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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/467,738	08/21/2007	7259521	MIC-M192	4013

32566 7590 08/01/2007
PATENT LAW GROUP LLP
2635 NORTH FIRST STREET
SUITE 223
SAN JOSE, CA 95134

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

David W. Ritter, San Jose, CA;

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

32566 7590 04/13/2007

PATENT LAW GROUP LLP
2635 NORTH FIRST STREET
SUITE 223
SAN JOSE, CA 95134

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
Electronically Filed (Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/467,738	08/28/2006	David W. Ritter	MIC-M192	4013

TITLE OF INVENTION: VIDEO DRIVER ARCHITECTURE FOR AMOLED DISPLAYS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$0	\$1700	07/13/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHILOGENE, HAISSA	2821	315-169100

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Patent Law Group LLP
2 Carmen C. Cook
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Micrel, Inc.

San Jose, California

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies None

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

☐ A check is enclosed.
☒ Payment by credit card. ~~XXX PTO 2008 is attached.~~
☒ The Director is hereby authorized to charge ~~the credit card~~ any deficiency, or credit any overpayment, to Deposit Account Number 502226 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature Carmen C. Cook

Date 7/11/07

Typed or printed name Carmen C. Cook

Registration No. 42,433

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal				
Application Number:		11467738		
Filing Date:		28-Aug-2006		
Title of Invention:		VIDEO DRIVER ARCHITECTURE FOR AMOLED DISPLAYS		
First Named Inventor/Applicant Name:		David W. Ritter		
Filer:		Carmen C. Cook/Linda Richardson		
Attorney Docket Number:		MIC-M192		
Filed as Large Entity				
Utility Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	1501	1	1400	1400
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1700

Electronic Acknowledgement Receipt

EFS ID:	1960477
Application Number:	11467738
International Application Number:	
Confirmation Number:	4013
Title of Invention:	VIDEO DRIVER ARCHITECTURE FOR AMOLED DISPLAYS
First Named Inventor/Applicant Name:	David W. Ritter
Customer Number:	32566
Filer:	Carmen C. Cook
Filer Authorized By:	
Attorney Docket Number:	MIC-M192
Receipt Date:	12-JUL-2007
Filing Date:	28-AUG-2006
Time Stamp:	12:42:41
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$ 1700
RAM confirmation Number	5879
Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
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1	Issue Fee Payment (PTO-85B)	MIC-M192-Issue-Fee-Pmt.pdf	197350 fa14e637dc7c4eb1b5afc686b2d7d580149fca4b	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-06)	fee-info.pdf	8295 953359f5b5dac8a0c38343f9c82b12a94e612e5a	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			205645		
This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503. <u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application. <u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course. <u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.					



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NOTICE OF ALLOWANCE AND FEE(S) DUE

32566 7590 04/13/2007

PATENT LAW GROUP LLP
2635 NORTH FIRST STREET
SUITE 223
SAN JOSE, CA 95134

EXAMINER	
PHILOGENE, HAISSA	
ART UNIT	PAPER NUMBER
2821	
DATE MAILED: 04/13/2007	

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/467,738	08/28/2006	David W. Ritter	MIC-M192	4013
TITLE OF INVENTION: VIDEO DRIVER ARCHITECTURE FOR AMOLED DISPLAYS				

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$0	\$1700	07/13/2007

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. **PROSECUTION ON THE MERITS IS CLOSED.** THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN **THREE MONTHS** FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. **THIS STATUTORY PERIOD CANNOT BE EXTENDED.** SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

- A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.
- B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

- A. Pay TOTAL FEE(S) DUE shown above, or
- B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
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Alexandria, Virginia 22313-1450
or Fax **(571)-273-2885**

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CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

32566 7590 04/13/2007

PATENT LAW GROUP LLP
2635 NORTH FIRST STREET
SUITE 223
SAN JOSE, CA 95134

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

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(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/467,738	08/28/2006	David W. Ritter	MIC-M192	4013

TITLE OF INVENTION: VIDEO DRIVER ARCHITECTURE FOR AMOLED DISPLAYS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$0	\$1700	07/13/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
PHILOGENE, HAISSA	2821	315-169100

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
 (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
 (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
 1 _____
 2 _____
 3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

- ☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

- ☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/467,738	08/28/2006	David W. Ritter	MIC-M192	4013
32566	7590	04/13/2007	EXAMINER	
PATENT LAW GROUP LLP 2635 NORTH FIRST STREET SUITE 223 SAN JOSE, CA 95134			PHILOGENE, HAISSA	
			ART UNIT	PAPER NUMBER
			2821	
DATE MAILED: 04/13/2007				

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

TH

Notice of Allowability	Application No.	Applicant(s)	
	11/467,738	DAVID W. RITTER	
	Examiner	Art Unit	
	Haissa Philogene	2821	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to application filed 8/28/06.
2. ☒ The allowed claim(s) is/are 1-8.
3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 - a) ☐ All b) ☐ Some* c) ☐ None of the:
 1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
 - (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
 - 1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
 - (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. ☒ Notice of References Cited (PTO-892) 2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3. ☒ Information Disclosure Statements (PTO/SB/08),
Paper No./Mail Date <u>8/28/06</u> 4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material | <ol style="list-style-type: none"> 5. ☐ Notice of Informal Patent Application 6. ☐ Interview Summary (PTO-413),
Paper No./Mail Date _____. 7. ☐ Examiner's Amendment/Comment 8. ☒ Examiner's Statement of Reasons for Allowance 9. ☐ Other _____. |
|--|--|

Haissa Philogene
 Primary Examiner

Haissa Philogene 2821, 10/1/06

DETAILED ACTION

Allowable Subject Matter

The following is an examiner's statement of reasons for allowance: The prior art fails to disclose an AMOLED display system having, inter alia, "a video driver.....referenced to a positive power supply voltage...and the drive current being.....independent of the positive power supply voltage" (claim 1). The remaining claims 2-8 are allowed by virtue of their dependencies from claim 1. Hence, the examiner has allowed claims 1 through 8.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Zhang et al., Patent No. 6,999,015 ; Nakahira et al., Patent No. 7,005,916 ; Libsch et al., Patent No. 7,038,392 ; Libsch et al., Patent No. 7,167,169 ; Howard, Patent No. 6,858,989; Reddy et al., Pub. No. 2005/0285822.

Correspondence

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Haissa Philogene whose telephone number is (571) 272-1827. The examiner can normally be reached on 8:30 A.M.-6:00 P.M..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Douglas W. Owens can be reached on (571)272-1662. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

hp

Haissa Philogene
Primary Examiner
A.U. 2821
Haissa Philogene

Notice of References Cited	Application/Control No. 11/467,738	Applicant(s)/Patent Under Reexamination DAVID W. RITTER	
	Examiner Haissa Philogene	Art Unit 2821	Page 1 of 1

U.S. PATENT DOCUMENTS

★		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
★	A	US-6,999,015	02-2006	Zhang et al.	341/144
★	B	US-7,005,916	02-2006	Nakahira et al.	330/9
★	C	US-7,038,392	05-2006	Libsch et al.	315/169.3
★	D	US-7,167,169	01-2007	Libsch et al.	345/211
★	E	US-6,858,989	02-2005	Howard, Webster E.	315/169.1
★	F	US-2005/0285822	12-2005	Reddy et al.	345/076
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

★		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

★		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
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PTO/SB/08a (08-03)

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	11/467,738
	Filing Date	2006-08-28
	First Named Inventor	David W. Ritter
	Art Unit	2821
	Examiner Name	PHILLOGNE
	Attorney Docket Number	MIC-M192

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	First Named Inventor	David W. Ritter	
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	Examiner Name	PHILOGENE	
Attorney Docket Number		MIC-M192	

hp	1	"Design of current programmed amorphous silicon AMOLED pixel circuit," B. Mazhari and Yogesh S. Chauhan, 8th Asian Symposium on information display, Nanjing, China, 2004, pp. 327-330.	☐
hp	2	YENCHUNG LIN et al., "A Novel Current Memory Circuit for Active Matrix Organic Light Emitting Display," SID 03 Digest, 2003, 4 pages.	☐
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EXAMINER SIGNATURE			
Examiner Signature		Maisha Philogen	Date Considered 3/24/07
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			
¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached.			

