

PIERS in Stockholm
August 12-15th, 2013

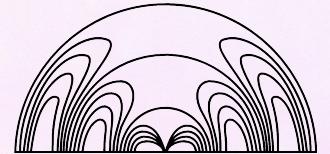
Design of a Single-board Two-port Analyzer for Microwave Dielectrometry

F. Micheletti and R. Olmi

Institute for Applied Physics – National Research Council, IFAC-CNR
Via Madonna del Piano, 10 – Sesto Fiorentino (Firenze), Italy

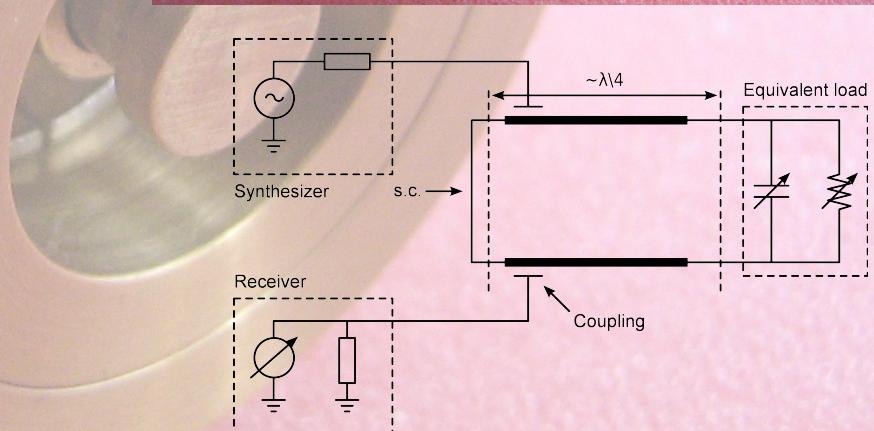
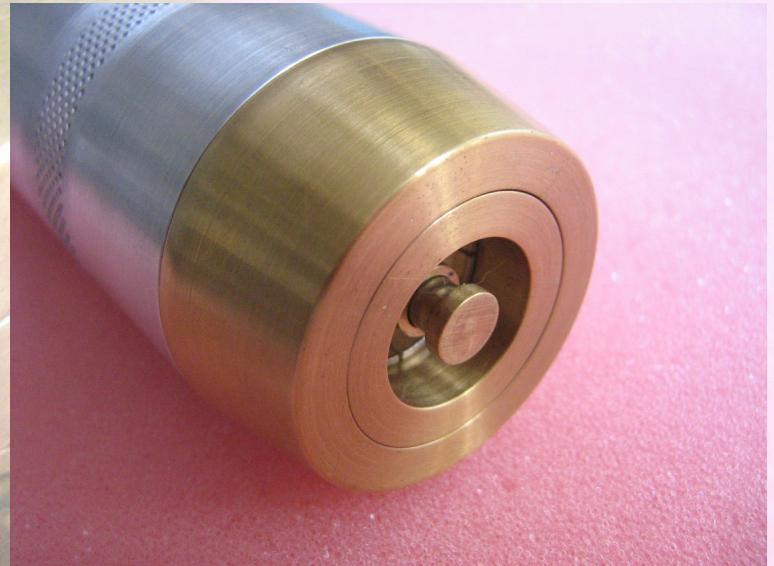


Microwave dielectrometry and SUSI



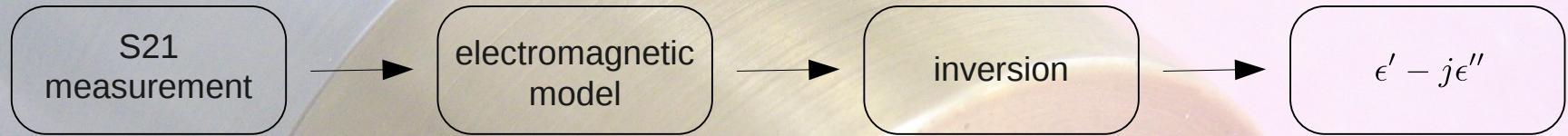
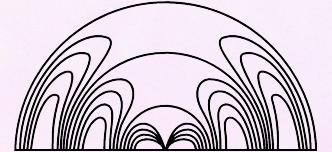
SUSI, Sensore per la misura di Umidità e Salinità Integrato (Moisture and Salt content integrated measurement sensor)

Microwave measurement system based on the transmission coefficient measurement of a two port resonant open-coaxial sensor



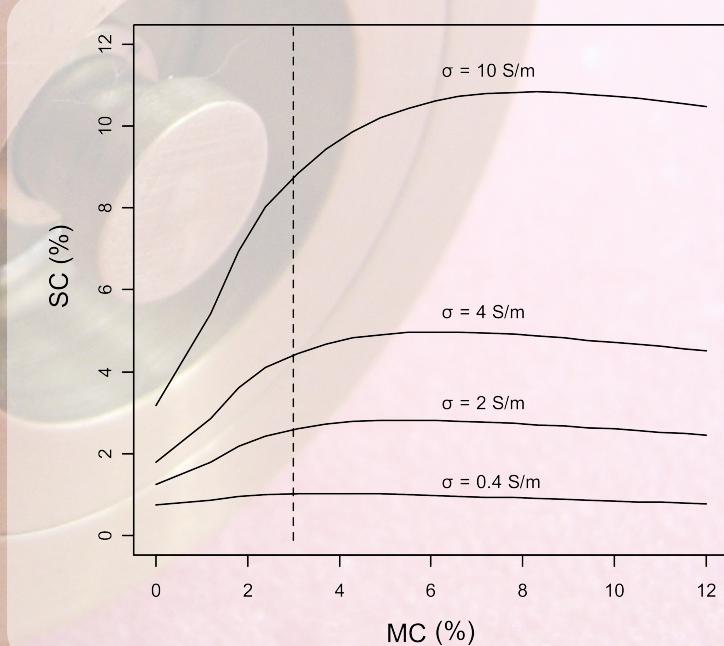
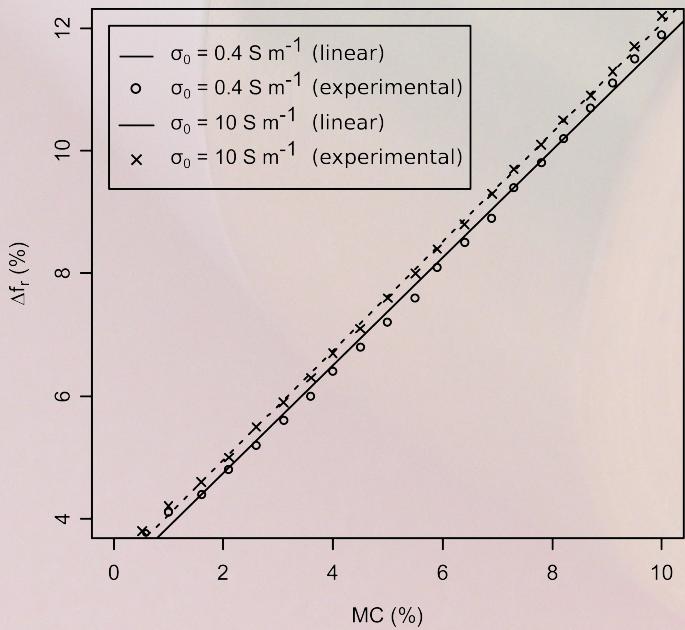
PATENT "Microwave Sensor For Measuring The Moisture Of Masonry Surfaces Comprising A Microstrip Resonator Coupled With An Open Coaxial Probe", US 7,560,937 B2, 2009.

SUSI, working principles

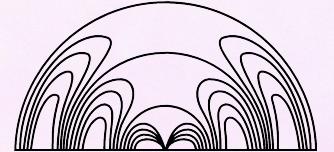


$$MC \propto \Delta f_r = \frac{f_{r_0} - f_r}{f_{r_0}}$$

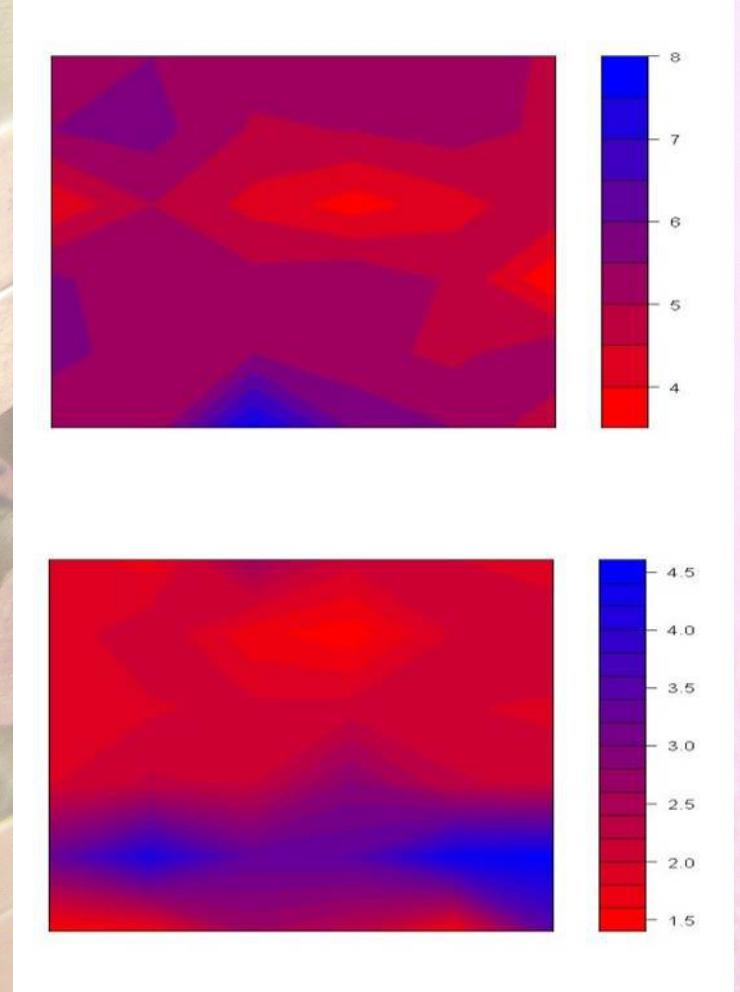
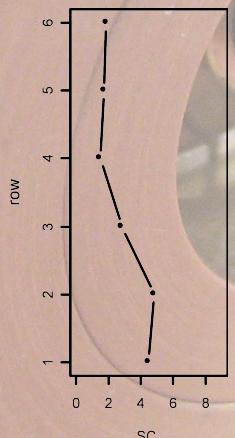
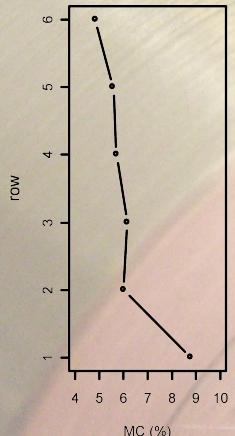
$$SC = \frac{1}{2} (\Delta f_r)^{-2} \frac{f_{r_0}}{f_r} \Delta \left(\frac{1}{Q} \right)$$



