Experimental Investigation of 3D Transmission Line Matrix (TLM) based Electromagnetic Simulations using Integers

Petr Lorenz emgine@petr-lorenz.com http://www.petr-lorenz.com

I. INTRODUCTION

Scattering in TLM

The scattering matrix for free-space TLM reads

$$\mathbf{S} = \frac{1}{2}\begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 1 & 1 \\
0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 & -1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & -1 & 1 & 0 & 0 \\
0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \\
0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 \\
1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\
-1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 1 & -1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & -1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}$$

Scattering for wave b1 equals

$$b_1 = \frac{1}{2}\left(a_7 - a_8 + a_{11} + a_{12}\right)$$

Integer representation of the TLM wave quantities

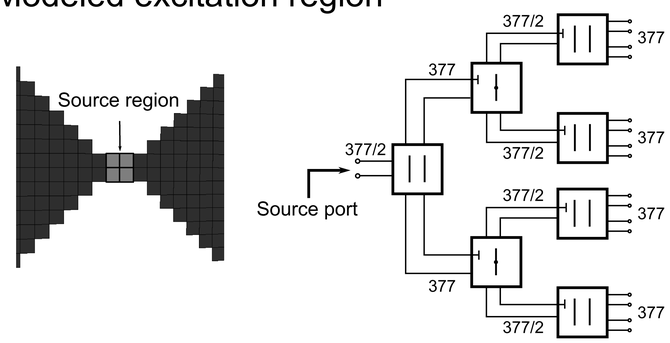
$$B_1 = \left(A_7 - A_8 + A_{11} + A_{12}\right) \gg 1$$

Addition, subtraction and bit shifting

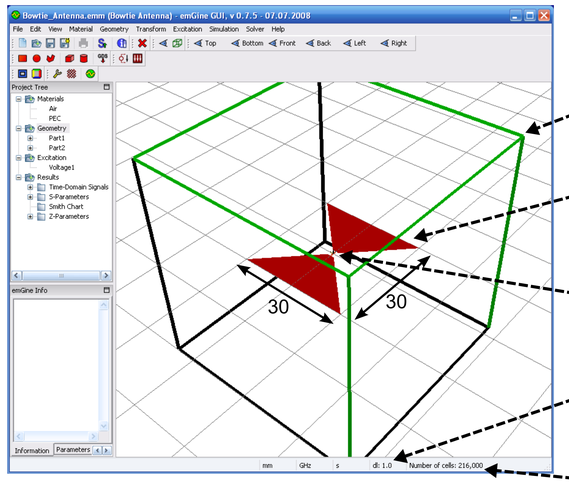
II. EXPERIMENTAL RESULTS

Bow-tie antenna in free-space

Modeled excitation region



Simulation setup



Boundary: Absorbing boundary condition

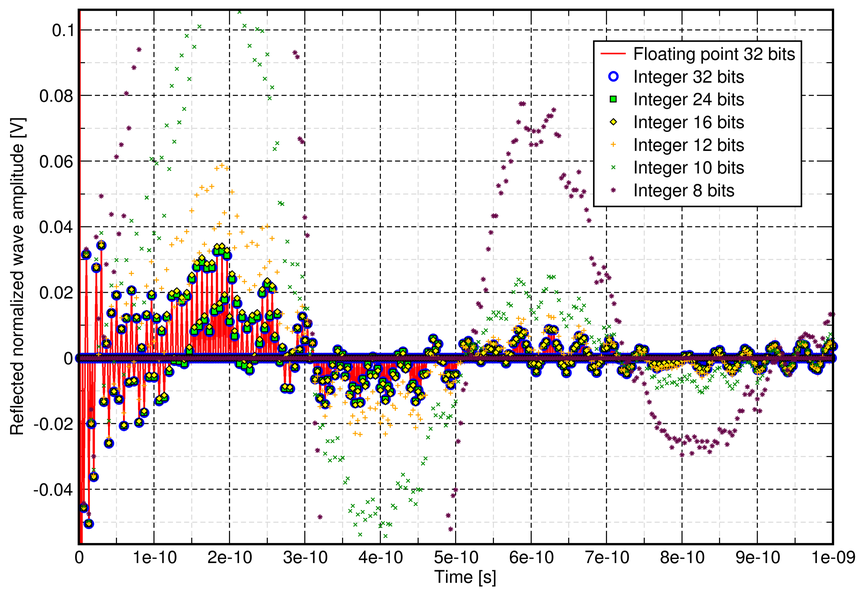
Antenna: PEC

Excitation: Discrete voltage port based on wave digital filters [1]

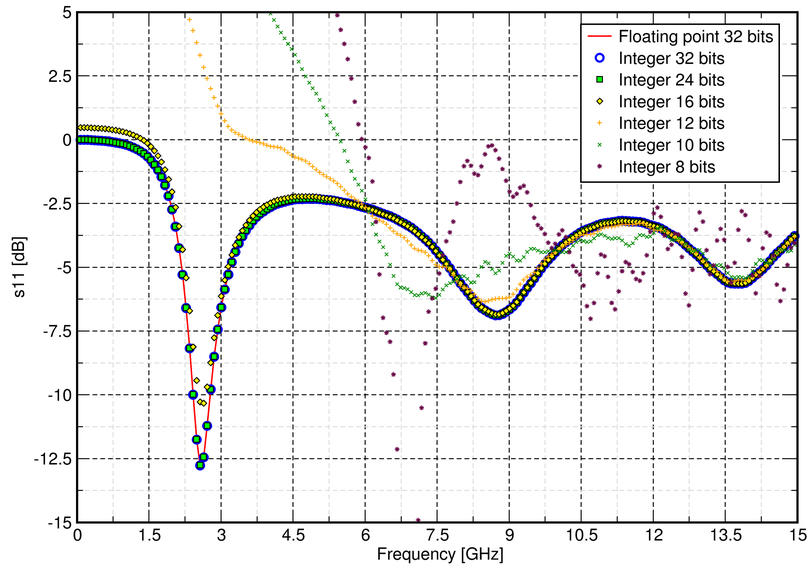
Spatial resolution: 1 mm

Number of TLM cells: 216 000

Comparison of the computed time-domain signals



Comparison of the computed S-parameters



III. CONCLUSIONS

- Electromagnetic field in free-space represented with integers
- TLM operations on integers using addition, subtraction and bit shifting only
- Input impedance of a bow-tie antenna computed using integers and floating point numbers
- Very good agreement in the comparison of the computed input impedance using integers (32 bit and 24 bit) and floating point numbers

REFERENCES

[1] Lorenz, P.; Russer, P., "Discrete and Modal Source Modeling with Connection Networks for the Transmission Line Matrix (TLM) Method," *IEEE/MTT-S IMS 2007*, pp.1975-1978, June 2007.

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Dedicated to Professor Peter Russer
on the Occasion of his 65th Birthday and his Retirement

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