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Advancement of Data Acquisition System for Neural Activity Experiments Using Multi-Electrode Arrays

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***Abstract*— We present the further development of the Data Acquisition (DAQ) system that uses Multi-Electrode Arrays (MEAs) for neural activity monitoring and electrical stimulation. The system is entirely operational at its full capacity (512 input/output channels) thanks to the refreshed design of its electronics.**

***Clinical Relevance*—This work enhances the spatial resolution of measuring and evoking neural activity up to 512 channels using the presented data acquisition system and Multi-Electrode Arrays.**

I. INTRODUCTION

Multi-Electrode Arrays (MEAs) are commonly used in neural activity research probing direct information about single-unit spiking activity and Local Field Potential (LFP). At the same time, MEAs can be used to inject current into the tissue to evoke the activity of nearby cells [1]. However, MEAs need to be backed up by a dedicated device able to sample, amplify and generate stimulation currents to unlock the entire potential of that technique. Moreover, the more independent channels are offered by such a device, the more flexibility it gives for researchers when designing experiments. On the other hand, it is also more demanding on the data processing side.

Here we present the updated version of the Neurostim-3 Data Acquisition (DAQ) system [2] dedicated for the usage of MEAs with up to 128 electrodes and 512 input/output channels at full capacity with 40 kHz sampling frequency.

II. METHODS

The enhanced Neurostim-3 is based on the ASIC Boards (ABs) housing two Neurostim-3 64-channel chips enabling measurements with 128-channel MEAs (Fig. 1). Up to four such ABs can be connected in parallel to the redesigned Interface Board (IB) which collects input/output data from all active ABs and bundles them to the computer running the DAQ software.

The DAQ software written in Python programming language required several minor adjustments thanks to the modularity of the system. However, handling all eight Neurostim-3 chips entailed an upgrade of the DAQ running computer which is based now on the AMD Ryzen 9 3900X CPU accompanied by 64 GB of working memory.

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Figure 1. New design of an ASIC Board housing two Neurostim-3 chips (under metal shielding) and allowing usage of 128-channel Multi-Electrode Arrays (double connector on the backside)

The performance of the system was measured by the internal generation of square wave stimulation pattern sequentially on all channels of each Neurostim-3 chip (all eight chips stimulating their *n*-th channel at the same time) and simultaneous recording of generated signals.

III. RESULTS & DISCUSSION

The DAQ cooperates with the upgraded electronics system similarly as reported previously. The fact of the higher count of working Neurostim-3 chips in parallel did not affect how the software processes input/output data. However, the demand for processing power is noticeably higher. Now, the software requires up to 35% of the total CPU time.

Interestingly, it is still possible to compress and save data from the entire system in a single computing thread. However, for experiments on living animal brains, it might no longer be true because of the different data characteristics which are more difficult to compress. The solution would be to disable compression which provides 10-20% data reduction only or to split data saving task into more threads (each of them could store data from a single Neurostim-3 chip and apply a more suitable compression algorithm).

These preliminary tests lead us to conclude that the Neurostim-3 512-channel system can be used for experiments with living animal brains. Compared to its previous iteration it offers more channels and is compatible with 128-channel MEAs that can be used to increase spatial resolution and lead to more detailed results.

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