SUSI, an operative example



The “Sant’Alessio legend” fresco
at San Clemente Basilica, Rome

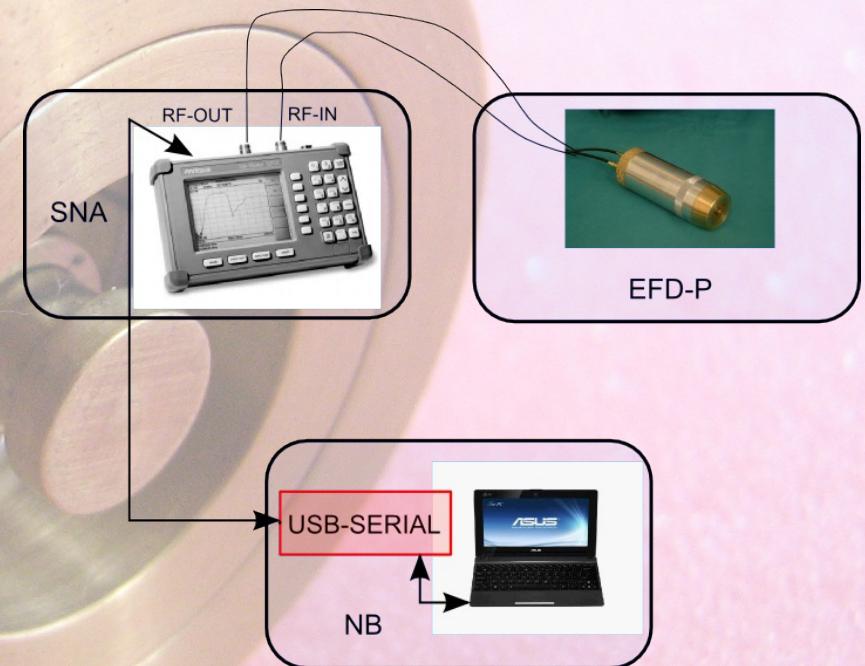


Why a standalone system?



- Size

Reducing size improve **portability** and **usability** the instrument



Why a standalone system?

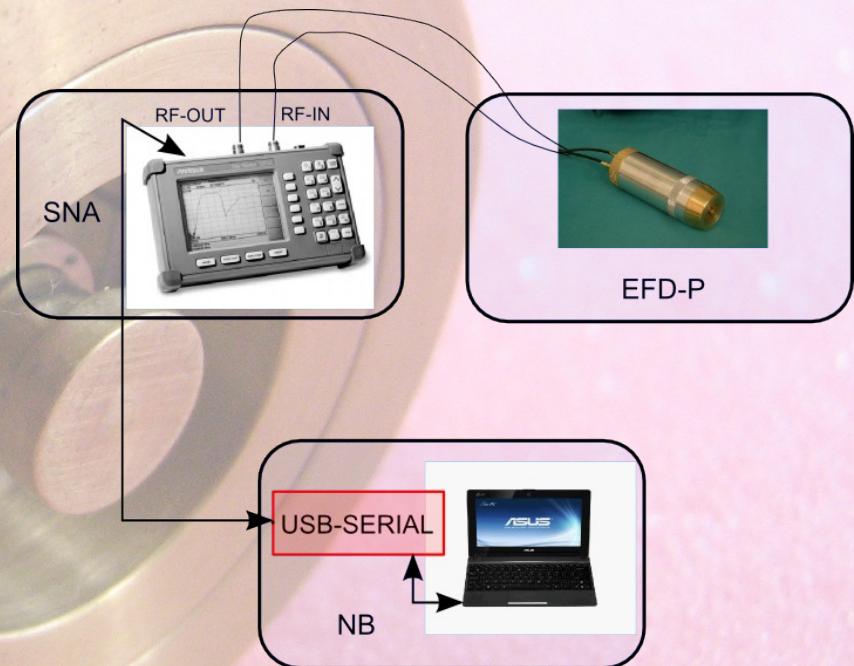


- **Size**

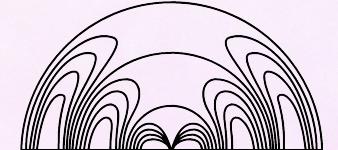
Reducing size improve **portability** and **usability** the instrument

- **Power**

A simpler battery powered instrument allows **long measurement campaign** also in the **absence of the main supply**



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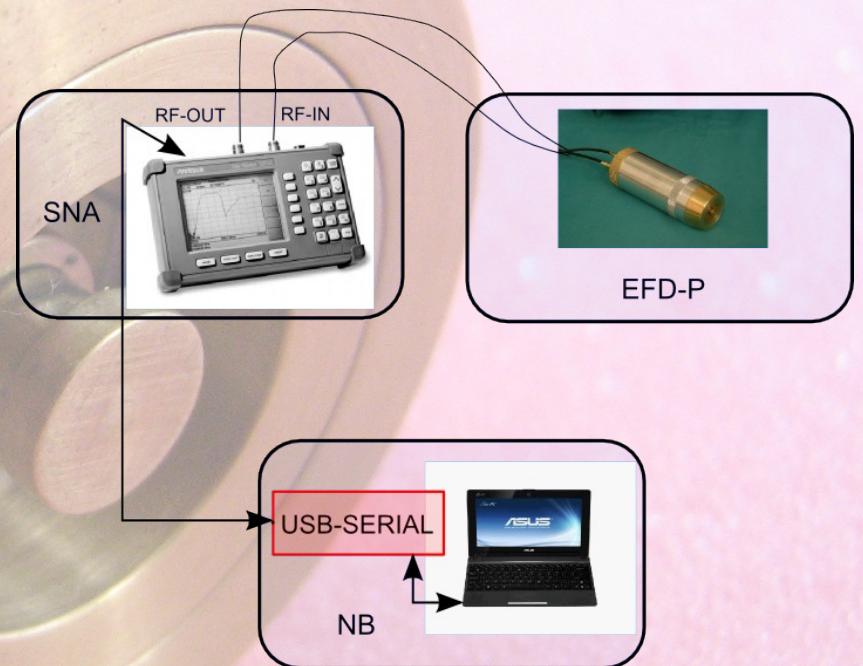
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- **Ease**

An easy-to-use instrument can be used by **non-specialized personnel**



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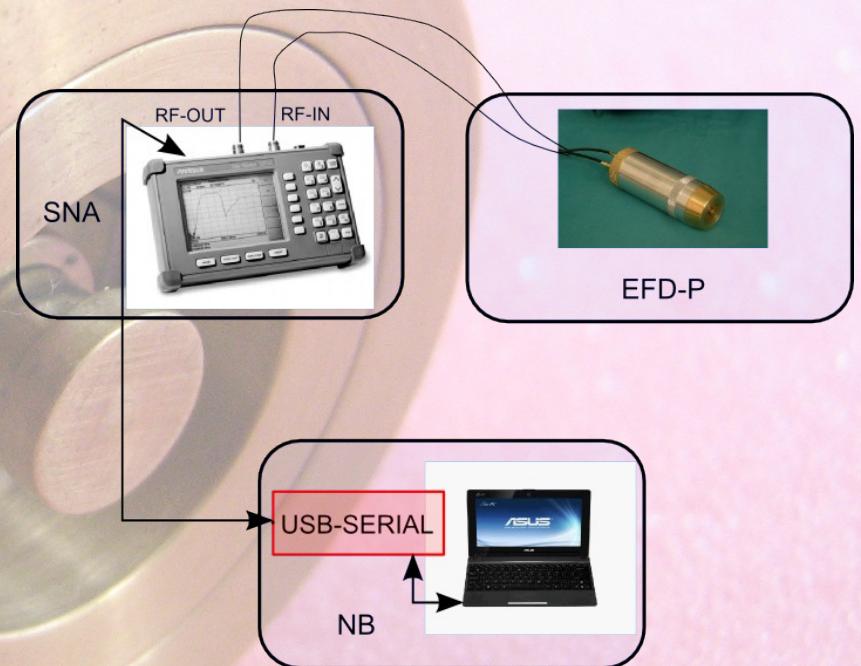
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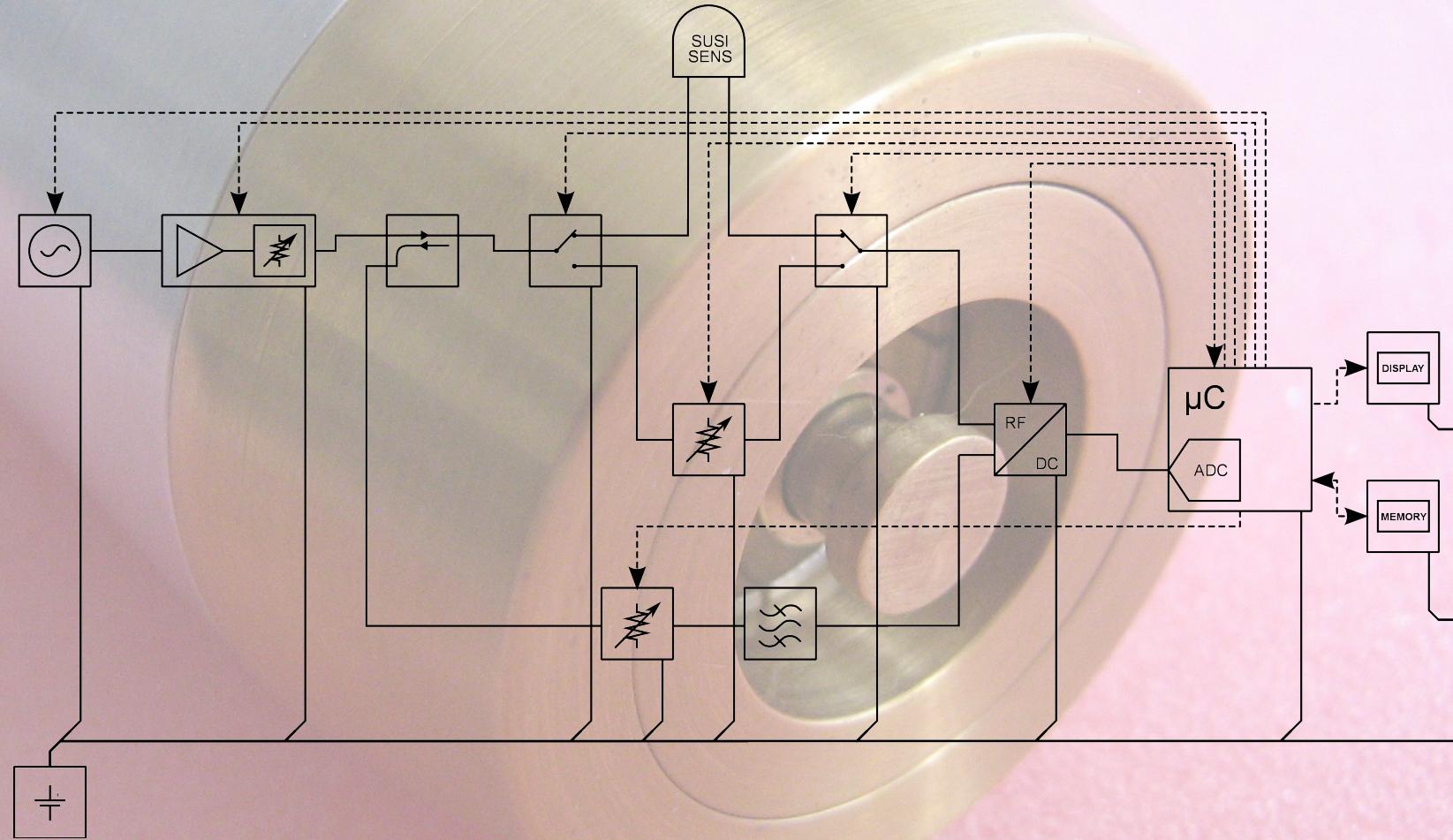
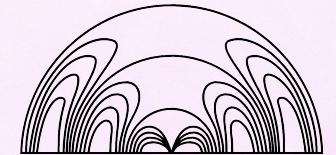
An easy-to-use instrument can be used by **non-specialized personnel**

