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Cardiac arrhythmias and degradation into chaotic behavior prevention using feedback control[1] ILIJA UZELAC, VENIAMIN SIDOROV, Vanderbilt University, Nashville TN, USA, MARC HOLCOMB, Hampden-Sydney College, Hampden-Sydney, VA, USA, JOHN WIKSWO, Vanderbilt University, Nashville TN, USA, RICHARD GRAY, Food and Drug Administration, MD, USA — During normal heart rhythm, cardiac cells behave as a set of oscillators with a distribution of phases but with the same frequency. The heart as a dynamical system in a phase space representation can be modeled as a set of oscillators that have closed overlapping orbits with the same period. These orbits are not stable and in the case of disruption of the cardiac rhythm, such as due to premature beats, the system will have a tendency to leave its periodic unstable orbits. If these orbits become attracted to phase singularities, their disruption may lead to chaotic behavior, which appears as a life-threating ventricular fibrillation. By using closed-loop feedback in the form of an adjustable defibrillation shock, any drift from orbits corresponding to the normal rhythm can be corrected by forcing the system to maintain its orbits. The delay through the feedback network coincides with the period of normal heart beats. To implement this approach we developed a 1 kW arbitrary waveform voltage-to-current converter with a 1 kHz bandwidth driven by a photodiode system that records an optical electrocardiogram and provides a feedback signal in real time. Our goal is to determine whether our novel method to defibrillate the heart will require much lower energies than are currently utilized in single shock defibrillators.

Ilija Uzelac
ilija.uzelac@vanderbilt.edu
Vanderbilt University, Nashville TN, USA

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