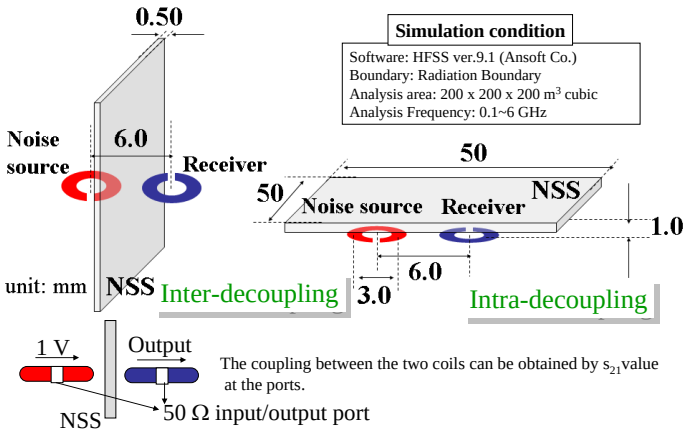
Abstract

This paper discusses how the magnetic characteristics of noise suppression sheet (NSS) work on electromagnetic noise based on 3D FEM electromagnetic field simulations and experiments. At low frequencies NSS shielded electromagnetic noise by its high permeability. Inter-decoupling ratio reaches 5 dB and intra-decoupling ratio is -2~-3 dB which points out that NSS sometimes has noise enhancement effects. At high frequencies, the NSS suppressed the noise by ferromagnetic resonance losses. Inter-decoupling ratio reaches 15 dB and intra-decoupling ratio is about 3 dB.

Simulation models



The coupling between the two coils can be obtained by s_{21} value at the ports.

Back ground

Recent IT devices and equipments become more compact and high speed.

RF electromagnetic noise is serious.

How to suppress the noise?

Noise suppression sheet (NSS)

NSS

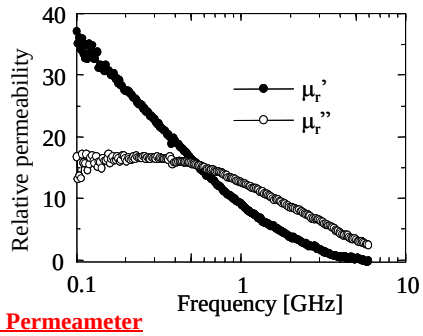
Noise suppression sheets are widely used to suppress electromagnetic noise generated in electronic devices.

M. Sato, S. Yoshida, E. Sugawara, Y. Shimada, *Trans. Magn. Soc. Jpn.*,20(2), 421-424 (1996)

Material profile of NSS

The following material parameters were used in the simulation.

μ_r:
ε_r'=59.8, ε_r"=4.04 (in plane)
ε_r'=8.79, ε_r"=0.710 (thickness direction)
σ=2.00 x 10^{-3} [S/m]



Measured by 9GHz Permeameter

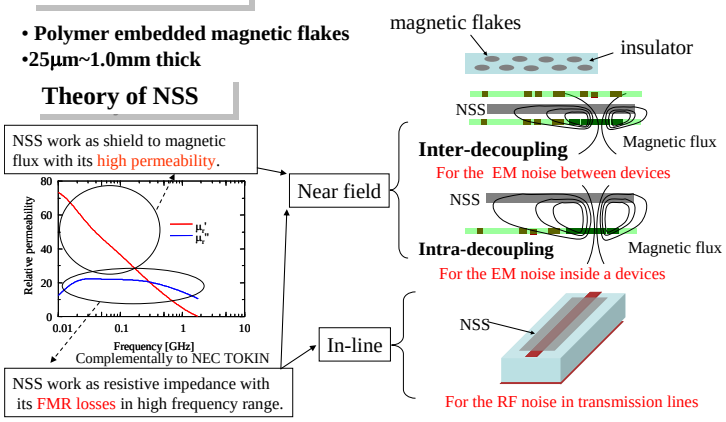
Masahiro Yamaguchi, Yasunori Miyazawa, Katsuji Kaminishi, Ken-Ichi Arai, *Trans. Magn. Soc. Jpn.* 3, 137-140 (2003).

Structure and RF property of NSS

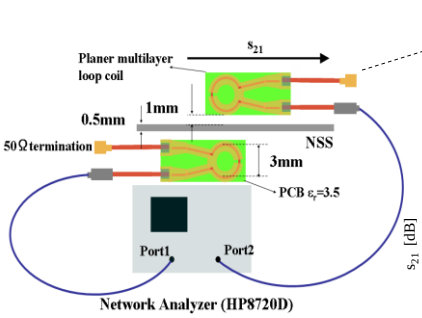
Structure of NSS

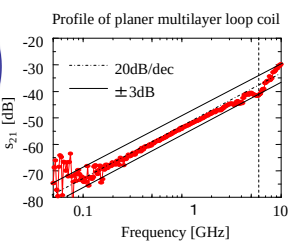
- **Polymer embedded magnetic flakes**
- **25μm~1.0mm thick**