- **Costs**

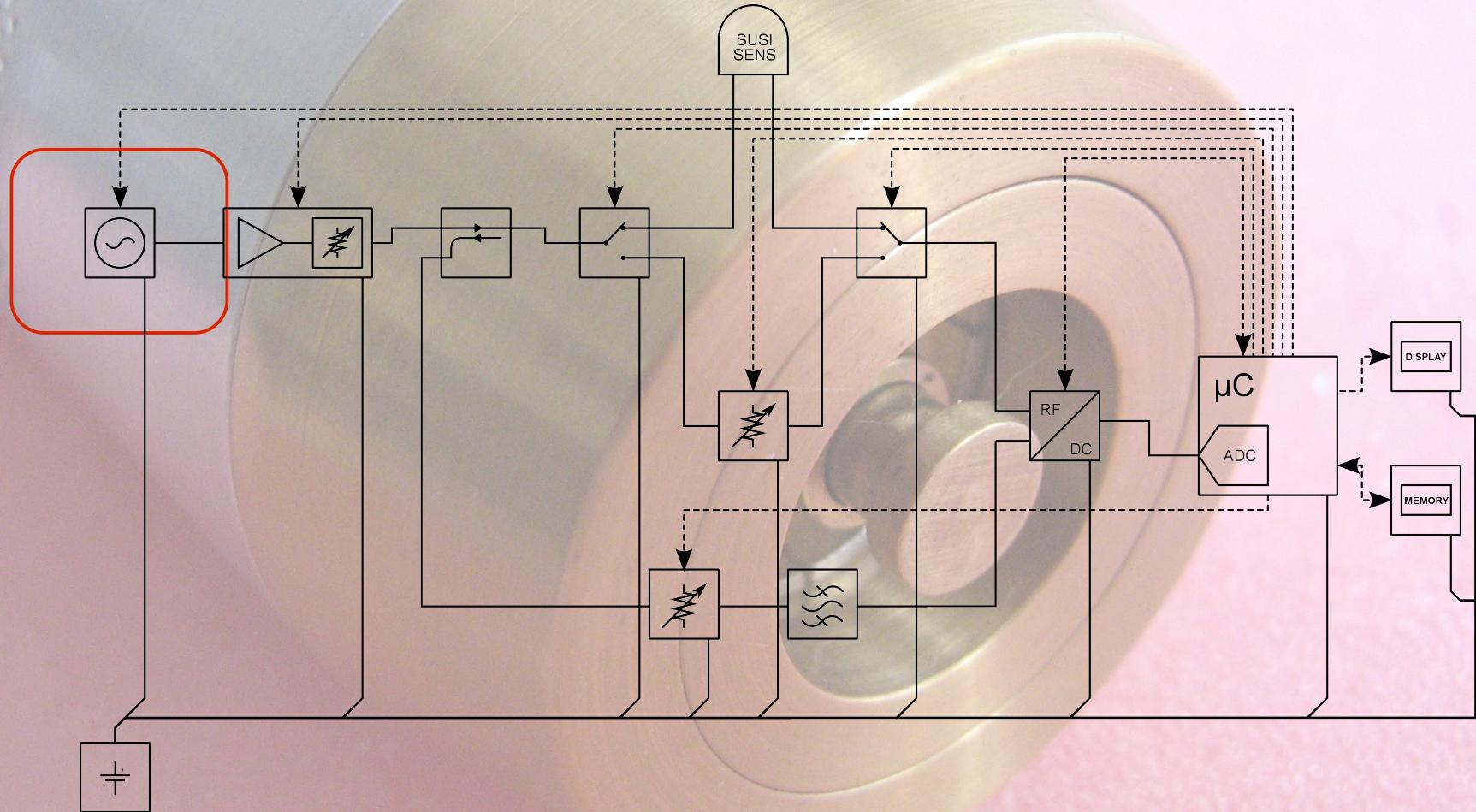
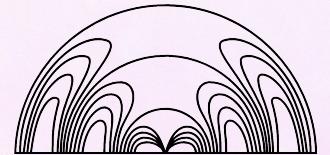
Reducing costs make possible to realize a **commercial instrument**



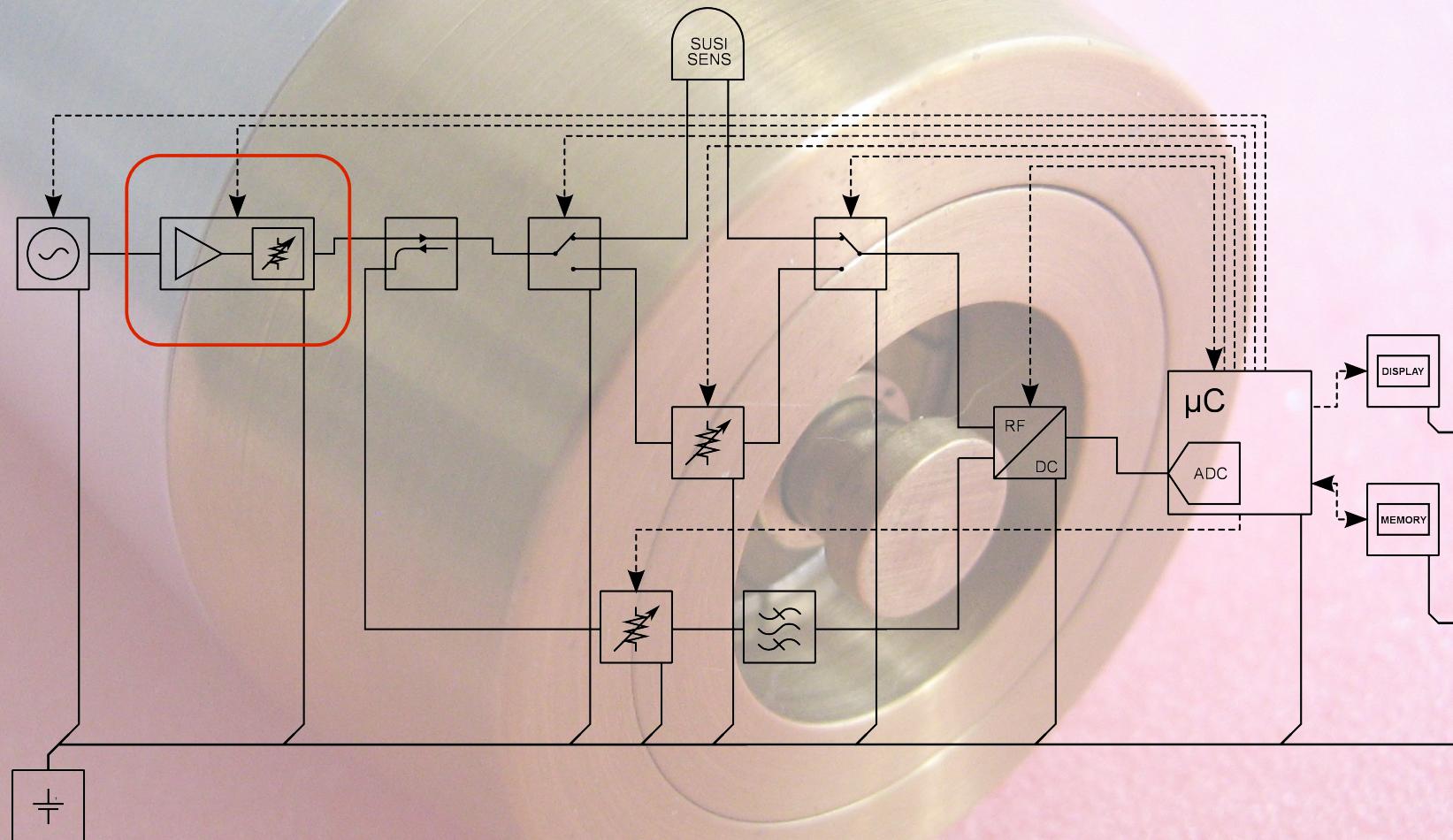
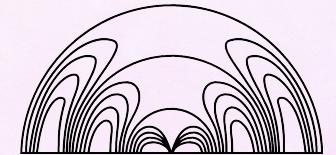
Standalone measurement system blocks



