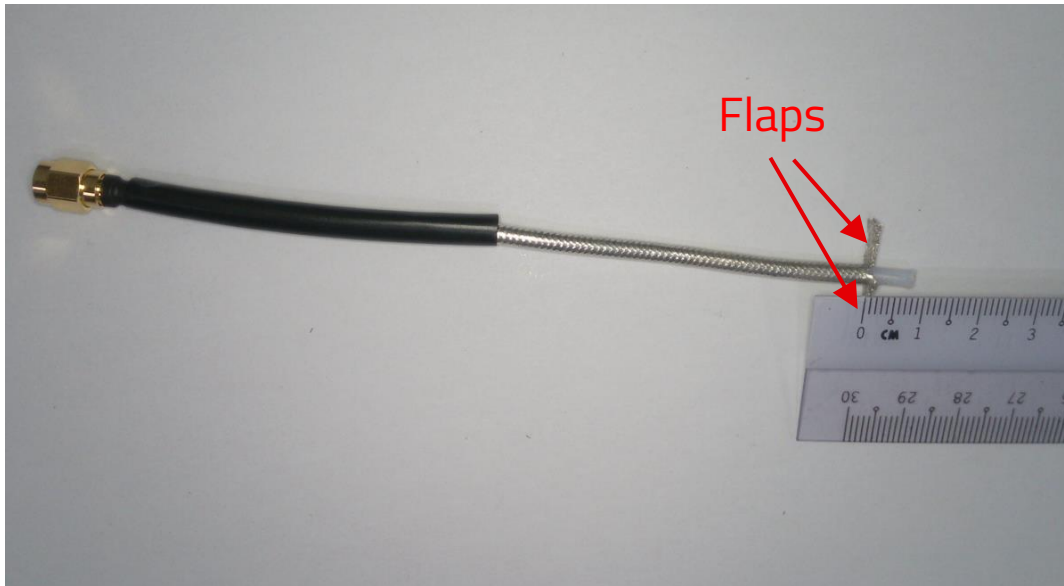
Adding cable ferrite(s) to a near field probe serves to reduce high-frequency noise coupling directly into the cable.



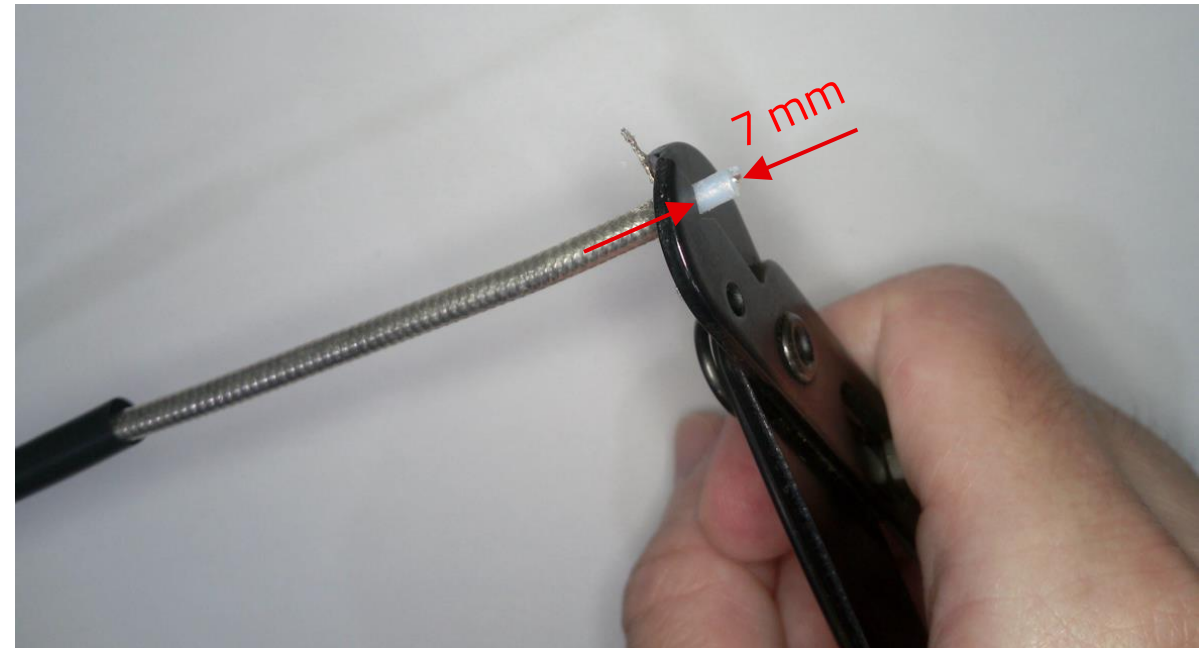
# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Peel back both side of the outer metal shielding as shown by 1cm from the end tip to form 2 flaps.



Strip the plastic insulation off (around 7mm) at the end tip of the cable as shown below to expose the inner core wire.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Exposed core wire (around 7mm) after stripping off the plastic insulation.



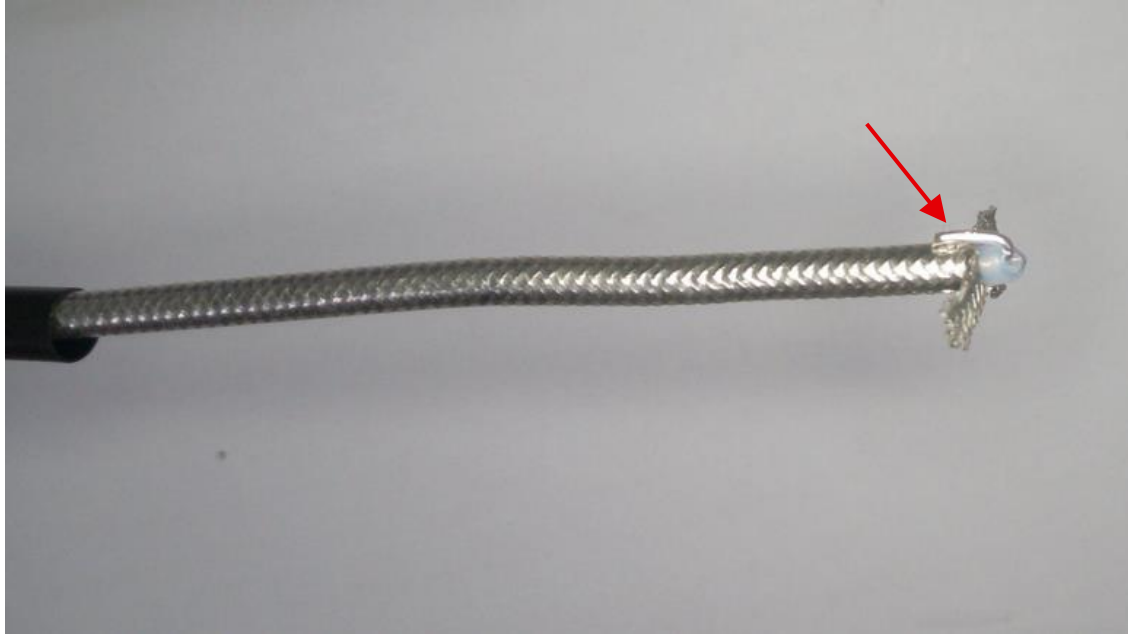
Bend the exposed core wire with a plier and flatten it against the cable.



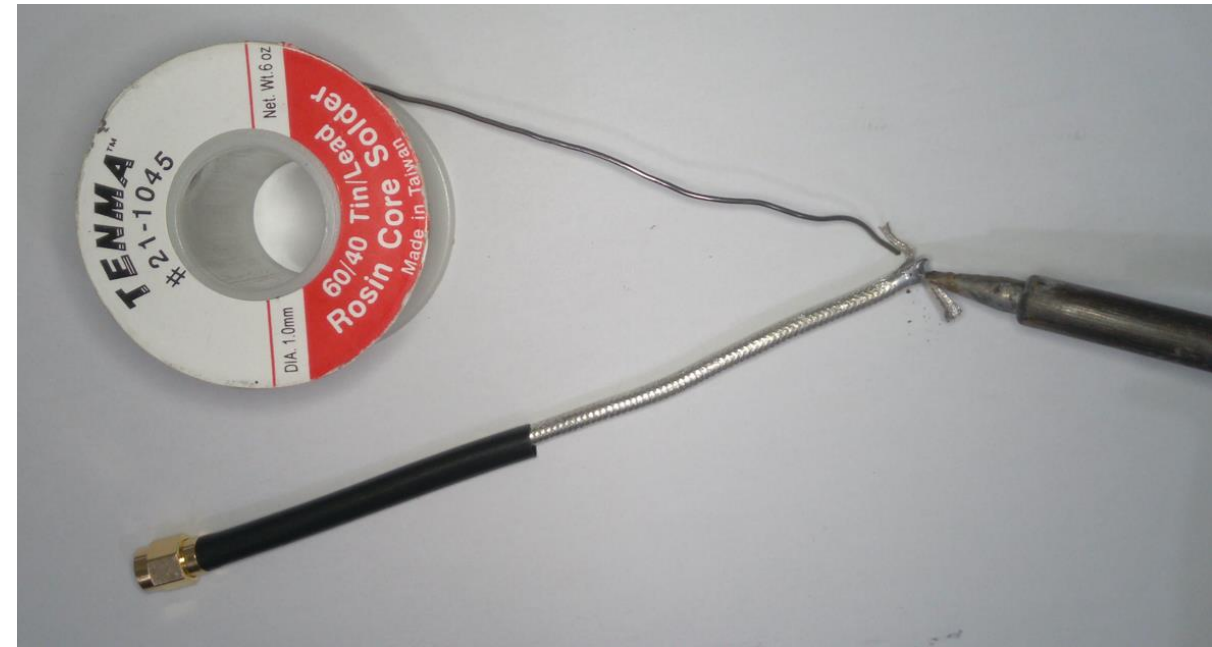
# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Core wire flattened against the cable.



Solder the bended core wire tip to the metal shielding of the cable body.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

The core wire tip soldered to the cable's metal shielding body.



Make a loop at the end of the cable around your finger as shown.



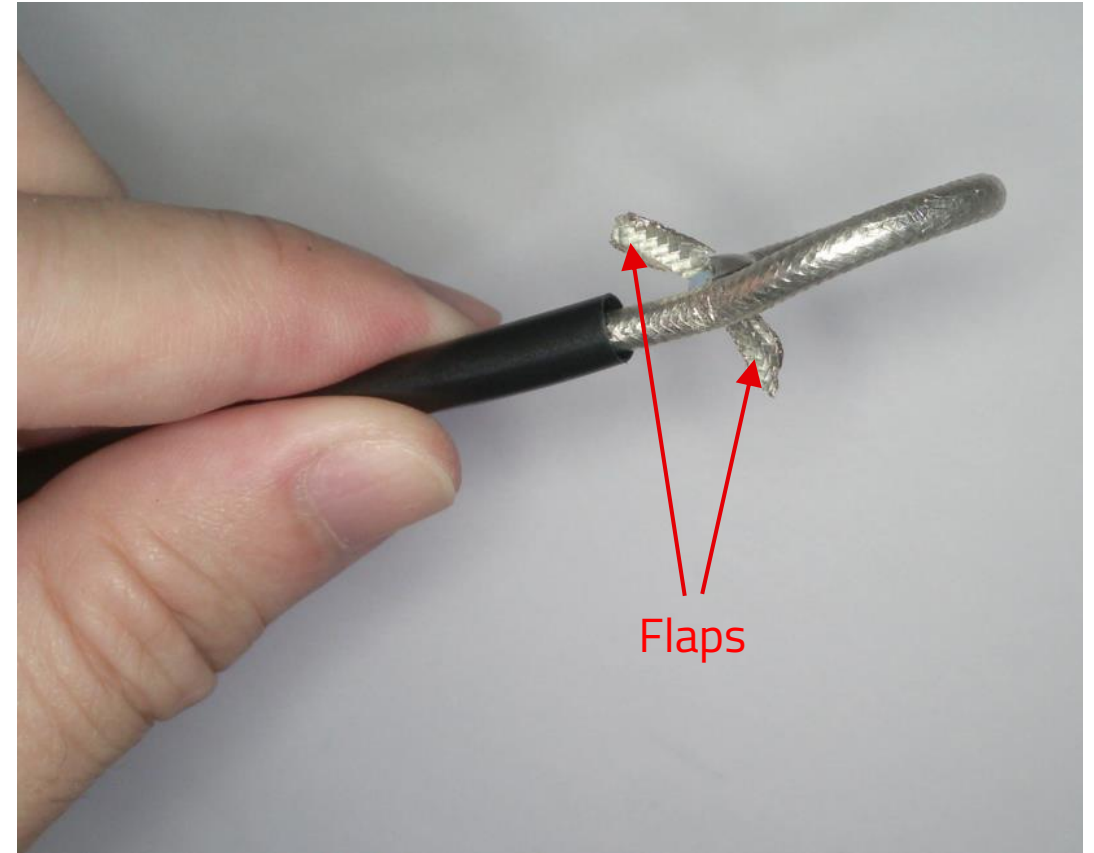
# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Make the loop with an internal diameter of around 2cm.



