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Comments on “Compact, Energy-Efficient High-Frequency Switched Capacitor Neural Stimulator With Active Charge Balancing”

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***Abstract*—This manuscript points out some mistakes in the Introduction and in the table of comparison of a paper already published in this journal by Hsu and Schmid [1]. Although the main claim of [1] is still preserved, we believe the paper needs to be rectified for scientific correctness of the work.**

***Index Terms*—High-frequency stimulation, power efficiency.**

I. Comments and corrections

In [1], the first High Frequency Switched-Capacitor (HFSC) stimulator is presented. The stimulation voltage is derived from the main supply by using an $1 : 1$ switched-capacitor DC-DC converter. This particular topology of DC-DC converter operates as a resistor [2]. The further away the output voltage is from the input voltage, the lower the power efficiency is. As a result, the output voltage of the DC-DC converter, and therefore the total charge delivered to the tissue, can only be regulated at the expense of the power efficiency.

Section I of [1], provides an overview of the most recently published works in the field of electrical stimulation. Based on the stimulation mode, Hsu and Schmid classify the papers into three categories, named voltage-mode stimulation (VMS), current-mode stimulation (CMS) and switched-capacitor stimulation (SCS).

In [1], the work presented in [3] has been classified as SCS. However, [3] proposes CMS which adapts the voltage supply of the neurostimulator to the voltage across the electrodes.

In [1], the work presented in [4] has been classified as VMS. However, [4] proposes a CMS. In fact, an inductor-based DC-DC converter without the output capacitance is used to deliver the charge to the tissue.

Section V of [1] provides a table of comparison, in which the performances of the stimulator circuit are compared with some relevant contributions found in literature. Several errors have been found in the comparison table. The entries in **bold characters** and red colour of Table I below corrects the table of comparison presented in [1].

II. Conclusion

The aim of this comment is two-fold. Firstly, it corrects a classification of the most recent works, which was presented in the Introduction of a paper previously published in this journal [1]. Secondly, it corrects some mistakes in its table of comparison. Although errors have been found, the main claim of [1], and hence its scientific contribution, are still preserved.

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TABLE I

	[5]	[6]	[7]	[8]	[4]	[3]	[1]
Process	0.5 μm	0.35 μm	0.18 $\mu m HV$	0.35 μm	0.18 $\mu m HV$	1.5 μm	0.18 $\mu m HV$
Supply voltage (V)	**$2.5 - 4.6$**	±2	**6**	3.3	20	±1.75	5
Power source	Inductive Link	Inductive Link	Battery	Battery	Battery	Inductive Link	Battery
Stimulus type	CMS	SCS	CMS	VMS	CMS	CMS	HFSC
Stimulation charge variation over electrode	Lowest	Low	Lowest	Low	N.A.	Low	Low
Peak Efficiency	68 %	80.4%	**80%***	50%	**50%**	N.A.	49%
Dedicated power management	Y	Y	Y	Y	Y	Y	N
Area per channel (mm^2)	0.23	0.37	**0.35**	0.58	0.21	0.317	0.035
Maximum charge (nC)	**> 992**	**> 840**	50.4	450	**1280**	678	190
# external components	0	2	0	2	1	N.A	0

* DC-DC converter only.