

Dual-Chamber Pacemaker Programming Simulator

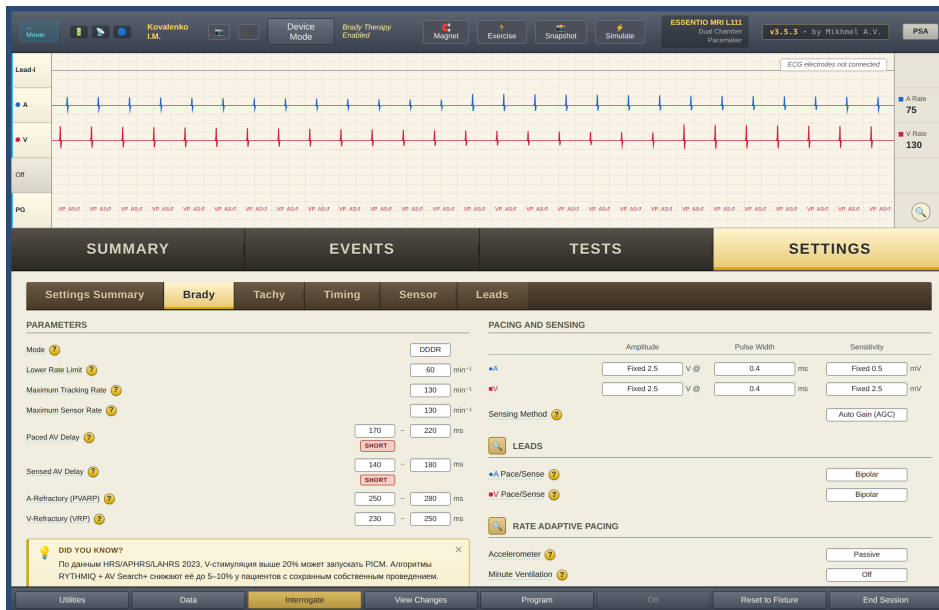
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Pacing minimization algorithms · PICM risk assessment · EGM events.

Reference interface — Boston Scientific Essentio MRI L111.

About the simulator

Browser-based educational simulator for cardiologist and follow-up specialist training. Covers a **class of algorithms** for ventricular pacing minimization (RYTHMIQ-class AAI↔DDD switching, AV Search+, Mode Switch on ATR, Auto-capture/AGC, PMT detection — techniques implemented by different manufacturers under different names), a **PICM Risk Management module** with PACEVALUE-style scoring and 12-month trajectory forecast, an **EGM event simulator** (PMT, oversensing, crosstalk), physical battery longevity model, 9 clinical scenarios, Quiz Mode. Reference programming interface is Boston Scientific Essentio MRI L111 (devices that continue to require follow-up in Russia and several Central Asian markets after 2022). Implemented strictly from **publicly available technical specifications and peer-reviewed literature**. Educational use only.



Implemented algorithms and references

Algorithm / Module	Source / Reference
RYTHMIQ AAI↔DDD switching (2-of-4 conduction-loss criteria)	Boston Scientific REF 359363-024; HRS/EHRA 2017 algorithm review
AV Search+ extension cycles (≤320 ms, 5-min interval)	Boston Scientific Essentio Tech Manual; Sweeney M.O. et al, JCE 2010
Paced AV Adapt (rate-adaptive shortening 30–50 ms at MTR)	BSC Pulse Generator Reference Guide (public)
PVARP / VRP refractory period adapt (low / high pair)	BSC Programmer Help; ESC 2021 pacing guideline
Mode Switch on ATR (DDDR → DDIR) with fallback rate	BSC technical specs; HRS practice 2017
Auto-capture / Auto-sense (AGC)	BSC Pulse Generator white papers
PMT detection and termination (PVARP extension)	BSC product documentation; standard implementation per IEEE
Lapique strength-duration: $V = V_{theo} \cdot (1 + \text{chronaxie}/PW)$	Lapicque L., 1907 (classic); modern IEC 60601-2-31 derivation
Battery longevity: $E_{pulse} = V^2 \cdot t/R$; 2550 J usable; 0.66 J/yr quiescent	BSC Essentio longevity datasheet; published Li-MnO ₂ characteristics
PICM Risk Score (PACEVALUE-style weights)	Khurshid S. et al, JACC EP 2019; PACEVALUE registry
PICM Trajectory forecast (12-month projection)	Original derivation from registry-published progression rates

Clinical fixtures (9)

Sinus node dysfunction (DDDR) · complete AV block III · paroxysmal AF with mode-switch burden · post-MI cardiomyopathy with PICM in development · CRT recipient · paced-AV-induced PMT · suspected lead fracture · biventricular non-responder · pacemaker-dependent with subnormal LVEF.

Validation

47-test automated regression suite (Playwright). Algorithm fidelity cross-checked against published behavior. PICM trajectory model evaluated against 9 fixtures. Battery longevity model tested against BSC published Essentio datasheet for representative scenarios.

Demonstration: babab.ru/demo-programmator.html · **Source code:** available for non-commercial educational review on request · **Disclaimer:** Educational tool only. Not for clinical decision-making. No affiliation with or endorsement by Boston Scientific Corporation.