Towards an Electrical Equivalent Circuit Model (SPICE Model) for Electrically-Suppressed Helix Ferroelectric Liquid Crystal

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Towards an Electrical Equivalent Circuit Model (SPICE Model) for Electrically-Suppressed Helix Ferroelectric Liquid Crystal

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We introduce for the first time a simple Electrical Equivalent Circuit (EEC) model for Electrically-Suppressed Helix Ferroelectric Liquid Crystal[i] (ESH-FLC). The ESH-FLC shows promise for use in many device types and configurations including reflective Liquid Crystal on Silicon (LCoS) microdisplays[ii]. Circuit simulation plays an integral role in the electronic design process for Active Matrix LC Displays (AMLCDs) from microdisplays to large flat panels. In any device/display, the design of the electronic drive circuit for the LC-cell/pixel is accepted to be more robust if the electrical load of the LC can be simulated and modelled accurately as part of the circuit alongside the active devices, passive components and parasitic components. The EEC Model (SPICE[iii] model) for the LC provides the key. SPICE models of LCs that have previously been developed include nematic LC[iv] and Surface-Stabilized FLC[v]. An EECM for ESH-FLC is required[vi]. Fig 1(a) shows the most basic circuit model which represents our starting point – the ESH-FLC cell is represented by a resistance, capacitance and current-source in parallel. Fig 1(b) extends the simulation into the optical domain in which the magnitude of E_{OUT} is proportional to the light level at the output of the FLC cell; it also allows the mathematical expressions underlying some of the components in Fig 1(a) to be replaced by additional circuit elements.

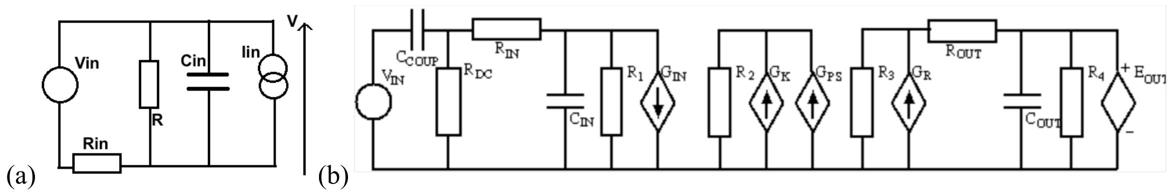

Figure 1. (a) Original simplified circuit model; (b) Expanded simplified model in PSPICE.

Simulations have been carried out using PSPICE. Experiments have been done on an optical bench with several samples of transmissive-mode glass cells containing ESH-FLC. Early results comparing simulation and experiment, in a small number of notionally identical LC cells over a limited range of operating conditions, indicate promising agreement on switching time and output voltage. Future work could include testing a larger number of LC cells with a broad range of parameters construction parameters. Extending the characterization and modelling to reflective cells will pave the way to a model suitable for microdisplay development.

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i AK Srivastava et al, JSID v. 23, (4), April 2015, p. 176-181, DOI: 10.1002/jsid.350

ii Armitage, D et al (2006) Introduction to Microdisplays, John Wiley & Sons, Ltd. doi: 10.1002/9780470057056.

iii https://en.wikipedia.org/wiki/SPICE

iv JR Moore, ARL Travis, IEE Proc J Optoelectronics, vol. 146 no. 5 pp. 231-237 1999, DOI: 10.1049/ip-opt:19990841

v S Smith et al, An improved SPICE model …, Intl Conf. on ICMTS, 2003, doi: 10.1109/ICMTS.2003.1197438

vi L Zhu, Electrically-suppressed helix ferroelectric liquid crystal, MSc Thesis, University of Edinburgh, 2016.

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