Calibration of RF matrix array detectors for environmental electromagnetic field

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INCDTIM

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PIM2021 International Conference Processes in Isotopes and Molecules

Introduction: Integrated logarithmic radiofrequency (RF) detectors provide a well known solution for RF to direct current (DC) conversion. The main issue of these detectors is caused by: (i) the variable output offset voltage measured in the absence of the input signal and (ii) variable RF to DC gain characteristic. Thus, different RF detectors will provide different output voltage for the same RF input signal amplitude or in the complete absence of the input signal.

Materials and methods: We designed and manufactured a matrix of 64 RF intelligent detectors [1]. Each detector input is connected with a miniature antenna. Each detector output is connected with the AD input of a low power *node* microcontroller. Each *node* (fig.1) measures the voltage delivered by the sensitive RF detector, collected through an antenna and displays the amplitude of the EM field as a distinct colour on an RGB LED. There are nine voltage thresholds for detectors DC comparison. Each *node* microcontroller send its data to a *supervisor* microcontroller using a blocking asynchronous proprietary communication algorithm. The *supervisor* is able to load at once all the *64 nodes* with data. Each *node* blocks the other *nodes* during its own transmission slot-time in a node chain sequence.

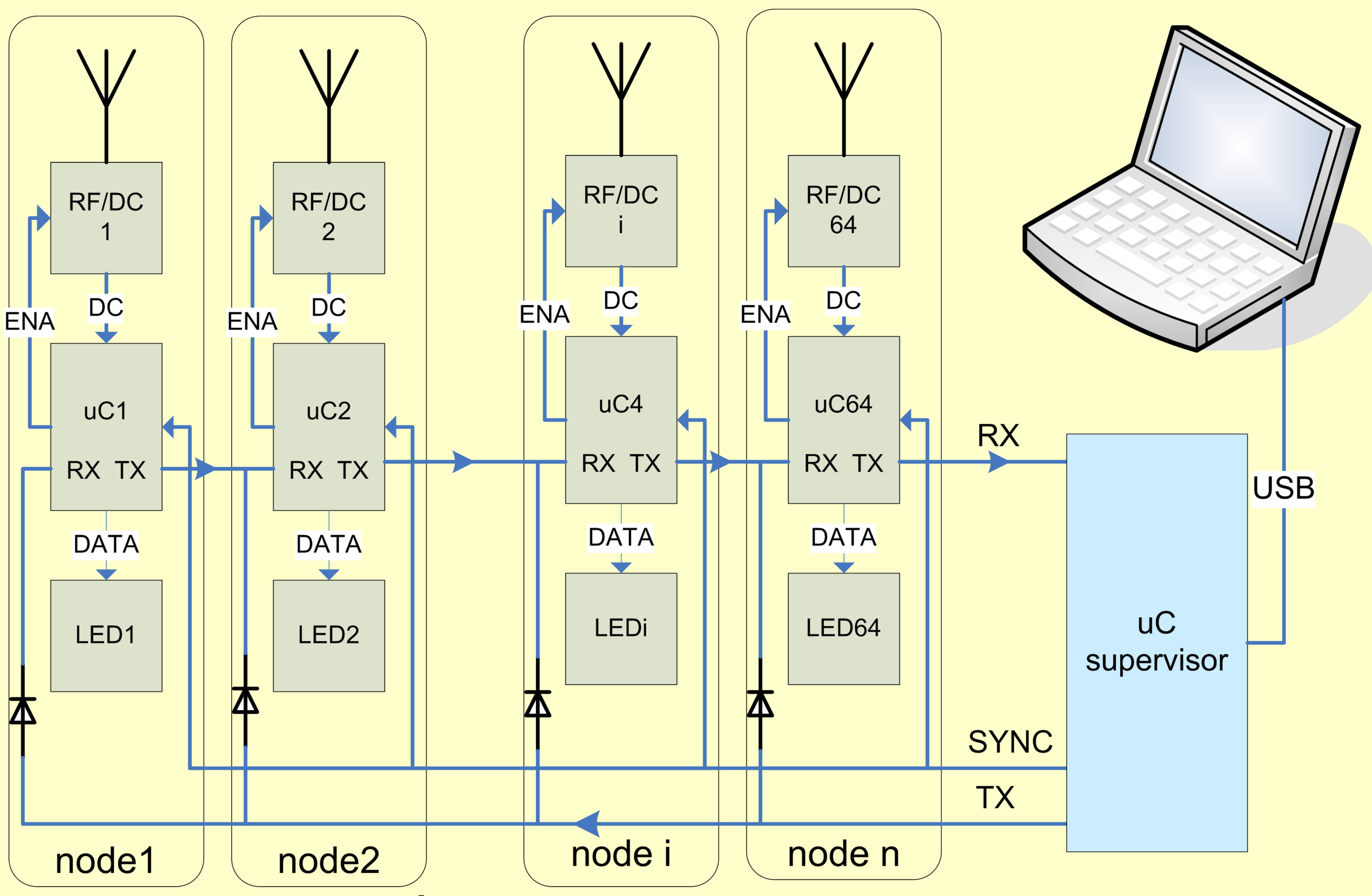

Figure 1. Detector array structure

Each RF measurement discussed below occurred in anechoic chamber. The proposed calibration algorithms consists of:

(i) Manual measurement of detectors offset (fig.2, Vos-blank) with all microcontrollers in blank state (no firmware loaded, lowest noise level on board). Replace detectors with large offset and perform offset measurement after replacement.

(ii) *Node:* detector offset (Vos-prog) automatic measurement in the absence of RF field (fig.2) and sending data to *supervisor*.

(iii) *Node:* detectors full scale voltage (Vfs) automatic measurement with far field condition met (plane wave on detectors array) and sending data to *supervisor*.

(iv) *Supervisor:* receive data from 64 *nodes,* detect the maximum values of Vos-m and Vfs-m and transmit those values back to all nodes.

(v) *Node*: each i node set the lowest voltage threshold above the Vos-m and compute the required gain (Gi) to reach the Vfs-m. AD output data is multiplied with Gi, compared with thresholds and displayed accordingly on RGB LED.

(vi) Testing the calibration results with node offset detect (no RF) and node maximum RF signal detect.

Results and discussions:

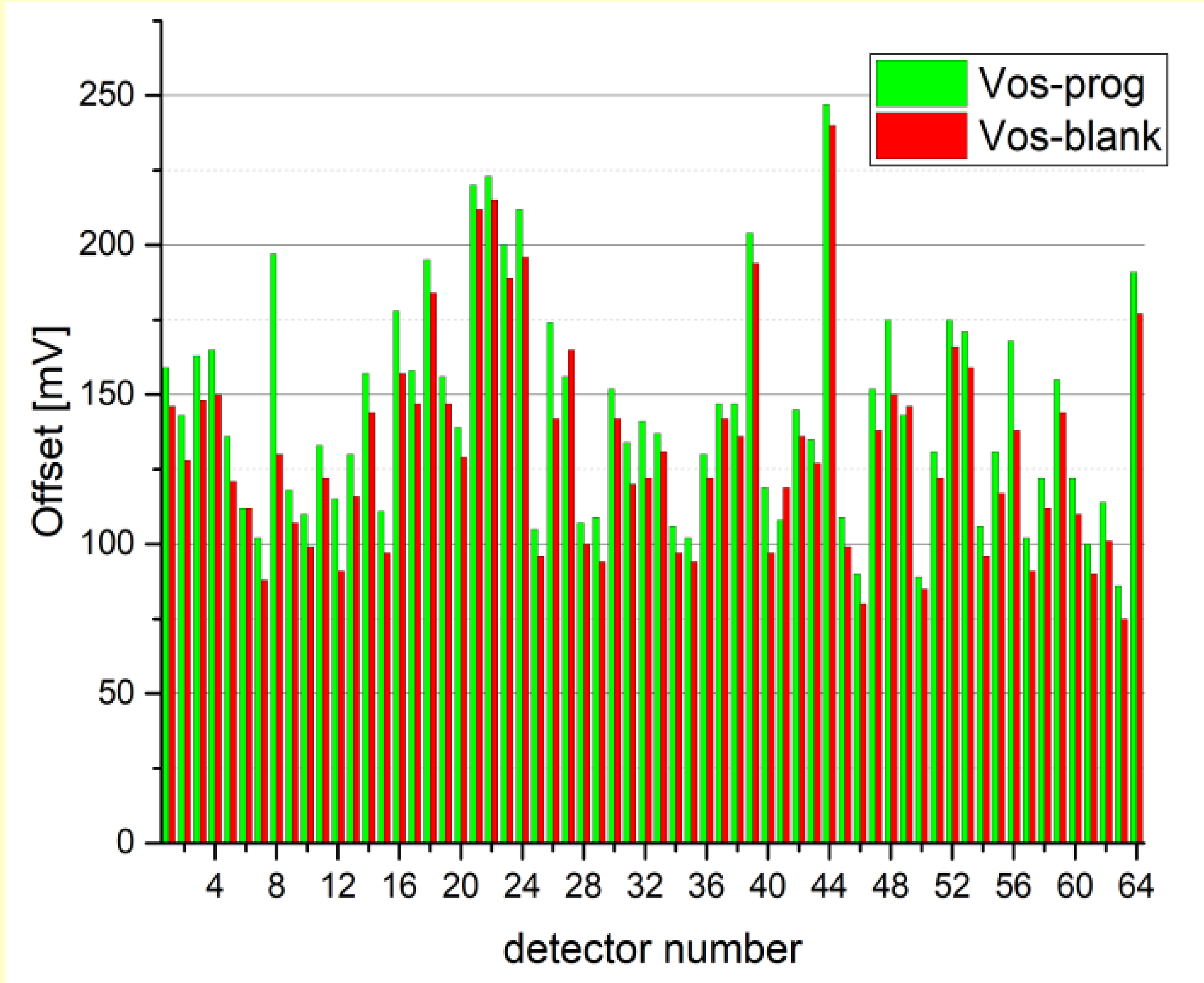

Figure 2. Offset voltage

The average Vos-prog of 64 detectors is below 150mV, however 6 RF detectors had Vos-prog ≥ 200mV offset and must be replaced. Detector's gain characteristic is quasi-linear in 300mV- 2.2V output (fig.3), allowing a detector output useful voltage swing of 1.9V (around 211mV per interval between two adjacent thresholds). We choose 9 comparison thresholds which represents 8 distinct RGB colors to be displayed.

The data value to be compared with the thresholds is: Vfs-i=Gi*ADCread-i

The maximum Vos-prog value measured at 25ºC after detectors replacement is 191mV, smaller than the lowest comparison threshold. However, an increase of device temperature above 40ºC may produce corrupted displayed results due the offset increase.