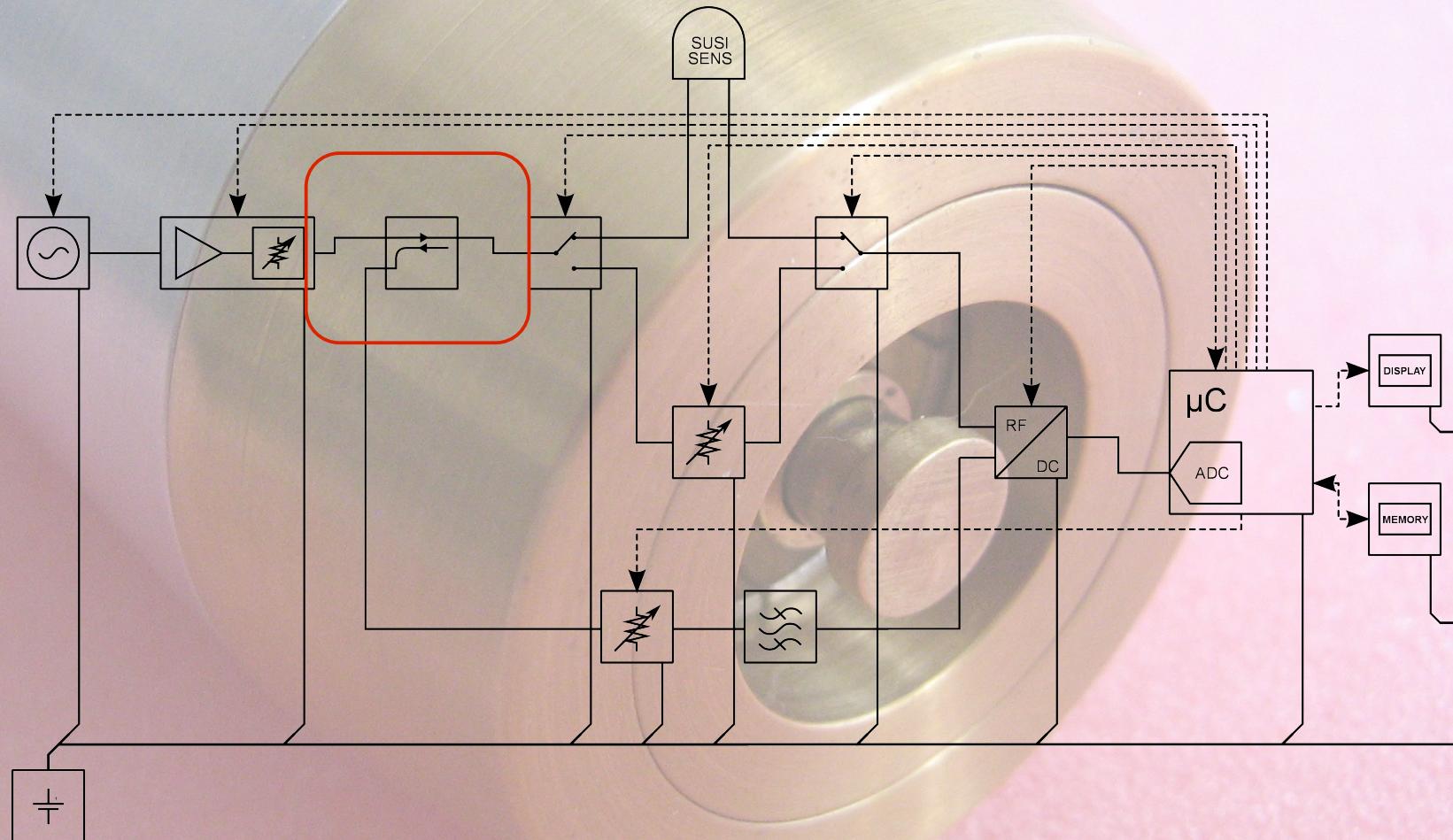
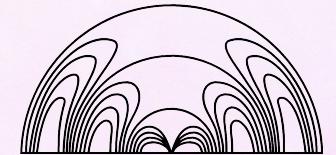
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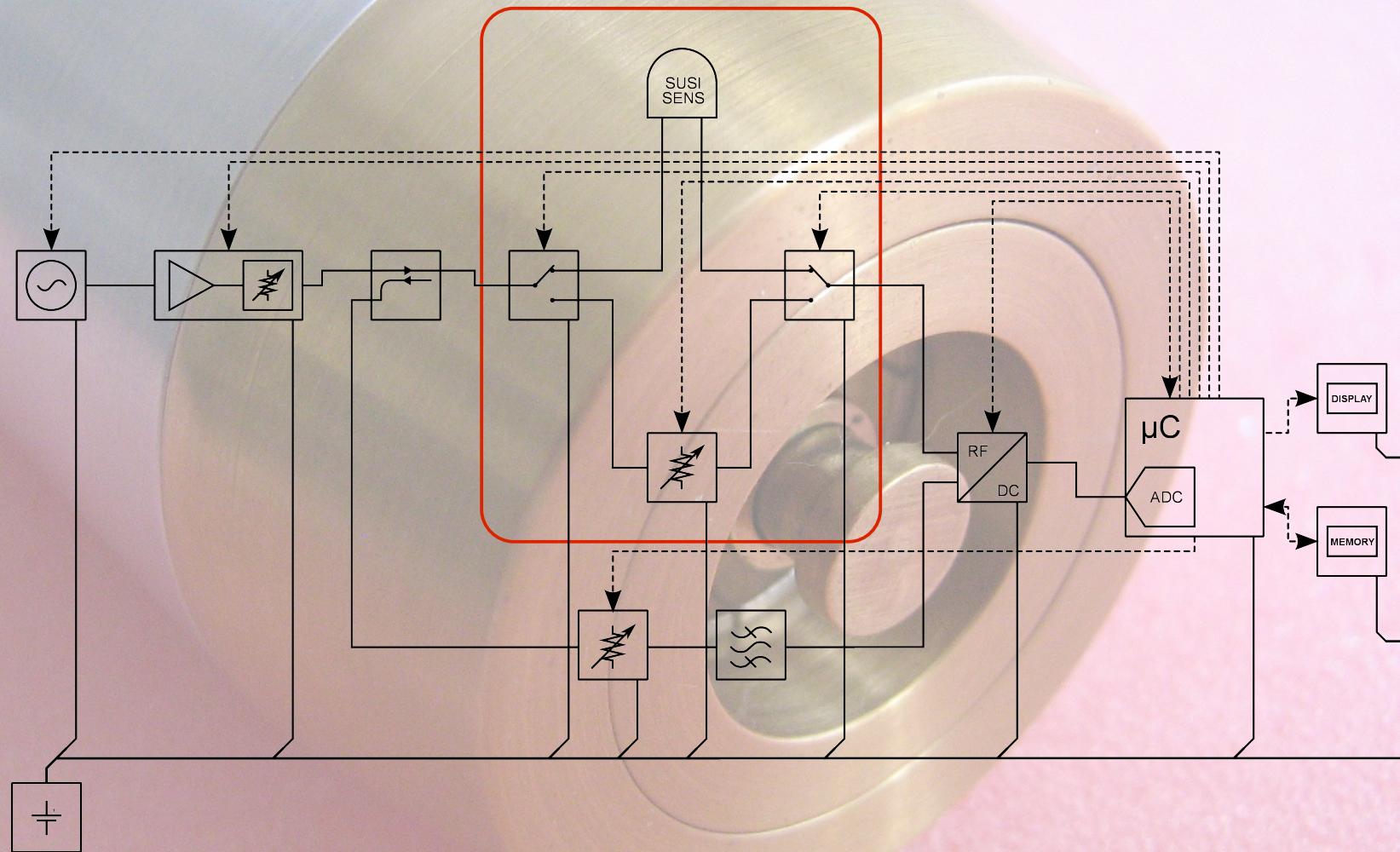
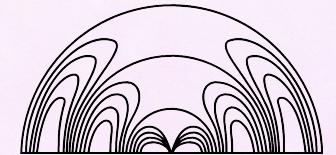
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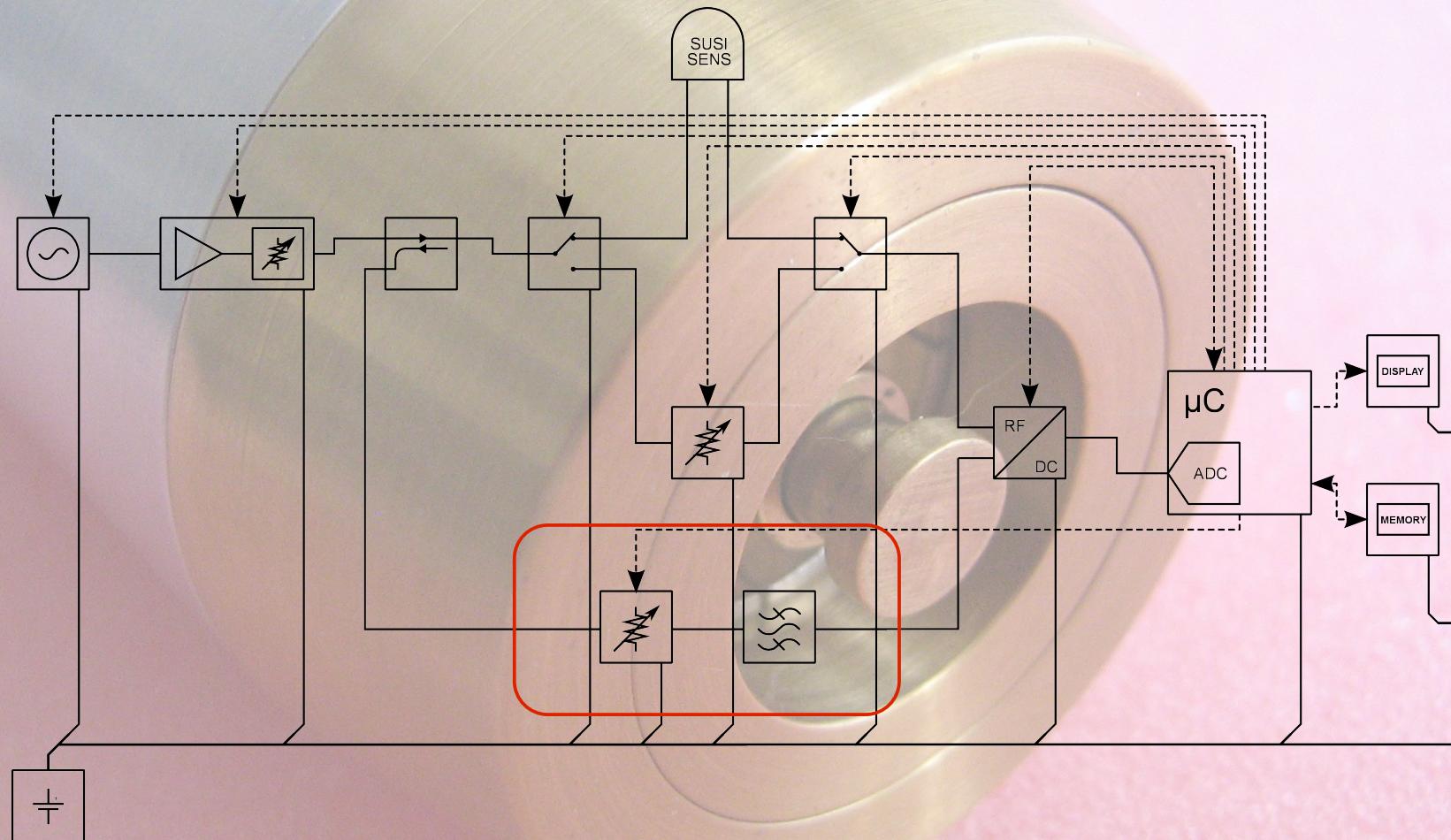
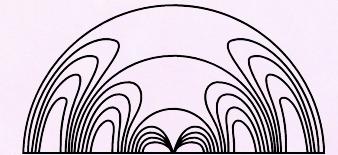
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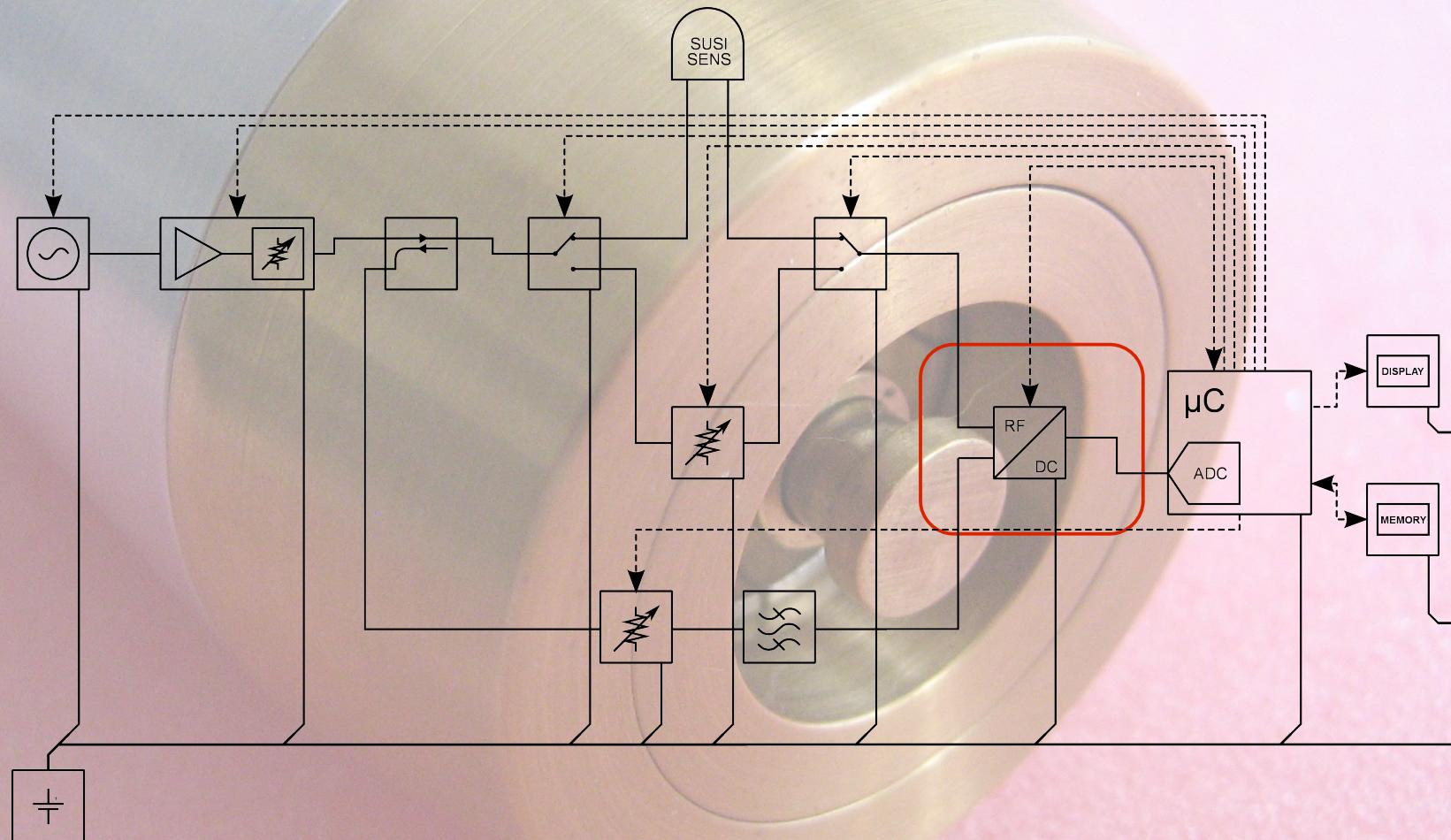
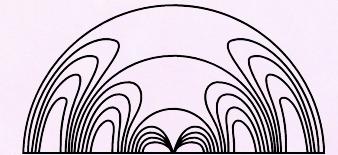
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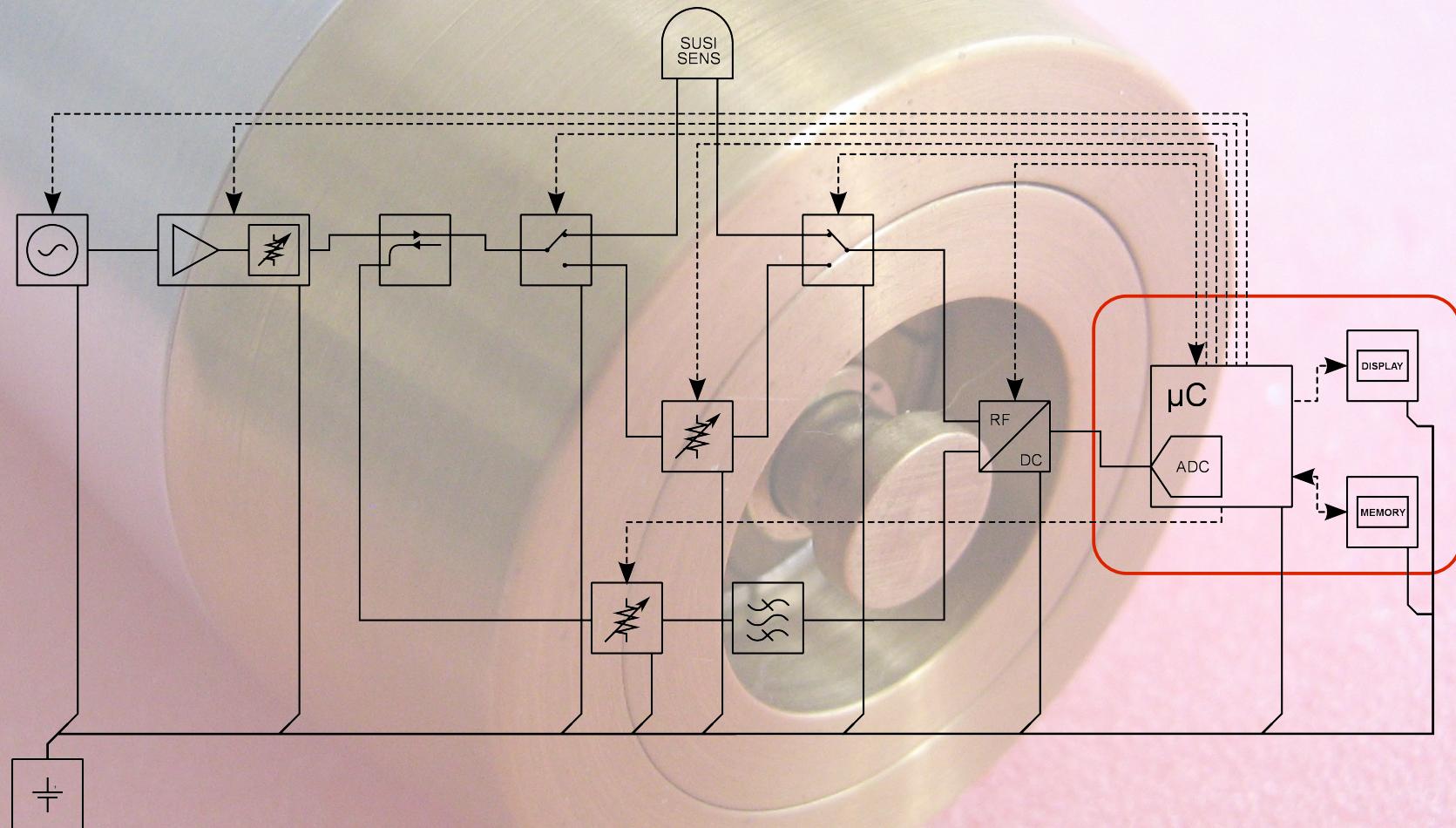
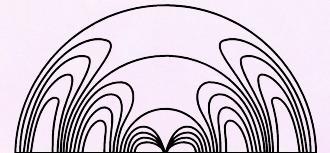
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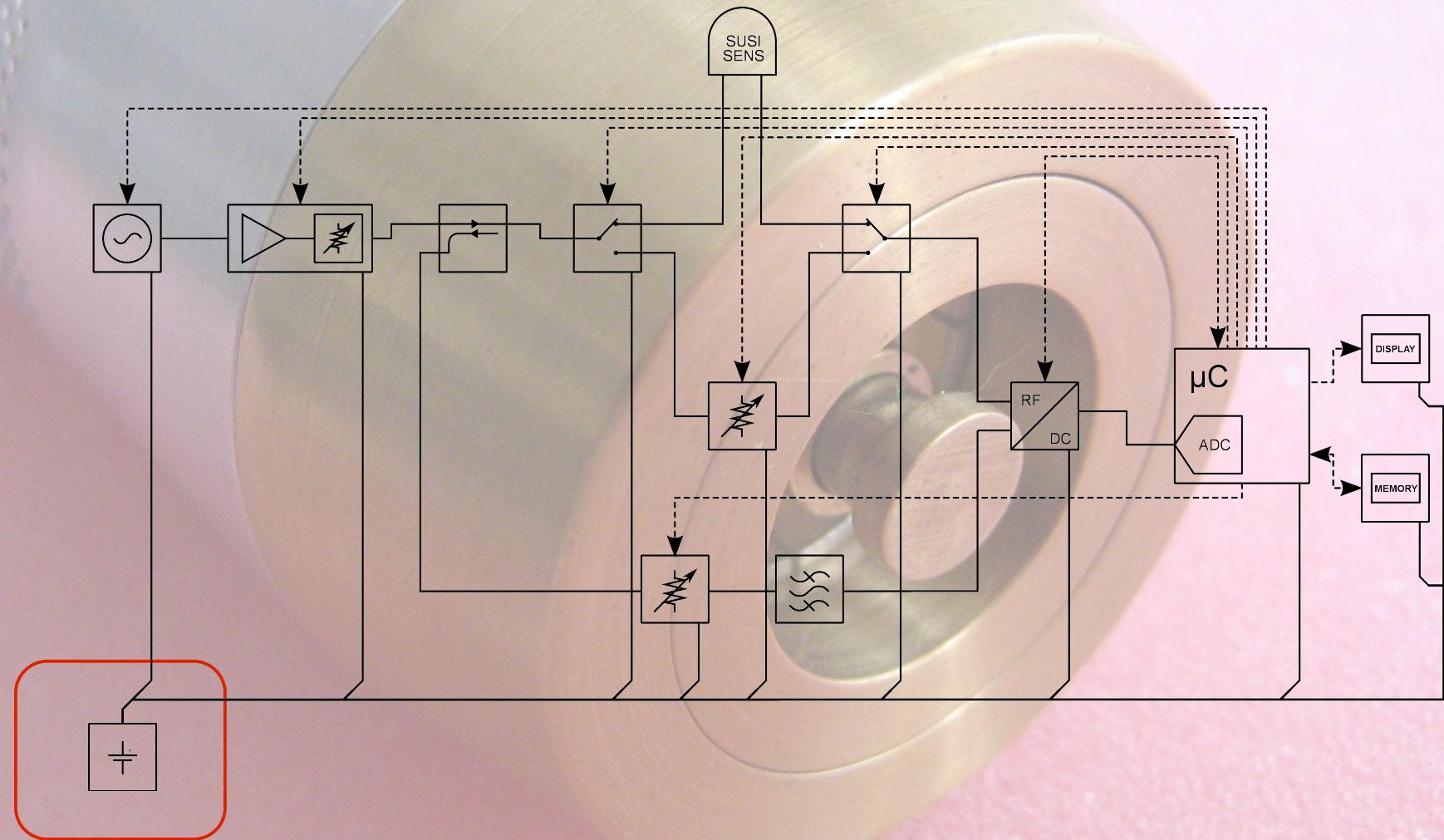
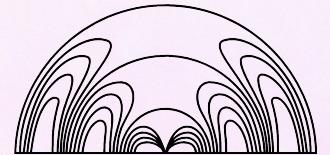
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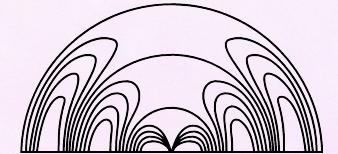
Standalone measurement system blocks