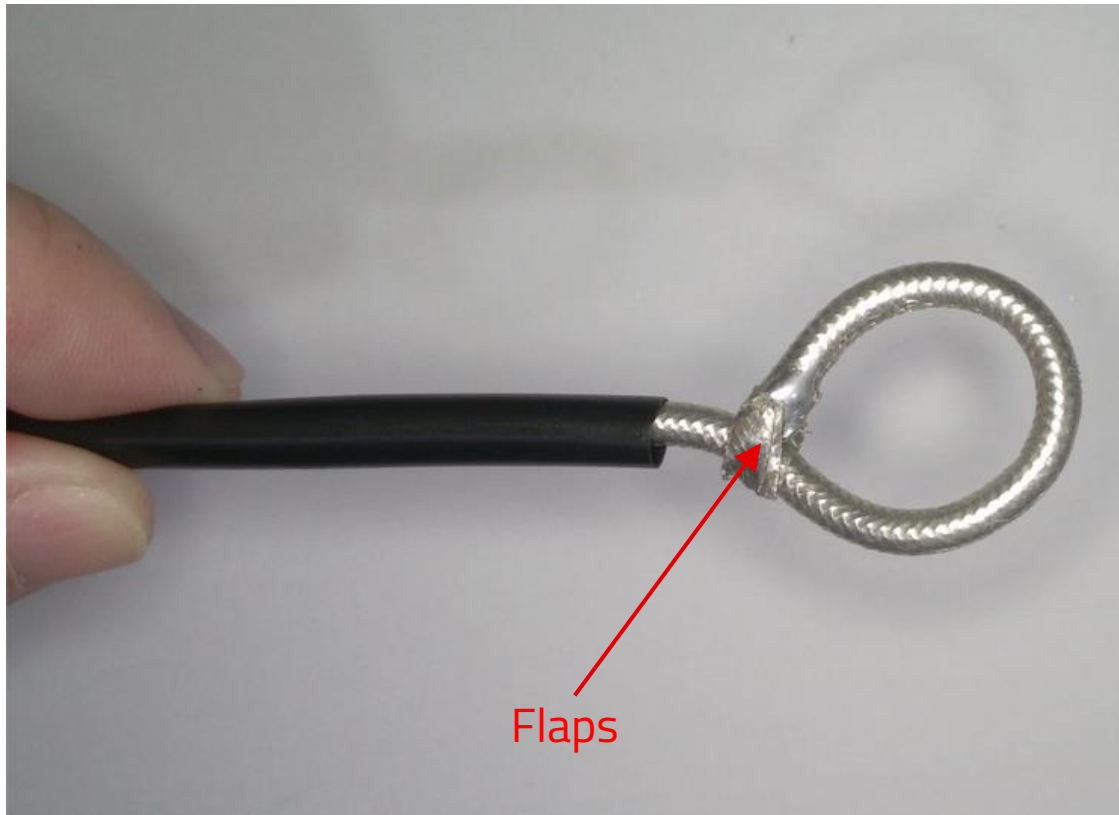
Wrap the 2 metal shielding flaps down and around the cable.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Make sure the 2 flaps are wrapped around the cable.



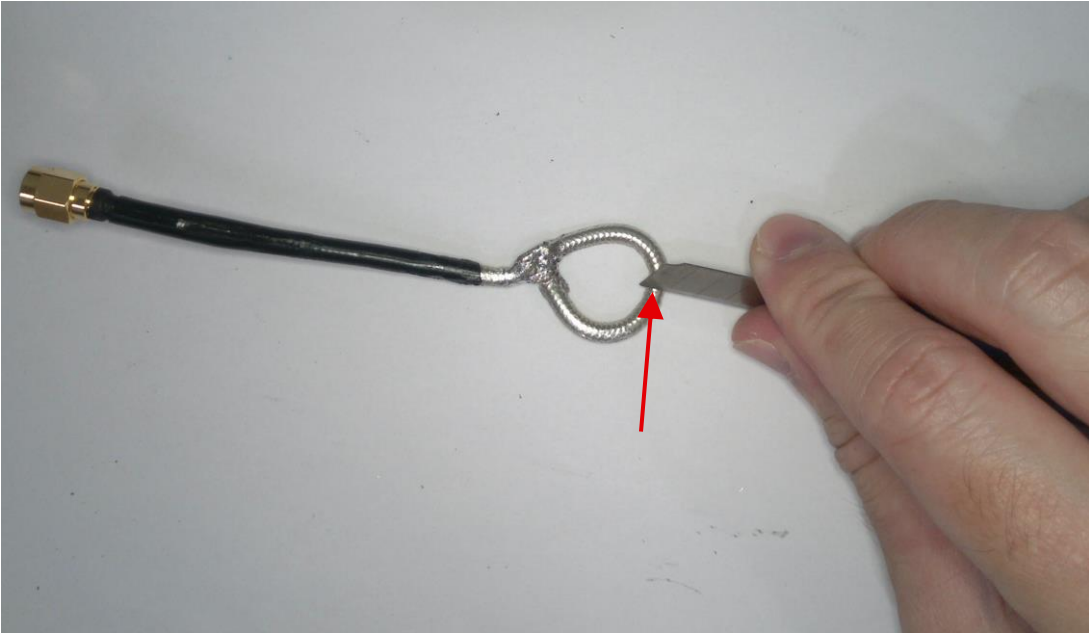
Solder the 2 flaps completely to the cable shielding, make sure there are no gaps or holes.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

Cut a small (1mm width) groove at the top center of the loop.



You can make use of a cutter to help you to grind a groove.



Note: Take great care not cut too deep into the plastic insulation. Just cut enough to form an exposed groove at the outer metal shielding.

# DIY MAGNETIC NEAR FIELD PROBE

## Procedure

1mm width groove at the top center of the loop exposing the plastic insulator.



Shrink down the heat shrink tube with a solder iron.



# DIY MAGNETIC NEAR FIELD PROBE

## Procedure – Optional Materials

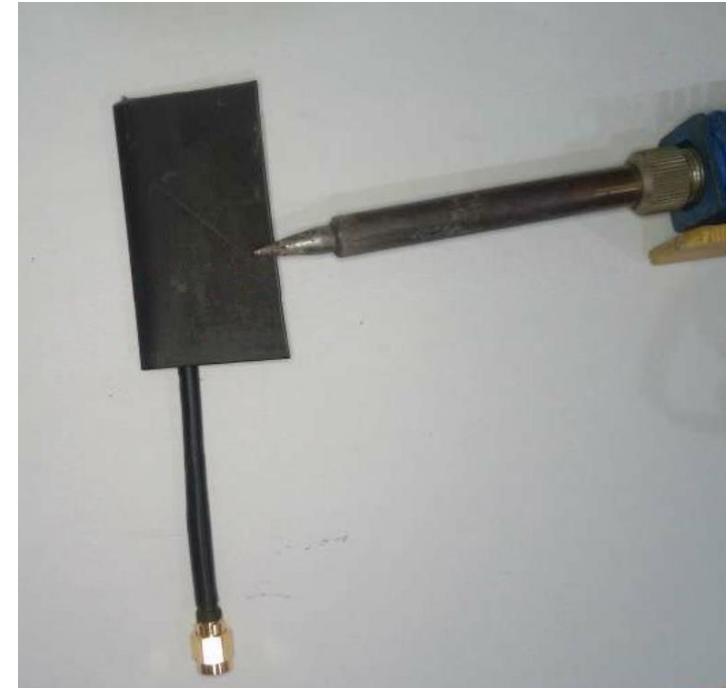
Adding PVC insulation tape to wrap around the conductive loop.



Insulation of the probe:

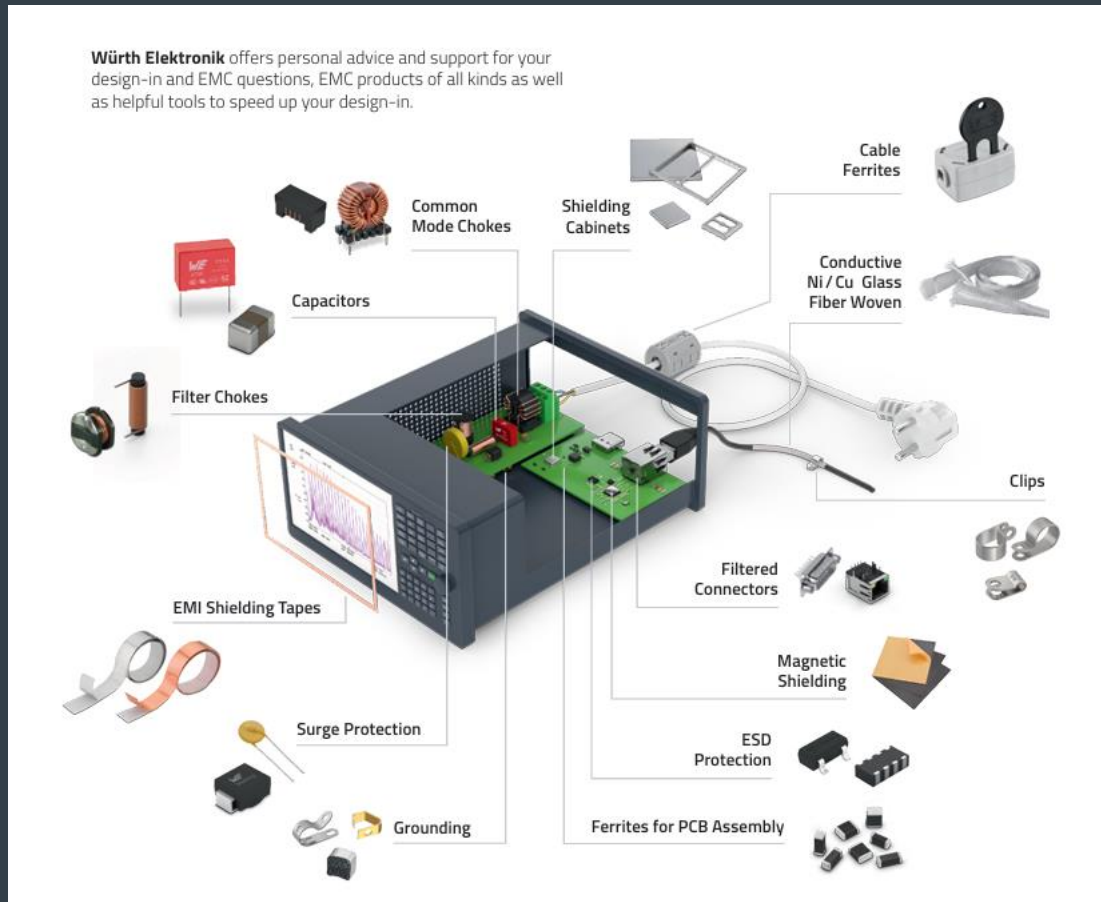
Cut about 6cm using a thick heat shrink tube like the 71232011. And slip it into the loop end.

Shrink down the heat shrink tube with a solder iron.



