UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

- - - - - - - - - - - - - - - - - x
LG DISPLAY CO., LTD., :
    Petitioner :
v. : Case IPR2015-00885
SURPASS TECH INNOVATION LLC, : Patent 7,202,843
    Patent Owner :
- - - - - - - - - - - - - - - - - x

Deposition of RICHARD ZECH, PH.D.

Washington, D.C.

Friday, November 13, 2015

9:30 a.m.

Job No.: 96195

Pages 1 through 158

Reported by: Marilyn Feldman, RPR

Deposition of RICHARD ZECH, PH.D., held at the offices of:

MAYER BROWN LLP
1999 K Street, NW
Washington, D.C. 20006-1101
202.263.3154

Pursuant to agreement, before Marilyn Feldman, Registered Professional Reporter and Notary Public in and for the District of Columbia.

A P P E A R A N C E S

ON BEHALF OF PETITIONER LG DISPLAY:

WILLIAM J. BARROW, ESQUIRE
MAYER BROWN LLP
1999 K Street, NW
Washington, D.C. 20006-1101
202.263.3154

ON BEHALF OF PATENT OWNER SURPASS TECH:

WAYNE HELGE, ESQUIRE
DAVIDSON BERQUIST JACKSON & GOWDEY LLP
8300 Greensboro Drive
Suite 500
McLean, VA 22102
571.765.7708

C O N T E N T S

E X H I B I T S (marked previously)

EXHIBITS ATTACHED:

LG Display Exhibit 1001 Shen patent 7,202,843
LG Display Exhibit 1010 Lee, Korean translation
LG Display Exhibit 1011 Declaration of Richard Zech

P R O C E E D I N G S

RICHARD ZECH, PH.D.

having been duly sworn, testified as follows:

EXAMINATION BY COUNSEL FOR PATENT OWNER

BY MR. HELGE:

Q Good morning, Dr. Zech.
A Good morning, sir.
Q Dr. Zech, you provided an opinion regarding U.S. patent 7,202,843 in this case; is that right?
A That's correct.
Q This case that I'm referring to is LG Display Company v. Surpass Tech Innovation LLC, correct?
A Correct.
Q And the case number is IPR2015-00885, correct?
A Well, I'll take your word for it.
Q I understand.
A I didn't happen to memorize that.
Q Fair enough. We are here for a deposition on your declaration; is that right?

A I believe that is true, yes.
Q Have you seen the notice of deposition for this case?
A I don't believe I have.
Q Are you appearing voluntarily?
A Oh, yes, yes indeed.
Q And you are appearing probably pursuant to that notice of deposition?
A I'm sure that was the case.
MR. BARROW: Yes.
Q Thank you. Dr. Zech, can you please state your full name for the record?
A Be happy to. Richard, initial G, last name Zech, Z-e-c-h, 130 Cresta Road, C-r-e-s-t-a, Colorado Springs, Colorado 80906, (719) 633-4377.
Q Dr. Zech, I am going to stop you there. What I don't want is any more information that you might consider private.
A You are entitled to my full contact information, although you have my card, but for the record to make sure I'm the same person.
Q Thank you. I take it you have been

deposed before?
A Once or twice.
Q Probably more than that; is that right?
A Many times more.
Q Probably at the beginning of all those depositions the attorney who has been asking you questions has stated some ground rules for the day; is that right?
A Absolutely.
Q One of those ground rules that I think we are doing a pretty good job at so far is only one person can talk at a time because the reporter can only take the transcript of testimony from one person at a time. Do you understand that?
A I understand.
Q Dr. Zech, are you taking any medication or do you have any other reason why you may not be able to give true and accurate testimony today?
A Other than old age.
Q Understood.
A I haven't been taking any medicines.
Q And you can give true and accurate

testimony today?
A I certainly hope I can. I'll do my best.
Q You'll let me know if you feel you are not able to answer a question?
A Absolutely.
Q And you'll let me know if you have a question about anything I have asked you?
A Absolutely.
Q One other thing that has come up recently, but I suspect it won't come up here, is if I ask you a question, I will need an affirmative verbal response because head-nodding and shaking of the head won't get onto the reporter's transcript.
A I understand. I won't do it on purpose but as the day goes on I may wear out and start doing something like that. Please bring me up short if I do.
Q Absolutely. Thank you. Dr. Zech, this is a case before the Patent Tral and Appeal Board; do you understand that?
A Yes, I do.
Q Have you been before the Patent Tral and

Appeal Board or been offered as an expert before the Patent Tral and Appeal Board before?

A No more than six times in the last year.

Q Have you been deposed in any of those cases?

A All but this one.

Q Okay, good. Something I'm going to read to you comes from the Patent Office Trial Practice Guide and maybe this has been read to you before, maybe not, but I want to make sure you understand the particular rules of this forum. "Once the cross examination of a witness has commenced and until cross examination of the witness has concluded, counsel offering the witness on direct examination shall not (A), consult or confer with the witness regarding the substance of the witness's testimony already given or anticipated to be given except for the purpose of conferring on whether to assert privilege against testifying or on how to comply with a board order; or (B), suggest to the witness the manner in which any questions should be answered."

Do you understand the paragraph as I have just read it?

A That's the way it has been for the prior five depositions.

Q Great. And so the way the board interprets this is that even when I have concluded asking questions and when your counsel may be preparing to ask you additional questions during this deposition, this prohibition against conferring with your counsel still applies.

A Okay.

Q And so until we actually close everything up with the reporter and shut the deposition down for the day, this prohibition still applies. Does that make sense?

A I understand it and I'll respect it.

Q Thank you. Dr. Zech, you submitted your CV in this case back in March; is that about right?

A Yes, I believe so, about the same time that I submitted the declaration.

Q Right. Is that CV still accurate?

A Probably not because, as I say, I have done depositions on five of the declarations I submitted at about the same time I submitted the one for LGD. But other than saying here's the case, here is the fact that I did a deposition, probably not very informative, but I'd be glad to supply Mr. Barrow with an up-to-the-minute resume if that would be helpful.

Q I'll just ask you, have you added any more engagements to your CV since March?

A Yes, I have, yes.

Q Do you recall the case names or the patents at issue in any of those cases?

A The only current activity of mine has to do with a litigation that hasn't been filed yet, it's prelitigation.

Q In that case please don't tell me anymore.

A I didn't intend to.

Q Thank you. So is that the sole addition you think from your CV?

A I'm embarrassed to say I can't remember.

Q Why don't we do this. I'm going to hand you exhibit 1011. Dr. Zech, does this document look

familiar to you?
A It sure does.
Q Is that your name on the cover?
A It sure is.
Q If you were to turn to page -- and this is going to be a little bit tricky because some of them are numbered sequentially and some of them have these Bates numbers, but it looks like page 48 on the bottom middle and page 654 using the Bates numbers.
A Yes, sir.
Q Is that your signature there?
A It is indeed.
Q This is going to be page 662 and it's page 7 of 26 on your CV which is just a few more pages beyond where we were just looking.
A I have the first page, for example.
Q Looking at page 7 of 26.
A Thank you. Yes, sir.
Q Do you see the top, this looks like your litigation support experience, correct?
A Yes, sir, it is.

Q At the top you have the Intellectual Ventures case versus Canon and that appears to be your most recent engagement listed on this paper.
A Oh, actually that engagement came in January of 2015 and this following, the one with Mr. Barrow here, so at the bottom of each section I have the starting date and whether or not I have terminated my work with this particular customer, and every place you see the TBDs -- oh, this is from February, this is out of date unfortunately -- all of these TBDs with the exception of this matter I have been deposed on.
Q I see.
A Yes. I have not -- it wouldn't do you any good because I have not revealed anything about the current work and I couldn't and shouldn't so it wouldn't be on here anyway. But if you'll just --
Q When you say current work, you mean the prelitigation work.
A Prelitigation.
Q Understood. Thank you. So that prelitigation is the only new engagement since this

Intellectual Ventures v Canon case; is that right?
A Yes, to the best of my recollection. I have been offered by one of the brokers, DDW Brokers, expert witness brokers, probably 5, 6, 10 people, but they tend to get in early and the lawyers won't be looking for an expert for 6 or 10 months from now.
Q Right, I understand. Dr. Zech, what did you do to prepare for this deposition today?
A Well, I'll work backwards. Yesterday I spent the day with Mr. Barrow, we went over my declaration, the '843 patent, some other documents, and prior to that I reviewed -- oh, yesterday included review of the Lee not patent but the application and translation from the Korean. Prior to that -- well, I didn't have a lot of time, so for the last week or so, maybe two weeks, at a low level I reviewed my materials on LCD products, did quick scans through the declaration, the patents, other documents that I relied on.
Q So let's start with the people that you spoke with. You spoke with Mr. Barrow yesterday?

A Yes.
Q Did you speak with any other attorneys?
A I did. Is it Kamir?
MR. BARROW: Kfir.
A Kfir, yes, he stopped in briefly. All we did was say hello, no real interaction. Mr. Barrow has been my primary contact on this in all regards.
Q Yesterday was the first day you met in person with him?
A No. I met in person with him in either November or December of last year, I don't remember when.
Q Okay. We don't need to get into that. Thank you. Did you talk with any nonattorneys about this case prior to this deposition?
A No, sir.
Q Dr. Zech, let's go through some of the documents that you mentioned.
A Okay.
Q I want to get my hands on what you reviewed. So yesterday you looked at the '843 patent; is that right?