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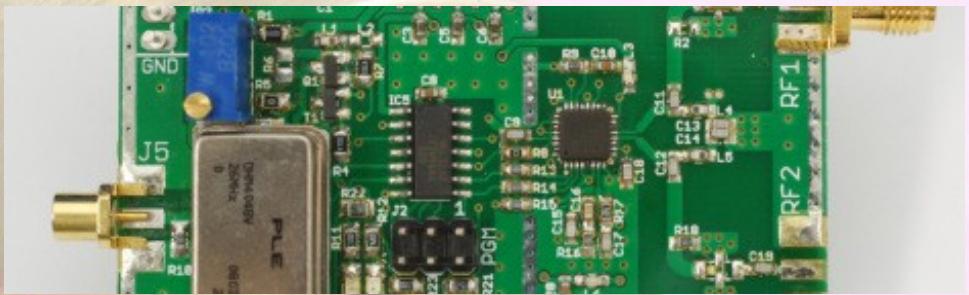
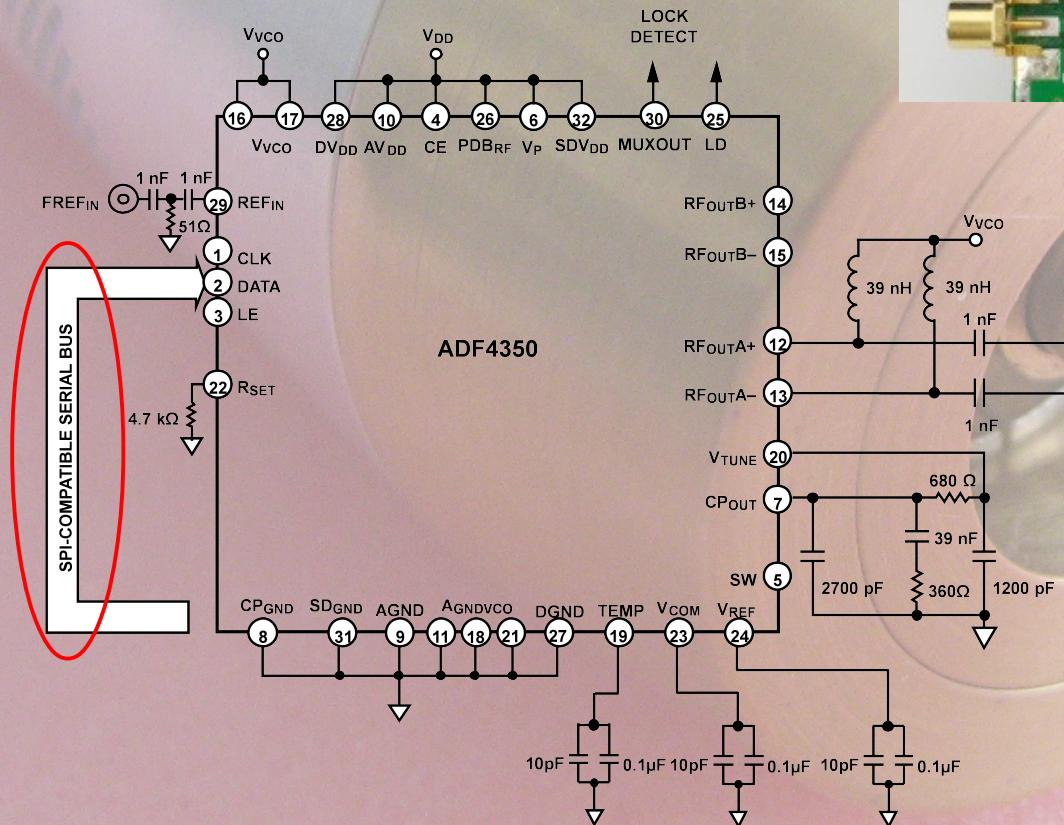


