Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Propagation Characteristics for Intra-Device Comunications

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Abstract: This contribution presents first results on measuing basic propagation charcteristics for short-range intra-device communication at 60 GHz and 300 GHz

Purpose: Information of IEEE 802.15 SG 100G

Propagation Characteristics for Intra-Device Communications at 60 GHz and 300 GHz

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Scope

- Capacity to transfer data between circuits or chips suffers from limitation of using cables
- RF/Wireless connections are proposed, e. g. in [1]
- Demand for high throughput of several Gbit/s
- Carrier frequencies in the millimeter or sub millimeter domain are suitable to provide enough bandwidth
- Multipath propagation within devices may become relevant
- Measurement and modeling of basic propagation characteristics in intra- and inter-device communication is required.
- This contribution presents first results based on [2] and [3].

Reflection and Transmission Properties of Plastic Materials

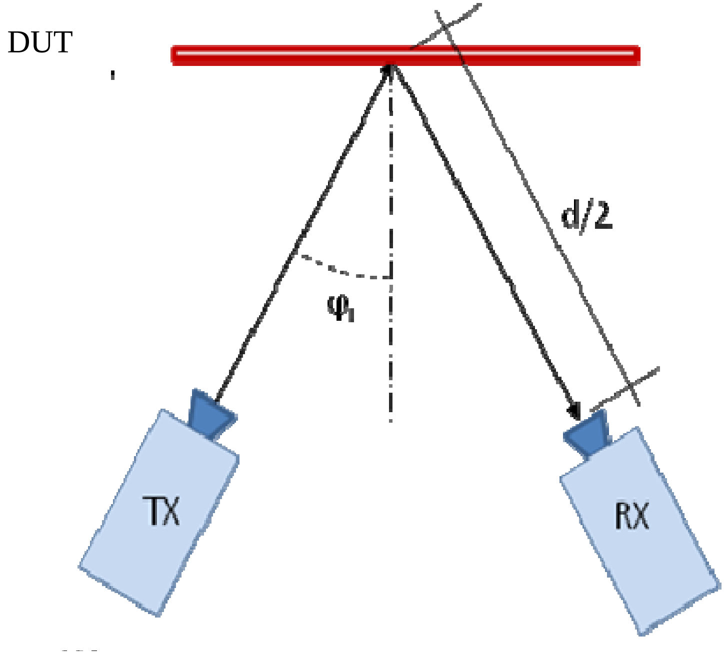
based on [2]

Measurement Set-up (1/2)

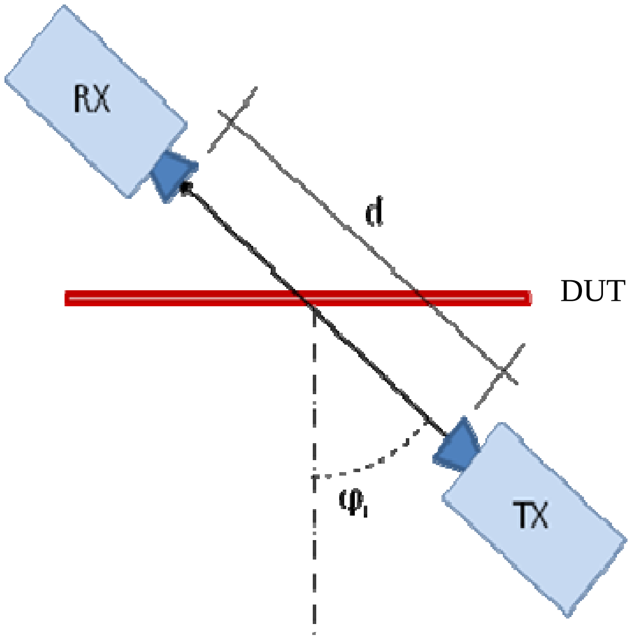
- Rohde& Schwarz ZVA50 Vector Network Analyzer with frequency converters used for both 60 GHz and 300 GHz
- 60 GHz measurements:
  - ZVA-Z75 milimetre-wave converters (50-75 GHz)
  - Concial horn antennas with 20Bi gain plus PE lenses with 16 dBi gain at both ends of the link
- 300 GHz measurements
  - ZVA-Z325 milimeter-wave converters (270 to 320 GHz)
  - Pyramidal horn antennas with 20Bi gain at both ends of the link

Measurement Set-up (2/2)

- Mechanical set-up for reflection and transmission geometry consists of two arm goniometers capable of rotating the antennas around the DUT.