Issue Classification 	Application/Control No.	Applicant(s)/Patent under Reexamination	
	11/467,738	DAVID W. RITTER	
	Examiner	Art Unit	
	Haissa Philogene	2821	

ISSUE CLASSIFICATION									
ORIGINAL				CROSS REFERENCE(S)					
CLASS		SUBCLASS		CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
315		169.1		315	169.3				
INTERNATIONAL CLASSIFICATION				345	82	84	214		
G	0	9	G	327	108	246	355		

_____ (Assistant Examiner) (Date)		Haissa Philogene Primary Examiner 3/25/07 Haissa Philogene 3/25/07 (Primary Examiner) (Date)		Total Claims Allowed: 8	
_____ (Legal Instruments Examiner) (Date)				O.G. Print Claim(s) 1	
				O.G. Print Fig. 2	

☒ Claims renumbered in the same order as presented by applicant										☐ CPA		☐ T.D.		☐ R.1.47	
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		31		61		91		121		151		181		211
	2		32		62		92		122		152		182		212
	3		33		63		93		123		153		183		213
	4		34		64		94		124		154		184		214
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	17		47		77		107		137		167		197		227
	18		48		78		108		138		168		198		228
	19		49		79		109		139		169		199		229
	20		50		80		110		140		170		200		230
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	27		57		87		117		147		177		207		237
	28		58		88		118		148		178		208		238
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	30		60		90		120		150		180		210		240



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Bib Data Sheet

CONFIRMATION NO. 4013

SERIAL NUMBER 11/467,738	FILING OR 371(c) DATE 08/28/2006 RULE	CLASS 315	GROUP ART UNIT 2821	ATTORNEY DOCKET NO. MIC-M192
APPLICANTS David W. Ritter, San Jose, CA;				
** CONTINUING DATA ***** <i>NONE</i>				
** FOREIGN APPLICATIONS ***** <i>NONE</i>				
IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** 09/08/2006				
Foreign Priority claimed ☐ yes ☒ no 35 USC 119 (a-d) conditions ☐ yes ☒ no ☐ Met after met ☐ Allowance		STATE OR COUNTRY CA	SHEETS DRAWING 3	TOTAL CLAIMS 8
Verified and Acknowledged <i>Marissa Thibault</i> Examiner's Signature Initials				INDEPENDENT CLAIMS 1
ADDRESS 32566				
TITLE Video Driver Architecture for AMOLED Displays				
FILING FEE RECEIVED 1000	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:		☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit	

Search Notes

Application/Control No.

11/467,738

Examiner

Haissa Philogene

Applicant(s)/Patent under
Reexamination

DAVID W. RITTER

Art Unit

2821

SEARCHED

Class	Subclass	Date	Examiner
315	169.1, 169.2, 169.3	3/24/2007	HP
345	82, 84		
	98, 211		
	212, 214		
327	100, 108		
	127, 137		
	245-248		
	355, 359		
	358, 361		
326	82, 83		
	86		
341	144		

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
315	169.1, ~~169.3~~	3/25/2007	HP
345	82, 84, ~~214~~		
327	108, 246, ~~355~~		
see int. search history printout			

**SEARCH NOTES
(INCLUDING SEARCH STRATEGY)**

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West Search	3/24/2007	HP

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Term:	L17 and (active adj matrix)  
Display:	10 Documents in Display Format: TI Starting with Number 1
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Search History

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side by side			
<i>DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=YES; OP=OR</i>			
<u>L18</u>	L17 and (active adj matrix)	10	<u>L18</u>
<u>L17</u>	L16 and current	13	<u>L17</u>
<u>L16</u>	(operational adj amplifier) and resistor and feedback and ((video or data) near2 signal) and ground and (positive near2 voltage) and OLED	13	<u>L16</u>
<u>L15</u>	L14 and amplifier	1	<u>L15</u>
<u>L14</u>	OLED and (video adj driv\$3 adj signal)	3	<u>L14</u>
<u>L13</u>	AMOLED and (video adj driv\$3 adj signal)	0	<u>L13</u>
<u>L12</u>	AMOLED and (video adj driver)	0	<u>L12</u>
<u>L11</u>	L1 and (video adj driver)	0	<u>L11</u>
<u>L10</u>	L5 and (video near2 driver)	0	<u>L10</u>
<u>L9</u>	L5 and indicative and independent	6	<u>L9</u>
<u>L8</u>	L6 and indicative and independent	0	<u>L8</u>
<u>L7</u>	L6 and (voltage adj variations)	2	<u>L7</u>
<u>L6</u>	L5 and (current adj driver)	10	<u>L6</u>
<u>L5</u>	(positive near2 voltage) and AMOLED	51	<u>L5</u>

<u>L4</u>	L1 and (positive near2 voltage) and AMOLED	0	<u>L4</u>
<u>L3</u>	L1 and (positive adj power adj supply)	1	<u>L3</u>
<u>L2</u>	L1 and (positive adj power adj supply adj voltage) ((active matrix adj organic adj light adj emitting adj diode adj display) or	0	<u>L2</u>
<u>L1</u>	AMOLED) and (current adj driver) and (noise or drift\$3 or glitch\$2) and (voltage adj variations)	92	<u>L1</u>

END OF SEARCH HISTORY

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Term:

L1 and voltage and (power adj supply) and
 (operational adj amplifier)

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DB=PGPB,USPT,USOC,EPAB,JPAB,DWPI,TDBD; PLUR=YES; OP=OR

L2 L1 and voltage and (power adj supply) and (operational adj amplifier)
 ((active adj matrix adj organic adj light adj emitting adj diode) or AMOLED)
 L1 and pixel and ((video or data) adj signal) and display\$3 and (current adj
 driv\$3)

11

L2

92

L1

END OF SEARCH HISTORY

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875 Effective December 8, 2004

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A
SEARCH FEE (37 CFR 1.16(a), (d), or (m))	N/A	N/A
EXAMINATION FEE (37 CFR 1.16(a), (p), or (q))	N/A	N/A
TOTAL CLAIMS (37 CFR 1.16(i))	33 minus 20 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	
APPLICATION SIZE FEE (37 CFR 1.16(e))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$250 (\$125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))		

SMALL ENTITY	
RATE (\$)	FEE (\$)
N/A	150.00
N/A	\$250
N/A	\$100
X\$ 25	
X100	
+180=	
TOTAL	

OTHER THAN SMALL ENTITY	
RATE (\$)	FEE (\$)
N/A	300.00
N/A	\$500
N/A	\$200
X\$50	650
X200	
+360=	
TOTAL	1650

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED - PART II

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT	(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total (37 CFR 1.16(i))	33	Minus 33	
Independent (37 CFR 1.16(h))	3	Minus 3	
Application Size Fee (37 CFR 1.16(s))			
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))			

SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)
X\$ 25	
X100	
+180=	
TOTAL ADD'L FEE	

OTHER THAN SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)
X\$50	
X200	
+360=	
TOTAL ADD'L FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT	(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total (37 CFR 1.16(i))	33	Minus 33	
Independent (37 CFR 1.16(h))	3	Minus 3	
Application Size Fee (37 CFR 1.16(s))			
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))			

SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)
X\$ 25	
X100	
+180=	
TOTAL ADD'L FEE	

OTHER THAN SMALL ENTITY	
RATE (\$)	ADDITIONAL FEE (\$)
X\$50	
X200	
+360=	
TOTAL ADD'L FEE	

- If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
- If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
- If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.
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Video Driver Architecture for AMOLED Displays

FIELD OF THE INVENTION

[0001] The invention relates to video driver for AMOLED displays and, in particular, to a video driver for AMOLED displays that is capable of isolating the pixel circuit from power supply voltage variations.