A Yes.
Q You looked at your declaration?
A Yes.
Q You looked at the Lee translation?
A Yes.
Q Do you speak Korean?
A No, but my wife does.
Q Do you read Korean?
A No.
Q Did you talk to your wife at all about the contents of the original Lee documents in Korean?
A No, not to my wife.
Q Did you talk to anybody else about the contents of that document in Korean?
A Yes.
Q Whom did you talk to?
A My niece and my nephew.
Q Are they Korean speakers?
A Yes.
Q Are they able to read Korean?
A Yes.
Q What was the nature of your conversation

with your niece and your nephew about the Korean documents?

A Well, mainly -- it involved entirely the figures and I just wanted to make sure that my guesses about what these Korean words represent were correct.

Q Okay. Did you compare what you were told by them to what you found in the English translation of Lee?

A Yes, I did.

Q Did that information that you received from your niece and your nephew match what you found in the translation?

A They were spot on. I can't tell you how impressed I was with the way they translated these things. It included a lot of technical terms. Neither one of them is a college graduate and have no technical background so I was impressed.

Q When you say they translated, you are referring to your niece and nephew?

A Yes. Just the figures.

Q Did you have them translate all of the figures with you?

A I think we went through most all, but I really can't recall at this point.

Q So you are not sure how many figures you looked at with them?

A There were quite a few as I recall but I couldn't answer your question and say there were 20 of them, did I do all 20 or just 15 or what have you. I'm pretty sure we did them all.

Q And you didn't spot any errors during that process?

A No, that wasn't my mission. As far as I know, there were no technical errors, although I wasn't purposely trying to seek them out.

Q Dr. Zech, I just want to understand what you just said. You said you weren't trying to seek out any errors; is that right?

A Yes. My mission was not to find errors but to get the English meaning of the words so at some future date if I chose to review it in detail, say I didn't get a certified English translation, I'd still be able to work with them.

Q How did you get the Lee documents in the first place?
A My guess is it came from Mr. Barrow.
Q You don't recall looking for it yourself then?
A Well, I do have things from Lee but they are patents, not that Korean application. I have U.S. patents that have been issued to Lee.
Q Did you search for those yourself and find them?
A I found those on my own.
Q Was that before or after you received the Lee reference we are talking about in this case?
A I don't really recall.
Q But you didn't rely on any other Lee reference in your declaration, correct?
A No.
Q And you didn't identify it in appendix B which lists the documents that you relied upon in this case, right?
A Yes. I did not use anything other than the Lee translation.

Q And so you found that your niece and nephew's translations matched what is in the English translation of Lee, correct?

A Very close, very close.

Q At any point was there a situation where you deferred to your niece and nephew rather than the English translation that we have in this case?

A No.

Q So the English translation is the primary source of your understanding of Lee; is that right?

A Yes, sir.

Q You mentioned, if I recall, when you were discussing the work you did yesterday that you looked at some other papers. Do you recall what those other papers are?

A Well, give me a moment to reflect and maybe I can recall them all. We have already mentioned the Lee translation, the '843 patent, my declaration. I suspect we might have looked at the petition coming from LGD. That's all I can remember, sir. Sorry.

Q Dr. Zech, did you look at all at any

documents from other papers filed with the Patent Trial and Appeal Board relating to the '843 patent? I can give you some examples if you like.

A No, that's okay. The only thing I looked at was the Sharp petition.

Q The Sharp petition?

A Yes, it's in the public domain, I found it on the Internet.

Q You looked at that yesterday?

A No, I didn't.

Q In the past?

A Sorry?

Q In the past?

A Yes, before I did my declaration.

Q You understand that Sharp petition was denied on most grounds, correct?

A Yes, I got that impression from some of the documentation. Oh, one other thing was your document -- having a senior moment here -- it was your reply, your response, and it was very clear to me that Sharp had been denied.

Q Have you looked at any deposition

transcripts from other cases against Surpass Tech Innovation before the Patent Trial and Appeal Board?

A No, sir. Until this case I had never heard of Surpass before.

Q I will tell you, I can represent to you recently other depositions were taken of experts in related cases dealing with the '843 patent, depositions of experts provided by petitioners, and so I was curious if you had looked at any of the transcripts of those depositions and this would have been in the last month or so.

A I understand your question. The answer is no. Mr. Barrow did not share those things with me. I didn't even know those depositions had taken place.

Q Thank you. I am going to go back to last week because you mentioned things that happened last week. You said you looked at some LCD materials and I'm curious what those materials were.

A Basically industry papers. The field of liquid crystal displays, whether used for monitors or televisions, is very complex and because I was working on other things as my resume indicates, optical data storage drives, scanners, etc., and really it's been a year since I have worked on this case, I just wanted to refresh my memory.

Q So that was primarily for general understanding of the technology?

A Exactly.

Q Did you rely on any of those materials in preparing your declaration?

A I don't believe so.

Q Because I know they are not listed in appendix B.

A No. In something like a declaration -- and this year wasn't the first time I have done a declaration -- I'm basically instructed to stick closely to the program, that is you have patents, you may have some other supporting documents, and I should wait until my expert report, if there is going to be one, to perhaps introduce some of this material.

Q Okay. When you were reviewing those LCD materials, did you come across any disclosure that

would contradict what you said in your declaration?
A I don't believe so.
Q When you were reviewing those other LCD materials, did you find any disclosure that may contradict what you saw in Surpass's reply in the Sharp case?
A Well, I don't really remember much about your reply to the Sharp case so my answer would be no.
Q And it's no because you don't really remember what --
A I really don't. I try not to depend on other people. If I say something to you, it's because I'm saying it to you, not someone else.
Q Okay. Thank you, Dr. Zech.
A You're welcome.
Q You mentioned also some other documents that you reviewed last week. Do you recall any of those other documents?
A Pretty much what we talked about yesterday and the tutorial material, as I call it.
Q What is that, doctor?

A Those were the industry papers and what have you, books, I have a number of books.
Q Dr. Zech, when was the last time you looked at the prosecution history for the '843 patent?
A I know I have it and it had to be about a year ago.
Q You looked at it in preparation for your declaration, right?
A Oh, yes.
Q I know it is listed on appendix B. So you are aware of the '843 patent issue in the Patent Office, are you not?
A I am.
Q Do you recall seeing a document called Reasons For Allowance that was issued by the examiner during prosecution?
A Only most vaguely.
Q Do you recall that the examiner commented on another reference called Ham, H-a-m, and the reasons for allowance?
A No.

Q And you don't recall looking for the Ham reference in preparation for your declaration at all?

A I really don't recall. It's been a year ago and at my age I not only can't remember if I had breakfast but if I did, what I had.

Q Understood. So Dr. Zech, let me ask you this. In preparing your declaration, at any point did you feel that you should compare the art that you were relying on in this declaration against art that was examined and looked at and considered by the examiner in the prosecution?

MR. BARROW: Objection, relevance.

A Well, normally I would do that of course. I just don't recall having done it in this case. As I recall, we were on a very short schedule and I may have done that, I just don't plain remember.

Q Would you have any notes if you had done that?

MR. BARROW: I would caution the witness not to reveal the substance of any privileged communication.

Q Sir, if you have notes, but not the contents of those notes.
A Well, I have notes of course, but as you say or as Mr. Barrow said, I can't reveal what they are.
Q When was the last time you reviewed those notes?
A Early this year probably.
Q Did you review them in preparation for this deposition?
A Actually not. I forgot I had them.
Q Okay. Doctor, you looked at the petition yesterday as well; is that right?
A Yes.
Q Did you review it in some detail, do you think?
A No.
Q How would you describe your review of the petition?
A We had quite a few documents to go through and there were certain portions of it that were more important than others, and I remember that we looked

at those, discussed them, and the same with my declaration, we only had one day.
Q Would you say that you reviewed your declaration in detail yesterday?
A That I looked at more carefully, yes.
Q In reviewing your declaration, did you spot any errors?
A Yes.
Q Would you describe those errors for me.
A I forget exactly where but figure 2 is referenced and said that it's shown below and I don't know what happened, it was in there originally. I think I wanted to annotate it so I took it out and then forgot to put it in.
Q Is there anything else that you noticed?
A No, nothing that I would call an error or misrepresentation or anything like that.
Q So that was the only one that figure 2 was missing?
A Yes, but I know it's in the patent so it's not an entirely lost cause.
Q Was this a figure 2 from the '843 patent?

A Yes.
Q So as you were going through your declaration, aside from figure 2 that was missing, did you see anything else that you would change if you could go back and do it over?
A No, I don't think so.
Q So your declaration stands with that?
A Yes.
Q Dr. Zech, let's talk about LCD technology in general.
A Sure.
Q When did you first hear the term overdrive, do you recall?
A Sometime in the '90s --
Q 1990s?
A -- at a conference.
Q If you weren't finished, I apologize.
A No, I'm through. I have a good memory but 20 years later or so it's not as good as I would like it to be.
Q When you heard about overdrive in the 1990s, do you remember the context in which it was

being discussed?

A Yes, I think I can say that with certainty. The LCD products were not introduced until about 1985. They weren't very good. In the mid '90s they still weren't very good. Now if you understand the physics, and I'm not going to put you on the spot here, but to those who understand the physics of the device, they know that you can build a good panel and it is what it is. If you want to improve its performance, you have to do things in the electronics and you got to look at these as two separate entities, LCD panel, electronics.