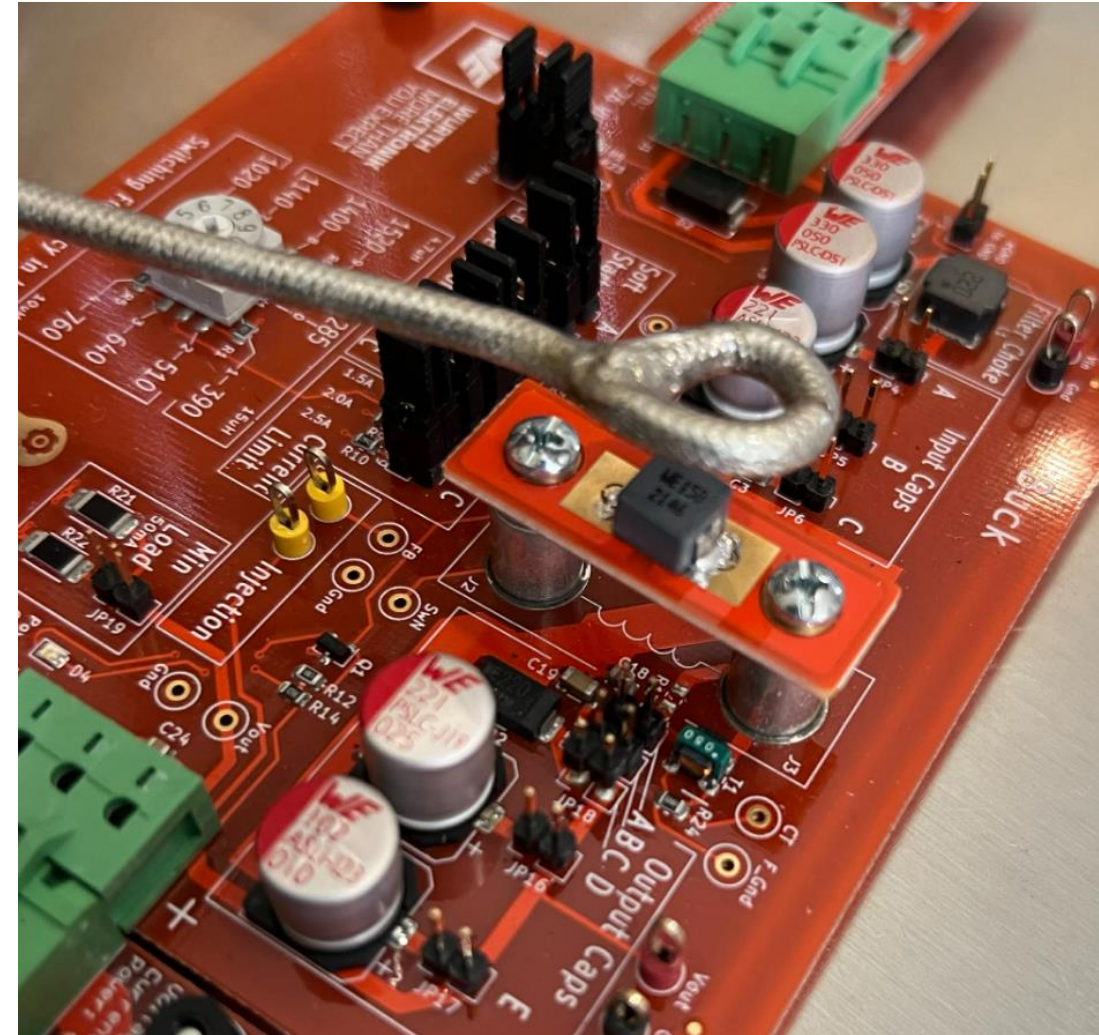
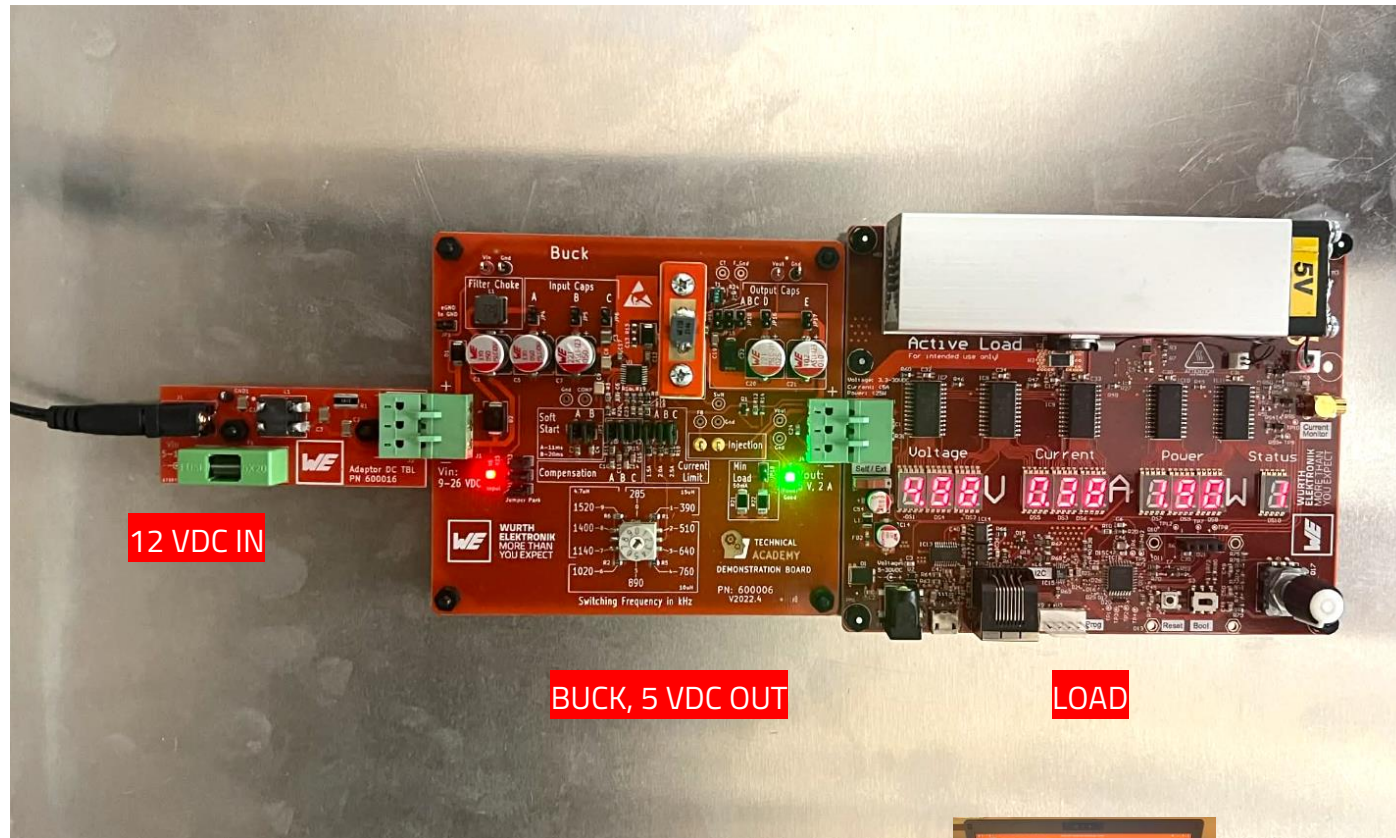
# TESTING

Würth Elektronik offers personal advice and support for your design-in and EMC questions, EMC products of all kinds as well as helpful tools to speed up your design-in.



# TESTING

## Setup

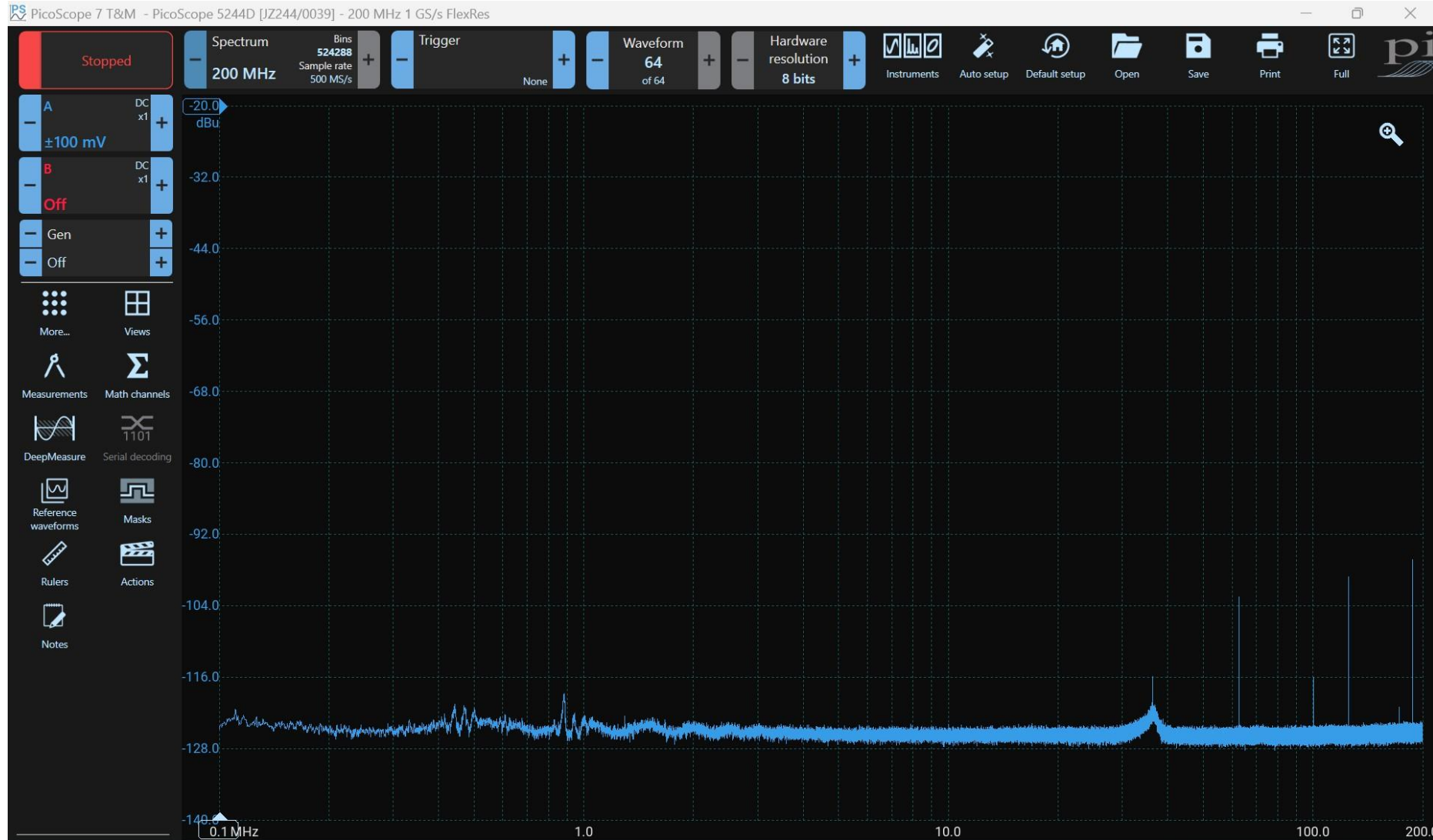


- FAE Demo Kit
- Picoscope and computer app
- DIY Near Field Probe
- Some magnetic shielding sheets



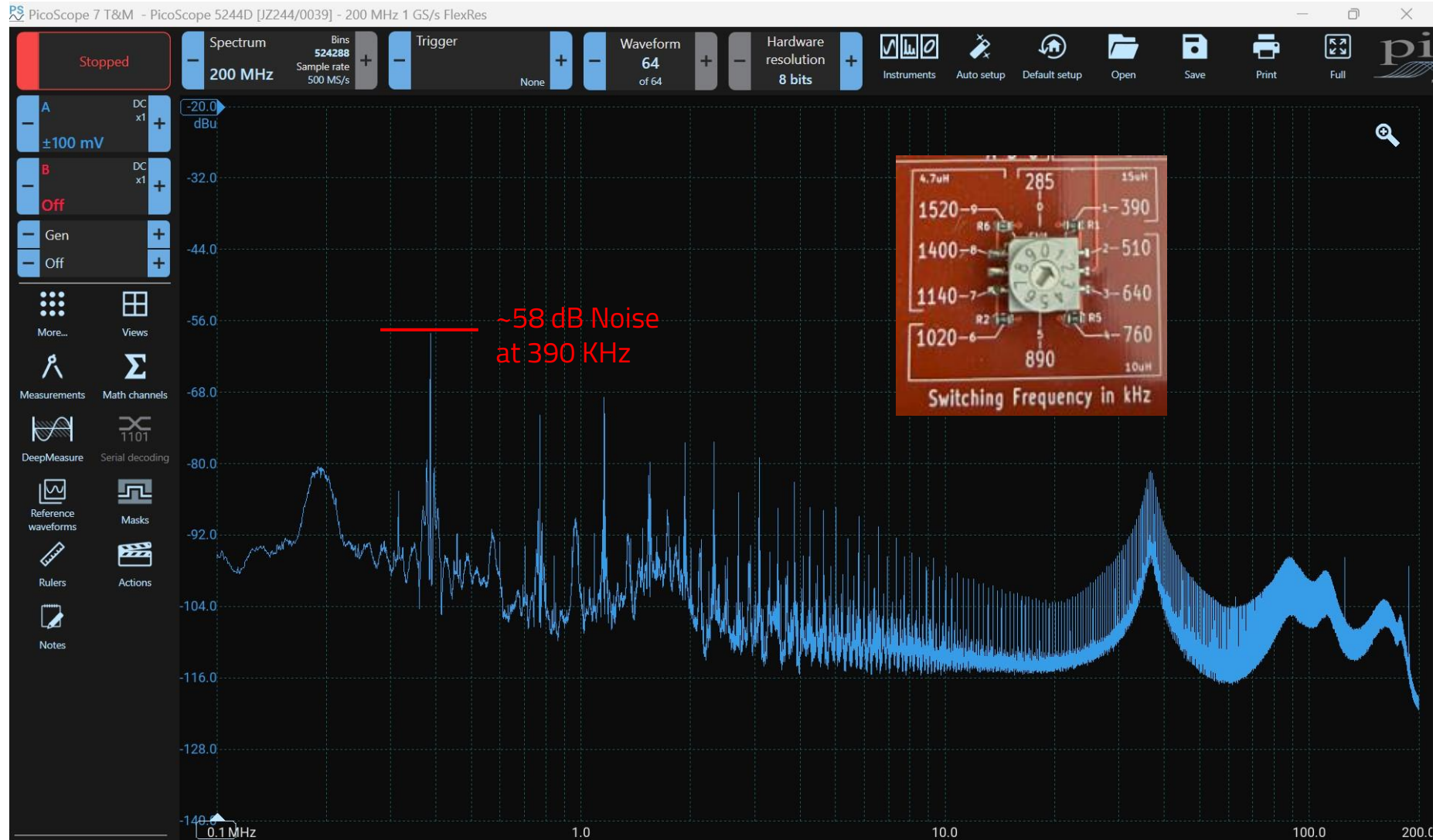
# TESTING

## Measurement - Noise Floor



# TESTING

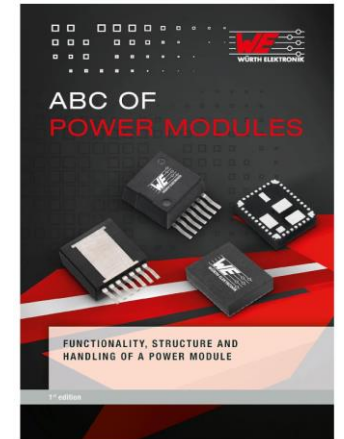
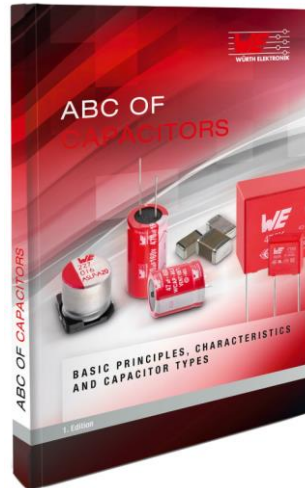
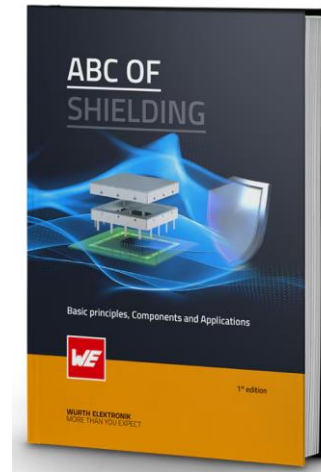
## Measurement - No Shielding



