

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
27 November 2003 (27.11.2003)

PCT

(10) International Publication Number
WO 2003/098242 A3

(51) International Patent Classification⁷: G02F 1/13

(21) International Application Number:
PCT/US2003/015585

(22) International Filing Date: 15 May 2003 (15.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/380,662 15 May 2002 (15.05.2002) US
10/313,178 6 December 2002 (06.12.2002) US

(71) Applicant (for all designated States except US):
THREE-FIVE SYSTEMS, INC. [US/US]; 1600 North
Desert Drive, Tempe, AZ 85281-1230 (US).

(72) Inventors: YANG, Qingsheng, J.; 1007 West First
Street #206, Tempe, AZ 85281-2576 (US). HOFFMAN,

Dan, D.; 943 North 104th Street, Apache Junction, AZ
85220-1007 (US). SMITH, Peter, A.; 1416 W. Lark Dr.,
Chandler, AZ 85248-8319 (US). PFEIFFER, Mathias;
950 East Knoll Street, Mesa, AZ 85203-1926 (US).

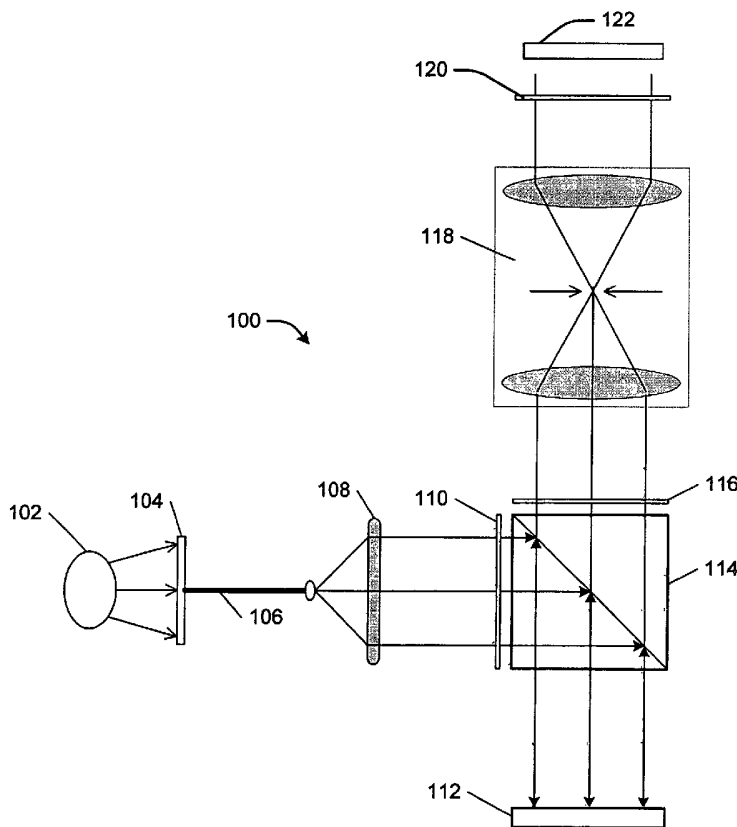
(74) Agent: SLAYDEN, Bruce, W., II; Baker Botts L.L.P., 910
Louisiana Street, Houston, TX 77002-4995 (US).

(81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD,
SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US,
UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[Continued on next page]

(54) Title: TESTING LIQUID CRYSTAL MICRODISPLAYS



(57) Abstract: By rendering a special test image and applying flat-field correction for a device under test (DUT) non-uniformity, the E-O response of a reflective LCOS microdisplay (112) can be quickly determined through an image processing algorithm. The measurement is made in a spatial domain instead of in a temporal domain. From the measurement, the driving voltage of maximum brightness, V_{bright} , can be determined. The use of V_{bright} enhances the visibility of pixel and sub-pixel defects to the test system (100). Other defect visibility enhancements are achieved through appropriate sampling rate, optical axis rotation and improved parallelism between the DUT and the CCD sensor camera (122). By modeling a sub-pixel defect as a local non-uniformity, a near neighborhood algorithm may be used for detection. The neighborhood algorithm does not rely on the alignment between the display pixels and the camera pixels.

