

# and their implementation in OhmPi

# Electrical resistance measurement strategies **Olivier Kaufmann<sup>1</sup>,** Arnaud Watlet<sup>1</sup>, Guillaume Blanchy<sup>3</sup>, Yannick Fargier<sup>4</sup>, Hélène Guyard<sup>5</sup>, and Rémi Clément<sup>2</sup>

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OhmPi

The OhmPi project aims to provide an open-source, open-hardware resistivity meter to the community. OhmPi is specifically designed for



small-scale field experiments, and is particularly suited for monitoring experiments. The transmitter of OhmPi v2024 is voltage regulated. Applying a strategy thus requires to determine the setpoint on  $V_{AB}$ .

## More flexible strategies...

Using the highest possible injection potential is just one strategy. Depending on the application, other strategies may be of interest. For example, one might want to minimise the power delivered while ensuring that the voltage measured at the receiver reaches a threshold, or try to inject a given current independently of variations in contact resistances. We propose to define the strategies by setting minimum, requested and maximum values for physical quantities such as  $V_{AB}$ ,  $i_{AB}$ ,  $V_{MN}$  or  $P_{AB}$  and by specifying how to aggregate requested values. The optimal  $V_{AB}$  to be applied for the measurement is then calculated as follows

 $V_{AB}^{opt} = min\{max\{max\{V_{AB}^{min}[q]\}, agg\{V_{AB}^{req}[q]\}\},\$  $min\{V_{AB}^{\max}[q]\}\}$ 

Where agg is either the *min* or *max* operator and

 $V_{AB}^{p}[q]: V_{AB}|q = q^{p}, p \in \{min, req, max\}$ 

 $q \in \{V_{AB}, i_{AB}, V_{MN}, P_{AB}\}$ 



The optimal  $V_{AB}$  depends on  $R_{AB}$  and R and the strategy. The minimum, requested and maximum values are bounded by the system operational range.

## **Take-home message**

OhmPi v2024 includes major evolutions in hardware and software. Among the latter, flexible measurement strategies have been introduced and tested. Theses new strategies pave the way for more customized acquisition protocols for lab experiments or small-scale field monitoring. The work also hints at some critical parameters in the design of an experiment using the OhmPi system.

The transmitter setpoint must be chosen so as to remain within the operating range of the OhmPi system. However, R and  $R_{AB}$  are unknown prior to the measurement. The optimal setpoint is determined incrementally. At each step, short pulses of  $V_{AB}$  are created (here two alternating pulses) and the optimal  $V_{AB}$  is computed taking the uncertainties on  $i_{AB}$  and  $V_{MN}$  into account. The process is repeated up to an adequate  $V_{AB}$  or until a predefined number of steps is reached. The figure on the right shows successive steps in the search for the optimal  $V_{AB}$ .



## **Comparing strategies with OhmPi on a resistor board**

Measurements were conducted on a set of R and  $R_{AB}$  using an OhmPi and a resistor board designed for this purpose. Here we **compare the results** of the "vmax" strategy (where the requested and maximum  $V_{AB}$  are set to the system boundary of 50 V) with the "**vmin**" strategy where a  $V_{MN}$  of 1.5V is requested. The graphs of the first row show the results with the "vmax" strategy while those on the second row show the difference between this strategy and the "vmin" strategy.



#### **References & useful links**

Kaufmann, O., Watlet, A., Blanchy, G., Dubois, V., Fargier, Y., Forquet, N., Guyard, H., Quatela, V. and Clément R., 2023. Latest Developments of OhmPi: a New Software Architecture for Modular, Flexible and Evolutive ERT Acquisition Systems. EAGE, NSG2023 Conference Proceedings. doi: 10.3997/2214-4609.202320204.

Clement, R., Fargier, Y., Dubois, V., Gance, J., Gros, E. and Forquet, N., 2020. OhmPi: An oper source data logger for dedicated applications of electrical resistivity imaging at the small and **Documentation**: https://ohmpi.org

Gitlab repository: https://gitlab.com/ohmpi/ohmpi **Contact**: olivier.kaufmann@umons.ac.be - remi.clement@inrae.fr





Gitlab repository



Hardware & software documentation