# TESTING

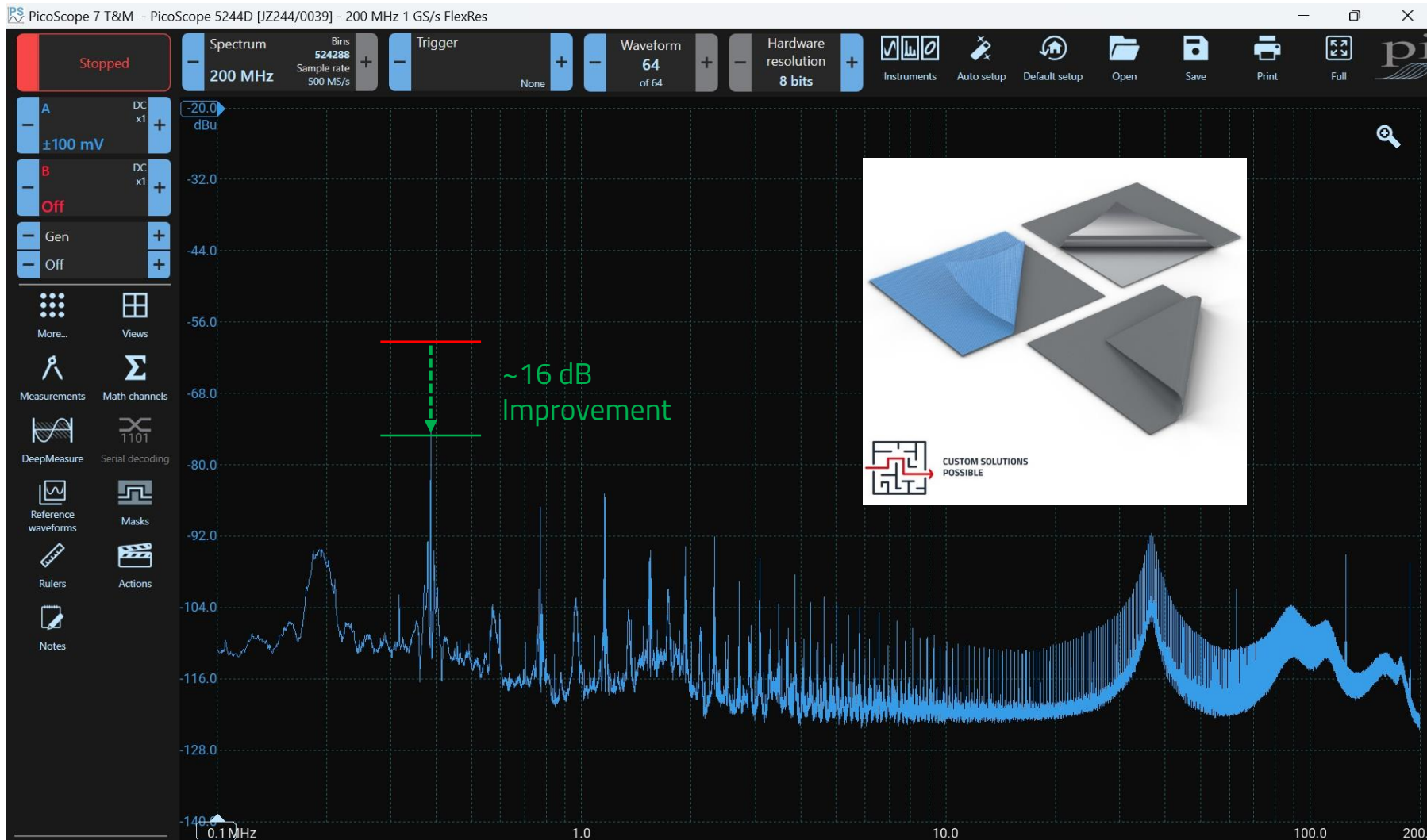
## Reference guides for the winning participants

- 1) Shielding
- 2) Connectors
- 3) Capacitors
- 4) Magnetics
- 5) DC-DC Converters
- 6) Wireless Power Transfer
- 7) Power Modules
- 8) LT Spice



# TESTING

## Measurement - WE-FAS Flexible Absorber Sheet: [34411A7](#)

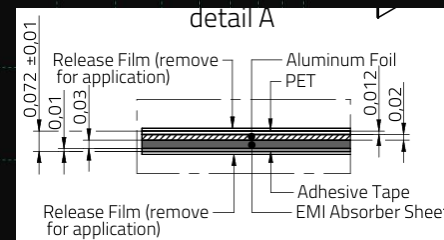
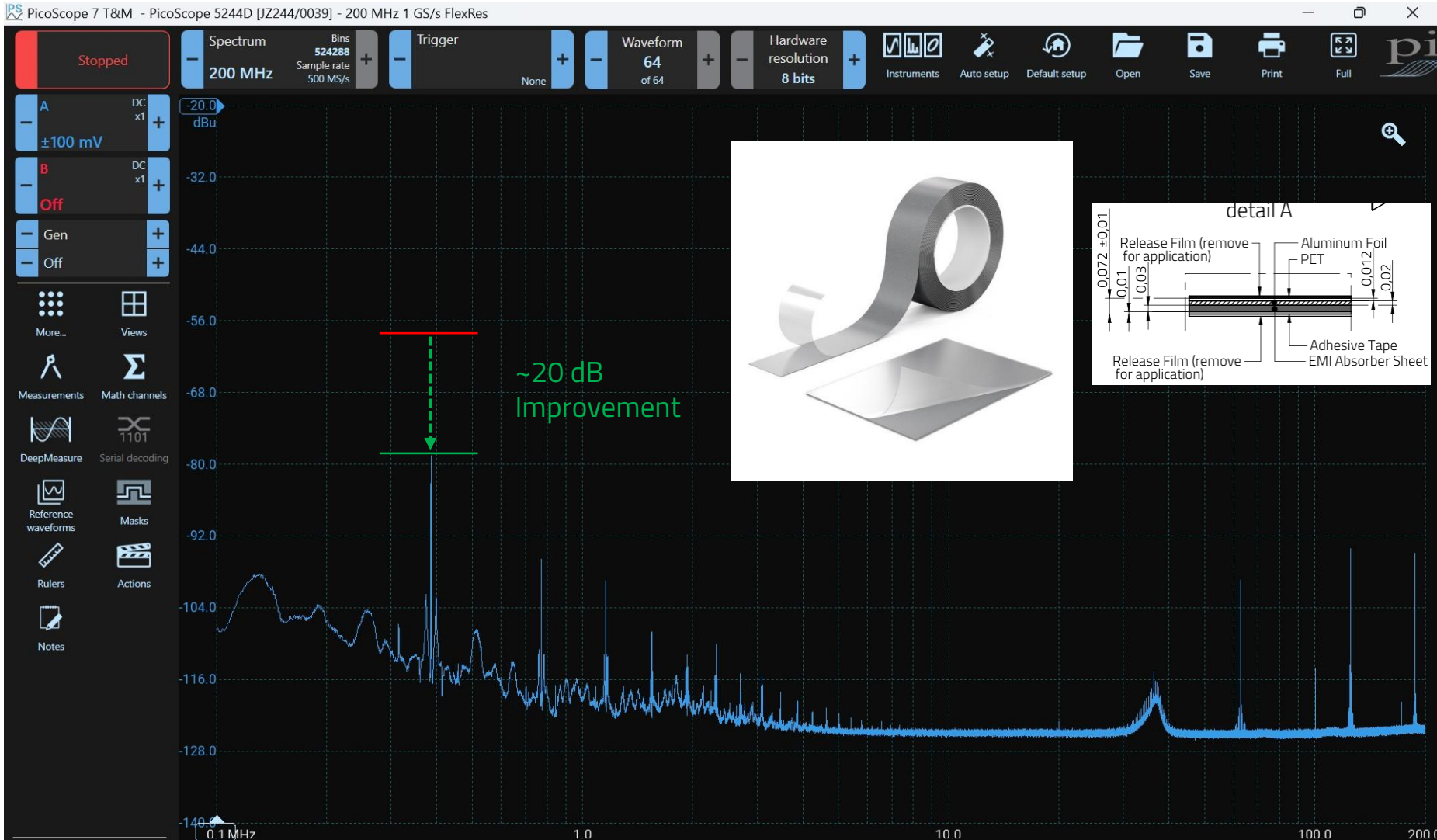


### WE-FAS Characteristics

- Customizable for dimensions & form.
- Wide range working temperature of -40 up to +160 °C.
- Wide frequency range 1 MHz up to 10 GHz
- High surface resistance & High permeability.
- Extremely flexible
- Thickness available from 0.05 mm to 30 mm.
- Adhesive surface for easy installation.
- Easy to process
- Thermal conductive interface with conductivity values up to 1.4 W/mK
- Free samples.

# TESTING

## Measurement - WE-EMIP EMI Patch: [371101](#)

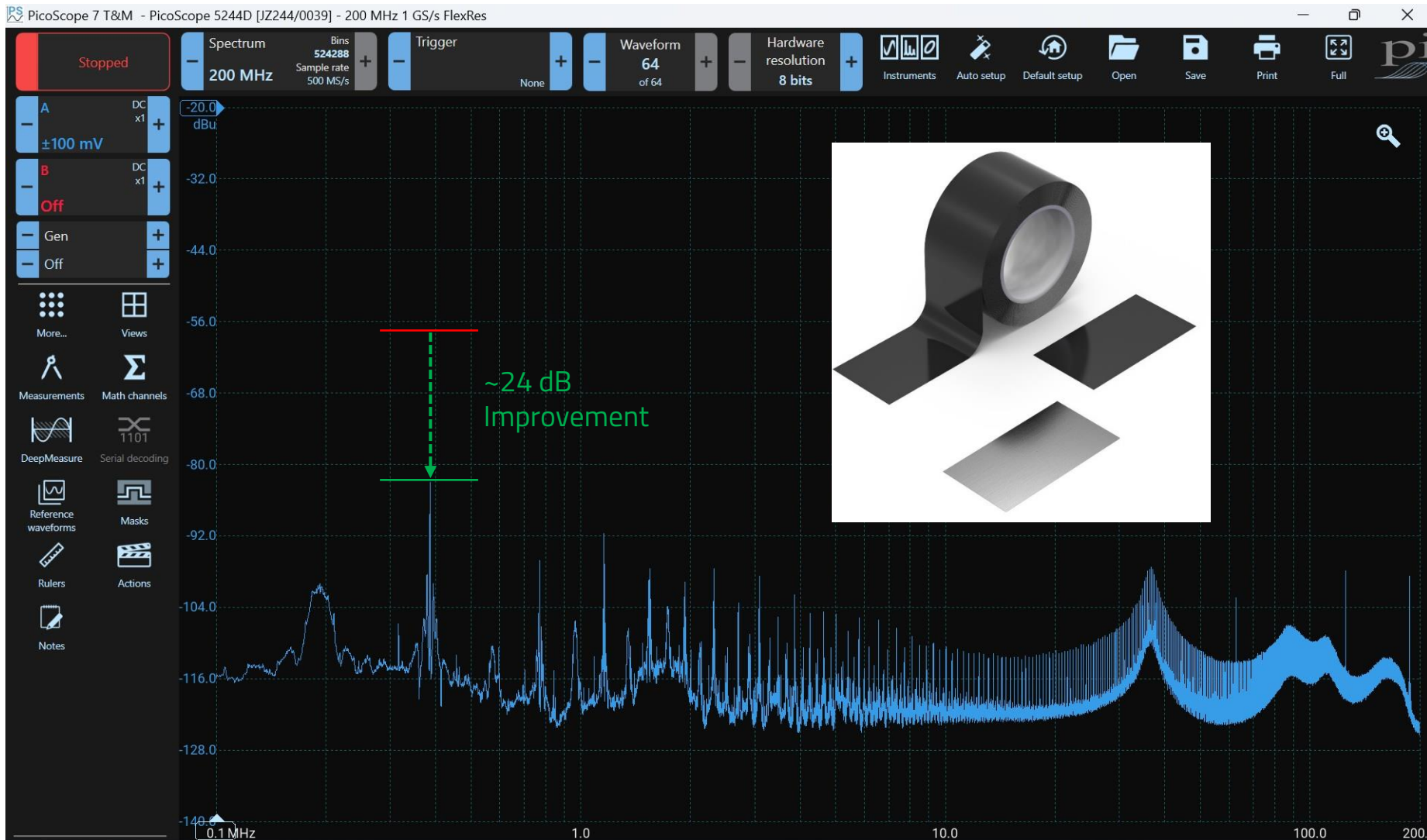


### WE-EMIP Characteristics

- Hybrid material with absorber and metal layers, effective both against magnetic and electric fields
- Wide frequency range from 100 Hz up to 25 GHz
- Extremely flexible
- Very low thickness: 0.072 mm
- Isolated version with high surface resistance
- Non-isolated version which allows the connection of the metal layer to ground, housing,...
- With self-adhesive backing for easy installation
- Absorber layer with permeability of 100
- Metal layer: Aluminum
- Operating temperature: -25 up to +105°C
- Easy to process
- Custom designs on request
  - Permeability
  - Shape and size
  - Metal layer
  - Thickness
  - Isolation
  - Adhesive.

