Pixel current calibration in digital-driven active matrix displays

Jan Genoe[1,2], Lynn Verschueren[1,2], Florian De Roose[1,2], Wim Dehaene[2,1] and Paul Heremans[1,2]
[1] Large Area Electronics Dept., imec, Kapeldreef 75, 3001 Leuven, Belgium
Tel.:+32-16-288705, E-mail: jan.genoe@imec.be
[2]ESAT (Dept. of Electric Engineering), KU Leuven, 3001 Leuven, Belgium

The overall energy efficiency of AMOLED displays is substantially reduced by the relatively large voltage drop that is required between the source and the drain of the driving transistor. This relatively large voltage drop cannot be avoided if the transistor is driven in saturation and hence actively controls the current of the pixel. The voltage drop over the drive transistor and the backplane energy losses can be substantial reduced when the transistor is driven in the linear region. However, in this case, active control of the pixel current is no longer possible. We can still control the pixel impedance such that all pixels along a power line are driven at an equal current. This enables digital Pulse Width Modulation (PWM) of the AMOLED displays [1-3].

The advantages of PWM implementation are numerous: very compact pixels are possible as only 2 transistors in the pixel are needed and short channel effects are no longer relevant. Moreover, the PWM modulation of the active matrix driving enables 2^{16} grey scales per color implementations with perfect linearity and up to a duty cycle of almost 100% [4]. Disadvantages of this PWM AMOLED implementation are (1) that the external driving silicon chips need to operate at much higher speed and (2) that the complexity of the calibration is moved into the silicon driver chips.

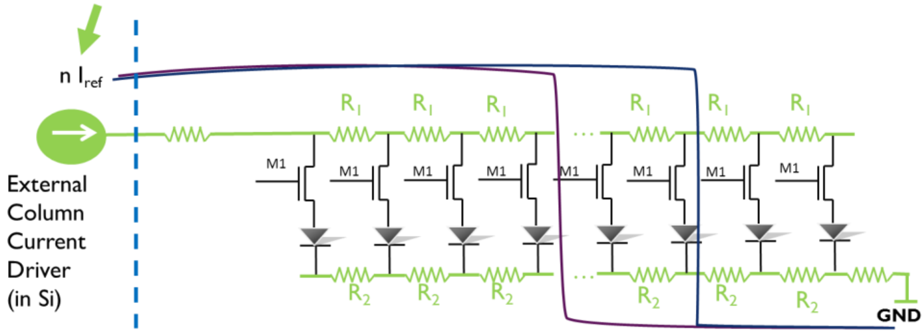

Fig. 1. Method of pixel current matching by assessing the overall path impedance

In this presentation, we elaborate the accuracy at which the real-time calibration can be done. Calibration is done to compensate for a-IGZO TFT non-uniformity, OLED non-uniformity, temperature variation effects, resistive drops on the power lines and a-IGZO TFT V_T shift due to bias stress [4,5]. This calibration substantially increases the design complexity of the silicon drivers but we demonstrate that calibration can be done in real-time at typical display refresh rates.

References

1. J. Genoe, *et al.*, IEEE Journal of Solid-State Circuits, vol. 50, p 282, Jan. 2015.
2. J. Genoe, *et al.*, 2014 IEEE International Solid-State Circuits Conference (ISSCC), p 488, 2014
3. J. Genoe, *et al.*, Proc IMID 2015, Daegu, Korea, 2015, p. 231.
4. J. Genoe, Low power digital driving of active matrix displays, Patent no. WO2014080014; --, Digital driving of active matrix displays, Patent no. WO2014068017
5. F. De Roose, *et al.*, Proc. International Display Workshop (IDW) 2014, p 1382