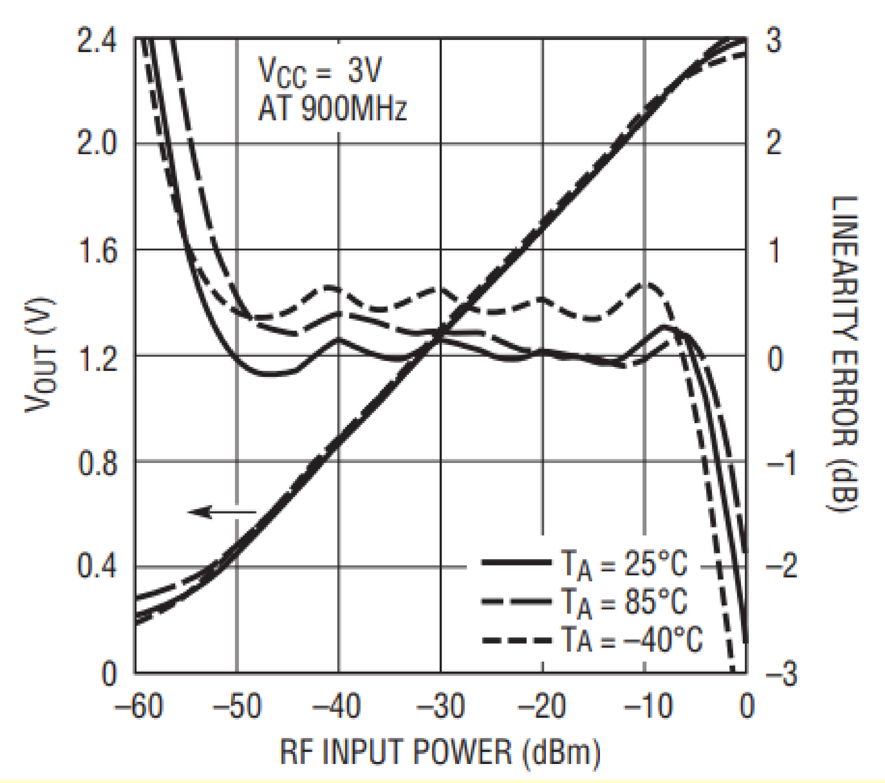

Fig.3 Detector in-out characteristic

Conclusions: Preliminary results are optimistic, allowing a computed RF detection difference between nodes of ±2.4dB (detector and RF circuits inaccuracies). Fig.4 reveals displayed data after partial calibration. Identical colours displayed by all nodes suggest good array detection homogeneity for far field detection. The work is in progress.

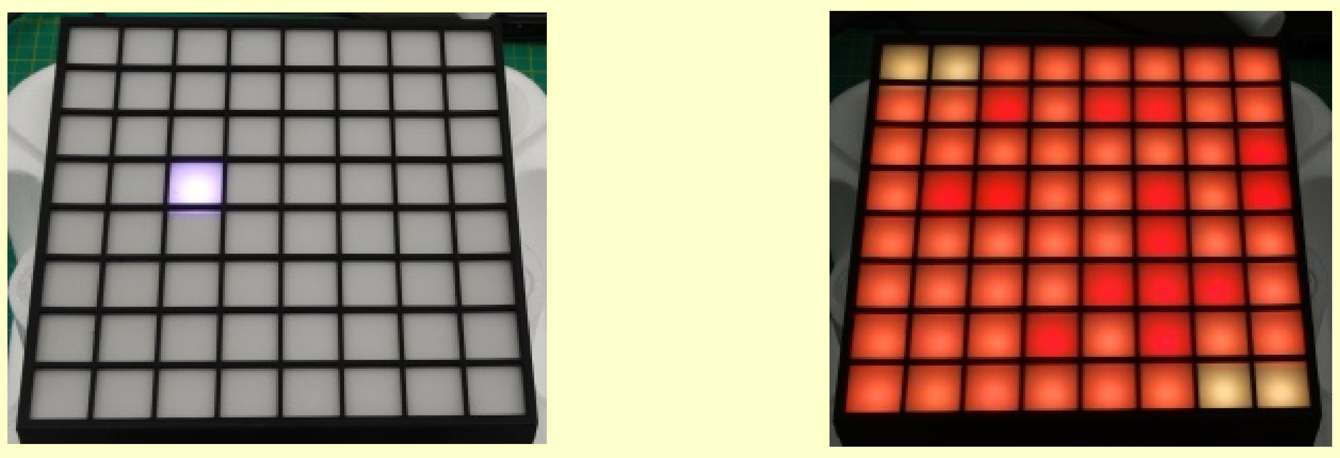

Figure 2. Detection of far field, left: -30dBm (Vos), right: +25dBm (Vfs)

References : [1] E.surducan, V.Surducan, Process for visual detection of microwave radiation and visual microwave detector carried out by said process, patent pending RO135000A0, 2021.

Acknowledgments: This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project number PED-2019-1453, within PNCDI III