Theory of NSS



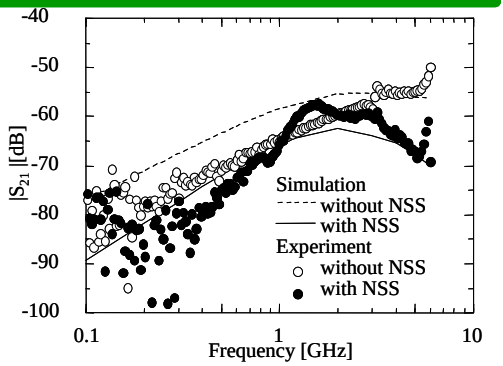
Experimental Setup





This planer multilayer loop coil exhibits 20 dB/dec ±3.0 dB output up to 10 GHz

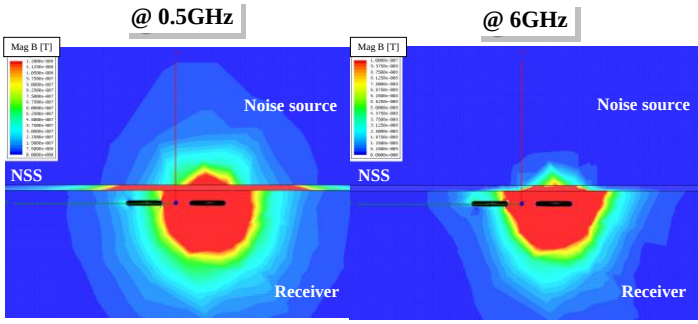
Inter-decoupling -Simulated $|s_{21}|$ and measured $|s_{21}|$-



Simulation: Noise suppression ratio was over 10dB in this range.
Experiment: Noise was suppressed by several dB except 1~2 GHz range.

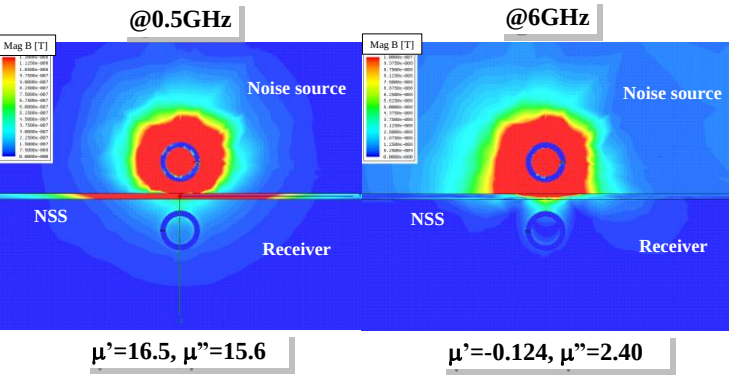
Measured profile deviated from simulated one and a peak appeared in the 1~2 GHz range, both are due to the cables and connectors associated with NSS

Intra-decoupling -Distribution of magnetic flux-



@0.5GHz: The flux linkage at the receiver coil was high by the magnetic shielding of the NSS
@6GHz: The flux linkage at the receiver coil became low.

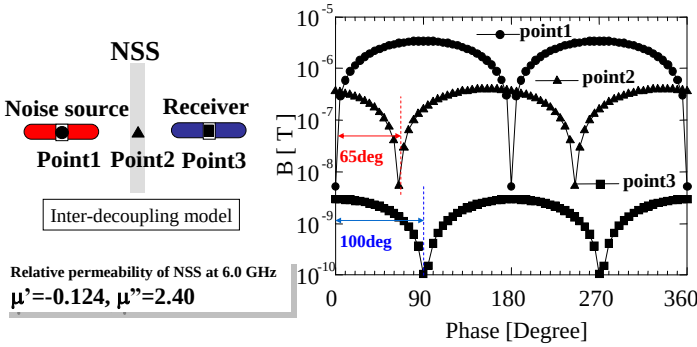
Inter-decoupling -Distribution of magnetic flux-



@0.5GHz: The flux linkage at receiver coil became low by the magnetic shielding of the NSS
@6GHz: The flux was not so shielded in the NSS, but the flux linkage at receiver coil became low.

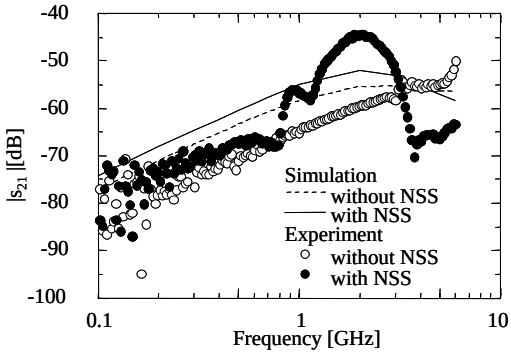
Effect of μ_r"

Check the phase and intensity of magnetic flux in an inter-decoupling model at 6.0 GHz.



The phase of magnetic flux gradually shifted from the NSS to the receiver coil.
This means that magnetic flux was greatly influenced by the μ_r" in the high frequency range.

Intra-decoupling -Simulated $|s_{21}|$ and measured $|s_{21}|$-



Simulation and Experiment:
Noise was enhanced by several dB up to 4GHz , in the higher frequency range noise was suppressed by several dB.
Measured profile deviated from simulated one and a peak appeared in the 1~3 GHz range, both are due to the cables and connectors associated with NSS

Conclusion

•Up to the FMR frequency , inter-decoupling ratio was about 5 dB, and intra-decoupling ratio was -2~ -3 dB, which meant the noise power was not always negative.

•Above the FMR frequency, both inter- and intra- decoupling ratio were over 3 dB due to FMR losses.

•The highly accurate discusses about the characteristics of the NSS will be possible by improvement of the experimental setup.