Reflection Geometry



Transmission Geometry

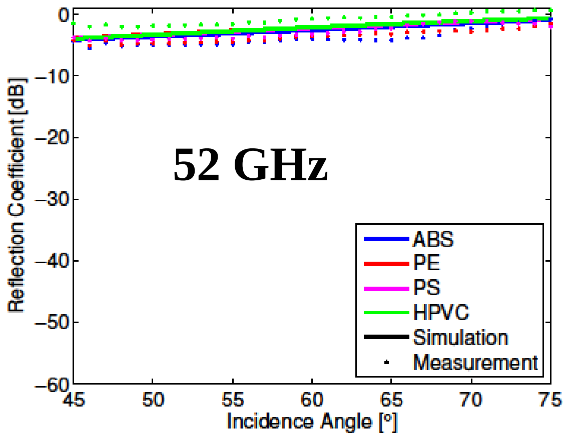
Parameter Extraction Methodology

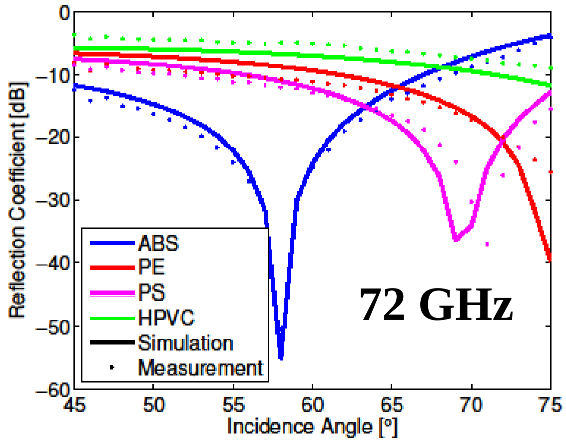
- Using Transfer Matrix Method (TMM) as decribed in [4]
- Determinaton of material parameters in two steps:
    1. Determining reflection coefficients for incidence angles between 45° and 75°
    2. Running simulations using TMM with variation of phase and amplitude . Parameter set with lowest RMS error compared to measurements is selected
- Due to low two layer thicknessess (yielding low attenuation) only real part of the refractive index is determined at 60 GHz

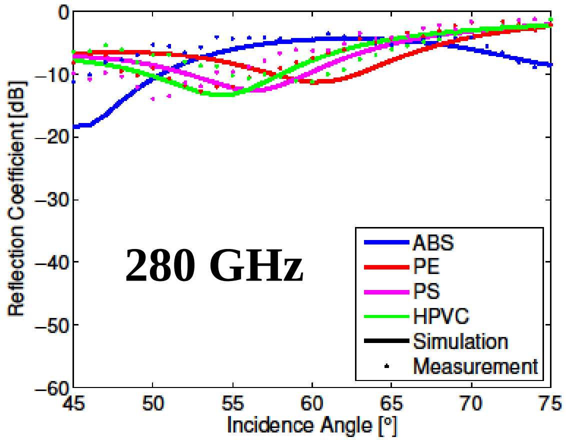
Parameters of investigated Material Samples

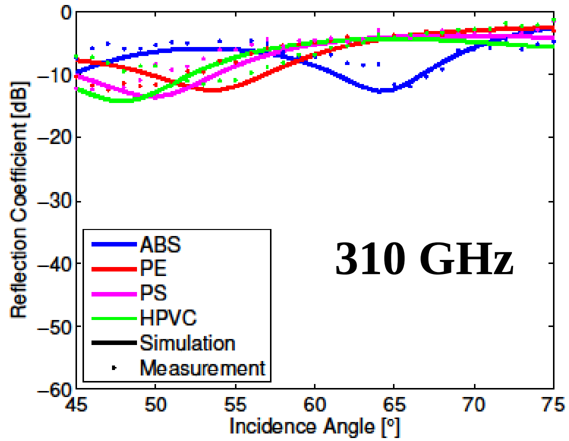
Material	Parameters	
	n’ 60 GHz	n’ 300 GHZ
Acrylonitrile Butadiene Styrene (ABS)	1.627	1.474 - 0.0122i
Polyvinyl Chloride unplast. (PVC-U)	1.691	1.558 - 0.0192i
Polyethylene (PE)	1.691	1.537 - 0.0190i
Polystyrene (PS)	1.675	1.526 - 0.0184i