Synthesizer



$$f \in [700, 1400] \text{ MHz}$$

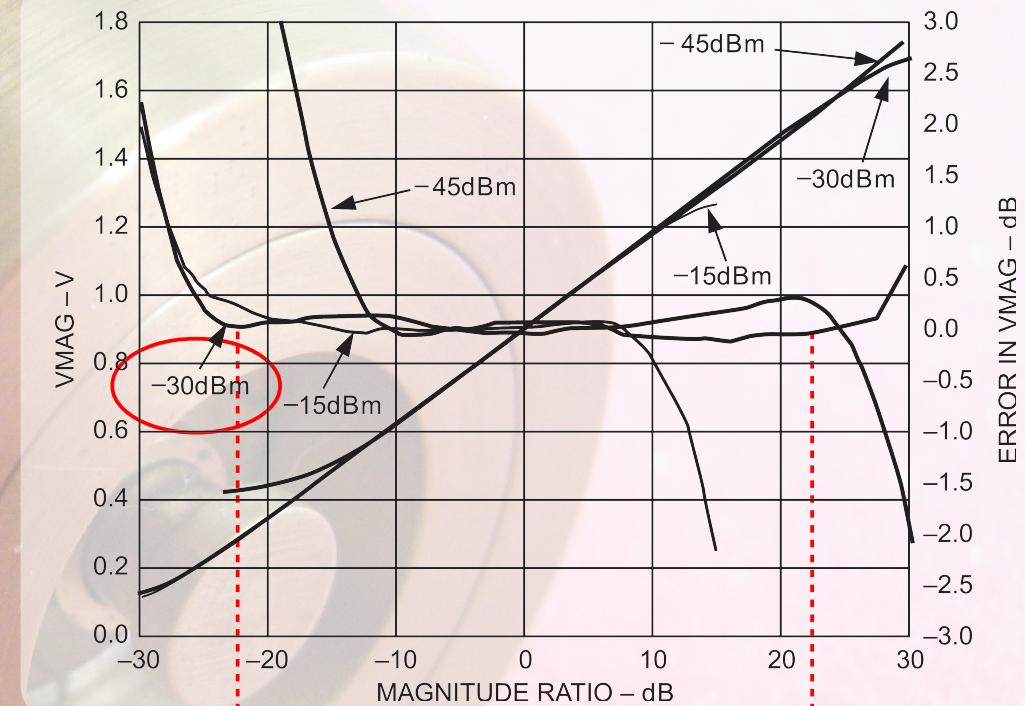
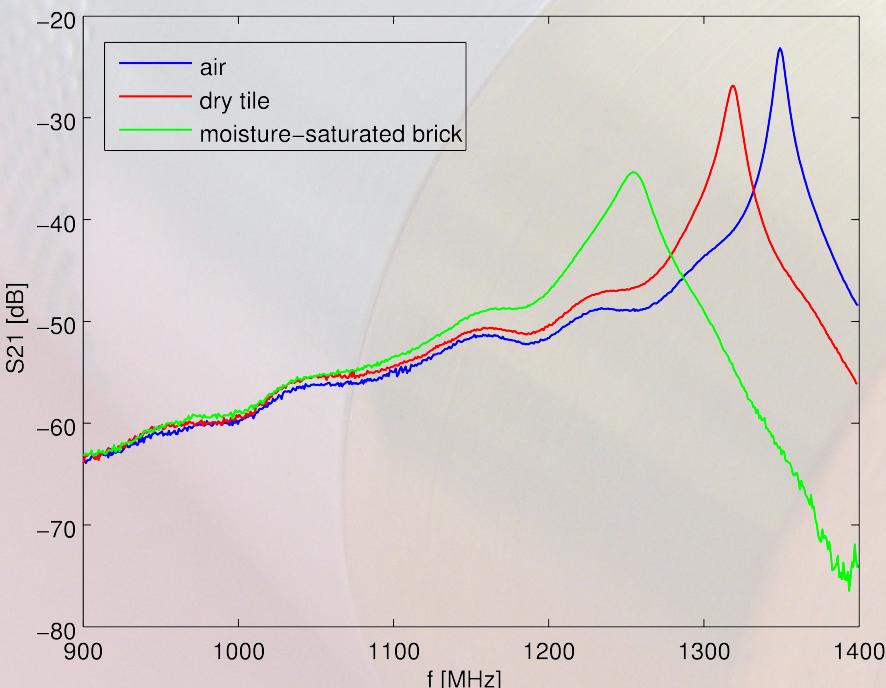
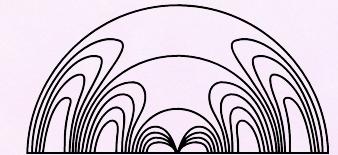
$$P_{in} = 0 \text{ dBm}$$