DESCRIPTION OF THE RELATED ART

[0002] Active matrix organic light emitting diode (AMOLED) displays are an emerging flat panel display technology. An AMOLED display panel contains many thousands of individual pixel drivers which provide current to energize the individual pixel OLEDs. These pixel drivers are programmed by a single current driver via a series of row and column decoders and switches such that, at any instant, only one pixel is connected to the current driver. The input to the current driver is the video drive signal.

[0003] The current provided by the current driver is proportional to the difference between the voltage level of the video drive signal and the positive power supply voltage of the display panel. Therefore, any variations in the power supply voltage will modulate the brightness of the AMOLED display. Power supply voltage variations that occur while a pixel is being programmed will be stored for an entire video frame. Since the power supply voltage variations are likely to be nonsynchronous with the video scan rate, the net result is flickers that can be observed on the display panel and are objectionable to the viewer. The direct relationship between the drive current and

the power supply voltage renders AMOLED displays extremely sensitive to power supply voltage noise. It also makes the AMOLED display's overall brightness extremely dependent on the absolute voltage of the power supply voltage. Thus, the brightness level of an AMOLED display will tend to drift with power supply voltage variations. Both of these effects are undesirable.

[0004] There are many sources of power supply voltage variations that can cause flickering in AMOLED displays. In particular, when the AMOLED display is incorporated in a battery powered application, the power supply voltage will inevitably fluctuate whenever circuitry in the application device is powered up from being in a standby mode. For example, the AMOLED display may be incorporated in a cellular telephone where the battery voltage is coupled to a voltage regulator to provide the power supply voltage for the AMOLED display system. The power supply voltage will fluctuate when the transmitter or receiver circuit is powered up. Furthermore, battery voltage tends to drift over time. Even for AC powered devices, the AC power often has noise and glitches. Sensitivity to these power supply voltage transients in AMOLED displays results in poor display quality.

[0005] Figure 1 is a schematic diagram of an exemplary AMOLED display system. In an AMOLED display system 10, a video source 12 provides a source of video signals to an AMOLED display panel 30 to be displayed. Video source 12 can be any systems that generate video signals to be displayed, such as an image processor. In most systems, the video signals are digital in nature and the final processing step of video source 12 is to convert the digital video signals to analog signals, thereby

generating the analog signal Video.DAC on an output bus 18. The analog video signal Video.DAC is summed with a DC voltage V_{DC} (node 14) at a summer 20 to generate the video drive signal $v(t)$ for driving the AMOLED display panel. In the conventional AMOLED display system, the video drive signal $v(t)$ is a signal that is referenced to the ground voltage (node 16) and has a voltage value given as:

$$v(t) = \text{Video.DAC} + V_{DC}, \quad \text{Eq. (1)}$$

where the DC voltage V_{DC} is related to the power supply voltage VDD of the AMOLED display system. The DC voltage V_{DC} is added to the analog signal Video.DAC to bring the DC range of the analog video signal to within the range of the AMOLED display panel. Basically, the analog signal Video.DAC is referenced to ground and the V_{DC} voltage level is added to offset the video signal to the power supply voltage VDD.

[0006] At the AMOLED display panel 30, the video drive signal $v(t)$ is coupled to drive a current driver 34 for providing a drive current I_D to an OLED 32. OLED 32 in Figure 1 represents one pixel element of the display panel. OLED 32 emits light indicative of the current level of the drive current I_D . In most AMOLED display panels, the current driver is implemented so that the current driver 34 is referenced to the positive power supply voltage VDD (node 24) of the display system 10. For instance, in the present illustration, current driver 34 includes a PMOS transistor M1 having its drain terminal connected to the VDD power supply voltage (node 24) and its gate terminal connected to receive the video drive signal $v(t)$. The source terminal of transistor M1 is coupled to the OLED 32 to provide the drive current I_D . The drive current I_D is a function of a voltage

Video.OLED across the drain-to-gate terminals of PMOS transistor M1. Current driver voltage Video.OLED is the voltage applied to the current driver 34 and determines the value of drive current I_D to be applied to the OLED pixel element of the display panel. Voltage Video.OLED is referenced to the power supply voltage VDD and is given as:

$$\text{Video.OLED} = \text{VDD} - v(t). \quad \text{Eq. (2)}$$

[0007] The power supply voltage VDD for the display panel, whether generated by a voltage regulator from a battery voltage or provided from an AC power source, will have variations due to voltage glitches, noise or drifts. The power supply voltage VDD can be characterized as the sum of an ideal power supply voltage VDDI and drift and noise components and given as

$$\text{VDD} = \text{VDDI} + V_{\text{drift}} + V_{\text{noise}}. \quad \text{Eq. (3)}$$

[0008] The current drive voltage signal Video.OLED at the display panel can be rewritten by substituting $v(t)$ from Equation (1) and VDD from Equation (3) into Equation (2). The DC voltage V_{DC} may not suffer from the same noise and drift issue as the power supply voltage and is thus assumed to have the same voltage magnitude as the ideal voltage VDDI (i.e., $V_{DC} = \text{VDDI}$). The current driver voltage Video.OLED at the display panel is then given as:

$$\begin{aligned} \text{Video.OLED} &= \text{VDD} - v(t). \\ &= \text{VDDI} + V_{\text{drift}} + V_{\text{noise}} - \text{Video.DAC} - \text{VDDI} \\ &= V_{\text{drift}} + V_{\text{noise}} - \text{Video.DAC}. \end{aligned} \quad \text{Eq. (4)}$$

[0009] As can be observed from Equation (4), the noise and drift components of the power supply voltage VDD appear directly in the current driver voltage signal Video.OLED which determines the drive current I_D for the OLED pixel element. Thus, the variations in the voltage Video.OLED due to the power supply voltage noise and drifts result in variations of the brightness level of the display, negatively impacting the display quality of the AMOLED display panel.

SUMMARY OF THE INVENTION

[0010] According to one embodiment of the present invention, an active matrix organic light emitting diode (AMOLED) display system, including an AMOLED display panel receiving a video signal to be displayed on the AMOLED display panel where the AMOLED display panel includes a plurality of organic light emitting diode (OLED) pixel elements, includes a video driver receiving the video signal and generating a video drive signal indicative of the video signal and referenced to a positive power supply voltage of the AMOLED display panel, and a current driver coupled to at least one OLED pixel element where the current driver receives the video drive signal and the positive power supply voltage and provides a drive current to the at least one OLED pixel element. The drive current is proportional to a current drive voltage which is indicative of the video signal and independent of the positive power supply voltage.

