A Study on Some Multi-Line Addressing Techniques for Driving Passive Matrix LCDs

by
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Thesis submitted to the Jawaharlal Nehru University
for the award of Doctor of Philosophy

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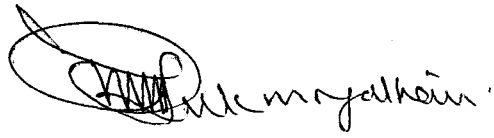
DECLARATION

I hereby declare that the work reported in this thesis is entirely original. This thesis is composed independently by me at Raman Research Institute under the supervision of Prof. T. N. Ruckrnongathan. I further declare that the subject matter presented in this thesis has not previously formed the basis for the award of any degree, diploma, membership, associateship, fellowship or any other similar title of any university or institution.



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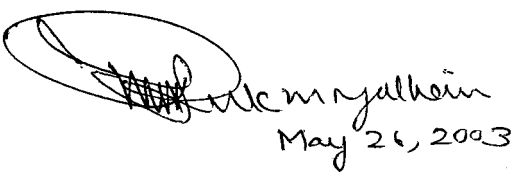
CERTIFICATE

This is to certify that the thesis entitled *A Study on some Multi-Line Addressing Techniques for Driving Passive Matrix LCDs* submitted *by K* G *Panikumar* for the award of the degree of DOCTOR OF PHILOSOPHY of Jawaharlal Nehru University is his original work. This has not been published or submitted to any other University for any other degree or diploma.



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Contents

PREFACE

This thesis presents the research and developmental work that has been carried out to improve the performance of passive matrix liquid crystal displays. A technique for displaying multiple waveforms with lower hardware complexity and supply voltage forms the first part of the research. A technique based on successive approximation and using multi-line addressing has been developed to display gray shades with low hardware complexity. Both these techniques have been demonstrated by developing suitable controllers using CPLDs. Theoretical analysis on reduction in supply voltage by using hybrid addressing techniques with low hardware complexity while using liquid crystal mixtures with steep electro-optic characteristics is presented in the last part of this thesis. The research work presented in this thesis has been carried out in the Liquid Crystal Laboratory, Raman Research Institute, Bangalore and is submitted to the Jawaharlal Nehru University, Delhi.

LIST OF ABBREVIATIONS

ADC	Analog to Digital Converter
AM	Amplitude Modulation
APT	Alt and Pleshko Technique
a-Si	Amorphous Silicon
CLK	Clock
CPLD	Complex Programmable Logic Device
CRT	Cathode Ray Tube
DAC	Digital to Analog Converter
D-STN	Double Super Twisted Nematic
EPROM	Electrically Programmable Read Only Memory
FIFO	First In First Out
GH	Guest Host
GND	Ground
IAPT	Improved Alt and Pleshko Technique
ITO	Indium Tin Oxide
JTAG	Joint Test Action Group
LCD	Liquid Crystal Display
LSB	Least Significant Bit
LUT	Look Up Table
MIM	Metal Insulator Metal
MSB	Most Significant Bit
OLED	Organic Light Emitting Diode
PDA	Personal Digital Assistant
PDP	Plasma Display Panel
PISO	Parallel In Serial Out
PRBS	Pseudo Random Binary Sequence
p-Si	Polycrystalline Silicon
PWM	Pulse Width Modulation
rms	Root Mean Square
SA	Successive Approximation
SIPO	Serial In Parallel Out

STN	Super Twisted Nematic
TFT	Thin Film Transistor
TN	Twisted Nematic
TV	Television
ZBD	Zenithal Bistable Display

LIST OF SYMBOLS

$\varepsilon_{\parallel}$	Dielectric constant parallel to liquid crystal director
$\varepsilon_{\perp}$	Dielectric constant perpendicular to liquid crystal director
$\Delta\varepsilon$	Dielectric anisotropy of the liquid crystal material (i.e., $\varepsilon\parallel - \varepsilon\perp$)
$n_{\parallel}$	Refractive index parallel to liquid crystal director
$n_{\perp}$	Refractive index perpendicular to liquid crystal director
Δn	Optical anisotropy of the liquid crystal material (i.e., $n_{\parallel} - n_{\perp}$)
$C_k(j)$	Column signal for the i^{th} row select pattern when the k^{th} subgroup is selected
d_{ks+i}	Data for the i^{th} pixel in the k^{th} subgroup
f	Frame number ranges from 0 to ($g - 1$)
g	Number of bits used to represent gray shade value
κ_f	Scaling factor corresponds to f^{th} frame
K_{11}	Splay elastic constant of liquid crystal mixture
K_{22}	Twist elastic constant of liquid crystal mixture
K_{33}	Bend elastic constant of liquid crystal mixture
I	Number of mismatches between the row select pattern and the data pattern
M	Number of columns in the matrix LCD
N	Number of rows in the matrix LCD
$\hat{n}$	Nematic director
$O(i, j)$	Element of the orthogonal matrix
p	pitch
q	Number of columns in the orthogonal matrix
s	Number of rows in each subgroup
V_{10}	rms voltage corresponds to the 10% of the total transmission
V_{50}	rms voltage corresponds to the 50% of the total transmission
V_{90}	rms voltage corresponds to the 90% of the total transmission
V_c	Amplitude of the column voltage

V_{DD}	Positive supply voltage
V_{EE}	Negative supply voltage
V_{ks+i}	rms voltage across the i'' pixel in the k'' subgroup
V_m	Amplitude of the column voltage in **MAT–S3**
V_{m1} and V_{m2}	Amplitude of the column voltages in IHAT–S4
V_{off}	rms voltage across the OFF pixel
V_{on}	rms voltage across the ON pixel
V_r	Amplitude of the row select voltage
V_{sat}	Saturation voltage
V_{SS}	Ground
V_{sup}	Supply voltage requirement of the addressing technique
V_{th}	Threshold voltage
W	Number of waveforms to be displayed