# Localization of electromagnetic radiation sources from a printed circuit board in the near field by the LASSO regression

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In the process of functioning of the printed circuit board, parasitic connections and interference are created between radio electronic components, which affect neighboring components of the printed circuit board. For this reason, successful attempts have been made to solve the problem of localizing radiation sources using Tikhonov's regularization [1]. However, LASSO regression showed more accurate recovery results [2]. This article presents the experimental results of the reconstruction of sources of electromagnetic radiation from a real printed circuit board in the near field.
An equivalent model of a printed circuit board is a grid, at the nodes of which Hertzian dipoles are located [3]. Hertzian dipoles with certain parameters (coordinates, power of radiation sources) generate radiation equivalent to radiation from a real printed circuit board. The coupling equations of Hertz dipoles and radiation from a printed circuit board are presented in book [4]. To solve the localization problem (finding the parameters of radiation sources on a printed circuit board) and to compare the operation of the two algorithms, Tikhonov regularization and LASSO regression are used. The initial data for the localization problem is electromagnetic radiation from the printed circuit board. The measurements were carried out at a frequency of $f$ = 100 MHz. The distance from the system of measuring probes to the printed circuit board is $h$ = 15 mm.


A B

**Figure 1.** Reconstructed dipole distribution A) Tikhonov regularization, B) LASSO regression

Figure 1 shows the reconstructed dipole distribution of radiation sources on a printed circuit board using two regularization methods. The colored outlines on the printed circuit board show the location of the radiation sources, and the color of the outline indicates the power of the radiation sources. The power values of the radiation sources are shown on the scale to the right of the figure. In LASSO regression, the dipole distribution is completely localized in the area where the crystal oscillator is located (the lower left area of the printed circuit board) and the printed "track" coming from the output of the oscillator. The crystal oscillator is a source of radiation at a frequency of $f$=100 MHz. With Tikhonov's regularization, it can be seen from the results obtained that a certain fraction of the power is located in areas where there are no electronic components on the board. This is due to the fact that when the radiation sources are reconstructed by the Tikhonov regularization method, a certain fraction of the radiation source power "spreads out" along the coordinate grid. The obtained experimental results of reconstruction of radiation sources on a printed circuit board are in good agreement with the results of reconstruction on the basis of model data [2].

## References

[1] X. Tong, “Simplified equivalent modeling of electromagnetic emissions from printed circuit boards,” Ph.D. dissertation, Univ. of Nottingham, Nottingham, England, 2010.
[2] I.V. Skvortsov, V.V. Bochkarev and R.R. Latypov, “Estimation of localization of point sources from a printed circuit board in the near field,” *Journal of Physics*, **1038**, 1, 2018, pp. 1-5, doi: 10.1088/1742-6596/1038/1/012043.
[3] B. Nishina and Q. Chen, “Estimation of Equivalent Current Distribution of Modulated EM Radiation Source,” *IEEE Transactions on Antennas and Propagation,* **64**, 4, February 2016, pp. 1334-1341, doi: 10.1109/TAP.2016.2526080.
[4] S. J. Orfanidis, *Electromagnetic Waves and Antennas*. New Jersey, USA, Piscataway:Rutgers University, 2016.