[0011] According to another aspect of the present invention, the video drive signal is indicative of the sum of or the difference between the positive power supply voltage and the video signal and the current drive voltage is indicative of the

difference between the positive power supply voltage and the video drive signal.

[0012] The present invention is better understood upon consideration of the detailed description below and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 is a schematic diagram of a conventional AMOLED display system.

[0014] Figure 2 is a schematic diagram of a video driver for an AMOLED display system according to a first embodiment of the present invention.

[0015] Figure 3 is a schematic diagram of a video driver for an AMOLED display system according to a second embodiment of the present invention.

[0016] Figure 4 is a schematic diagram of a video driver for an AMOLED display system according to a third embodiment of the present invention.

[0017] Figure 5 is a transistor level circuit diagram for implementing the video driver of Figure 2.

[0018] Figure 6 is a transistor level circuit diagram for implementing the video driver of Figure 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] In accordance with the principles of the present invention, a video driver for an AMOLED display system generates

a video drive signal that is referenced to the positive power supply voltage of the display panel. When the video drive signal is re-referenced to the positive power supply voltage, instead of to the ground voltage as in the conventional systems, the current driver in the AMOLED display panel will generate a drive current that is indicative of the video signal but independent of the power supply voltage. In this manner, the AMOLED display system is thus made to be immune to power supply voltage variations and provides display images that are free from undesired flickers and brightness variations. When the video driver of the present invention is incorporated in an AMOLED display panel, the display panel is no longer affected by power supply voltage fluctuations, noise or glitches. The video driver of the present invention eliminates the need for a highly accurate and noise free power supply voltage for use with an AMOLED display.

[0020] Figure 2 is a schematic diagram of a video driver for an AMOLED display system according to a first embodiment of the present invention. Referring to Figure 2, a video driver 102 is incorporated in an AMOLED display system 100 for receiving input video signals Video.DAC from a video source 12 and providing a modified video drive signal $v(t)$ for driving the current driver 34 in the AMOLED display panel 30. In the present illustration, video source 12 and AMOLED display panel 30 are implemented in the same manner as in Figure 1 above. That is, video source 12, such as an image processor, provides a source of analog video signals Video.DAC on a bus 18 to be displayed on AMOLED display panel 30. The current driver 34 in AMOLED display panel 30 receives the video drive signal $v(t)$ (node 122) from the video driver 102 and the power supply voltage VDD (node 124) and generates a drive current I_D as a function of the current driver

voltage signal Video.OLED. OLED pixel element 32 emits light in response to the drive current I_D .

[0021] The video source 12 and the AMOLED display panel 30 in AMOLED display system 100 are exemplary and their exact implementations are not critical to the practice of the present invention. Video driver 102 of the present invention can be incorporated in any AMOLED display systems to facilitate the generation of the video drive signals for an AMOLED display panel.

[0022] In the present embodiment, video driver 102 is implemented using a differential instrumentation amplifier circuit to re-reference the video drive signal $v(t)$ to the positive power supply voltage VDD. More specifically, video driver 102 includes an operational amplifier (opamp) 104 having a positive input terminal 109, a negative input terminal 110 and an output terminal (node 122) providing the video drive signal $v(t)$. The positive input terminal 109 of opamp 104 is coupled to a resistor 107 where the other terminal of resistor 107 is connected to the ground voltage. A resistor 108 is coupled between the positive input terminal 109 of opamp 104 and the power supply voltage VDD (node 124) of the AMOLED display system 100. The negative input terminal 110 of opamp 104 is coupled to a resistor 105 where the other terminal of resistor 105 is connect to bus 18 for receiving the video signal Video.DAC. A resistor 106 is connected between the negative input terminal 110 and the output node 122 of opamp 104 to form the feedback loop in the instrumentation amplifier circuit.

[0023] In a conventional differential instrumentation amplifier circuit, the positive input terminal of the opamp would

be connected through resistor 108 to the ground voltage. However, in accordance with the present invention, the positive input terminal 109 of opamp 104 is connected through resistor 108 to the power supply voltage VDD instead of the ground voltage so as to realize the re-referencing function of video driver 102. By connecting the positive input terminal 109 to the power supply voltage VDD, when the power supply voltage varies, the output signal of the instrumentation amplifier circuit, that is, the video drive signal $v(t)$ on node 122, will vary in such a way as to track the power supply voltage variations. As a result, the video drive signal $v(t)$ becomes the difference between the video signal Video.DAC and the power supply voltage VDD and given as:

$$v(t) = VDD - \text{Video.DAC.} \quad \text{Eq. (5)}$$

Instead of being referenced to the ground voltage, the video drive signal $v(t)$ is now made to be referenced to the power supply voltage VDD.

[0024] Then, when the video drive signal $v(t)$ is applied to the current driver 34 for the OLED pixel element 32, the current drive voltage signal Video.OLED at the current driver 34 is given as:

$$\begin{aligned} \text{Video.OLED} &= VDD - v(t); \\ &= VDD - VDD + \text{Video.DAC} \\ &= \text{Video.DAC.} \end{aligned} \quad \text{Eq. (6)}$$

As can be observed from Equation (6), the current drive voltage signal Video.OLED is made to be independent of the power supply voltage VDD. Thus, any noise or DC drifts in the power supply voltage VDD (node 124) will not disturb the current drive signal

Video.OLED and will not affect the brightness of the AMOLED display.

[0025] Thus, by using the video driver of the present invention to re-reference the video drive signal $v(t)$ so that it is referenced from the power supply voltage VDD, the AMOLED display panel 30 is made immune to noise and drifts in the power supply voltage and the display quality can improve without requiring the use of a high precision power supply voltage.

[0026] In the video driver 102, resistors 105 to 108 can have the same or different resistance values. When the resistance values of resistors 105 to 108 are the same, the differential instrumentation amplifier has unity gain. If some gain or attenuation is desired, then different resistance values for resistors 105 to 108 can be used, as is understood by one of ordinary skill in the art.

[0027] Figure 3 is a schematic diagram of a video driver for an AMOLED display system according to a second embodiment of the present invention. Referring to Figure 3, a video driver 202 is incorporated in an AMOLED display system 200 for receiving input video signals Video.DAC from a video source 12 and providing a modified video drive signal $v(t)$ for driving the current driver 34 in the AMOLED display panel 30, in the same manner as video driver 102 in Figure 2. In the present embodiment, video driver 202 is implemented as a current mode isolator circuit. Video driver 202 includes an opamp 204 having a positive input terminal receiving the video signal Video.DAC and a negative input terminal connected in a feedback configuration. The output terminal 205 of opamp 204 is coupled to drive an NMOS transistor M2. A resistor 206 is connected between the power supply voltage

VDD (node 224) and the source terminal (node 222) of transistor M2, which also provides the video drive signal $v(t)$. A resistor 207 is connected between the drain terminal (node 208) of transistor M2 and the ground voltage. The negative input terminal of opamp 204 is also connected to the drain terminal (node 208) of transistor M2) to form the feedback loop.

[0028] The combination of opamp 204 and transistor M2 forms a transconductance amplifier where the voltage of the video signal Video.DAC is converted to a current at transistor M2 and load resistor 207. The current that passes through transistor M2 is put through resistor 206 which is referenced to the power supply voltage VDD. In this manner, the current is converted to the voltage signal $v(t)$ at node 222 which is referenced to the power supply voltage VDD through the resistive load of resistor 206. By using video driver 202 incorporating a current mode isolator, the video drive signal $v(t)$ is made referenced to the power supply voltage VDD so that the current drive voltage signal Video.OLED is made independent of the power supply voltage VDD. Variations in the power supply voltage VDD will no longer adversely affect the AMOLED display.