WO 2003/098242 A3



ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designation US

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR,

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

(88) Date of publication of the international search report:

8 April 2004

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/15585

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC 7 G02F1/13</p> <p>According to International Patent Classification (IPC) or to both national classification and IPC</p>											
<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 G02F G01M H04N G01N G01R G06T</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, COMPENDEX, INSPEC, PAJ, IBM-TDB, WPI Data</p>											
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category °</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>PRATT W K ET AL: "Defect detection in reflective liquid-crystal microdisplays" 1999 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. SAN JOSE, CA, MAY 18 - 20, 1999, SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SAN JOSE, CA: SID, US, vol. 30, 18 May 1999 (1999-05-18), pages 468-471, XP002223723 the whole document</td> <td>1-10,13</td> </tr> <tr> <td>A</td> <td>US 6 154 561 A (PRATT WILLIAM K ET AL) 28 November 2000 (2000-11-28) column 10, line 9 - column 14, line 44; figures 1-8</td> <td>1-10,13</td> </tr> </tbody> </table> <p style="text-align: center;">----- -/--</p>			Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	PRATT W K ET AL: "Defect detection in reflective liquid-crystal microdisplays" 1999 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. SAN JOSE, CA, MAY 18 - 20, 1999, SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SAN JOSE, CA: SID, US, vol. 30, 18 May 1999 (1999-05-18), pages 468-471, XP002223723 the whole document	1-10,13	A	US 6 154 561 A (PRATT WILLIAM K ET AL) 28 November 2000 (2000-11-28) column 10, line 9 - column 14, line 44; figures 1-8	1-10,13
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.									
X	PRATT W K ET AL: "Defect detection in reflective liquid-crystal microdisplays" 1999 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. SAN JOSE, CA, MAY 18 - 20, 1999, SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SAN JOSE, CA: SID, US, vol. 30, 18 May 1999 (1999-05-18), pages 468-471, XP002223723 the whole document	1-10,13									
A	US 6 154 561 A (PRATT WILLIAM K ET AL) 28 November 2000 (2000-11-28) column 10, line 9 - column 14, line 44; figures 1-8	1-10,13									
<p><input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.</p>											
<p>° Special categories of cited documents :</p> <table border="0"> <tr> <td style="vertical-align: top;"> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </td> <td style="vertical-align: top;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </td> </tr> </table>			<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>							
<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>										
<p>Date of the actual completion of the international search</p> <p style="text-align: center;">14 November 2003</p>		<p>Date of mailing of the international search report</p> <p style="text-align: center;">11.02.2004</p>									
<p>Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016</p>		<p>Authorized officer</p> <p style="text-align: center;">Wolfrum, G</p>									

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/15585

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 361 307 A (HARTLEY RICHARD I ET AL) 1 November 1994 (1994-11-01) column 9, line 21 - column 11, line 3; claims 1-5; figure 14 -----	1-10,13
A	US 6 177 955 B1 (AOUN MICHAEL C ET AL) 23 January 2001 (2001-01-23) column 5, line 41 - line 55; figure 1 -----	1-10,13
P,A	"CCD CAMERA FINDS MICRODISPLAY DEFECTS" VISION SYSTEMS DESIGN, PENNWELL PUBL., TULSA, OK, US, March 2003 (2003-03), pages 17-20, XP009020630 the whole document -----	1-10,13
P,A	WO 02/39753 A (THREE FIVE SYSTEMS INC) 16 May 2002 (2002-05-16) page 8; figures 1,9 -----	1-10,13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 03/15585

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

- 1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

- 2. Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

- 3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

- 1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

- 2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

- 3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

- 4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-10,13

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-10,13

A method of fast electro-optical response measurement for liquid crystal microdisplays, comprising the steps of:

- loading a gamma table into a display drive electronics;
- displaying a test image of a gray shade chart having a plurality of gray shades;
- grabbing a camera image of said test image;
- locating an entire active area (global region of interest) from said grabbed camera image;
- computing gray zone locations by combining said entire active area with the locations of the plurality of gray shades;
- determining local regions of interest within each of the gray zone locations;
- calculating an average gray level intensity for each of the gray zone locations
- calculating an equivalent driving voltage from each of the gray zone locations, their gray shades and the gamma table so as to obtain set of electro-optical response measurement values.

2. claims: 11,12

A method of testing for liquid crystal microdisplay subpixel defects, comprising the steps of:

- performing dark alignment of a liquid crystal microdisplay;
- performing a camera fiducial alignment;
- scanning a plurality of sections of the liquid crystal microdisplay to acquire a plurality of camera images representing a white, gray and black image and a fine-tuned alignment image;
- normalizing each of the acquired plurality of camera images with camera calibration images;
- detecting subpixel defects from the white, gray and black images by neighborhood comparisons;
- sampling the plurality of camera images so as to generate maps of pixels of the liquid crystal microdisplay and stitching the maps together;
- detecting pixel defects from the maps of pixels using neighborhood comparisons.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/15585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6154561	A	28-11-2000	JP 3386818 B2 17-03-2003
			JP 2001527645 T 25-12-2001
			KR 2000016419 A 25-03-2000
			TW 385413 B 21-03-2000
			WO 9845800 A1 15-10-1998

US 5361307	A	01-11-1994	NONE

US 6177955	B1	23-01-2001	NONE

WO 0239753	A	16-05-2002	US 2002067184 A1 06-06-2002
			AU 3978602 A 21-05-2002
			EP 1328840 A2 23-07-2003
			WO 0239753 A2 16-05-2002
