CCi-MOBILE Research Interface
for Cochlear Implant and Hearing-Aid Research
'Low Pulse Rate Experiment – Single Channel (NYU Experiment)'

October 1, 2019

This document describes informal in-house testing at UT-Dallas CRSS-CILab which was performed on Sept. 3, 2019.

Purpose

The objective of the in-house test was to determine if CCi-MOBILE can stimulate at specified low number of pulses/frames.

Materials, Methods, and Analysis

The following user-defined settings were used to validate the output of CCi-MOBILE:

- Custom Script 'MySimplePulseTrainStimulation.m'
- Pulse width 25us
- N-Maxima 1 electrode (electrode 22)
- Stimulation Rate 125 pulses per second
- Clinical level 200

I. EXPERIMENT CONDUCTED BY NYU

Multiple pulses were observed from the output of the CCi-MOBILE using CCi-MOBILE Unit # NYUAU1612887B as seen in Figure 1 below.

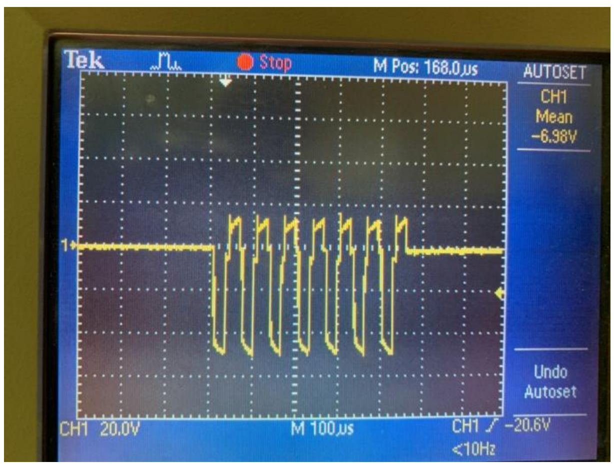

Figure 1. Oscilloscope output demonstrating approx. 7 pulses when 1 pulses per frame was specified.

II. EXPERIMENT CONDUCTED BY UWM

To validate the experimental results from NYU, three different experiments were carried out (validation of 1 ppf, validation of 1 ppf with highest CL, and validation of 1 pps with an increase in pulse width). The same testing conditions were used to evaluate the output of CCi-MOBILE for 1 pulse per frame in both the NYU and UTD experiments. As observed in Figure 2 below, only 1 single biphasic pulse was observed. Additionally, the same MATLAB script was used to also test the output of CCi-MOBILE using a clinical level of 255 instead of 200. Figure 3 demonstrates a single biphasic pulse regardless of the increase in clinical level. Figures 4 and 5 also demonstrate a single pulse per second regardless of pulse width and stimulation rate, respectively.

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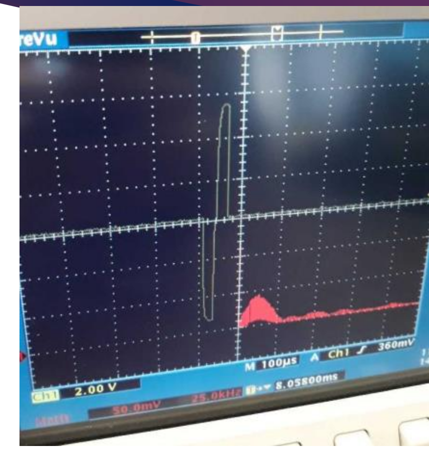

Figure 2. Output oscilloscope from the UWM test for CCi-MOBILE.

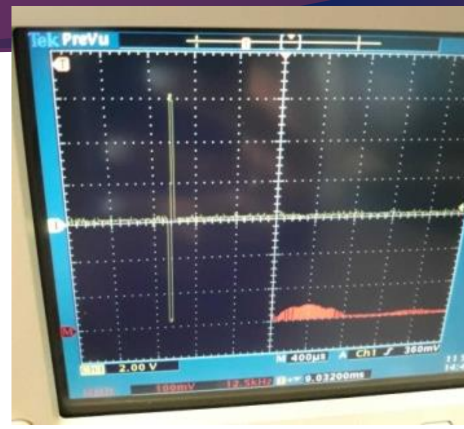

Figure 3. Single biphasic pulse observed with the same specified conditions using 255 as the clinical level instead of 200.

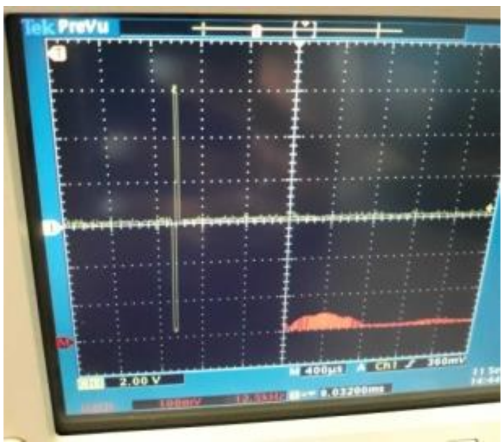

Figure 4 (left). Single biphasic pulse observed with the same specified conditions using 45 us for pulse width instead of 25.