Measured and Simulated Reflection Coefficients

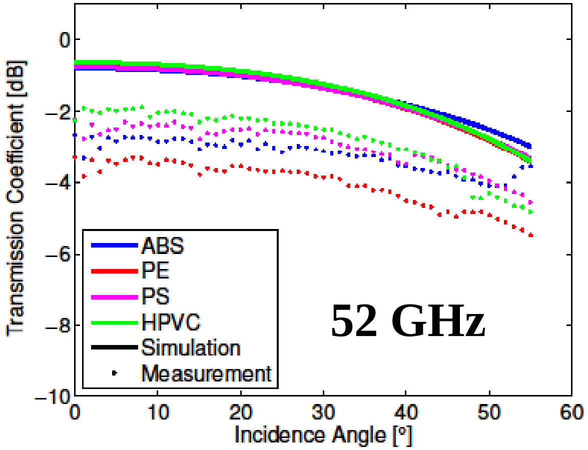


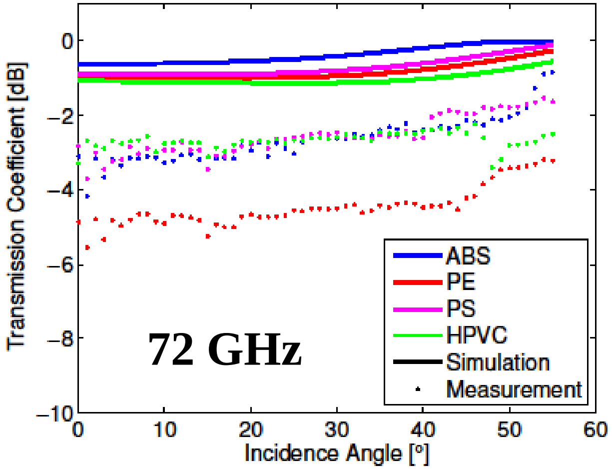


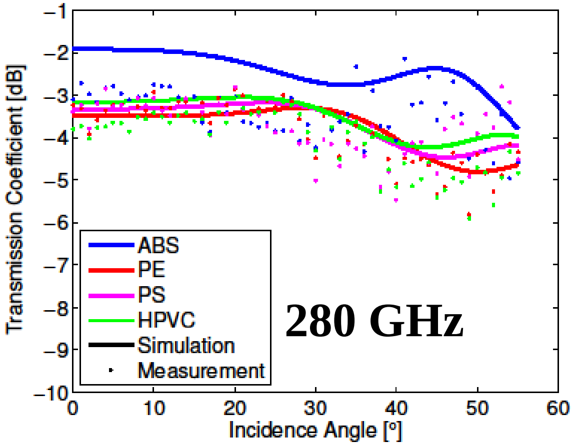


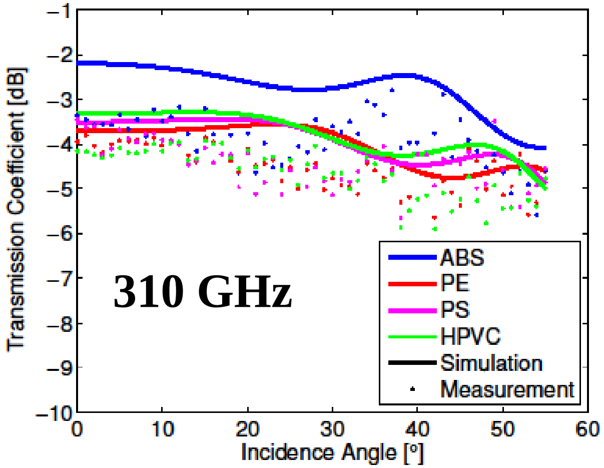


Measured and Simulated Transmission Coefficients







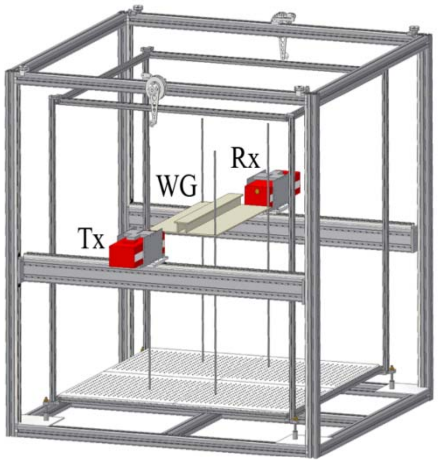


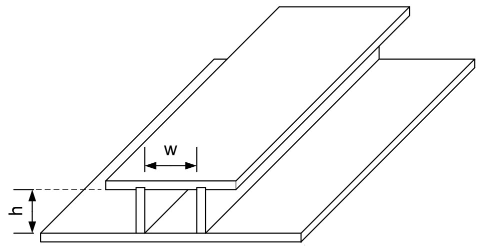
Propagation Characteristics of Waveguide-like ABS structures

based on [3]