[0029] In video driver 202, the video drive signal $v(t)$ is given as follows:

$$\begin{aligned} v(t) &= VDD - (Video.DAC/R) * R; \\ &= VDD - Video.DAC. \end{aligned} \quad \text{Eq. (7)}$$

Instead of being referenced to the ground voltage, the video drive signal $v(t)$ is now made to be referenced to the power supply voltage VDD.

[0030] Then, in the same manner as Equation (6) above, when the video drive signal $v(t)$ is applied to the current driver 34 for the OLED pixel element 32, the current drive voltage signal Video.OLED at the current driver 34 becomes:

$$\begin{aligned}\text{Video.OLED} &= \text{VDD} - v(t); \\ &= \text{VDD} - \text{VDD} + \text{Video.DAC} \\ &= \text{Video.DAC}.\end{aligned}$$

Thus, the current drive voltage signal Video.OLED is made to be independent of the power supply voltage VDD. Any noise or DC drifts in the power supply voltage VDD (node 224) will not disturb the current drive signal Video.OLED and will not affect the brightness of the AMOLED display.

[0031] In the video driver 202, resistors 206 and 207 can have the same or different resistance values. When the resistance values of resistors 206 and 207 are the same, the current mode isolator circuit has unity gain. If some gain or attenuation is desired, then different resistance values for resistors 206 and 207 can be used, as is understood by one of ordinary skill in the art.

[0032] Figure 4 is a schematic diagram of a video driver for an AMOLED display system according to a third embodiment of the present invention. In the embodiment shown in Figure 4, a video drive 302 is implemented using a video clamp circuit to reference the video drive signal to the power supply voltage VDD. In video driver 302, the video clamp circuit is implemented using an amplifier 306 coupled to receive the video signal Video.DAC and driving one plate of a capacitor C1. The other plate (node 322) of capacitor C1 is the video drive signal $v(t)$. Video driver 302

also includes an inverter 304 receiving the video blanking signal and driving a PMOS transistor M3. PMOS transistor M3 has a source terminal connected to the power supply VDD voltage (node 324) and a drain terminal connected to the left plate (node 322) of capacitor C1 providing the video drive signal $v(t)$.

[0033] As thus configured, when the Blanking signal is asserted at the beginning of each video line to re-establish the black reference of the video display, transistor M3 is turned on and the right plate of capacitor C1 is charged up to the power supply voltage VDD. In this manner, the power supply voltage VDD, including any voltage drifts, is stored on capacitor C1 as the clamping voltage V_{clamp} . When the Blanking signal is deasserted, transistor M3 is turned off and no longer drives node 322. Instead, the video signal Video.DAC is applied through amplifier 306 and is added to the clamping voltage V_{clamp} stored on capacitor C1. In this manner, the clamping voltage V_{clamp} is added to the video signal Video.DAC for the rest of the video line and the video drive signal $v(t)$ is now referenced to the power supply voltage VDD.

[0034] More specifically, video driver 302 is effective in removing voltage drifts in the power supply voltage but does not necessarily remove noise or glitches in the power supply voltage from impacting the video drive signal. This is because the clamping voltage V_{clamp} is recharged only once for each video line and thus any noise or voltage glitches that may appear on the power supply voltage VDD will not get charged to capacitor C1 until the next Blanking period. However, making the AMOLED display panel immune to voltage drifts is important as voltage

drifts in the power supply voltage VDD tend to cause the display panel to become brighter and brighter.

[0035] Again, assume that the power supply voltage VDD is the sum of an ideal power supply voltage VDC and noise and voltage drift. The clamping voltage V_{clamp} is given as:

$$V_{\text{clamp}} = VDD = VDC + V_{\text{drift}}. \quad \text{Eq. (8)}$$

Note that the noise component is not present in the clamping voltage because the capacitor C1 is only recharged once every horizontal line. The video drive signal $v(t)$ is given as:

$$\begin{aligned} v(t) &= V_{\text{clamp}} + \text{Video.DAC}; \\ &= VDC + V_{\text{drift}} + \text{Video.DAC}. \end{aligned}$$

[0036] The current drive voltage signal Video.OLED is given as:

$$\begin{aligned} \text{Video.OLED} &= VDD - v(t); \\ &= VDC + V_{\text{drift}} + V_{\text{noise}} - VDC - V_{\text{drift}} - \text{Video.DAC}; \\ &= V_{\text{noise}} - \text{Video.DAC}. \end{aligned} \quad \text{Eq. (9)}$$

[0037] As can be observed from equation (9), when the video driver 302 is implemented using a video clamp circuit, voltage drifts in the power supply voltage VDD are removed from the current drive signal Video.OLED but noise in the power supply voltage may remain to impact the current drive voltage Video.OLED.

[0038] The video driver circuit of the present invention described above with reference to Figures 2-4 can be implemented using discrete components. Alternately, the video driver circuit of the present invention can be implemented as an integrated circuit to be incorporated in the AMOLED display system. Furthermore, the video driver circuit of the present invention can be integrated with other circuitry of the AMOLED display panel into a single integrate circuit. For instance, the video driver of the present invention can be integrated on the same integrated circuit with the current driver and the OLED pixel elements of the AMOLED display panel. In Figures 2-4, the video drivers are shown as being formed outside of the AMOLED display panel 30. The embodiments in Figures 2-4 are illustrative only and are not intended to require the video driver to be formed outside of the AMOLED display panel. The video driver of the present invention can be integrated with the AMOLED display panel when desired to reduce the component count and size of the PC board space used.

[0039] Figure 5 is a transistor level circuit diagram for implementing the video driver of Figure 2. Figure 5 illustrates an exemplary implementation of a differential instrumentation amplifier circuit as the video driver in an integrated circuit. Figure 6 is a transistor level circuit diagram for implementing the video driver of Figure 3. Figure 6 illustrates an exemplary implementation of a current mode isolator circuit as the video driver in an integrated circuit. Figures 5 and 6 are provided as examples to illustrate the integrated circuit implementation of the video driver of the present invention. Figures 5 and 6 are illustrative only and are not intended to be limiting.

[0040] The above description provides several embodiments of the video driver of the present invention that can be used in an AMOLED display system to re-reference the video drive signal for the current driver of the OLED pixel elements to the positive power supply voltage. The above-described embodiments are illustrative only and are not intended to be limiting. One of ordinary skill in the art, upon being appraised of the present description, would appreciate that other video driver circuitry can be used to re-reference the video drive signal for the current driver of the OLED pixel elements in the AMOLED display panel.

[0041] By using the video driver of the present invention to re-reference the video drive signal to the power supply voltage, an AMOLED display panel can operate with power supply voltage that may not be highly accurate or highly precise. The video driver of the present invention provides a low cost solution to the power supply sensitivity of the AMOLED display panel. The simplicity and low cost advantage of the video driver of the present invention cannot be obtained by conventional solutions.

[0042] The above detailed descriptions are provided to illustrate specific embodiments of the present invention and are not intended to be limiting. Numerous modifications and variations within the scope of the present invention are possible. For instance, the ground voltage can be any ground reference voltage, including a negative power supply voltage. Furthermore, the resistance values of the resistors shown in Figures 2-6 can be the same or they can be different depending on the desired gain or attenuation for the video driver circuit. The present invention is defined by the appended claims.