Now we are in a situation here where we have a device whose inherent characteristic is what we call RC, resistance capacitance. It's essentially one big capacitor divided into M by N pixels. Now RC circuits don't like to be kicked around. You try to push them, they push back at you. You turn them off. They are still charged, drained from the capacitor part of it.

So an electrical engineer or a physicist who understand the physics of it will say gee, those darn liquid crystal molecules are going to give us a bad time almost no matter what we do unless we provide an electric field strong enough to overcome their reluctance to change orientation. So the way you do that is -- well, kind of work backwards. You have a capacitance -- for a particular pixel you have a capacitance, you apply a voltage to it, C times V gives you a charge, the charge provides the electric field. So high on voltage, the bigger the electric field, the more likely it's going to get that cantankerous liquid crystal molecule to do what you want it to do. For the record, a liquid crystal molecule is what we call acicular, that is, it's long and thin.

Q Can you spell that, please?

A Acicular. This early in the morning? A-c-i-c-u-l-a-r.

Q Thank you.

A Spelling is not my strong suit even as a young man. Thank God for word processors.

But anyway, there's a whole range of liquid crystals, and again I don't know if you are familiar with the subject or not, I'm not going to try and embarrass you, but there are liquid crystals that are relatively speaking this big and there's some that, big and there's some everywhere in between (indicating). They are what we call nonlinear entities. That is, if you look at any of the three axes of a liquid crystal, it's going to have different properties. So it's nonlinear.

The capacitance you have in the pixel is simply enough determined by the area of the pixel, the distance -- divided by the distance between them and what we call the permittivity, which is a property of the liquid crystal molecule.

Q Okay. Doctor, that's very good but I want to get back to the question a little bit.

A Did I not answer your question?

Q I don't think you did.

A I apologize.

Q I think you gave me a lot of good background and we are going to come back to a lot of those things.

A Sure.

Q But I would like to cover the question of overdrive. If you recall the question, I think it was the context in which you first heard the term overdrive.

A The context had to do with all the things I just told you. People thought out the physics of it, the electrical engineering of it, and concluded that if we want a bigger E field to change the orientation of that liquid crystal module, we had to have a bigger voltage.

Q Do you recall if that was within the context of any specific type of LCD panel?

A No, it really doesn't matter. You know physics is the same for all of them.

Q When you say all of them, are we talking both passive matrix and active?

A Yes, it's fair to say that.

Q Do you recall when you first heard about overdrive in the mid '90s whether it was directed towards improving response time of an active matrix or a passive matrix panel?

A Well, at the time the scientific and

engineering interest was in what they call AM LCDs, active matrix LCDs. Passive, well, it has no application in TV or monitors so I wasn't interested in it. I don't suspect anybody at the conference was either.

Q Do you recall the conference you attended when this came up?

A Probably one of SID conferences. That's the Society For Information Display. I used to go to a lot of conferences but those stand out. It could have been at CeBIT, big German show, might have been at the Consumer Electronics Show, but I suspect it was at SID or possibly some special conference whose name I have long forgotten.

Q Okay. But you think it came up in the context of active matrix LCDs?

A Oh, definitely, yes.

Q Do you recall if you have ever heard of the overdriving concept come up in the context of passive matrix LCDs?

A No, I haven't.

Q Dr. Zech, you have a fairly long CV in

looking at patents and providing opinions on patents; would you agree with that?
A Well, I have been doing this type of work for more than 25 years so I have on occasion been involved in patent litigation, yes.
Q In that time, those 25 years, have you developed any methodology for detailed analysis of a patent?
A I'd say the answer is yes.
Q Could you describe that methodology? Just for clarification, I'm talking about a patent that you are providing an opinion on, not necessarily a patent you are just reading for background.
A Sure, yes. I generally start by looking at the front page and then the claims. I then go through and parse the specification looking for novelty, new technology, and anything that might help or hurt the particular litigation. I have done charting and I find that to be very useful, mine or somebody else's. And then I analyze what I believe are the pertinent facts and document them.
Q In terms of reading through the claims,

what do you do when you find a term that you are unfamiliar with?

A Well, the first thing I'll do is I'll look for it in the specification. These days you can get searchable patents. If in fact if you go to the USPTO website, they have text only searchable patents. But I'll start with the patent in litigation, assuming it is, and I'll first search through that, the specification. If I don't find it there, then I have to go to some extrinsic sources. I may go to a dictionary. I may go to various papers that I rely on. And in desperation I may call a colleague and say what the devil is this.

Q Do you ever go through that process of checking the spec, looking through file history, calling a colleague, looking for extrinsic evidence, do you ever do that if you find a term in a claim where you understand it but you want to know if maybe that inventor has used it in a specific way in this case?

MR. BARROW: Objection, relevance.

A Look, I see my function as finding out the truth about things and I'll do whatever it takes to find out the truth. I don't always succeed monumentally but I often do, and I try to take into account for example patents that come from Asia, they often have some very strange language in them. We used to call it Japlish in the case of the Japanese. I'm a reasonable man and I can generally figure out what they meant, it's not necessarily what they should have said but it's what they meant.

Q Okay. Had you heard the term lexicographer in the context of claim construction?

A Yes.

Q What does that mean?

MR. BARROW: Objection, relevance.

Q What does it mean to you?

A To me it means that every inventor has a right to define his own terms, be his own lexicographer.

Q How do you determine whether an inventor has decided to be his or her own lexicographer?

MR. BARROW: Objection, relevance.

A That's easy enough. They have some weird terms and if they are not terms of the art, as I know them anyway, then I say whoa, we have things being redefined here.

Q Have you ever run into an instance where an inventor was a lexicographer of his or her own terms even though those terms were used in the art?

MR. BARROW: Objection, relevance.

A Oh, I'm sure I have. I can't tell you a specific example but I have looked at hundreds of patents and when I worked a lot with the Japanese companies I looked at patents that you know just made my head spin from the way they were written. But it's a random process. If you go through a hundred patents you are going to find so many are good, so many are bad, and so many are mediocre. That's just the way the universe works.

Q So if you read through a patent for the first time, you read the cover page and then the claims, correct?

A Yes.

Q What do you do to ensure that you understand the scope of those claims?

MR. BARROW: Objection, relevance.
A Well, generally I won't understand the entire scope of the claims until I have gone through the specification in detail. Once I have done that, I don't recall ever having any problems realizing what the claims -- what their scope was. After all the claims are the invention, right?
Q So why do you feel you need to read the specs to understand the full scope of the claims?
A Well, often the claims are reciting things that don't make sense to me and so I try my best to figure out what they are really trying to say.
Q How does reading the specifications help you on this?
A The specification teaches me what the inventor is up to.
Q Is it the entire specification that you read in that instance?
A Oh, yes.
Q So you read the background?
A Absolutely.
Q You read the summary of the invention?

A The background, the summary of the invention, the figures, a description of the figures, the embodiments.

Q The abstract?

A Well, that's on the first page.

Q And that methodology is what you have developed over your 20-plus years of experience with patents, right?

MR. BARROW: Objection, relevance.

A That's correct.

Q Is that methodology consistent in every case that you deal with?

MR. BARROW: Objection, relevance, foundation.

MR. HELGE: What is the foundation objection?

MR. BARROW: Can we hear the question back, please?

(Record read.)

MR. BARROW: The fact he has talked about a specific methodology. I don't think he has actually testified to that.

MR. HELGE: That's what we are trying to establish. I'll ask the question again.

Q Dr. Zech, the methodology we have been talking about here, is that methodology the methodology you developed over your experience in looking at patents in detail?

A Yes. I didn't have it from day one in 1990, but then the litigation was about optical data storage of which I am a pioneer, so it was a fairly easy and straightforward deposition lasting 15 minutes. But over the years -- I'm an old dog but I can still learn and I learned a lot from working with my attorneys and even those that deposed me, that were in opposition to me, and I'm a fairly quick study. In fact, I have the letters Ph.D. behind my name sort of indicates I'm not exactly stupid. But on the other hand, I don't claim to be a genius either and I worked hard at it, I took it very seriously. I have been involved in cases -- one case which we won, thank God, which was worth 300 million dollars. I take all of this very seriously.

Q And so you apply that methodology now consistently; is that right?
A Yes, I do.
MR. HELGE: Can we take a 5-minute break?
A Anything you need. I know how painful it is to have an injured back.
Q We'll go off the record at 10:19.
(Off the record 10:19-10:27 a.m.)
BY MR. HELGE:
Q Dr. Zech, you mentioned the references you reviewed yesterday and you only mentioned in terms of asserted prior art the Lee reference. Is that right?
A Yes, it is. I can't think of any other one.
Q Why did you only look at the Lee reference and not any of the others that were asserted in the challenges of the issue?
A I am going to tell you. I think the Lee work is outstanding, it's one of the best patent applications -- or as you know he has some patents -- that I have seen, he clearly understands

what he's doing, and I figured there's no way you aren't going to question me on it.

Q That's true. You did not review the Jinda or the Miyai reference, however?

A No, I did not.

Q Why didn't you review those?

A To be honest with you, I don't know, I guess I was not instructed. Mr. Barrow told me --

Q Let's stop there.

MR. BARROW: Yes.