# TESTING

## WE-FNCS Flexible Nanocrystalline Sheets: [353012](#)

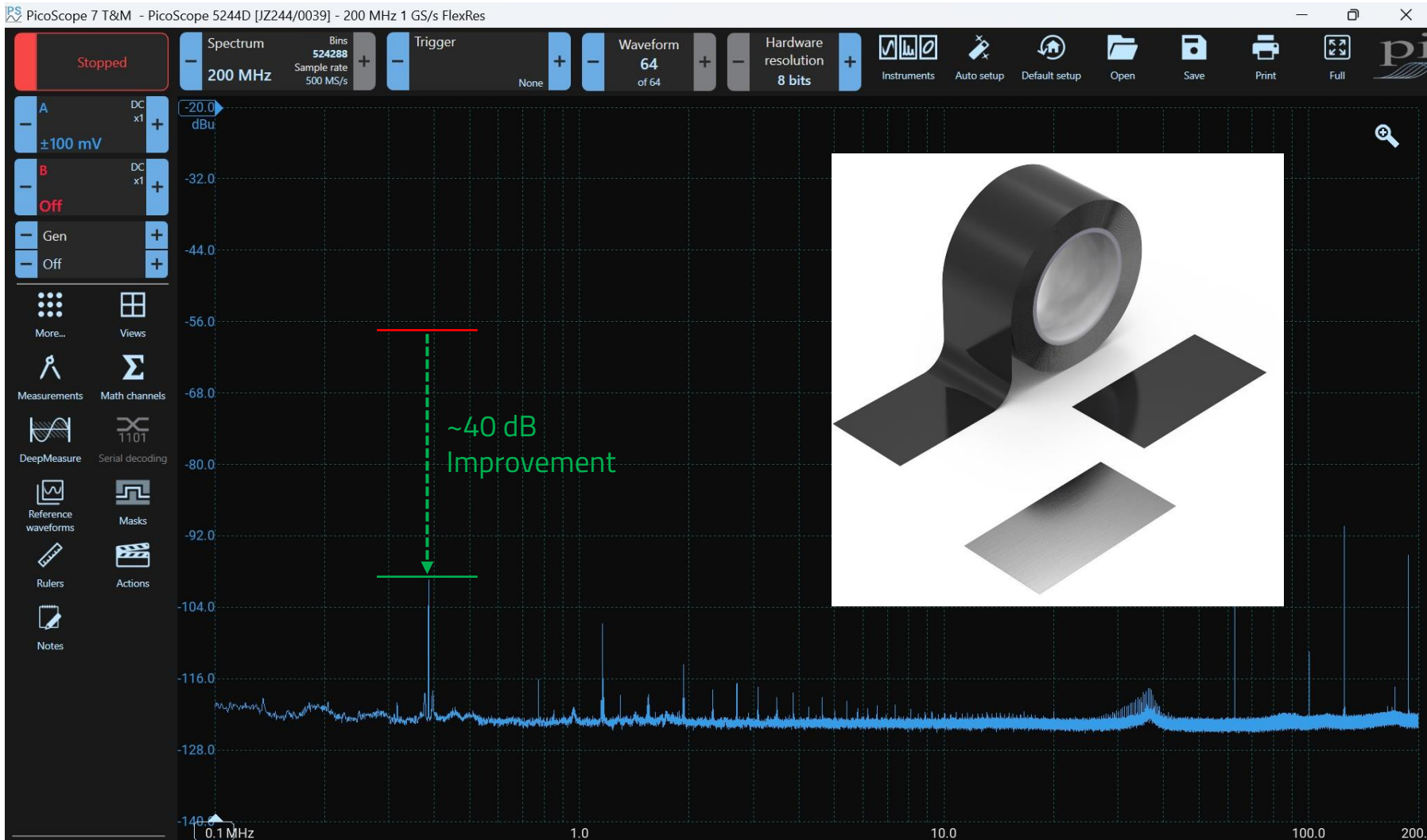


### WE-FNCS Characteristics

- Cost-effective solution as an alternative to mu-metal alloys for low frequency (LF) magnetic field applications
- Customizable: Length, width, thickness, shape and permeability
- Extremely flexible and thin
- Easy placement and handling thanks to standard adhesive backing
- High surface resistance
- Easy to process
- Maximum dimensions available: Length: 100 m (on roll), width: 65 mm (as the standard parts), thickness: 0.3 mm (12 nanocrystalline layers stacked)
- Custom designs under request
- Operating temperature: -40°C up to 85°C

# TESTING

## WE-FNCS Flexible Nanocrystalline Sheets: 353020

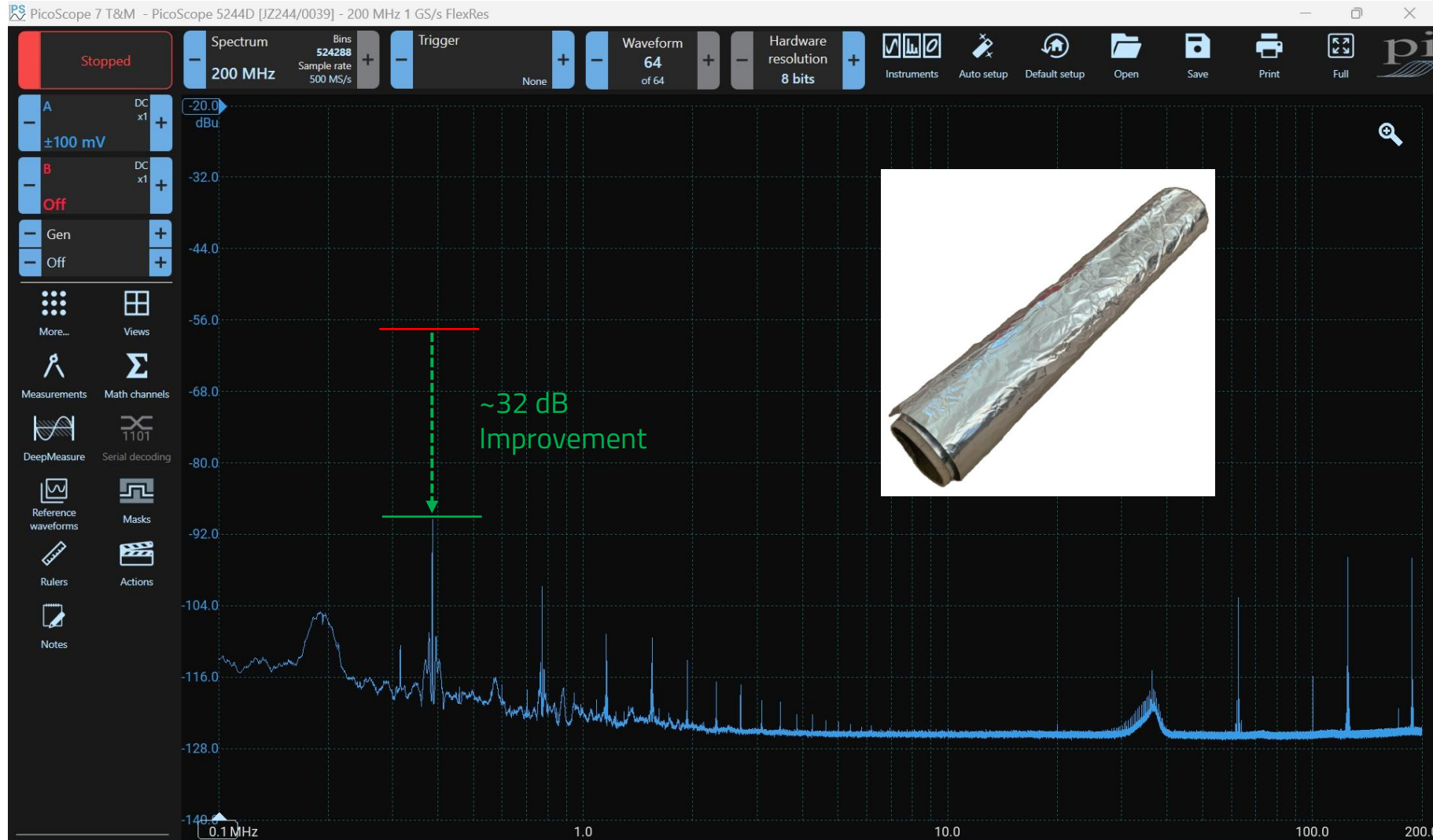


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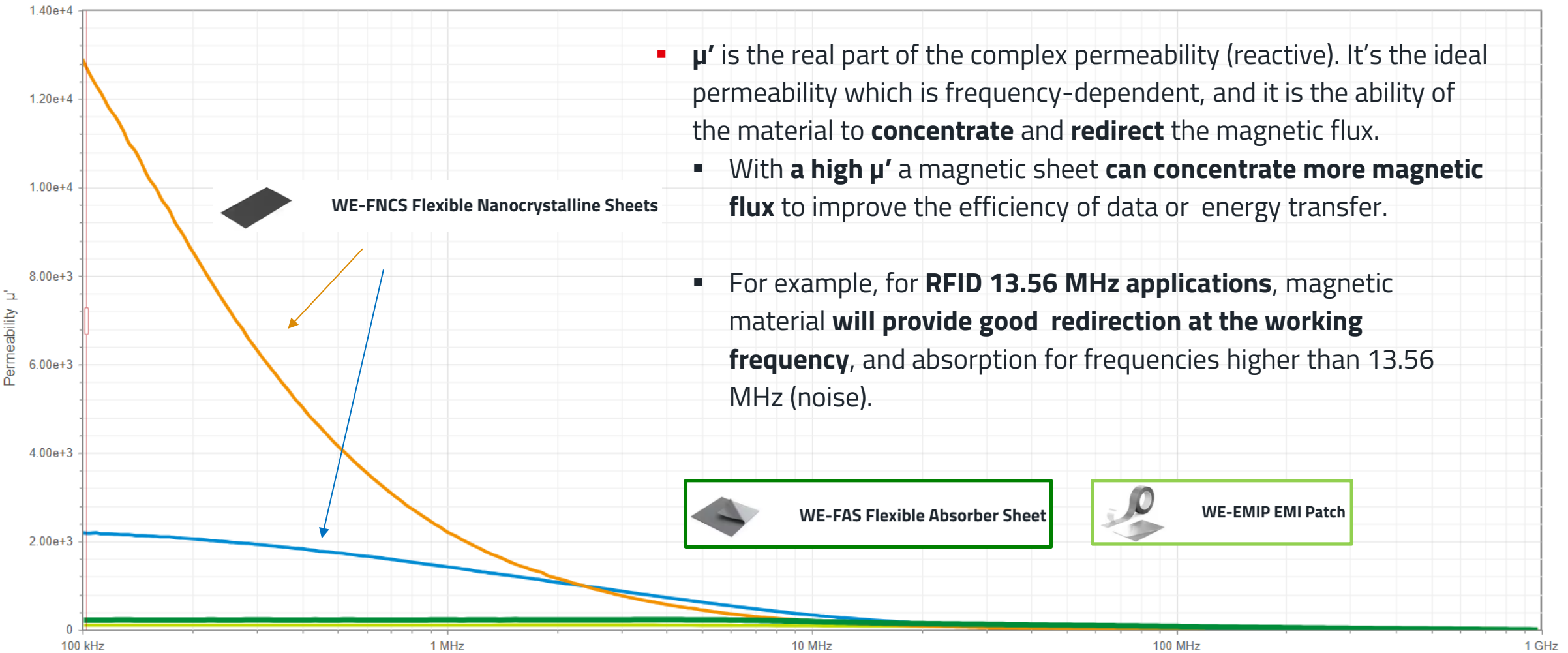
# TESTING

