

Topological Features of Classical and Quantized Electric Circuits

JOHN GOUGH*

Department of Physics, Aberystwyth University
jug@aber.ac.uk

The problem of giving an intrinsic Hamiltonian and Poisson Bracket formulation of electric circuits (both lumped and distributed) is revisited. The role of topology of the circuit is well-known to be critically important in determining a symplectic structure [?]-[?] and elucidates how Casimir functions arise and how network constraints can be applied. The quantization of such systems clearly requires a canonical structure with a natural “physical Hamiltonian” and the topology of the network lays the groundwork on how to proceed. We build on existing treatments [?]- [?] to show how this can be carried through.

References

- [1] L. O. Chua and J. D. McPherson, Explicit topological formulation of Lagrangian and Hamiltonian equations for nonlinear networks, *IEEE Trans. Circuits Syst.*, vol. CAS-21, no. 2, pp. 277-285, Mar. (1974)
- [2] J. Vanderwalle and L. O. Chua, The colored branch theorem and its applications in circuit theory, *IEEE Trans. Circuits Syst.*, vol. SAS-27, pp. 816-825, Sept. (1980)
- [3] G. M. Bernstein and M. A. Lieberman, A method for obtaining a canonical Hamiltonian for nonlinear LC circuits, *Trans. IEEE Circuits Syst.*, vol. CAS-35, no. 3, pp. 411-420, (1989)
- [4] B. M. Maschke, A. J. van der Schaft, and P. C. Breedveld An Intrinsic Hamiltonian Formulation of the Dynamics of LC-Circuits, *IEEE Trans. Circuits Syst.*, Vol. 42, no. 2, February (1995)
- [5] J. Gough, Non-Markovian Quantum Feedback Networks I: Quantum Transmission Lines, Lossless Bounded Real Property and Limit Markovian Channels, *J. Math. Phys.* 57, 122101 (2016)
- [6] U. Vool, M. Devoret Introduction to quantum electromagnetic circuits, *International Journal of Circuit Theory and Applications* 45 (7), 897-934 (2017)
- [7] H. Ding, Nina H. Amini, G. Zhang, J.E. Gough, Quantum coherent and measurement feedback control based on atoms coupled with a semi-infinite waveguide, *SIAM Journal on Control and Optimization*, (0): S231-S257 (2025)

*This is joint work with N. Amini, B. Maschke and A. van der Schaft).