ADF4350
Wideband fractional N-synthesizer
with integrated VCO
137,5 MHz - 4400 Mhz
-4 dBm - 5 dBm
Supply 3.0 V to 3.6 V



Receiver



$|S_{21}| \in [-65, -25] \text{ dB}$ → peak detection

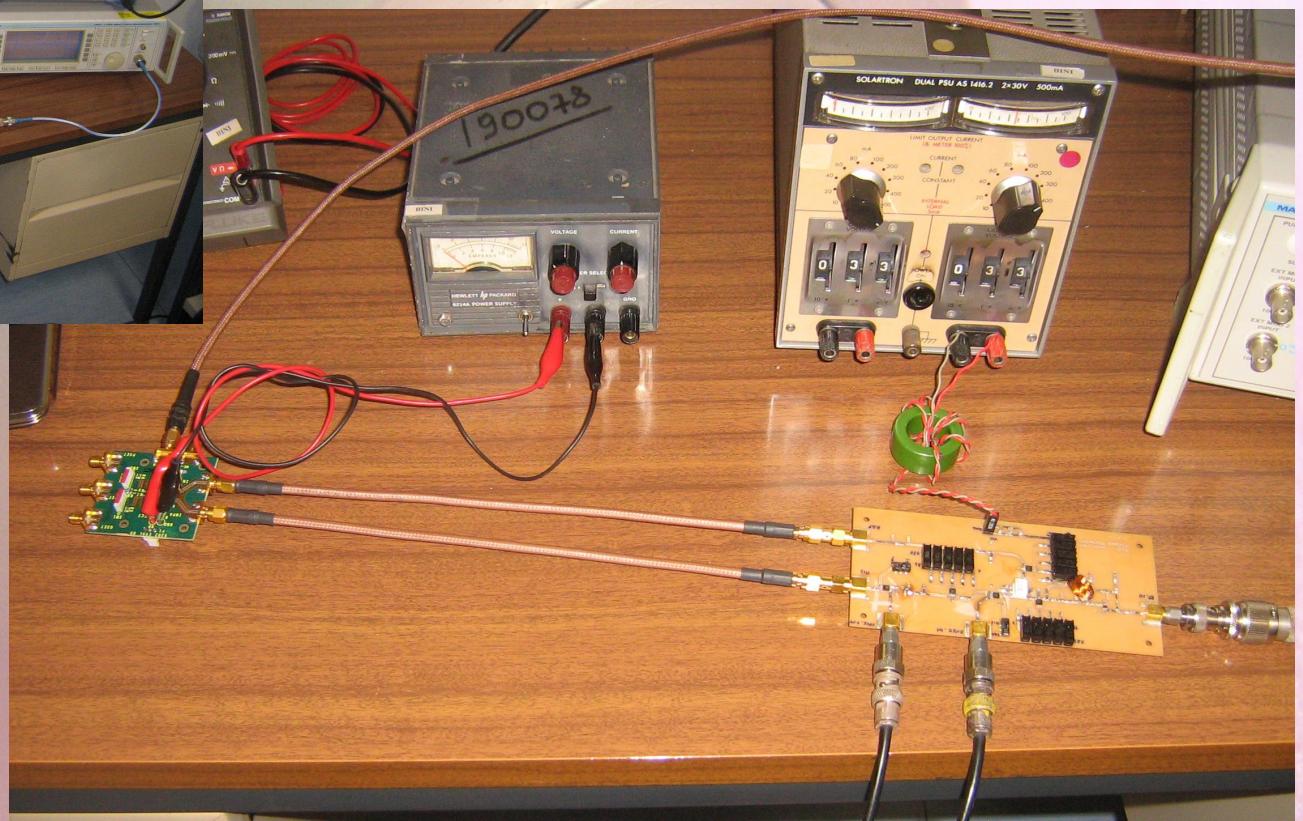
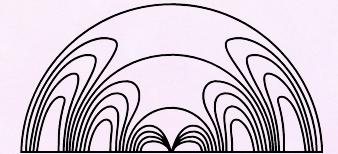
$|S_{21}|_{f_r} \in [-45, -25] \text{ dB}$ → 3 dB measurement

$$DR_{min} = 23 \text{ dB}$$

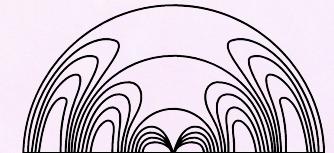
Analog Devices AD8302
Differential Gain/Phase Detector
LF – 2.7 GHz
Supply 3.0 V



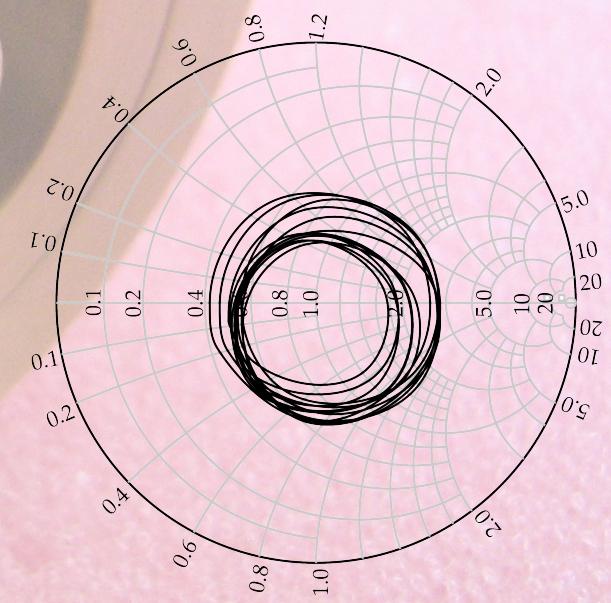
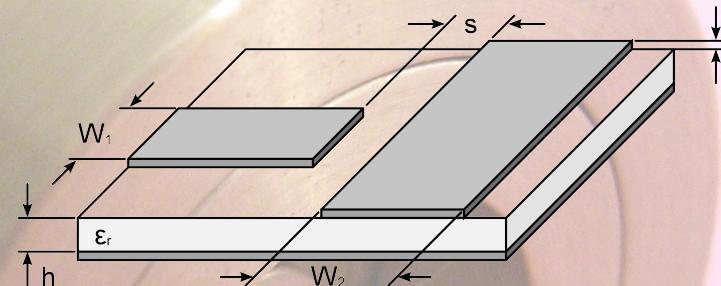
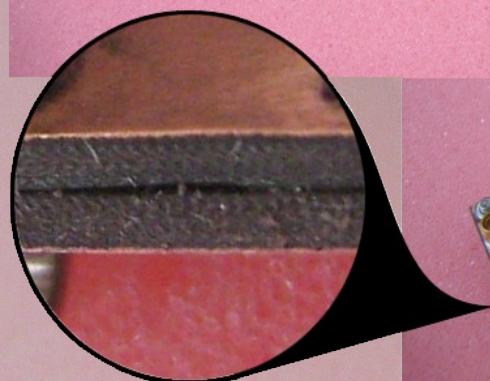
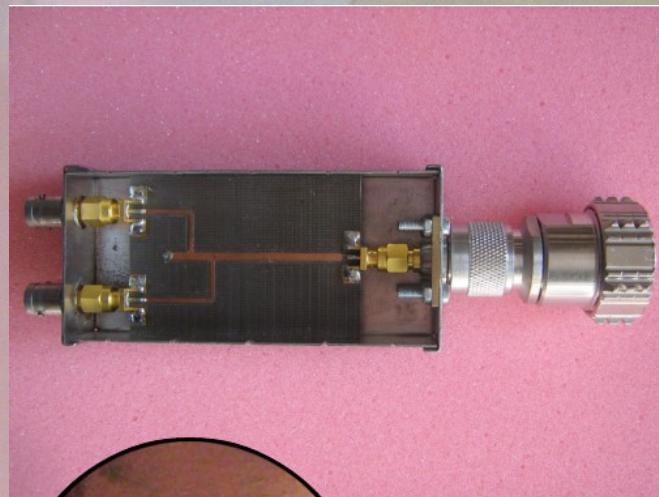
Development of a prototype



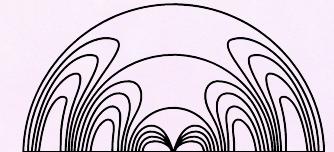
A problem with sensor mismatch



Coplanar gap coupling \Rightarrow mismatch \Rightarrow reflection \Rightarrow **PLL doesn't lock + phase noise**