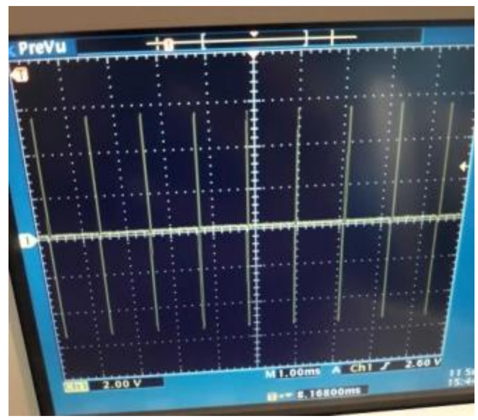

Figure 5. Output oscilloscope from an increase in stimulation rate (increase of 1 pps to 7 pps).

III. EXPERIMENT CONDUCTED BY UTD

To validate the experimental results from NYU, the specified parameters above were input into the signal processing routines from CCi-MOBILE Software Suite (v2.2c), visualized using an oscilloscope, and the output recorded from the DIET Box [1-3] (RF communication tool). Figure 6 demonstrates the output of the DIET Box which determine the out of the RF connected to the CCi-MOBILE unit.

<u>DIET Box Output Parameters:</u>

- Parameter ‘E’ Active Electrode
- Parameter ‘A’ Clinical Level
- Parameter ‘P1’/‘P2’ Cathodic/Anodic Pulse Widths
- Parameter ‘G’ Interphase Gap

The observations from NYU were not replicated. The output verified from the DIET Box shown in Figure 2 below resulted in an output of 22 as the active electrode (‘E’), 200 for the clinical level (‘A’), approx. 25us for the pulse width (‘P1’/’P2’), approx. 7.9 for the interphase gap (‘G’), and approx. 7999 for the interval between receive two biphasic pulses (‘T’).

```
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 584075.1 FN: 32 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 592074.9 FN: 33 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 600074.7 FN: 34 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 608074.5 FN: 35 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 616074.3 FN: 36 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 624074.1 FN: 37 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 632073.9 FN: 38 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 640073.7 FN: 39 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 648073.5 FN: 40 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 656073.3 FN: 41 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 664073.1 FN: 42 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 672072.9 FN: 43 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.8 P2: 25.2 G2: 0.0 P3: 0.0 T: 7999.8 TS: 680072.7 FN: 44 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.9 TS: 688072.6 FN: 45 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 696072.4 FN: 46 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 704072.2 FN: 47 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 712072.0 FN: 48 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 720071.8 FN: 49 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 728071.6 FN: 50 Clk: 0
Pr: 0 Cpc: 5 E: 22 M: 28 A: 200 P1: 25.1 G: 7.9 P2: 25.1 G2: 0.0 P3: 0.0 T: 7999.8 TS: 736071.4 FN: 51 Clk: 0
```

Figure 6. Output from the DIET Box from the UTD site.

From the DIET box recordings [1-3], we can observe that the CCi-MOBILE platform is stimulating only 1 biphasic pulse, every frame, as intended in the script ('MySimplePulseTrainStimulation.m'). Only one channel is active, i.e., electrode 22 with a frame duration of 8ms that is equivalent to 8000µs. Therefore, only 1 biphasic pulse with a pulse width of 25µs is stimulated every 8000µs.

Conclusions

Based on the results observed at UTD and UWM sites, the following conclusions can be drawn:

1. All the three sites – UTD, UWM and NYU – used the same MATLAB scripts and stimulation parameters to verify output of CCi-MOBILE.
2. UWM provided validation based on observations using an oscilloscope whereas UTD provided validation from the results of the burn-in using the DIET box.
3. There was no discrepancy between input stimulation rate or pulse width verified using the DIET Box.

Therefore, it has been shown by UWM and UTD that CCi-MOBILE can stimulate low number of pulses per frame.

References

[1] Chandra Shekar, R.C., Ali, H., Hansen, J.H.L. (2018) Testing Paradigms for Assistive Hearing Devices in Diverse Acoustic Environments. Proc. Interspeech 2018, 1686-1690, DOI: 10.21437/Interspeech.2018-1471

[2] Chandra Shekar, R.C., Hansen, J.H. (2019) CCi-MOBILE: Safety and Performance Evaluation, Conference on Implantable Auditory Prostheses, Lake Tahoe California, July 14-19, 2019.

[3] Chandra Shekar, R.C., Saba, J.N., Hansen, J.H. (2019) *insert journal title here.* Submitted to the Journal of the Acoustical Society of America August 30, 2019.