## Aluminum Foil



# SHIELDING

Permeability  $\mu'$ : FAS EMI vs. EMIP vs. FCNS

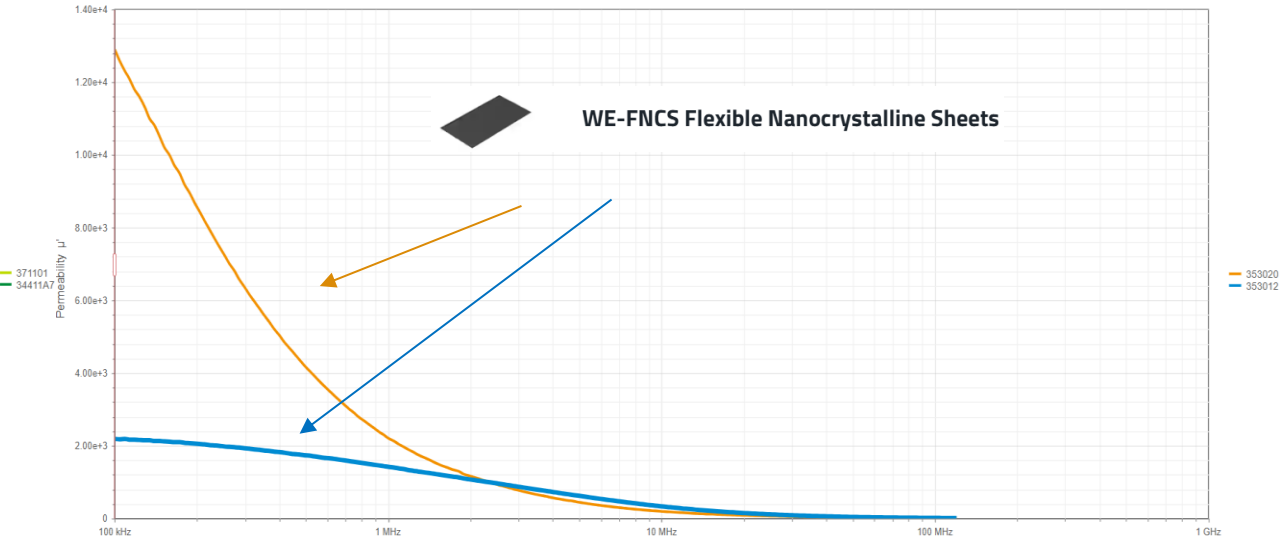
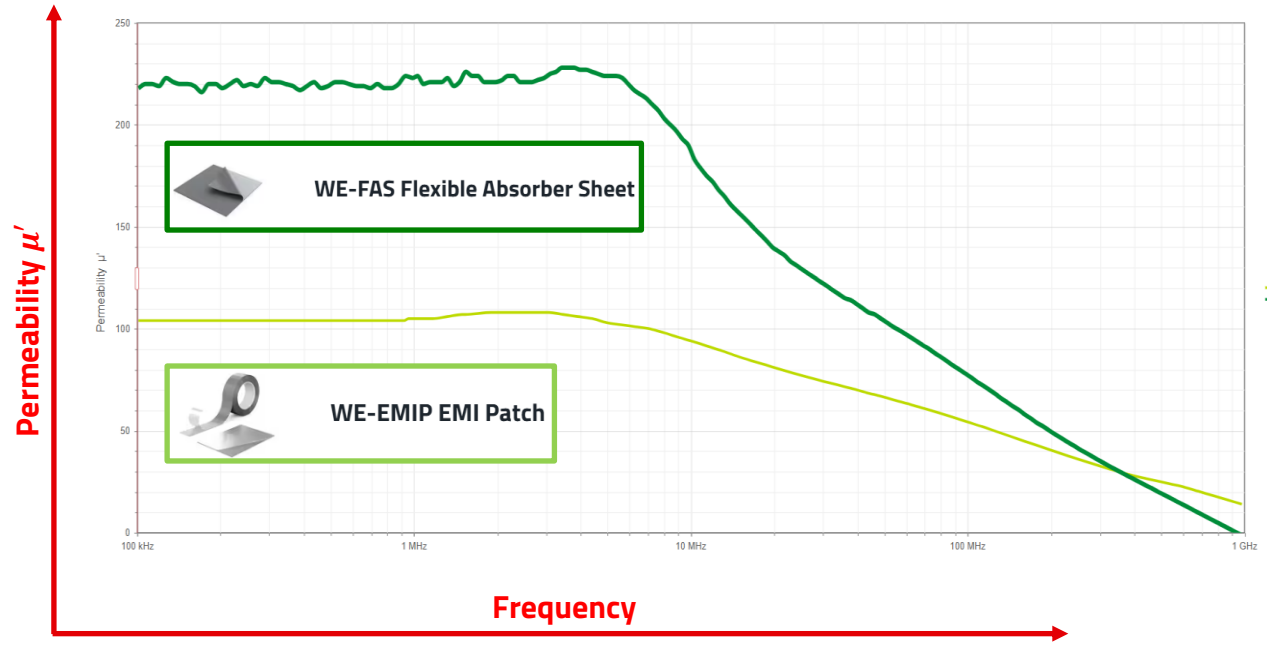


- $\mu'$  is the real part of the complex permeability (reactive). It's the ideal permeability which is frequency-dependent, and it is the ability of the material to **concentrate** and **redirect** the magnetic flux.
  - With a **high  $\mu'$**  a magnetic sheet **can concentrate more magnetic flux** to improve the efficiency of data or energy transfer.
  - For example, for **RFID 13.56 MHz applications**, magnetic material **will provide good redirection at the working frequency**, and absorption for frequencies higher than 13.56 MHz (noise).

# SHIELDING

Permeability  $\mu'$ : FAS EMI vs. EMIP vs. FCNS

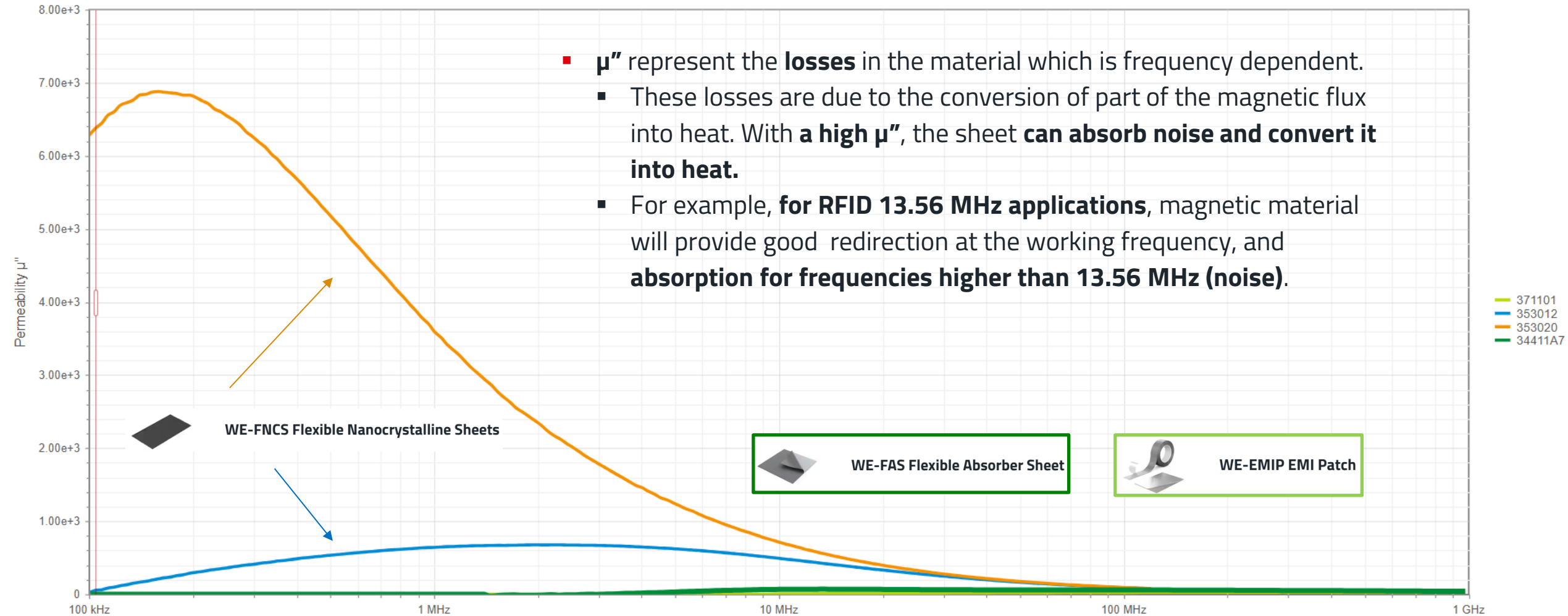
Order Code	Series	Spec	L	W	Thick...	Surface Resistance	Shielding E...	Peel ...	Ther...	$\mu'$ @ 13.56 MHz	$\mu'$ @ 1 MHz	$\mu''$ @ 13.56 MHz	$\mu''$ @ 1 MHz	Adhe...
34411A7	WE-FAS EMI		74.000 mm	105 mm	0.1000 mm	1.00e+7 $\Omega$ /cm <sup>2</sup>		400 N/cm		163	218	70.3	0.0100	0.0300 mm
353020	WE-FNCS		120.00 mm	65.0 mm	0.06000 ...	1.00e+7 $\Omega$ /cm <sup>2</sup>				137	2.21e+3	556	3.60e+3	0.0100 mm
371001	WE-EMIP		105.00 mm	74.0 mm	0.07200 ...	0.00200 $\Omega$ /cm <sup>2</sup>		400 N/cm		87.6	100	9.72	0.0100	0.0100 mm
371101	WE-EMIP		105.00 mm	74.0 mm	0.07200 ...	1.00e+8 $\Omega$ /cm <sup>2</sup>		400 N/cm		87.6	100	9.72	0.0100	0.0100 mm



# SHIELDING

Permeability  $\mu''$ : FAS EMI vs. EMIP vs. FCNS

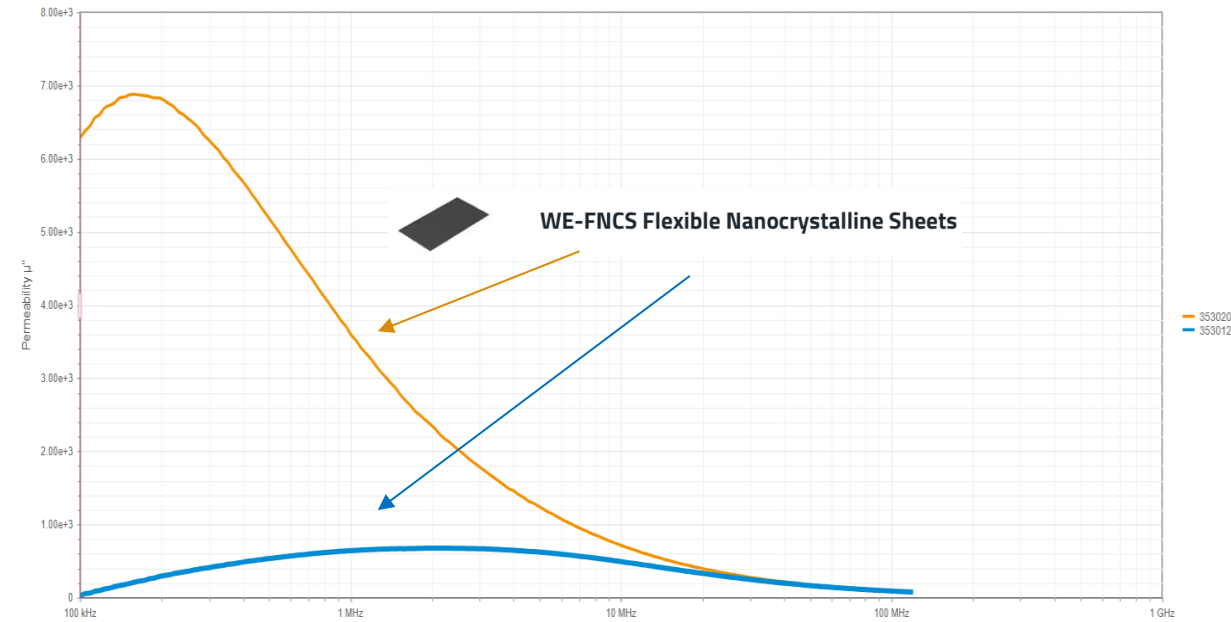
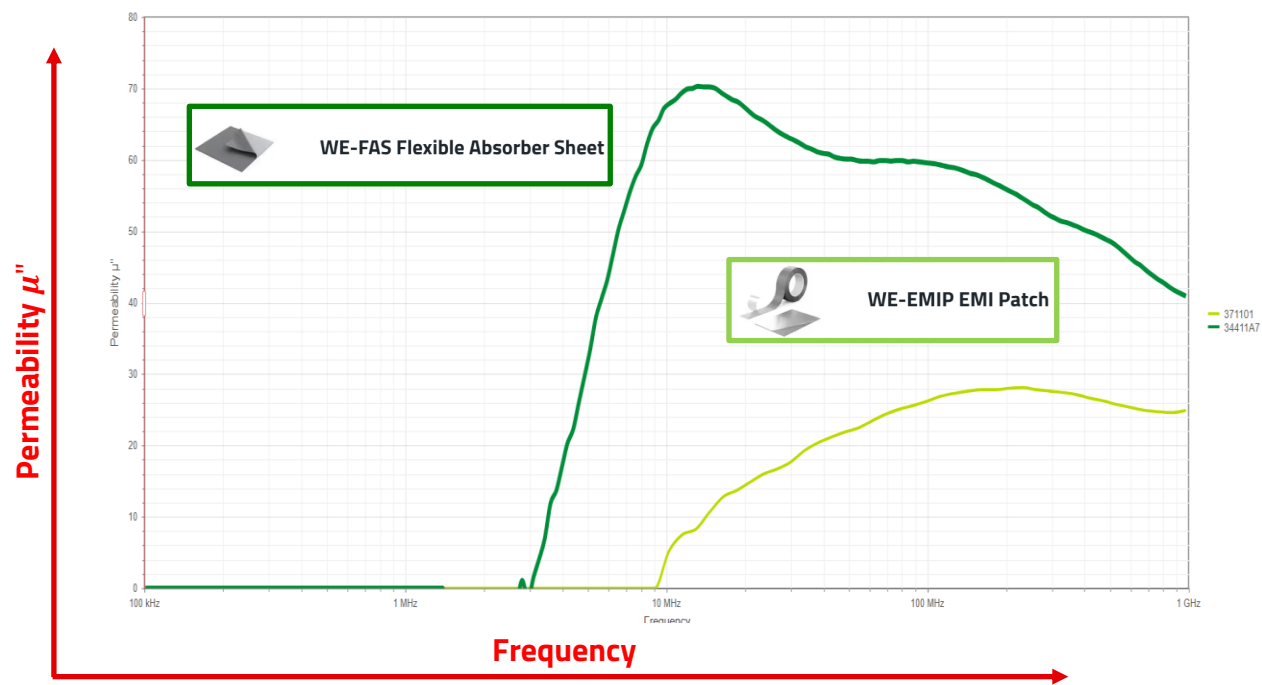
- $\mu''$  represent the **losses** in the material which is frequency dependent.
  - These losses are due to the conversion of part of the magnetic flux into heat. With a **high  $\mu''$** , the sheet **can absorb noise and convert it into heat.**
  - For example, **for RFID 13.56 MHz applications**, magnetic material will provide good redirection at the working frequency, and **absorption for frequencies higher than 13.56 MHz (noise).**