Measurement Set-up

- Channel Transfer Function is measured as S12 with a Rohde & Schwarz Vector Network Analyzer (ZVA 50) in combination with frequency extensions (ZVA-Z75/-Z325).
- Waveguide is mounted inside a box.
- Modular design offers possibility to alter widths and heights of the waveguide.
- Attenuators to suppress unwanted reflections (not shown).
- Distance between frequency extensions approx. 1m.
- Far field approximations are suitable.
- Polarization: E-field parallel to bottom panel.



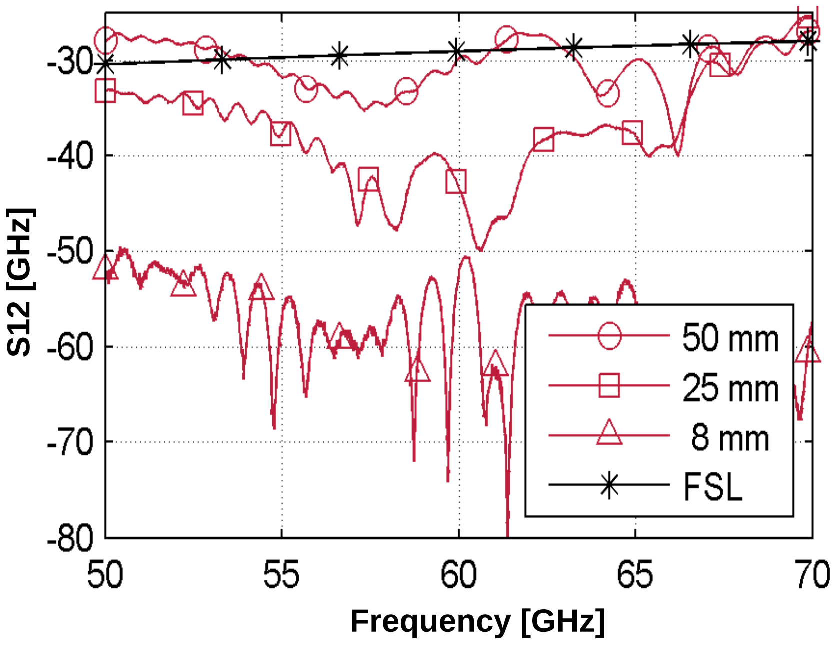


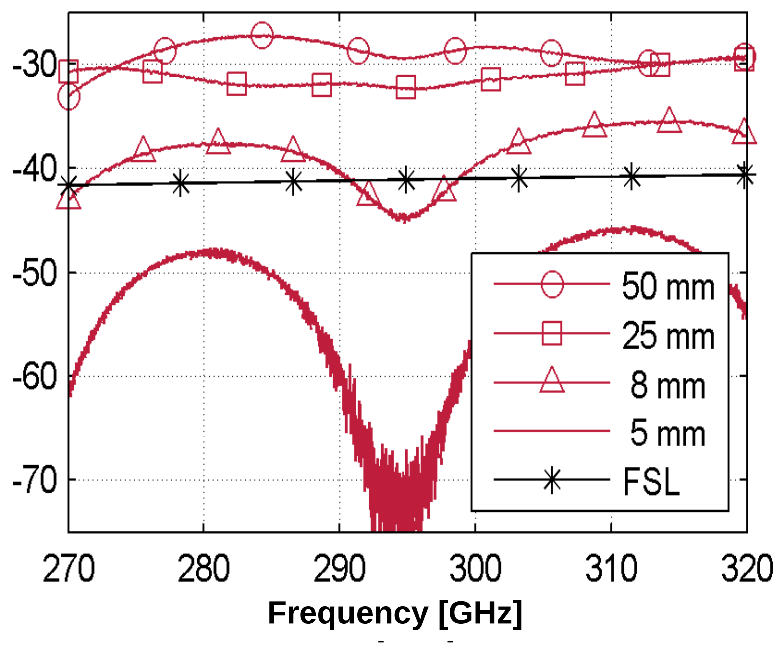
Measurement Set-up (2/2)