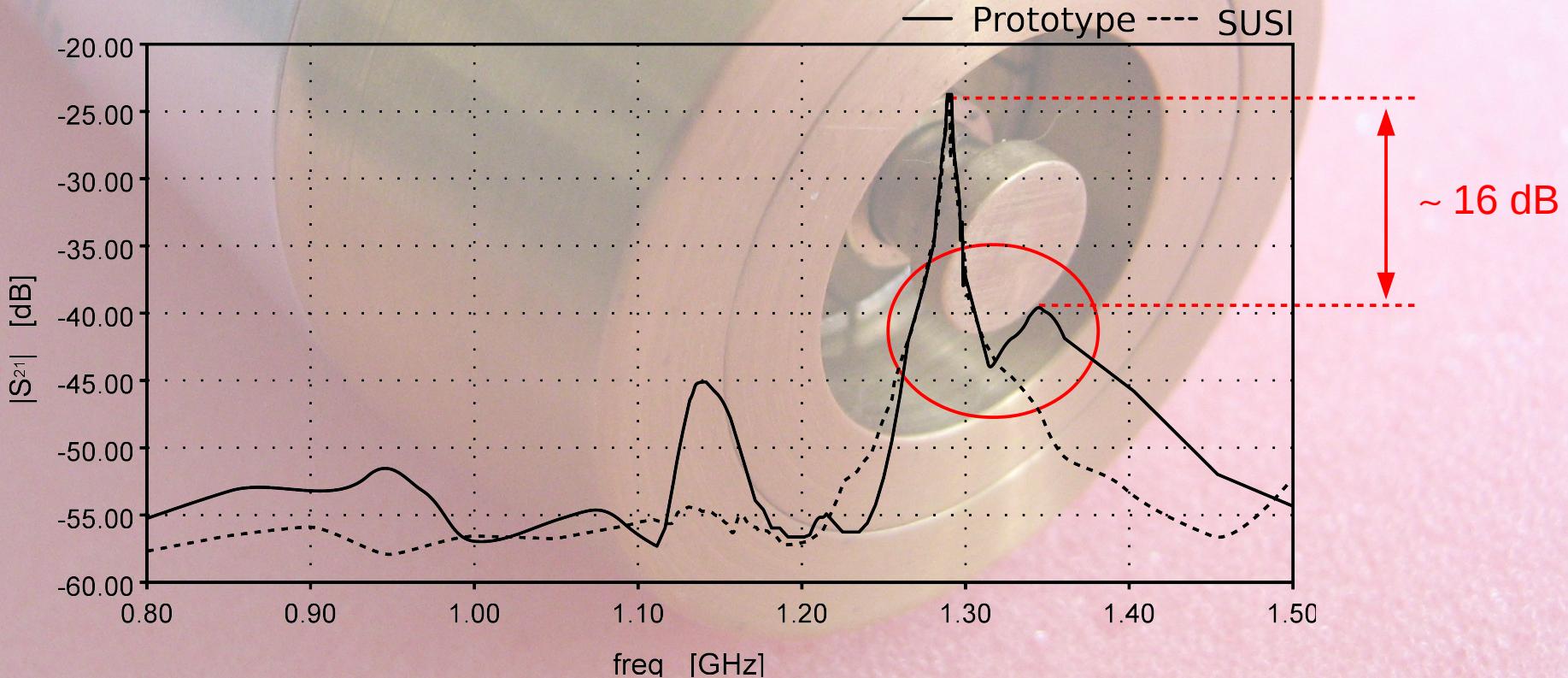


The weak link of the chain: the buffer

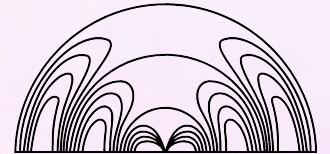


Amplifier + attenuator = RF buffer

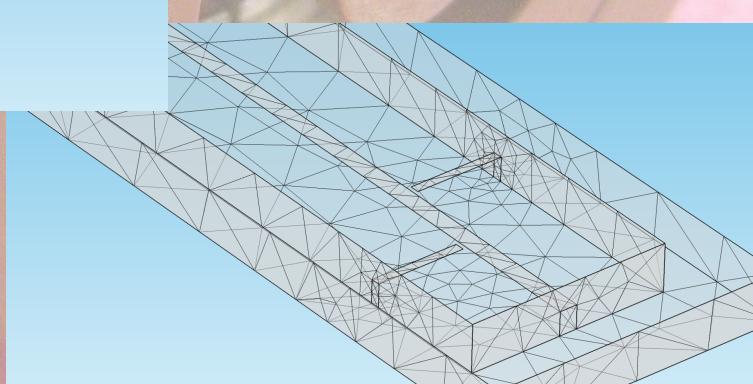
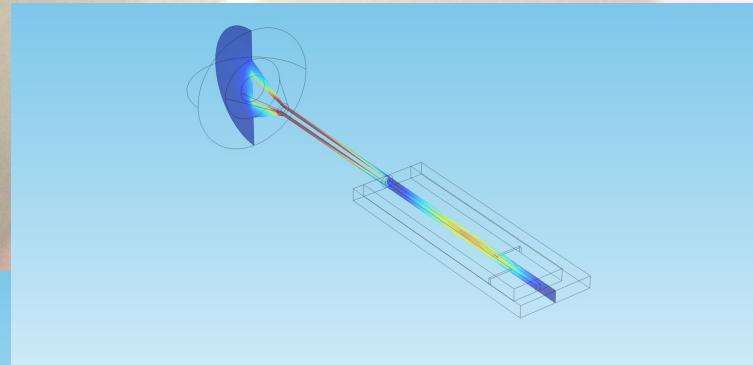
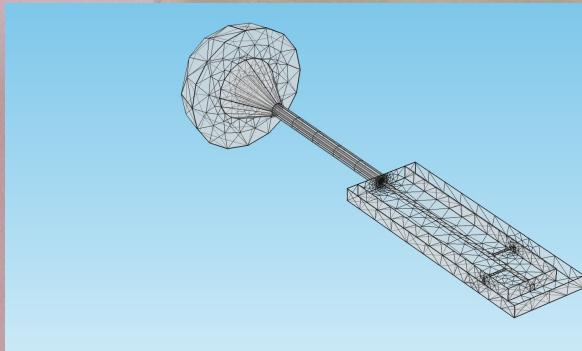
- High “active directivity” (S_{12})
- High linearity (CP1, IP3)
- Wideband
- Gain flatness
- Low voltage and power consumption



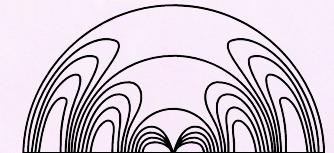
A new sensor approach



Maybe have you seen our poster on monday morning...?



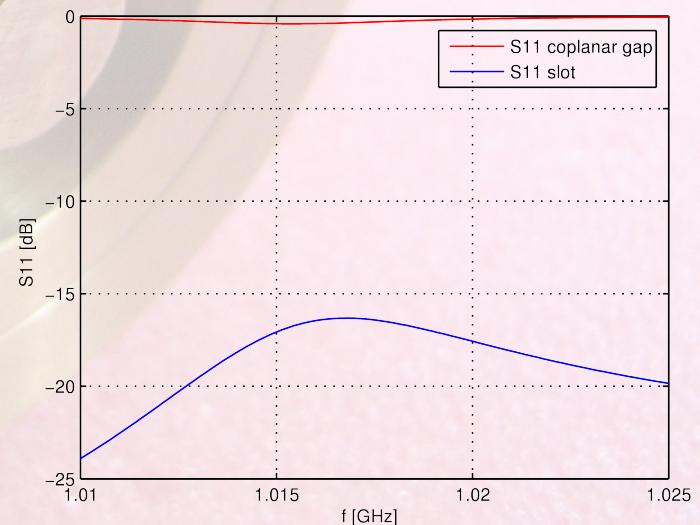
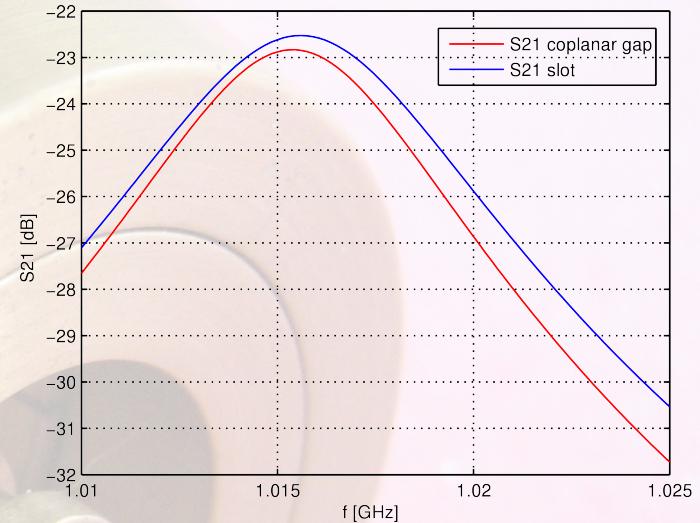
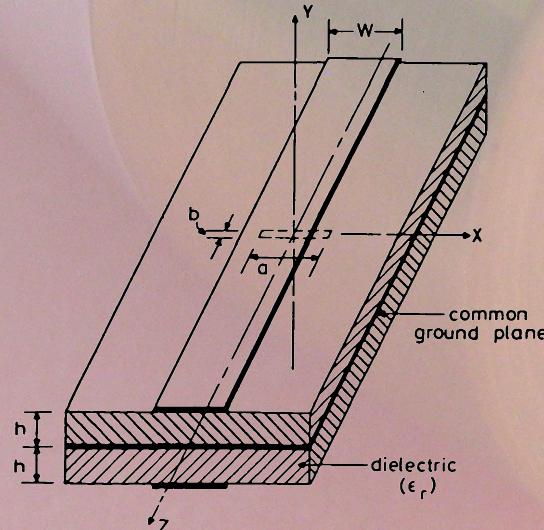
A new sensor approach



Coupling line through a slot on the common ground plane allows to terminate the lines on their characteristic impedance.

$$C = \begin{cases} -20 \log \left(\frac{\pi a^3 \sqrt{\epsilon_{eff}}}{24 w' h} \left(-\epsilon_0 \eta_0 + 2 \frac{\mu}{\eta_0} \right) \right) & a \leq 2b \\ -20 \log \left(\frac{\pi \omega \sqrt{\epsilon_{eff}}}{48 w' h} \left(-\epsilon_0 \eta_0 ab^2 + \frac{\mu}{\eta_0} \frac{a^3}{\ln(4 \frac{a}{b}) - 1} \right) \right) & a > 2b \end{cases}$$

$$w' = \frac{h}{Z_0} \frac{\eta_0}{\sqrt{\epsilon_{eff}}}$$





Thank you
for
your attention