# SHIELDING

## Permeability $\mu''$ : FAS EMI vs. EMIP vs. FCNS

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371001	WE-EMIP		105.00 mm	74.0 mm	0.07200 ...	0.00200 $\Omega$ /cm2		400 N/cm		87.6	100	9.72	0.0100	0.0100 mm
371101	WE-EMIP		105.00 mm	74.0 mm	0.07200 ...	1.00e+8 $\Omega$ /cm2		400 N/cm		87.6	100	9.72	0.0100	0.0100 mm

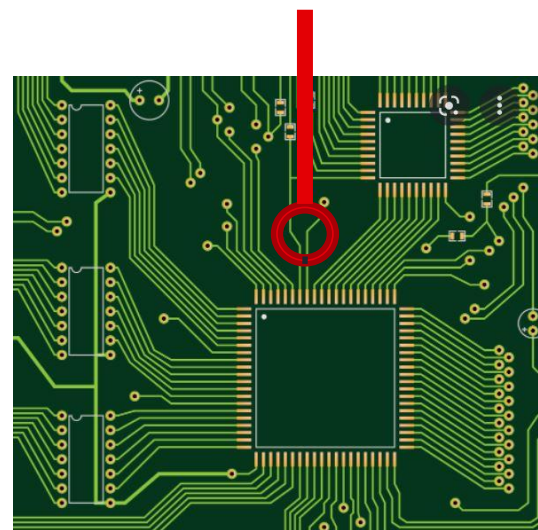
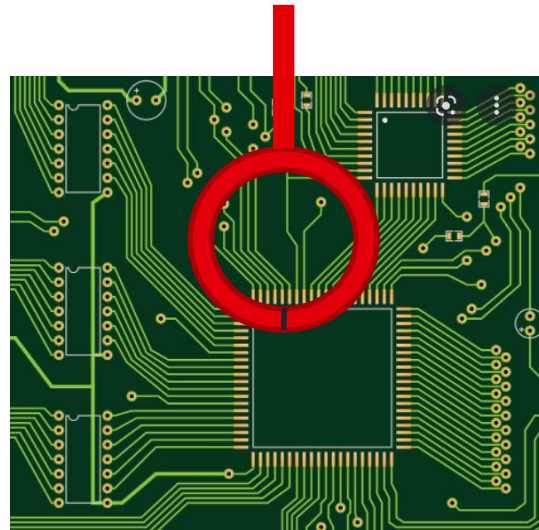


# PCB TROUBLESHOOTING TIPS

## Finding noise in the near field

### 1. Size

- When evaluating the EMI from the PCB, the diameter of the magnetic NFP loop determines:
  - The sensitivity of the probe
  - Spatial resolution
- Larger loop:
  - More sensitive and can pickup more magnetic field, or changes in current.
  - Less spatial resolution. Harder to pinpoint and narrow down to a single spot or trace.



# PCB TROUBLESHOOTING TIPS

## Finding noise in the near field

2. You can first use a larger diameter loop size, which is more sensitive to scan for potential EMI hot spot. Then shift to a smaller loop size to pin-point the exact spot.
3. The DIY magnetic NFP is used for doing relative comparison of the EMI level at the near field. Not so much for absolute value measurement like in the EMC lab.
4. You can use it for before and after comparison after you have made EMI mitigating design into your PCB. For example, comparing between 2 PCB design revision. Comparing the EMI level after you have added in some filter design, etc.

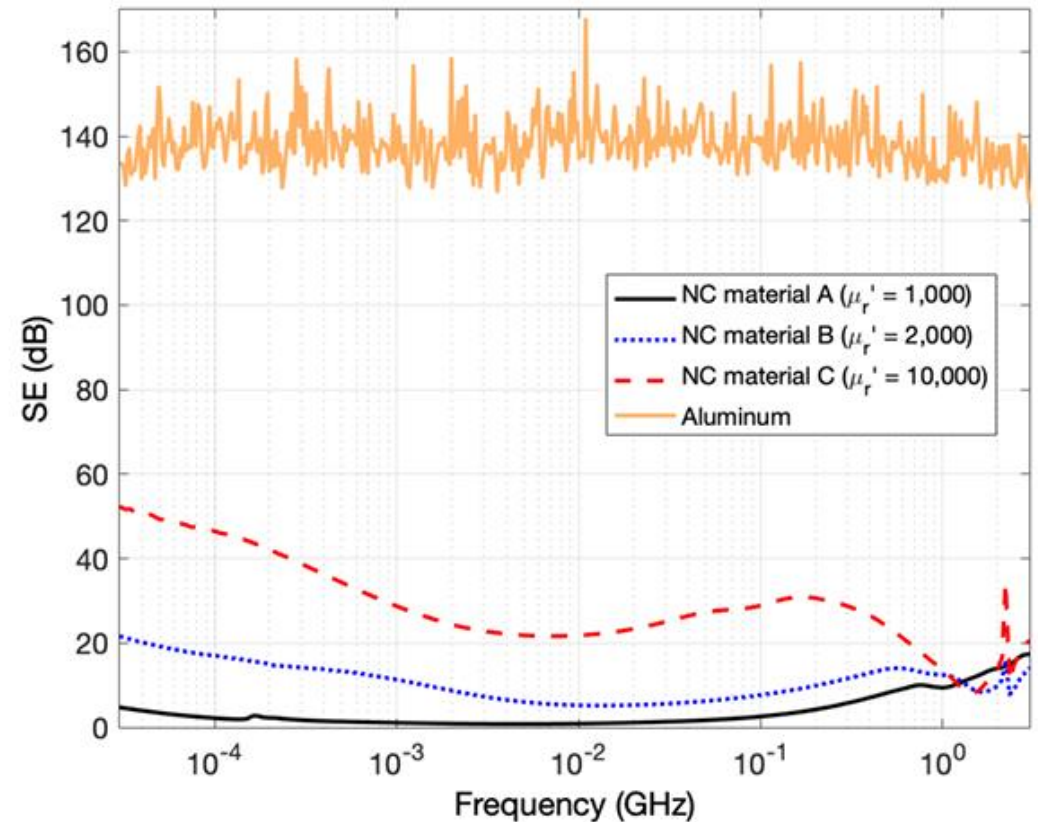
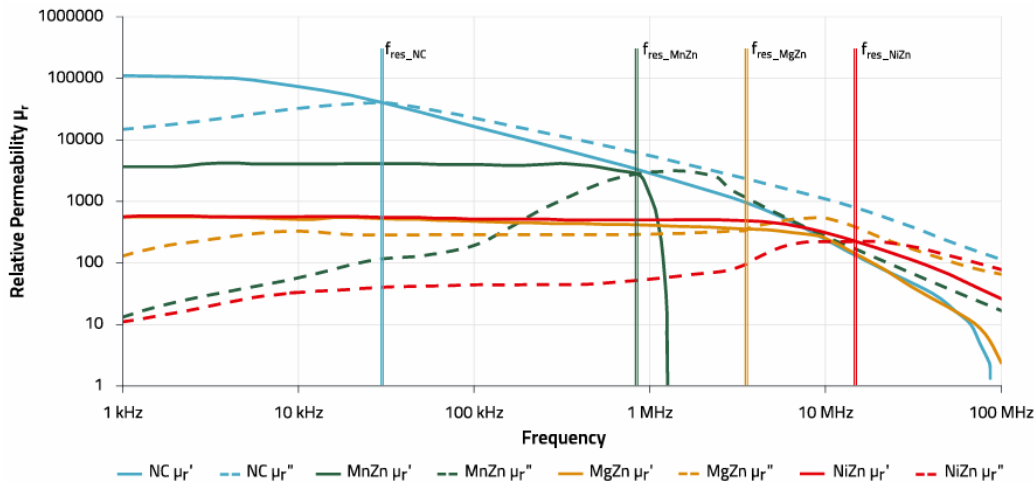


# NANOCRYSTALLINE

# NANOCRYSTALLINE

## Overview

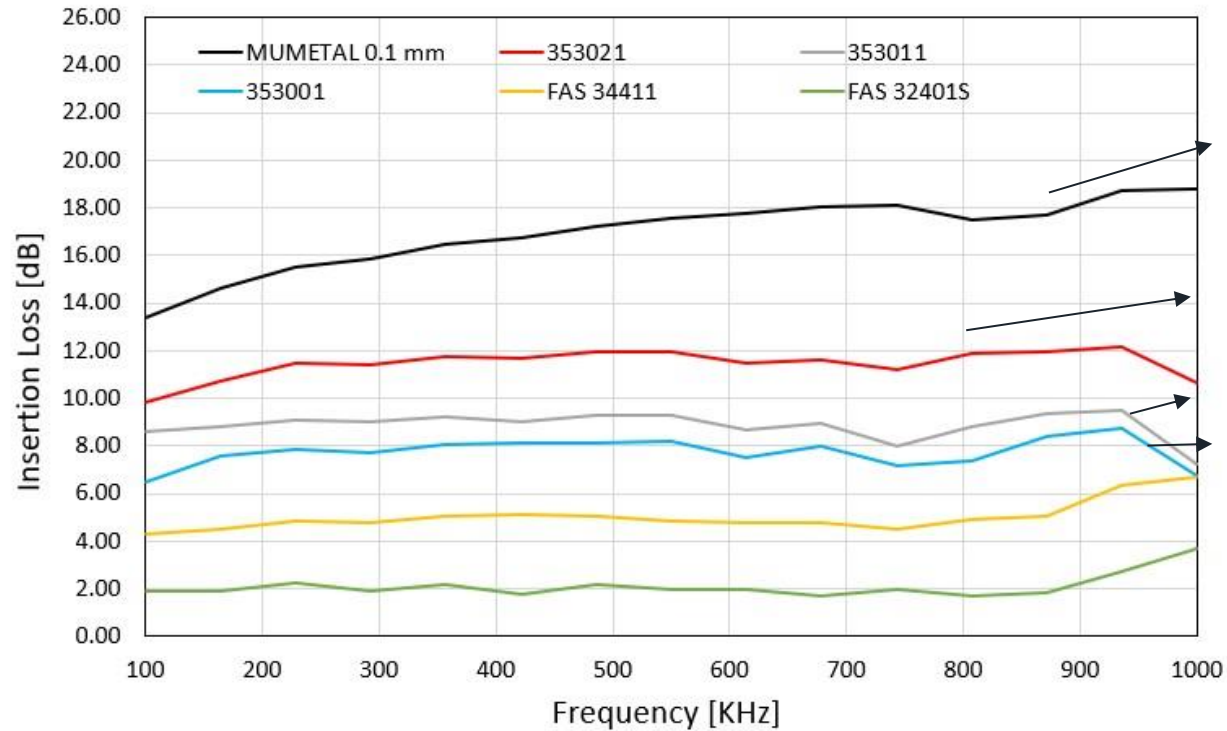
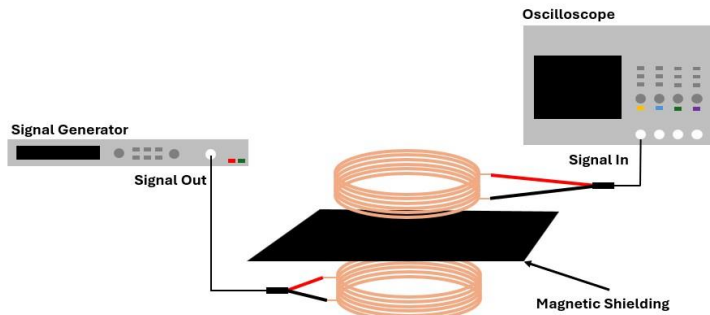
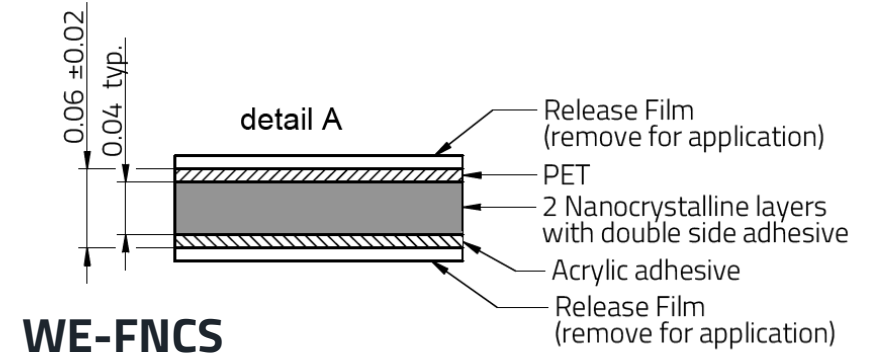
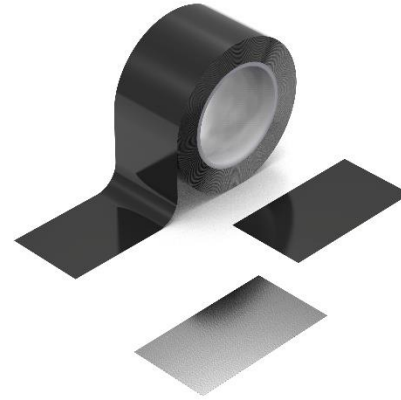
- NC material is not a ferrite material, but an iron-based material with a special crystal structure.
- It is a multilayer material produced by stacking and bonding different layers of nanocrystalline material, providing as result a very thin, light and highly flexible material with high permeability.
- With grain sizes in the nanometer range, typically between 1-100 nm.