- Standard horn antennae (Flann mircowave ltd.) are used
- Mean values of antenna characteristics (averaged over the frequency range):

Frequency range	Gain	$HPBW_{azimuth}$	$HPBW_{elevation}$
50 – 70 GHz	19.5 dBi	20.0°	18.6°
270 – 320 GHz	20.4 dBi	17.3°	16.1°

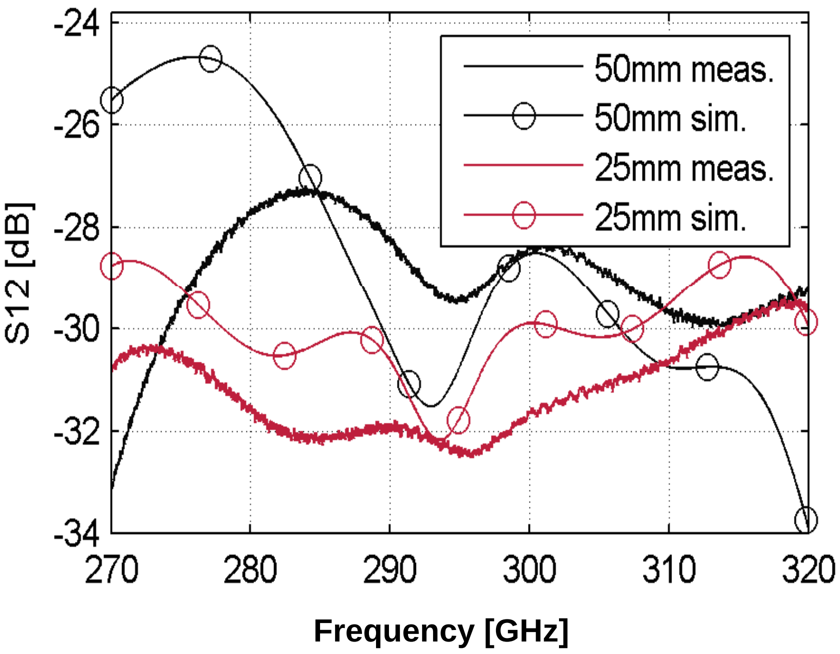
Measured S12 for different widths and a height of 18mm





Channel Modeling

- Modeling of the propagation as free space loss with antenna gains is insufficient.
- Ray tracing propagation model is based on transfer matrix method with the following material parameters for ABS at 300 GHz: $\varepsilon_r = 2.625 + j0.047$; $\tan\delta = 0.018$.
- Propagation paths with up to 5 reflections are considered.



Conclusion

- Transmission is a non-negligible effect, when it comes to plastic materials
- Reflection from plastic materials is heavily influenced by the multi-layer structure of a material
- Transfer Matrix Method is well-suited to account for both transmission and reflection in propagation simulation via ray-tracing
- Increasing attenuations through waveguide-like structures with increasing operating frequency and decreasing aperture of the waveguide.
- Ray tracing based model provides reasonable results for waveguides with a cut off frequency 50 times lower than the operational frequency.

References

[1] M. C. Frank Chang et. al., “RF/Wireless Interconnect for Inter- and Intra-Chip Communications” Proc. of the IEEE, VOL. 89, NO. 4, APRIL 2001.

[2] Fricke, A.; Rey, S.; Achir, M.; Le Bars, P.; Kleine- Ostmann, T.; Kürner, T.: Reflection and Transmission Properties of Plastic Materials at THz Frequencies. In Proc. 38th International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz), electronic paper (2 pages), Mainz, September 2013.

[3] Rey, S.; Fricke, A.; Achir, M.; Le Bars, P.; Kleine-Ostmann, T.; Kürner, T.: On Propagation Characteristics of Waveguide-like ABS Structures in 60 and 300 GHz Communications. In Proc. 38th International Conference on Infrared, Millimeter and Terahertz Waves (IRMMW-THz), electronic paper (2 pages), Mainz, September 2013.

[4] C. Jansen et. al., “The Impact of Reflections from Stratified Building Materials on the Wave Propagation in Future Indoor Terahertz Communication Systems,” IEEE Trans. on Ant. and Prop., vol. 56, no. 5, pp. 1413–1419