CLAIMS

I claim:

1. An active matrix organic light emitting diode (AMOLED) display system comprising an AMOLED display panel receiving a video signal to be displayed on the AMOLED display panel, the AMOLED display panel comprising a plurality of organic light emitting diode (OLED) pixel elements, the AMOLED display system comprising:

a video driver receiving the video signal and generating a video drive signal indicative of the video signal and referenced to a positive power supply voltage of the AMOLED display panel; and

a current driver coupled to at least one OLED pixel element, the current driver receiving the video drive signal and the positive power supply voltage and providing a drive current to the at least one OLED pixel element, the drive current being proportional to a current drive voltage being indicative of the video signal and independent of the positive power supply voltage.

2. The AMOLED display system of claim 1, wherein the video drive signal is indicative of the sum of or the difference between the positive power supply voltage and the video signal and the current drive voltage is indicative of the difference between the positive power supply voltage and the video drive signal.

3. The AMOLED display system of claim 2, wherein the video driver comprises a differential instrumentation amplifier circuit for providing the video drive signal being the difference between the positive power supply voltage and the video signal.

4. The AMOLED display system of claim 3, wherein the video driver comprises:

- an operational amplifier having a positive input terminal coupled to a first resistor, a negative input terminal coupled to a second resistor and an output terminal providing the video drive signal;

- the first resistor being coupled between the positive input terminal of the operational amplifier and a ground voltage or a negative power supply voltage;

- the second resistor being coupled between the video signal and the negative input terminal of the operational amplifier;

- a third resistor being coupled between the positive input terminal of the operational amplifier and the positive power supply voltage; and

- a fourth resistor being coupled between the negative input terminal and the output terminal of the operational amplifier.

5. The AMOLED display system of claim 2, wherein the video driver comprises a current mode isolator circuit for providing the video drive signal being the difference between the positive power supply voltage and the video signal.

6. The AMOLED display system of claim 5, wherein the video driver comprises:

- an operational amplifier having a positive input terminal coupled to receive the video signal, a negative input terminal and an output terminal;

- a transistor having a first current handling terminal providing the video drive signal, a second current handling

terminal coupled to the negative input terminal of the operational amplifier, and a gate terminal coupled to the output terminal of the operational amplifier;

a first resistor being coupled to the negative input terminal of the operational amplifier and a ground voltage or a negative power supply voltage; and

a second resistor being coupled to the first current handling terminal of the transistor and the positive power supply voltage.

7. The AMOLED display system of claim 2, wherein the video driver comprises a video clamp circuit for providing the video drive signal being the sum of the positive power supply voltage and the video signal.

8. The AMOLED display system of claim 7, wherein the video driver comprises:

a first inverter having an input terminal coupled to receive a video blanking signal and an output terminal;

a first transistor having a first current handling terminal coupled to the positive power supply voltage, a second current handling terminal coupled to a first node providing the video drive signal, and a gate terminal coupled to the output terminal of the first inverter, the first transistor being turned on when the video blanking signal is asserted and turned off when the video blanking signal is deasserted;

an amplifier having an input terminal coupled to receive the video signal and an output terminal; and

a capacitor coupled between the output terminal of the amplifier and the first node,

wherein the capacitor is charged to the positive power supply when the video blanking signal is asserted and is charged to a sum of the video signal and the positive power supply voltage when the video blanking signal is deasserted.

ABSTRACT OF THE DISCLOSURE

An AMOLED display system, including an AMOLED display panel receiving a video signal, includes a video driver receiving the video signal and generating a video drive signal indicative of the video signal and referenced to a positive power supply voltage of the display panel, and a current driver coupled to an OLED pixel element receiving the video drive signal and the positive power supply voltage and providing a drive current to the OLED pixel element. The drive current is proportional to a current drive voltage which is indicative of the video signal and independent of the positive power supply voltage. In one embodiment, the video drive signal is indicative of the sum of or the difference between the positive power supply voltage and the video signal and the current drive voltage is indicative of the difference between the positive power supply voltage and the video drive signal.

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AND POWER OF ATTORNEY**

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Video Driver Architecture for AMOLED Displays

which (check) ☒ is attached hereto.
☐ and is amended by the Preliminary Amendment attached hereto.
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I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby appoint the following practitioners to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

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Full name of first and sole inventor: **David W. Ritter**

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	Filing Date		2006-08-28
	First Named Inventor	David W. Ritter	
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	Attorney Docket Number		MIC-M192

1	"Design of current programmed amorphous silicon AMOLED pixel circuit," B. Mazhari and Yogesh S. Chauhan, 8th Asian Symposium on information display, Nanjing, China, 2004, pp. 327-330.	☐
2	YENCHUNG LIN et al., "A Novel Current Memory Circuit for Active Matrix Organic Light Emitting Display," SID 03 Digest, 2003, 4 pages.	☐

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☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Carmen C Cook/	Date (YYYY-MM-DD)	2006-08-28
Name/Print	Carmen C. Cook	Registration Number	42433

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		Application Number	
Title of Invention	Video Driver Architecture for AMOLED Displays		
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Attorney Docket Number	MIC-M192	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Suggested Class (if any)		Sub Class (if any)	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	3	Suggested Figure for Publication (if any)	2

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	MIC-M192
		Application Number	
Title of Invention	Video Driver Architecture for AMOLED Displays		

Publication Information:	
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Organization Name		Micrel, Inc.			
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Signature		/Carmen C Cook/		Date (YYYY-MM-DD)		2006-08-28
First Name	Carmen	Last Name	Cook	Registration Number	42433	

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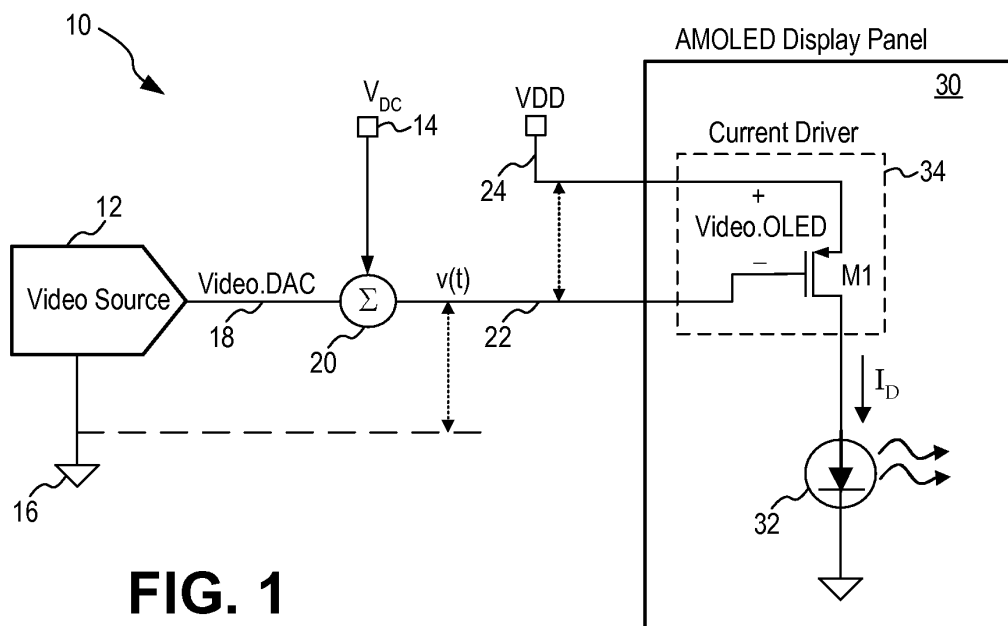