Q Dr. Zech, are you aware that the only ground instituted by the board in this case is claims for 8 and 9 of the '843 patent in view of Lee?

A Yes.

Q Is that the reason why you only looked at Lee?

A Well, now that you put it that way, I could answer honestly yes, but I would have looked at Lee no matter what.

Q I see. Dr. Zech, let's take a look at your declaration --

A Yes, sir.
Q -- dealing with the '843 patent. As I recall, you said you looked at the '843 patent yesterday?
A Yes.
Q You looked at it briefly?
A Yes.
Q When was the last time you looked at the '843 patent in detail?
A Probably about the time I did the declaration.
Q Are you providing any opinion on claim construction of the '843 patent?
A I'm not qualified to do that. I'm not a lawyer, I'm an engineer.
Q Okay. Now in terms of trying to understand the '843 patent, did you have to go through that process that you talked about earlier of understanding the claims where you would read the specification to understand the claims?
A Okay, well, that's two different things there. It's not that I'm unfamiliar with the claim

construction, I had a chart I believe back in March or whenever I did my declaration back in -- interesting people don't put on dates anymore. Anyway, I had some familiarity with the claim construction or lack thereof and I factored that in of course.

Q Did you perform any independent evaluation of claim term meanings of the '843 patent?

A I'm not sure I know what you mean by that.

MR. BARROW: Objection.

Q You mentioned a moment ago that you had a chart so it sounded like you had some document that said this term of the '843 patent means X. Is that accurate?

A Yes, I guess it was something like that, but I think it was a comparison between what Surpass believed and what LGD believed.

Q How did you understand the scope of the '843 patent claims?

MR. BARROW: Objection, form.

A Forgive me, sir, I don't really understand that question. It's so wide open that you'll get me

talking again for 20 or 30 minutes.
Q I just want to understand, Dr. Zech. I assume that you had the '843 patent in front of you and you read the cover page, right?
A Okay.
Q And you read the claims?
A Okay.
Q And claims 1, 4, 8, and 9 were included in the petition here?
A Yes.
Q So I presume at some point in trying to understand the '843 patent you read claims 1, 4, 8, and 9, correct?
A Yes.
Q And you told me a little bit ago about your methodology for understanding the claims.
A Yes.
Q Did you apply that methodology when trying to understand the '843 patent claims?
A I believe I did.
Q And so after reading the claims you would have gone back and read through the entire spec,

correct?

A Yes.

Q And in reading that specification did you see anything that indicated that the inventor of the '843 patent had acted as his own lexicographer?

A I think in a few cases.

Q Do you recall any of those cases?

A Well, the one that sticks in my mind is transmission rate.

Q Tell me about transmission rate. Actually would it be helpful if we had a copy of the '843 patent in front of us?

A It would be, but I can tell you about transmission rate without it.

Q Why don't we start there.

A Okay. Transmission rate is not only not a term of the art, it's not a term of anything. Let's parse it and I'll explain. Transmission generally in the context of these type of devices, LCD devices, means the ratio of the input light to the output light. Rate has to do with something happening per unit time like 60 frames per second, etc. The two words -- I can't remember in my lifetime where I saw them put together but I took it, I interpreted it to mean that rate probably got mistranslated, it should have been ratio.

Q And did you find anything in the '843 specification that supported that understanding?

A Well, based on the figures and I'm sure on some of the text I was able to take the meaning of transmission ratio. You have to understand, the term really bothered me because it was absurd and I'm sure that -- I don't know Mr. Shin but I'm sure he's smart enough not to put in a stupid term like that intentionally, even being his own lexicographer, because I don't recall he ever defines it, and so I concluded rightly or wrongly that it should have been translated as ratio.

Q So you interpreted transmission rate as transmission ratio; is that right?

A Yes.

Q What does transmission ratio mean to you in the LCD context?

A Well, it's telling you how much light

depending on where you want to start. Starting at the back lighting unit to the observer, or a smarter way because the losses are so great until the light gets to the pixel, only about 5 percent of the initial light gets there, maybe you want to take that as your denominator and put over that the amount of light that comes out and that would be the transmission ratio, although technically you don't need the word ratio. I mean transmission is sufficient.

Q Are there any other words that are also synonymous with transmission?

A Well, transmittance. Each has a slightly different meaning, but I don't recall that term being in the patent, transmittance.

Q But transmittance to you as someone with experience in LCD panels would mean the same thing as transmission ratio; is that right?

A It would be close.

Q How would it be different?

A Well, transmission involves simple ratios. Transmittance involves those ratios plus other

factors.
Q What other factors?
A Oh, I don't remember, counselor.
Q So in your mind, transmission ratio is not the same as transmittance; is that right?
A Like I said, close. In fact, I'd go further and say it doesn't make a dime's worth of difference because everybody involved should know what we are talking about and the whole purpose of the '843 patent is to control that transmission.
Q You say the purpose of the '843 patent is to control the transmission. Is that the same thing as controlling the transmission rate?
A I'm going to say yes because there is no such thing as transmission rate. I'd be willing to stand corrected if anybody can show me that in the literature, in the dictionary or anything else. But they are two different concepts. Rate, you want to talk about that? Then talk about 60 frames per second, that's a rate. But the amount of light that passes through a pixel has to do with transmission or transmittance or what have you.

And by the way, I didn't add -- and I apologize for this -- when I say pixel, I'm saying pixel with a capital P. I'm making fun of the calorie thing, big calories, little calories. Everything that we tend to call a pixel is actually made up of three subpixels for the red, green, and blue signal, and if you want color accuracy and luma accuracy, then you need to be able to reproduce what the input video signal is telling you.

Q Are you aware of the Lee reference that shows those three subpixels as part of a pixel?

A I don't recall, counselor. Sorry.

Q Do you recall if the '843 patent shows the three subpixels as part of a pixel?

A I must give you the same answer. I don't believe they do, but I honestly don't recall.

Q So when you talk about your use of the term pixel with a capital P as referring to all three subpixels, whether we use a capital P or a lower case pixel does that change any analysis in your declaration?

A No, and I made a little fun with you in the sense of capital P just to get through the idea that it's not one entity but three sub entities. People will say pixel. If there's any question in your mind about what they mean, you should ask because they may be talking about the three as one or they may be talking about one of the subpixels.

Q Dr. Zech, can you agree with me that for the rest of today if the difference between pixel or subpixel affects your answer, you will let me know?

A Yes. I think I can tell you with certainty that it doesn't, but let me make it even simpler than that. We talk about a process, mainly electronics, whereby we try to get the right voltage to a pixel. Now the fact of the matter is you got to get the right voltage to all three subpixels. So it doesn't really matter. I would agree and we should assume that when we say something happens to a pixel, it's probably happening to all three.

Q Does the digital data coming in to be used to drive an LCD panel specifically call out in one frame or one subframe different data for each subpixel?

A Yes.
Q And in your general experience, are different voltages being applied to different subpixels to achieve a desired color?
A Yes.
Q Dr. Zech, we were talking about the term transmission or transmission rate or transmission ratio or transmittance. Is that about all the terms that we can use to describe that concept?
A I am just as confused as you are. I once offered a service where before you submit that application to the USPTO, let me take your application and go over it, correct any technical errors if I find them, sharpen your abstract and your claims, and I think I only had one customer for that in 25 years. Despite the fact that my business, the no. 1 principle is we do everything in confidence, we never talk in public about our customers' business. So here's the case, I'm saying that if they had sent it to me first, we could have gotten all this cleaned up, but it didn't happen.
Q Okay. Is there any other term that you

could use in LCD technology to describe this transmission or transmission ratio?

A Well, you got to look at this from the perspective of the user of the device. Now he's looking for a couple of things: resolution, which is a function of how many pixels you have on the screen, brightness, and contrast. Those are the three main ones, whether it's a computer monitor or television. And so as it turns out, there are systems that can actually go and measure these variables. There are even ones that can check your color. And as a result, the concept of transmission (finger quotes) being the amount of light that reaches the user's eye becomes a fundamental one.

Now let me give you a case in point. Let's talk about one of those pixels that has three subpixels. We can generalize this, if you want but let's just look at one pixel. Now they represent the three color primaries, red, green, blue. Now when you mix those in the proper ratio, you are supposed to get the true color. If you don't, that is you get your voltages screwed up or something or another, you don't get the true color. So transmission is you know an indication of how close you have come to getting things right.

Q And you don't know any other word that we might use to describe that specific property, not necessarily the color quality in general; is that right?

A No, and you know I should add that I'm really an optical engineer and I ought to know that, but I don't like to speak with absolute certainty about anything, but I am unaware in the 50 years I have been in business of transmission ratios or anything else -- I mean transmission rates.

Q Okay. So when you came across the term transmission rate in the claims of the '843 patent, what did you do?

MR. BARROW: Objection to form.

A Well, I didn't know what the hell the term meant, to be honest with you, so I went to the specification and after plodding through that two or three times I still didn't know what it meant. I mean I could infer from the text and the graphs what it probably was, but I hate uncertainty and so I mulled it over and mulled it over and finally I said this has got to be a translation error and that rate probably should have been ratio. I mean I think it's the '843 patent that has got that French sounding word in one of its figures, it meant to say controller but it says "controuer" or something or another, now that was an easy one. But transmission rate was very difficult.

Q In claim 4 there is the term control or controlling the transmission rate.

A Yes.

Q Were you equally confused when you read that phrase?