# WE-FNCS

## Comparison with conventional solutions

- Insertion Loss, and vs. Nickel-Iron Alloy



Nickel-Iron Alloy ↑ ↑ ↑ €

WE-FNCS ( $\mu'$  10000 @128 kHz)











WE-FNCS ( $\mu'$  2000 @128 kHz)

WE-FNCS ( $\mu'$  1000 @128 kHz)

# WE-FNCS

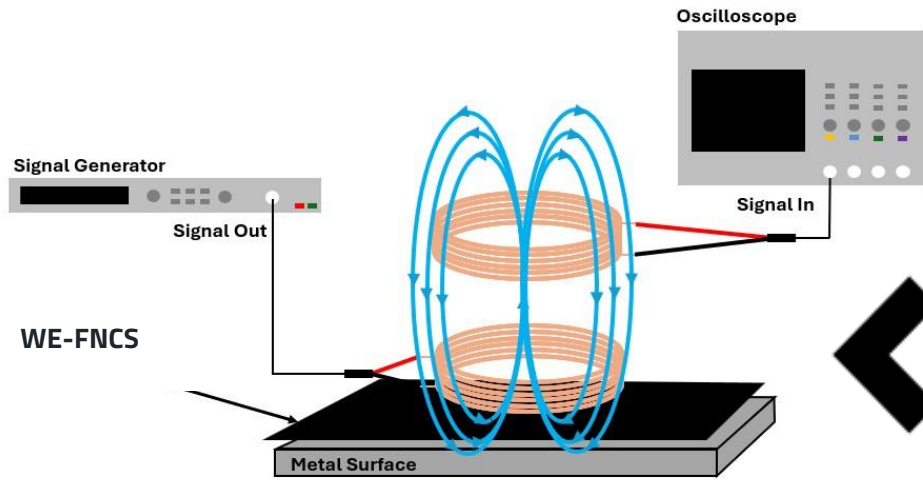
## Comparison with conventional solutions

- Overall, WE-FNCS is a more cost-effective solution, lighter, and easier to handle than the NiFe.

	Competitor	WE-FNCS
<b>Material Base</b>	Nickel-Iron alloy	Nanocrystalline
<b>Frequency range</b>	Low frequencies (Hz-kHz)	Low frequencies (Hz-kHz)
<b>Performance</b>		
<b>Customizable</b>		
<b>Easy to handle</b>		
<b>Weight</b>		
<b>Cost</b>		

# WE-FNCS

## Applications

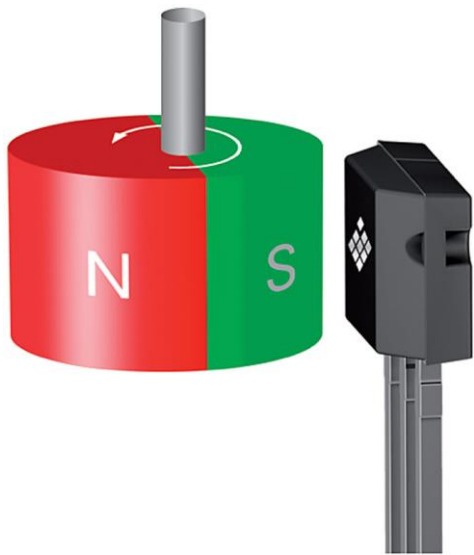


NEW



Wireless Power Efficiency

Common mode chokes



Hall sensor protection against EMI



Medical applications



# **WE** PORTFOLIO

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# EMC Shielding

Filter by values

H | Height



L | Length



W | Width



## EMC Tapes

WE-CF EMC Shielding Tape | WE-TS Shielding Textiles | WE-EMIP EMI Patch



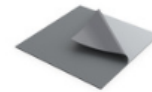
## EMC Gaskets **EXTENDED**

WE-CSGS Contact Spring Gasket | WE-EGS Conductive Elastomer Gasket | WE-LT Conductive Shielding Gasket | + 4 more



## Grounding

WE-SECF SMT EMI Contact Finger | WE-SMGS Surface Mount Solderable Gasket | WE-ST Conductive Ni/Cu glass fiber woven | WE-EEL Earthing Metal Clip | + 1 more



## Magnetic Shielding **EXTENDED**

WE-FAS Flexible Absorber Sheet | WE-FSFS Flexible Sintered Ferrite Sheet | WE-FNCS Flexible Nanocrystalline Sheets | + 2 more



## Board Level Shielding

WE-SHC Shielding Cabinet | WE-SHC Seamless Shielding Cabinet | Shielding Cabinet Clip



## Reference Guides Shielding

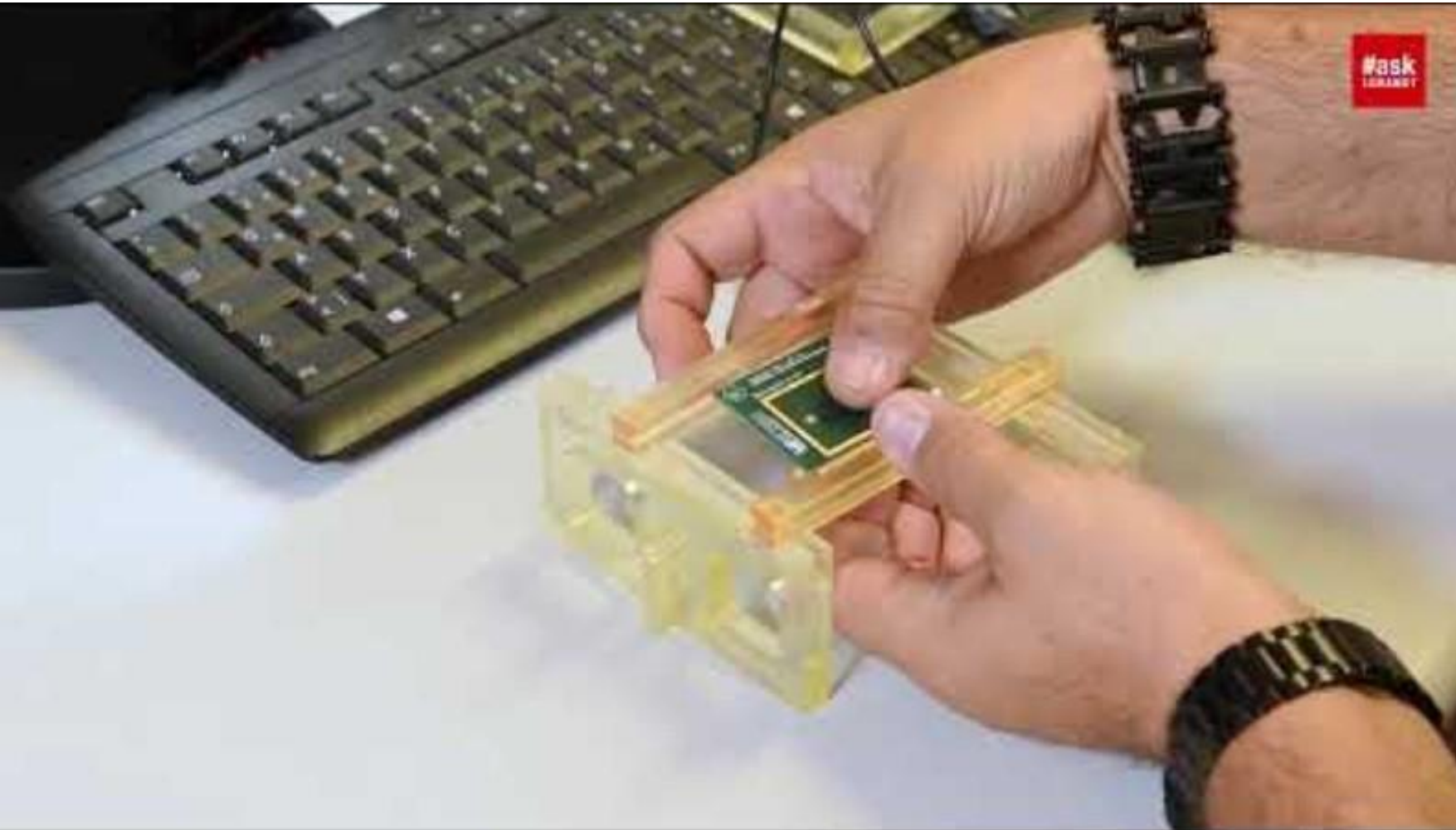
Reference Guide ABC of Shielding English

https://redexpert.we-online.com/we-redexpert/en/#/home

The screenshot displays the WE RedExpert website interface. At the top, the WE logo and 'WÜRTH ELEKTRONIK' are on the left, and 'REDEXPERT' is in the center. A navigation bar on the right includes a shopping cart icon with a '2' notification, a chat icon, and a 'Menu' button. The main content area features a large banner with the text 'Low entry access to electronics design with REDEXPERT'. Below this, there are two main columns: 'Design Tools' and 'Product selection'. The 'Design Tools' column lists various tools like 'EMI Filter Designer', 'Magi<sup>3</sup>C Power Module Designer', and 'Resonance Tank Calculation for Wireless Power'. The 'Product selection' column lists categories such as 'EMC Components', 'Power Inductors and Magnetics', and 'Signal & Communications'. A red dashed arrow points from the 'EMC Shielding & Grounding' category in the 'Product selection' column to a red-bordered inset window. This inset window, titled 'Product selection', shows a list of sub-categories: 'Magnetic Shielding', 'Grounding Contacts', and 'Shielding Gaskets'. A red arrow points from the 'Grounding Contacts' category in the inset to a chat notification bubble in the bottom right corner of the main interface. The chat bubble contains the text: 'Unfortunately, all our chat team members are currently unavailable. Please leave your request and contact details, and your local team will get back to you as soon as possible. Thank you!'.

# SHIELDING

## Design Kit ShieldDIY Custom Shielding Cabinets



### Characteristics

- Do It Yourself Shielding Cabinet, create your own cabinet with this kit.
- Shape your Board Level Shielding.
- Foldable and cuttable with carved lines every 5 mm.
- Material: Nickel Silver. Same performance as the tinplated steel used in the standard cabinets.
- Useful for fast prototyping.



# REFERENCES

## From our website

- [SN026](#): Isolated RS-485 interface based on 4-channel Digital isolator with integrated DC/DC converter.
- [SN028](#): Isolated CAN Interface Based on a 2-Channel Digital Isolator and an Isolated Power Supply Module.
- [ANS021](#): Ensuring Safety without Compromising Data Integrity – Critical Characteristics of Digital Isolators.
- [Industries \(Application\) Guide](#)
- [IC Reference Designs](#)
- [ANS022](#): Bridge capacitor for isolated power modules, the whole truth, no myths.
- [Toolbox](#): Design tools.
- [All Application Notes](#)

# THANK YOU

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Carpov.Pascual@we-online.com