FIG. 1
(Prior Art)

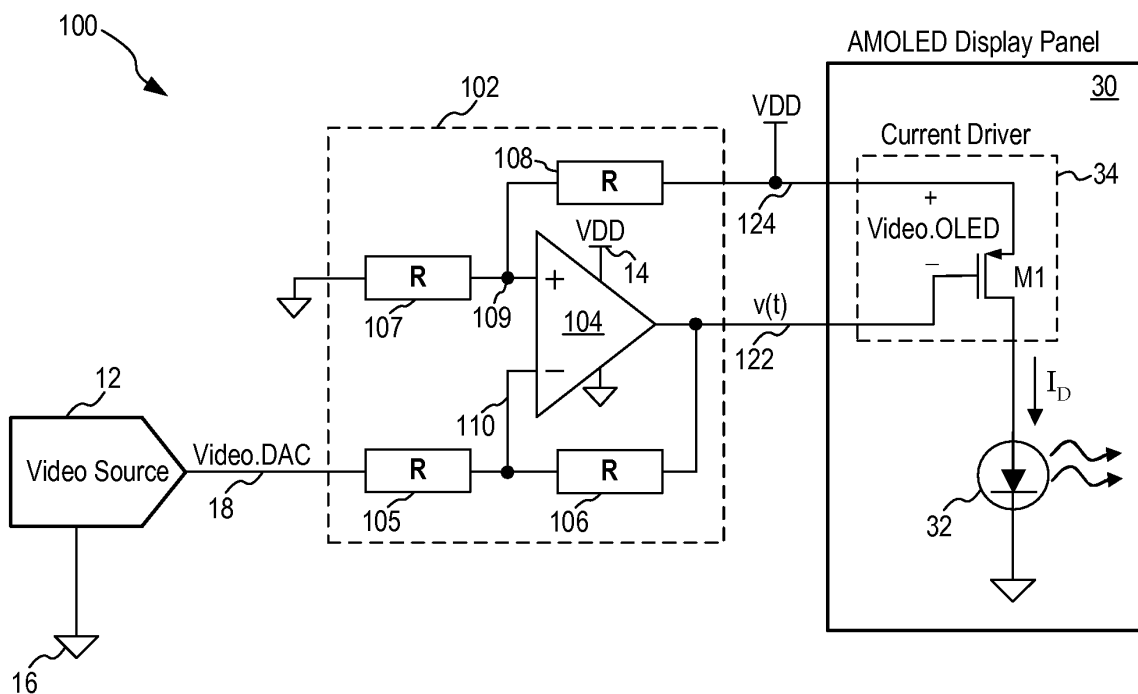
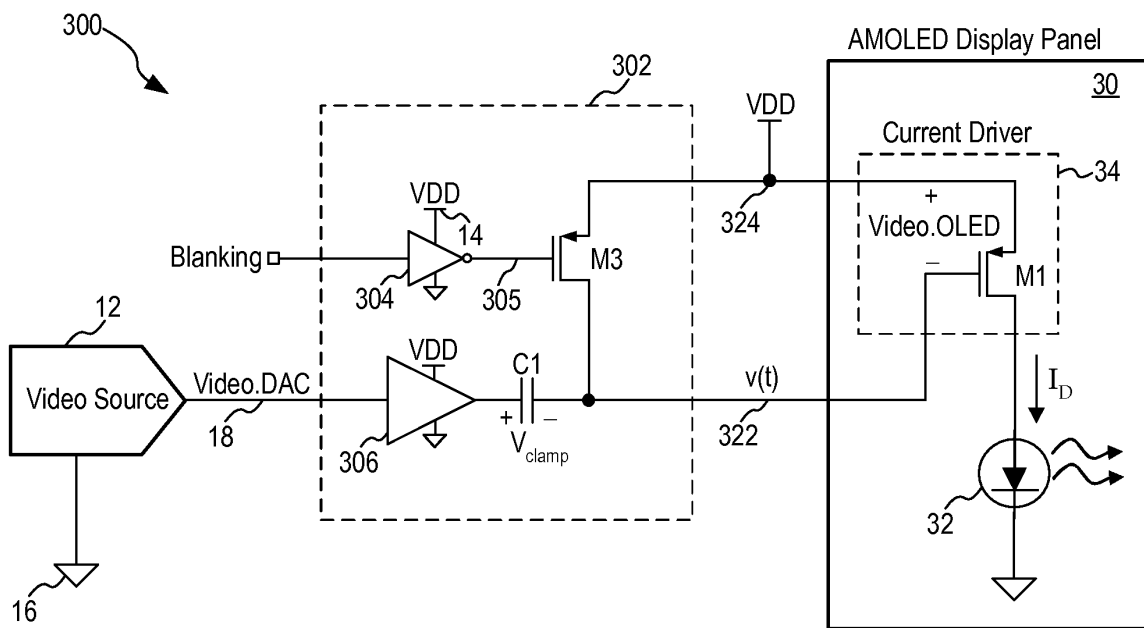
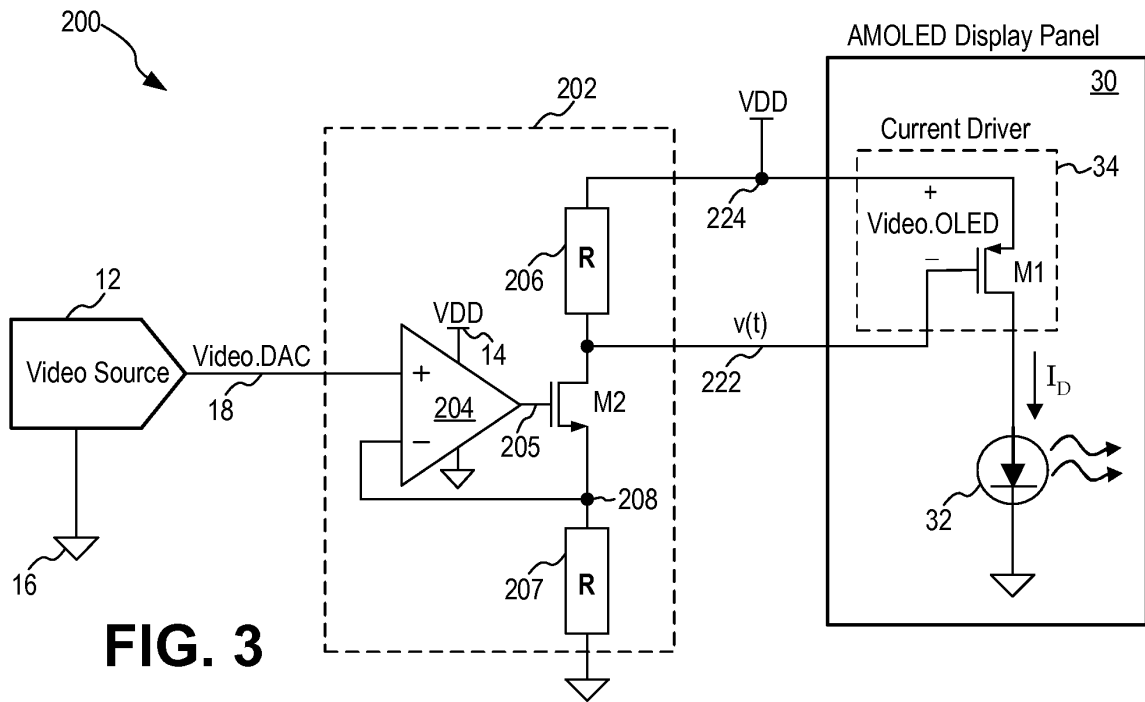