A Initially I didn't know what transmission rate was. I can't say I was confused. I was ignorant. Eventually I found out enough about the term where I can understand claim 4.

Q How did you go about doing that?

A Well, as I have said before, it took some research and a lot of thinking and eventually I came to the conclusion they probably meant transmission

ratio, in which case it was fine with me.
Q Let's take a look at the '843 patent (handing document).
A Okay. Thank you very much, sir.
Q Dr. Zech, does this document look familiar?
A It sure does.
Q What document is this?
A This is the Shen patent U.S. 7,202,843 B2.
Q Do you see at the bottom the exhibit number is LD Display exhibit 1001?
A Yes, I do.
Q You have seen this document before, right?
A Yes, I have.
Q This is the document we have been talking about that is the '843 patent, correct?
A Correct.
Q Dr. Zech, can you please turn to figure 3 for me?
A Be happy to.
Q Have you evaluated this figure before?
A Yes, I have.

Q Are you aware of what these different elements show in figure 3 are?
A Well, once I figured out what signal "controuer" was -- controller of course -- yes.
Q Do you see there is this dashed box 10 and this is a reference numeral referring to the entire dash area?
A Um-hmm. We talked about that.
Q When have we talked about that?
A When I told you that any LCD device has two parts, the LCD panel plus the electronics.
Q Okay. To you numeral 10 refers to electronics?
A Yes, it does.
Q And the LCD panel is referenced in 30?
A Yes.
Q And you see a signal coming into electronics labeled S sub C, correct?
A Yes, I do.
Q What does that represent?
A Well, it represents depending on the application, either a computer signal or a

television signal. For purposes of this patent, I think we can assume that it's digital -- could be analog and then you'd have to add an ATD converter but that could be done in the signal controller. The signal controller is more than -- you might wonder what it's doing but -- and in simple terms the incoming signal, S sub c, is not suitable for developing the voltages to drive the pixels so it has to be amongst other things decoded, error detected and corrected, reformatted, to be in a form for which it could be passed on to the blur clear converter.

Q So it looks like the signal controller 12 is passing on two signals, G and C. Do you see that?

A Yes, I do.

Q Do you know what either of those signals represent?

A I don't. May I look to refresh my memory?

Q Please do. You may wish to look to column 3.

A Thanks for the tip. Okay. The G frame

signals and C is control signals. It just hit me that above there you see the term composite video?

Q Yes, I see that referring to S sub c.

A Yes. You know what composite video is?

Q I would like you to tell me.

A I'd be happy to tell you. There's two way a video comes to us. The old way, national television standards committee way, well also c cam, they take all the information, video and audio and mix it all together, make one string, and then that has to be broken apart at some other point to process it.

What the term there should be or -- you asked me about that before and I didn't remember, but what you want is component. At this stage of development of LCD and of television standards, it's component. Now what is component? Component video says you take all of the pieces, the red, the green, the blue signal, separate channels, the audio separate channel, and they are transmitted separately and they can be acted upon separately by the signals, the control signals, C.

Now I'm not sure exactly -- let me go back to 3 so I don't misrepresent or confuse anything here. Yes, signal controllers, as I explained before, you don't want to put trash into blur clear converter so you have to go through this process of cleaning up the signal. If it's a composite, you probably want to break it into its components, you know do error detection, correction, reform, whatever is necessary. Of course you can't tell that from a box with signal and a misspelled controller in it, but I can assure you that's what's going on there.

Q So C represents control signal; is that right?

A Yes, that's what the specification says.

Q And G represents a frame signal; is that right?

A That's a fair statement.

Q And those go into the blurred converter 14, right?

A Correct.

Q What is the function of the blur converter

in the '843 patent?
A First of all, I had never heard of the term blur clear converter and I struggled mightily to find anybody who used that term before. So it's new. Looks more like a marketing concept than a technical one, but that's fine, no problem. Blur clear converter is your signal processing element.
Once you have an LCD panel, and we have had some pretty good ones even in the '90s, there's not much you can do independently of the electronics. In the '90s the electronics just put out whatever signals were appropriate and you took your chances. Signal processing allows you to vary the data signals that come off the source driver here, manipulate them in a way that you can overcome some of the physical limitations of the LCD panel, and we talked about that, the fact it's you know a highly resistive capacity for circuits and they don't like to be pushed around, etc., etc. So the only avenue anybody has, Shen, Lee, you name it, and there are numerous patents on the subject that really are focusing on signal processing, that's the

only avenue you have for improving the performance of an LCD.

Q So what form of signal processing does the blur clear converter form?

A Basically what it's trying to do is determine what the next values from the source drive should be on each pixel, so that's done by -- and that's not all explained in here but I'll tell you what I think is done anyway. They have a number of frame memories, frame buffers, if you want to call them that, they have processing elements. What you are doing is basically you are saying well, what was, what's to be, and what's the difference, and the overdriving, or underdriving as the case will be, is done, applied.

Q So the blur clear converter performs underdriving or overdriving?

A No. I think it feeds that information to the source driver.

Q Do you have any understanding of what G prime represents coming out of the blur clear converter?

A I'd have to look at the patent again. Sorry, I didn't memorize these things.

Q Dr. Zech, I'll refer you to column 3, lines 24 to about 28.

A There's nothing there about primes. Am I missing something?

Q You are correct, although why don't I read this aloud.

A Okay.

Q "Subsequently, the blur clear converter 14 continuously receives the control signals C and the frame data" -- now that frame data is in the form of frame signal G, correct?

A Absolutely.

Q I'll continue -- "included in the frame signals G and generates processed frame signals G" -- now you are right, it doesn't say G prime, but do you think that the process frame signals G represent the G prime coming out of the blur clear converter 14?

A I do.

Q So G prime probably represents the

processed frame signals G, correct?
A Yes.
Q And those processed frame signals G prime include a plurality of overdriven data according to the frame data; is that right?
A Yes.
Q So G prime probably represents processed frame signals including a plurality of overdriven data; is that right?
A That's what it says.
Q Okay.
A Yes, I left out the blur clear converter also splits the frame and I assumed, and I hope you assumed, the same, that the division of the frame was in time, not in space, and by that I mean if it were in space maybe the top half of the frame or the bottom half some -- but it's rather in time.
Q Maybe if you look at figure 5 --
A Sure.
Q Do you see at the bottom it talks about frame original and frame double?
A Yes.

Q Is that what you are referring to when you say it split the frame?
A Yes.
Q It generates two subframes for each frame?
A Yes, sir.
Q Dr. Zech, do you have an understanding of what these pixel data values shown on figure 5 are? When I say that I mean G, GN, GN(2), GN+1 and GN+1(2). Do you see those?
A Yes.
Q Do you have an understanding of what those represent?
A I have taken it to mean those are the process pixels and when they say data value, that doesn't necessarily have to be interpreted in terms of anything but it's a relative scale.
Q The pixel data values shown in figure 5, are these overdriven pixel data?
A I believe they are, sir.
Q So for each frame there are two overdriven pixel data per frame?
A Yes.

Q And this is consistent with the declaration, correct?
A I believe so.
Q I have paragraph 47 which appears on page 17 of your declaration.
A Yes, sir.
Q The last sentence on page 17 of this paragraph states, "Figure 5 reproduced below right" -- it's actually above right -- "shows two overdriven pixel data GN+1 and GN+1(2) generated by the blur clear converter 14 for each pixel in the frame period N+1."
A You said page 17?
Q Yes, at the very bottom.
A Okay. Paragraph 48?
Q If you look about the middle of the page there is a paragraph --
A Middle of the page? Sorry.
Q The last sentence in that paragraph, can I read that again to you?
A Certainly, go right ahead.
Q "Figure 5 reproduced below right shows two

overdriven pixel data GN+1 and GN+1(2) generated by the blur clear converter 14 for each pixel in the frame period N+1." Is that correct?

A Yes.

Q So figure 5 is showing a plurality of overdriven pixel data per frame; is that right?

A I think that's what I said initially, yes.

Q And you don't disagree with that sentence, do you?

A Not at the moment, I don't see anything to disagree about.

Q Okay. Dr. Zech, let's take a look back at the '843 patent. I would suggest maybe it's good to have both those documents close by.

A Sure.

Q Take a look at figure 7 on page 8. Dr. Zech do you see reference numeral 14 referring to everything in this dash box?

A Yes, I do.

Q You see control signal C coming into this box, right?

A Yes, I do.

Q And you also see a sync signal coming into this box?
A Yes, I do.
Q And you see reference numeral G coming into this box?
A Yes, I do.
Q I'll ask you this. Do you recall what reference numeral 14 corresponds to?
A That's a blur clear converter.
Q So are we looking at an embodiment of the blur clear converter here in figure 7?
A I think that's a fair.
Q Because we have data G coming in.
A Sure.
Q Coming out of figure 7 I have signal C2. Do you see that?
A Yes, I do.
Q What does that represent?
A Well, actually it represents frame doubling as I recall.
Q That's still a control signal, correct?
A Well, it's the multiplier takes C and

gives you C2, so if C is the control signal, then C2 should be a control signal.

Q And you said earlier the blur clear converter doubles the frame, correct, into two subframes?

A Yes.

Q Does that occur as a result of C2?

A Well, not necessarily as a result of C2, but rather C2 provides control for each subframe.

Q I understand. Dr. Zech, do you see the other output from the blur clear converter on figure 7?

A The one for GN and GN(2)?

Q Yes, sir.

A Yes.

Q You see that?

A Yes.

Q What do those two data represent?

A Well, by definition it has to represent the overdriven pixels, and when I use overdriven, I use Shen's definition of that either up or down, inclusive of both.

Q Okay. So the output per frame is 2 overdriven pixel data per frame; is that right?
A I believe that's correct.
Q And that's consistent with what we just talked about in figure 5, correct?
A Yes.
Q And now it's consistent with what's in your declaration as well?
A I hope so, yes.
Q Dr. Zech, will you turn to figure 8. Do you recall what's being shown here in figure 8?
A Looks like another embodiment of the blur clear converter.
Q And this is referred to as element 60, correct?
A Yes.
Q And you have control signal C coming in in the upper left, correct?
A Yes.
Q And you have frame data G coming in on the left?
A Yes.

Q And the output you have C2 again?
A Um-hmm.
Q Is that again a control signal corresponding to the two subframes per frame?
A Yes.
Q What is the other output of this embodiment of a blur clear converter?
A Well, again it has to be overdriven pixels.
Q Is it two overdriven pixel data per frame?
A Yes. The actual notation there is -- well, it should be only three dots, but it's telling you that goes on and on and on. The next one should be GN-3, GN-4, etc., etc.
Q Dr. Zech, can you take a look at column 3 again, please.
A Yes.
Q I am going to direct you to the very top of the column.
A Okay.
Q Specifically the description of the figures. Do you see those up there?

A Yes, I do.

Q I'm going to read to you the first sentence. "Figure 7 is a block diagram of the blur clear converter according to the first embodiment of the present invention." Did I read that correctly?

A Yes.

Q And that corresponds to figure 7 that we just looked at, correct?

A Yes.

Q "Figure 8 is a block diagram of the blur clear converter according to the second embodiment of the present invention." Did I read that correctly?

A Yes.

Q Figure 8 corresponds with the embodiment we just looked at of the blur clear converter, correct?

A Yes.

Q Are you aware of any third disclosed embodiment of the blur clear converter in this '843 patent?

A I don't recall any, but if you are willing to give me a moment or two, I'd be happy to scan through and see if there is one.

Q Please, let's get a clear answer on this one.

A Sure. Would you repeat the question, please?

Q Absolutely. Dr. Zech, are you aware of any disclosed third embodiment of the blur clear converter in the '843 patent?

A Well, I don't immediately see one. I've got to answer you I don't know, and under the circumstances this would not be the place for me to sort of try and read between the lines.

Q Understood. You haven't seen in the last few minutes that you have been reviewing the patent, you haven't seen any term third embodiment of the blur clear converter in this patent, right?

A I have not seen the term third embodiment, you are right.

Q Dr. Zech, just for clarification, in the embodiment that we talked about, figure 8, the output was two overdriven pixel data per frame,

correct?
A Yes.
Q And figure 7, the output was 2 overdriven pixel data per frame, correct?
A I believe that's true.
Q And those are embodiments of the blur clear converter shown in figure 3, correct?
A Yes.
Q Dr. Zech, are you aware of any other driving circuits shown in the figures of the '843 patent?
A Well, if they are not shown in figures of a specification, I don't understand -- there couldn't be any. I mean that document is an issued valid patent but what you have is what you have.
Q So if we take a look at figure 1, does that show a driving circuit?
A No.
Q Does figure 2 show a driving circuit?
A I could interpret based on my know-how and knowledge that a driving circuit of some kind is involved here.

Q Is involved. But is it shown in figure 2?
A The details, is that what you are asking about, or block diagram?
Q I am simply asking does figure 2 show a driving circuit.
A Nothing so labeled.
Q How about figure 3, would you characterize figure 3 as displaying a driving circuit?
A Yes.
Q That's the one we have been talking about, correct?
A Yes.
Q With the blur clear converter?
A Yes.
Q Does figure 4 show a driving circuit?
A Figure 4 shows the pixel architecture.
Q So you said before you separate the electronics and the LCD panel, correct?
A Yes.
Q And this is the LCD panel?
A This would be in reference to the LCD panel. By the way, the pixel architecture is very

primitive and old fashioned. Nobody does it like that anymore or did it even at that time.

Q Let's come back to that.

A Okay.

Q Does figure 5 show a driving circuit?

A No.

Q Does figure 6 show a driving circuit?

A One could infer that one was involved, but no, it does not specifically show a driving circuit.

Q Okay. And figure 7 shows the blur clear converter 14 that we talked about before?

A Yes.

Q That's part of the driving circuit shown in figure 3, correct?

A Yes. It provides the output to the drivers circuitry which in turns provides the voltages.

Q And so it's an embodiment of the electronics that we saw in figure 3, correct?

A I think that's a fair statement, yes.

Q Does figure 8 show an embodiment of the electronics that we looked at in figure 3?

A Yes, and this is not driving but this is rather signal processing in both 7 and 8, and there's a difference.
Q There's a difference between signal processing and driving?
A Oh, yeah -- yes. Sorry about that.
Q Does figure 9 show a driving circuit?
A No.
Q Does figure 10 show a driving circuit?
A No.
Q Dr. Zech, let's turn -- you are on column 2 there -- look down at the description of figure 3 on line 61.
A Okay.
Q Do you see that phrase figure 3 is a block diagram of a driving circuit and an LCD panel according to the present invention? Do you see that?
A Well, counselor, it depends on how you define a driving circuit. Now that's a misstatement because what you have is a signal processor plus the actual drivers. You could define, and I won't argue

with it, that the whole thing is a driving circuit but that's not the way I defined it in my answer to you. They are separate entities, they do different things, they have different designs. You can have a quote driving circuit without any signal processing.

Q Dr. Zech, will you turn to column 3, please.

A Yes, sir.

Q Take a look at line 15.

A Yes.

Q I'm going to read this sentence. "Please refer to figure 3 showing a block diagram of a driving circuit 10 and an LCD panel 30 according to the present invention." Did I read that correctly?

A Yes, you did.

Q We go to figure 3. Do you see element 10 on that figure?

A Yes, I do.

Q Do you see the dash box that refers to element 10?

A I do.

Q Is the blur clear converter contained

within element 10?
A Yes.
Q Is the gate driver included within element 10?
A Yes, it is.
Q Is the source driver included within element 10?
A Yes.
Q How about the panel control?
A Yes.
Q Signal control contained within element 10?
A Yes.
Q Do you see LCD panel 30?
A Yes, I do.
Q Dr. Zech, do you agree that figure 7 shows an embodiment of a blur clear converter contained within driving circuit 10 figure 3?
A Yes.
Q Dr. Zech, do you agree that figure 8 shows an embodiment of blur clear converter contained within driving circuit 10 of figure 3?

A Yes.
Q Dr. Zech, can you turn to column 2 of this '843 patent, please? This is on page 12.
A Okay.
Q Dr. Zech, do you see in column 2 line 16 under summary of the invention?
A Yes.
Q I am going to read this to you and please tell me if I make any errors. "It is therefore a primary objective of the claimed invention to provide a driving circuit of an LCD panel and its relating driving method to solve the problem mentioned above." Did I read that correctly?
A Yes, you did, sir.
Q So the objective of the invention of the '843 patent is to provide a driving circuit of an LCD panel, correct?
A Yes.
Q And a driving method of the driving circuit of the LCD panel; is that right?
A Yes.
Q Dr. Zech, do you understand in that

sentence I just read the problem mentioned above? Do you understand what the '843 patent is talking about of the problem mentioned above?

A Sure.

Q What is that problem?

A That problem is blur, image blur, which is a function mainly of the source data, whatever television or movie you happen to be trying to watch. I think the difficulty we are having here, counselor, is that I have a definition of the driver circuitry that differs from that of Shen. It's really not terribly relevant whether you talk about it piece wise or as block 10. Its job is the same thing, to get the right, correct voltages to the LCD pixels.

Q Can we do a 5-minute break?

A Of course.

MR. HELGE: Going off the record at 11:23.

(Off the record 11:23-11:32 a.m.)

BY MR. HELGE:

Q Dr. Zech, I'm going to ask you a question about the '843 patent's use of the term overdriving.

Do you recall that the '843 patent discusses the concept of overdriving?

A Yes.

Q And I believe you hinted at this earlier when you talked about over or under. Do you recall where the '843 patent discusses first the concept of overdriving?

A Well, I know it's in here someplace. If you want me to, I'll be happy to find it for you.

Q Paragraph 40 of your declaration points to column 2, lines 2-7.

A Yes, we had talked about that before when I said I took Shen's meaning that overdriven can be either higher or lower.

Q Is that what's here at column 2, lines 2-7?

A Basically, yes.

Q And you are referring to here where it says, "in order to improve that" -- and I believe that refers to blurring -- "some conventional LCD are overdriven, which means applying a higher or a lower data impulse to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules so that the pixel can reach the predetermined gray level in a predetermined frame period." Did I read that correctly?

A Yes.

Q And that blurring is the problem that you had said was discussed in the first sentence of the summary of the invention, right?

A Yes, yes. I'm sorry.

Q As we continue on in column 2, the '843 patent is discussing curve C2 that's shown in figure 2, correct?

A I recall that it is.

Q That's correct?

A Yes.