FIG. 2



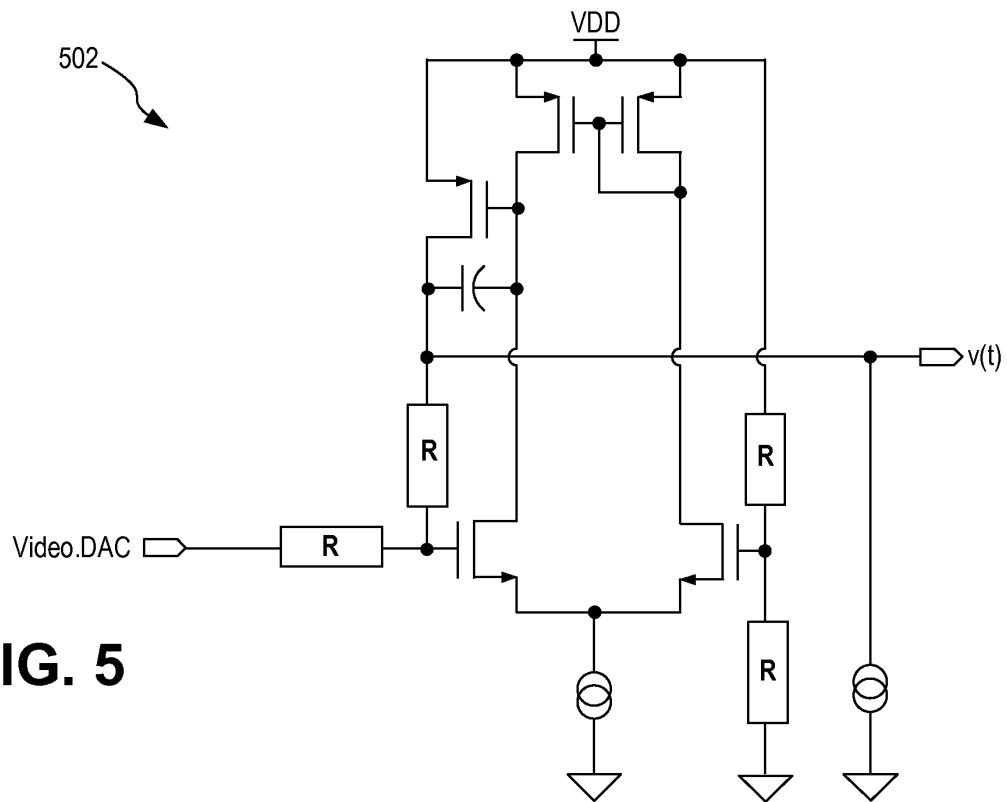


FIG. 5

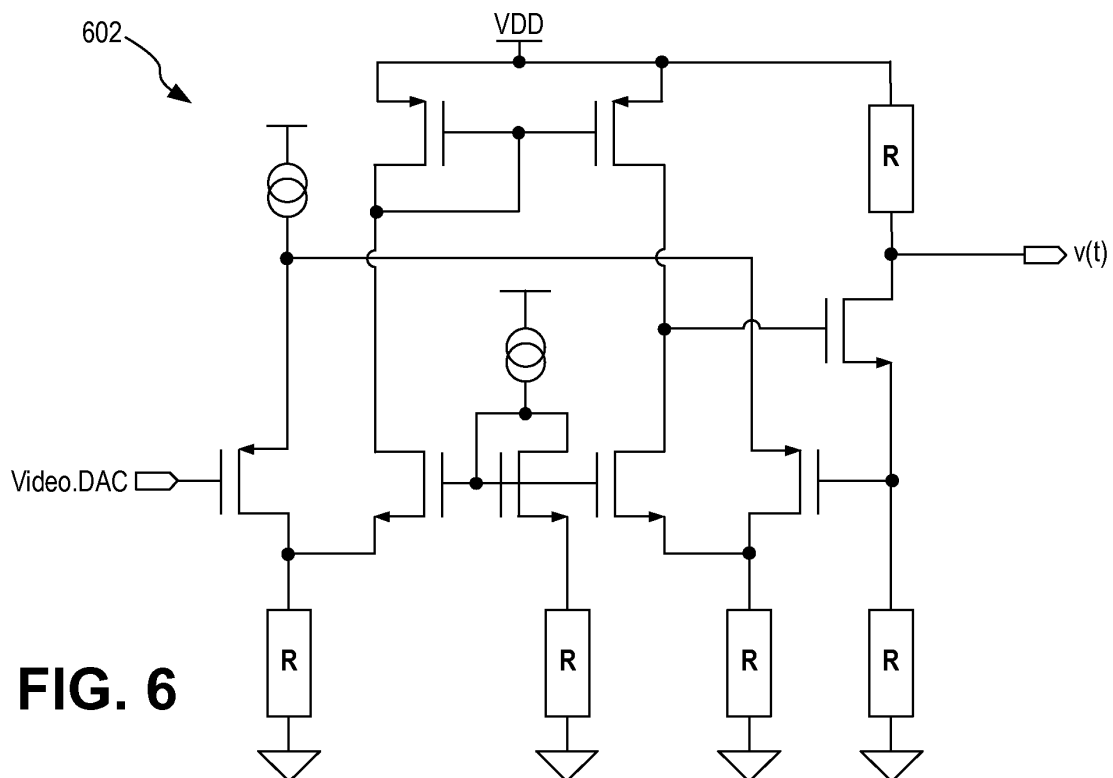


FIG. 6

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		Video Driver Architecture for AMOLED Displays		
First Named Inventor:		David W. Ritter		
Filer:		Carmen C. Cook/Edith Fuentes		
Attorney Docket Number:		MIC-M192		
Filed as Large Entity				
Utility Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Utility application filing	1011	1	300	300
Utility Search Fee	1111	1	500	500
Utility Examination Fee	1311	1	200	200
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

Electronic Acknowledgement Receipt

EFS ID:	1174529
Application Number:	11467738
Confirmation Number:	4013
Title of Invention:	Video Driver Architecture for AMOLED Displays
First Named Inventor:	David W. Ritter
Customer Number:	32566
Filer:	Carmen C. Cook
Filer Authorized By:	
Attorney Docket Number:	MIC-M192
Receipt Date:	28-AUG-2006
Filing Date:	
Time Stamp:	16:03:51
Application Type:	Utility
International Application Number:	

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$ 1000
RAM confirmation Number	194
Deposit Account	502226
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part	Pages
1		MIC-M192-App.pdf	127957	yes	21
	Multipart Description				
	Doc Desc		Start	End	
	Specification		1	16	
	Claims		17	20	
	Abstract		21	21	
Warnings:					
Information:					
2	Oath or Declaration filed	MIC-M192-Signed-Dec.pdf	74341	no	2
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Filed	MIC-M192-IDS.pdf	547741	no	3
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4	NPL Documents	Mazhari-article.pdf	382997	no	4
Warnings:					
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5	NPL Documents	Lin-article.pdf	262983	no	4
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6	Application Data Sheet	MIC-M192-ADS.pdf	667337	no	3
Warnings:					
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7	Drawings	MIC-M192-Dwg.pdf	166363	no	3
Warnings:					
Information:					
8	Fee Worksheet (PTO-875)	fee-info.pdf	8343	no	2
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