Q As column 2 describes, "as shown by the curve C2, in the case of being overdriven, although the reaction speed of the liquid crystal molecules is faster than in case of not being overdriven, the transmission rate has to wait until frame period N+1 to reach T2." Is that right?

A That's what it says, yes.

Q So overdriving in the standard frame rate is not enough according to the '843 patent, correct?
A Yes.
Q Not enough to reduce blurring?
A Yes. The technology of the '90s was not very good at doing that. It was only 60 hertz technology in those days.
Q Let's take a look at figure 4 of the '843 patent.
A Okay.
Q You mentioned earlier that this is not generally how LCD panels are built now, I think you said; is that right?
A Well, now and already by the turn of the century.
Q So even at 2003 this is fairly rudimentary?
A Yes, this would be a primitive pixel architecture. The major change would be the addition of a storage capacitor in the parallel with the liquid crystal capacitor.
Q What is the purpose of the storage

capacitor?

A It's to prevent charge leakage.

Q By charge leakage you mean that the voltage from one frame to another would decrease?

A Probably, yes.

Q So the desired transmission ratio wouldn't be achieved, is that right, or maintained?

A Well, that's right, you would get an incorrect answer. I'm a little conflicted here, I have to tell you, because when I look at this I'd say okay, it's for illustrative purposes, but on the other hand it's not my job to judge what the inventor had in mind, and the problem I have here is in my opinion I will tell you that the addition of a storage capacitor would not make this method work very well, it would be too much capacitance.

Q By 2003 was it very common to indicate a storage capacitor in an LCD panel schematic?

A Yes. In fact, if you look at Lee, you can see it that way. That's 2001.

Q So you were surprised in seeing no storage capacitor in figure 4, correct?

A I won't say I was surprised because Shen is not the only one who has done this in a patent. I have seen a number of them. Even in some papers and textbooks today I occasionally see that, and these people should know better. If you want a smoother picture, put that storage capacitor in there.

There are exceptions. I'm sure that if you have a signal processing implementation of some type, maybe you don't want to put the storage capacitor in there. But a lot of this is trade secret so I can't really tell you more than that.

Q Dr. Zech, LC molecules don't emit light, correct?

A Ha ha. Not in my lifetime.

Q Have you heard of a phrase called the ramp retrace?

A Ramp retrace, yes, there are electronic instruments that do that.

Q Have you heard of the term ramp retrace in the context of LCD technology?

A No, I can't really say that I have. A

ramp is, as you know, a triangular section of either current or voltage that can be terminated abruptly. There's positive ramps, there's negative ramps. Regardless, they still have to face the RC capacitance resistance that we talked about earlier.

Q So ramp retrace isn't a common term used in LCD technology?

A It's an electrical engineering term. It really has nothing to do with LCD unless you have an electrical engineer involved and he wants to talk that way about it. If you are talking about -- I mean we could really get into this -- if you are talking about ramps for example driving the gates, doesn't happen. Then you would see square top pulses.

Q Sorry, square top pulses?

A Square top pulses, yes. Also what we haven't talked about here is there's some technology, some designs in which at the end of the frame you jam pulses through to erase everything that's in the pixels through the gate lines.

Q Is that referred to as ramp rephrase?

A No, I don't think so, at least I have never heard it. This is such a big field. You got to realize more than 100 million TVs and monitors using LCD technology were sold last year. There's dozens of companies, many with leading names, Hitachi, Sony, Samsung, LG, and on and on, and then you have got the Taiwanese companies, a few Chinese. There must be over a thousand patents in the field. It's just almost overwhelming.

Q Have you heard of the term hold drive in the context of an LCD technology?

A Well, again, that's an electrical engineering term. You know for example there's sample hold. I'm not sure I know exactly what sample drive --

Q Hold drive.

A -- what hold drive means. It could be that it has to do with the fact that in some cases the blur clear converter says hey, you know what, this pixel is just fine and so no output is given to that pixel.

Q So you have no understanding right now whether sample drive means the same thing as hold drive?

MR. BARROW: Objection, relevance.

A No, I don't.

Q Dr. Zech, are you aware of whether the background of the invention as described in the '843 patent uses the term control the transmission rate?

A It sounds familiar but I'd like to check if you don't mind.

Q Please do. Specifically I'm asking the background of the invention.

A Okay. I'll make a comment here if you don't mind. He talks about 8 bit pixels. The standard is 10. It's in the column 1, line 36, 36, 37. Now your question says controlling the transmission rate. Do I remember that correctly?

Q Right, control the transmission rate or controlling the transmission rate. Please let me know if you see that term appearing anywhere in the background of the invention.

A Well, I see transmission rate in column 1 referring to figure 2. Again, line 59, the term is used.

Q When you say the term --

A I'm talking about transmission rate. I'm still looking for the word controlling. Well, surprise me, counselor. I don't see the word controlling in this background.

Q So the background as you have just read it does not state the phrase control or controlling the transmission rate, correct?

A I did not see it. Doesn't mean it isn't there. I just haven't seen it.

Q Okay. Can you please turn to column 4, line 22.

A Yes, sir.

Q Thinking back to our discussion before, you agree that the driving circuit 10 shown in figure 3 includes the blur clear converter both of which embodiments we discussed output a plurality of overdriven data per frame, correct?

A Sounds correct, yes.

Q Beginning column 4, line 22, I'm going to read here. "The driving circuit 10 generates two pieces of pixel data in each frame period, and then the source driver 18 generates two corresponding data impulses according to the two pieces of pixel data and applies them to the pixel electrode 39 of the corresponding pixel 36 in order to control the transmission rate and gray level of the pixel electrode." Did I read that correctly?

A Yes, you did.

Q So this portion of the disclosure falls within the detailed description of the invention, correct?

A Yes.

Q And so the background of the invention does not use the term control the transmission rates, but the detailed description of the invention does use the term control the transmission rate, correct?

A Yes. I see where we have variance about the box 10. When I talk about driving the actual data values to the LCD, only the driver does that. The blur clear converter doesn't do it, the timing circuitry doesn't do it, the input processing circuitry doesn't do it. But on the other hand, if you have to say 10 all together represents my electronics that ultimately drives the LCD, fine, no problem.

Q Dr. Zech, let's take a look back at your declaration.

A Yes, sir.

Q Can we go back to page 19?

A Yes, sir.

Q Do you see in paragraph 2 you have a table here?

A You are talking about the '843 patent terms?

Q That's right, sir.

A Okay.

Q You see the '843 patent and right next to it are the Lee terms?

A Yes.

Q Do you see under the '843 patent terms you listed overdrive?

A Yes.

Q You see the Lee terms?

A Yes.
Q What terms are listed there?
A Let me explain this. I should have done this in the declaration. Overdrive is a process of actually doing something. Overshoot and undershoot is a result of overdriving.
Q Okay.
A Normally -- well, time is not on my side, I had to do what I could do.
Q So what terms in Lee are you comparing to overdrive from the '843 patent?
A I don't understand that question.
Q The '843 patent terms includes overdrive, correct?
A Yes.
Q The Lee term that you are using as corresponding to overdrive, what terms are those?
A Well, Lee calls them overshoot and undershoot.
Q Okay. So your view is that overshoot and undershoot in Lee are comparable to overdrive in the '843 patent; is that right?

A No. What I'm saying is that if you overdrive something without proper design and caution, you will get overshoot. But you'll get overshoot no matter what because of the RC capacitive situation. The figures in Shen you know are not to be taken literally, they are illustrative and I accept them for that. But I'd be very surprised if you could actually do that kind of curve, get that kind of curve.

Lee I think is a little bit more honest in things. He says look, I'm going to overdrive them, I know they are going to overshoot in the first subframe but I'll correct it in the second subframe. I think it's figure 12 in Lee.

Q Would it help you if we pulled out Lee and looked at it along with this declaration?

A Wouldn't do any harm, sure.

Q I think you can put away the '843 patent for a little bit. Dr. Zech, I'm going to hand you what has been premarked as LG display document 2010. Does that document look familiar to you? Are you looking for the English version?

A No, let's do the Korean version. Yes, I'm looking for the English version. In my world travels I have learned to speak survival Italian, German, French, Spanish, I studied Russian intensively for one year, but I have to tell you, I have never been able to master anything but the food words in Korean.

Q All right. Dr. Zech, you are looking at figure 12; is that right?

A Yes, I am.

Q Figure 12 of the English translation?

A Of the English translation document LGD under score 000600.

Q Okay. I'm looking at the same page then. You were going to explain to me a little bit about overshoot and undershoot and you referred to figure 12, so please continue.

A Thank you very much. Now let's examine this curve. Let's start from the outside. The independent variable is called transmission and we have had that discussion so we don't need to do it again. The dependent -- independent variable --

transmission is the dependent variable, sorry, of the subframes actually are the independent variables. What Lee shows here is a typical 1 over RCX positive voltage. Where it says loss, that was not helpful. If you really want to interpret it, forget that. Forget the gate stuff. Not helpful. So anyhow, he shows to get to I guess we would call it T2 in the language of Shen, he shows an exponential curve which is applied voltage, it has all the earmarks of function like V 0 times E to the plus T over RC. Now he'd like it to stop at what we have called T2. The problem is nature doesn't give you that right. So he does what's called overshooting, that's where his term comes. He admits that you know I'm not going to do a cartoon of what goes on, I'll show you the reality.

Now when he gets up to the end of the N plus subframe, he's finally got this thing to stop, you know he may have cut the voltage off, I don't know, even before you get to the line T2. But the charge keeps pouring out there, nothing he can do about it.

So finally knowing that he has overshot due to overdriving, he puts in a negative, a minus, E to the minus T over RC -- I'm just being very generic here, okay? -- which is of course a negative voltage and that trims it down to what we have been calling T2.

Q Dr. Zech, is it your testimony that N plus and N negative are both subframes within one frame?

A I believe that's true, yes.

Q Okay. Is it your testimony that the voltage being applied in the first subframe, N plus, is applied in nearly that entire subframe?

A Well, according to the drawing, that's correct. Excuse me. As I said before, it's not that you want to. Nature doesn't give you any choice. That voltage, even when you put the magnitude to zero, you know it's going to go on and put out some voltage beyond that.

Q Dr. Zech, why don't you turn back to page 594.

A It's in my --

Q No, still in the same document, 594 is figure 5.

A Thank you.

Q You need to go backwards through the pages.

A Sorry.

Q Figure 5 is actually on the same page as figure 6.

A Yes, you are right, absolutely right. Here it is.

Q Top of the page. See that there, figure 5?

A Yes, I do.

Q Do you see what appears to be frame N and then frame N+1?

A Yes, I do.

Q Doesn't look like this figure is showing subframes, correct?

A No, not given the notation on the horizontal axis.

Q Okay. For how long a frame N is figure 5 indicating that there's actually an applied voltage to the pixel?

A Well, that's not readily determined. I guess we could for the sake of an argument split the difference between N and N+1, call that the frame life, so that if you go up, you see if there's still a voltage applied at the end of frame N. Now I don't know if that's true or not, but given what I have in front of me, I don't have much choice.

Q Dr. Zech, do you see a data impulse applied in figure 5?

A Yes.

Q Where is that?

A On the far left on the top applied data voltage.

Q Where does that data impulse end?

A I don't know, quarter way through the frame.

Q So that data impulse is being applied at only a small portion -- let's say less than 50 percent of the entire frame length; is that correct?

A Looks like about 25 percent.

Q Is that common for driving LCDs that a data impulse is only being applied for a small

portion of the frame period?
A No. Simple answer to that. There are so many variables. You'd have to define just about everything before I could answer that.
Q Okay.
A I wouldn't put you to that.
Q But you agree that Lee shows in this figure 5 that the applied data voltage impulse is only occurring during a small portion, maybe 25 percent of the frame; is that right?
A Well, in this particular figure, but you know it could have been drawn a lot differently. I don't know why he chose this particular one, but I don't take this as gospel. You know the applied data voltage could be run the whole frame, for all I know.
Q So your knowledge of how long a data impulse is applied to a pixel depends on many variables; is that right?
A Yes.
Q Let's take a look back at figure 12.
A Okay.

Q Based on what we just talked about, do you have an understanding about how long during subframe N plus data voltage is being applied to a pixel?

A No. I could only infer that it's not much different than figure 5.

Q But you don't know for sure, right?

A No. None of these things are explained. There are no captions on the figures. You know, as an engineering manager, if you brought me a document like this, I'd fire you on the spot. Yes, I would. I understand that you know this is the U.S. Patent and Trademark Office and things are done differently, but it doesn't make our job any easier.

Q Dr. Zech, you mentioned earlier that an impulse usually has a flat top, correct?

A No. An impulse can be anything.

Q Could it be ramp?

A Could be a ramp.

Q Is it common in LCD technology to apply variable voltage to a pixel over a subframe?

A That's the whole business of driving the pixel. You know it depends on what the intelligence of the system says that that particular pixel ought to have in terms of overall luma, brightness, and its RGB outputs, and there's no one simple answer to that. We are talking basically again -- I'll repeat this -- about a random process.

Q All right. In your paragraph 52 of your declaration which you still have open there --

A Yes, sir.

Q -- you are comparing overdrive from the '843 patent to overshoot and/or undershoot of Lee, correct?

A No.

Q Okay.

A I'm not comparing, I'm just listing the terms and about 5 minutes ago I explained to you one is the cause, the other one is the effect, but the effect can only come if it has this cause.

Q Understood. Is there any other effect of overdriving disclosed in Lee?

A Not that I recall, counselor. By the way, if I may add, overdriving isn't just an open-ended thing. You push it too far, you introduce other artifacts into the image. So it's something that has to be fairly tightly controlled.

Q Does Lee disclose tightly controlling as --

A No, none of these guys do. At that time period they were interested in trying to control a problem that wasn't their fault, that is, what I'm saying is the TV program or the movie you know if it has chop chop, a lot of action stuff, there's some image blurring. That's not the fault of the LCD other than it's only a 60 hertz machine. If you build or emulate 120 hertz machine, you take a final leap forward in terms of your blur minimization or elimination.

Q Dr. Zech, let's take a look at paragraph 63 on page 24.

A Yes, sir.

Q In paragraph 63 you are discussing gray level signals with respect to figure 12, correct?

A Yes.

Q You agree that figure 12 does not show any gray level signals, correct?

MR. BARROW: Objection, form.

A Did I say that? That doesn't sound like something I would say. Anyway, the way you got to view this is you are looking at a single pixel. Every pixel or subpixel has its own gray level ranging from pure white at the one end and pure black on the other, or so they would have you to believe. There is -- no, I couldn't tell you what gray level is involved here, no, that's impossible. Again, there was no discussion of that.

This stuff is standardized in some cases, the gray levels, okay, but probably not when these patents were done, probably not. I mean we knew about gray level and Kodak could sell you a gray level chart and all of that, but these days you know they can refer to gray level by number and you go look at the chart and see what number is it is. I don't think you could do that back in 2003.

Q Do you see the value of the signals being applied to the pixel in figure 12?

A Value. No, no, I don't.

Q Because figure 12 is showing transmission

versus the frame, correct?
A Yes.
Q So you can't tell the value of the signal being applied in sub frame N plus, correct?
A I don't believe I can.
Q You can't tell the value of the signal being applied in sub frame N minus, right?
A Yes. I would comment that this is a generic diagram. I'm trying to illustrate the principal.
Q So you can't understand the levels of the signals being applied to the pixels from this figure, correct?
A No. I don't see why you would have to. The figure tries to teach you something and it does it in a generic fashion. It's very common in scientific and engineering writing.
Q In the context of an LCD pixel, what is a target value?
A I don't know what you mean by the target value. The only thing I could infer from that is that you are talking about the brightness of the

perceived pixel output and that varies all over the map depending on what product you buy and what kind of back lighting unit it has.

Q Why don't you turn to page 25 of Lee. This is the English translation, Dr. Zech.

A Okay, I'm glad it is. Otherwise we'd have to wait until my nephew and niece got here.

Q Like you, my Korean is rudimentary as well.

A Just don't mention eating dog. You said 25 I believe, sir?

Q Yes. Are you there?

A I am indeed.

Q Take a look at lines 9-13.

A Okay.

Q Why don't you read that to yourself and let me know when you have completed it.

A I shall. Okay.

Q What did they mean when they said originally desired target value?

A We went through that. Let's look at the curve, 12. We have called that line up on top T2 to be consistent with other figures.

Q And that line is the line --

A That's the desired level of transmission.

Q Okay.

A Now what he's simply saying there is look, I overdrive this thing and I wanted to stop at T2 but it doesn't want to stop at T2, it goes on -- and again this is illustrative, it's almost a cartoon -- so being unable to precisely control when this signal stops, he runs up to the point where it does stop.

Q That's at the end of N plus, correct?

A At the end of N plus. Now of course that's not very good, right? That's not the solution to the problem. But you know, this is all done by test and measurement to see how these things work out. There's some analytical work that goes along with it. But he or his computers can and the firmware he writes for, he can figure out that this is going to happen or approximate it anyway, and so he'll hit it with another pulse which is negative to take you down from that voltage level where you don't want to be down to T2 where you do want to be, and his only constraints are he has got to do that within the two subframes, in other words, the whole frame.

Q And so what is the originally desired target value discussed on page 25, lines 9-13?

A It's the line we call D2.

Q So it is the desired transmission?

A Yes.

Q Doctor, in paragraph 52 you talked about overdriving in the '843 patent and overshoot and undershoot in the Lee reference. Do you recall that?

A Yes, I do.

Q Do you include anything about rollback in the Lee in that table?

A Rollback is not a term that was used in either patent that I'm aware of. Was it?

Q Let's take a look at page 25, lines 9-13.

A Oh, oh, rolled back. What he is simply saying is I put too much voltage on the pixel, now I got to correct that overvoltage. That's what he means by rollback. I'm sorry. I remembered rolled back but not rollback, which could be a different thing. Okay, we are set on that.

But basically that's his version of -- excuse me a moment -- of underdriving and even with underdriving and he gets some undershoot. There's no perfection in any of this. We are looking at highly idealized figures. I guarantee you that's not what you get in the laboratory.

Q Do you compare rolling back to underdriving according to Lee; is that your testimony?

A They are using different words but the concept is -- the concepts are standard. I wish there was a standard dictionary that went with this, but there isn't. I don't know who translated it but he may not have read Shen first. Oh, he couldn't because Shen was not around.

Q Let's take a look again at page 150, line 12-13. Line 11: "A driving with the overshot value rolled back to an originally desired target value is conducted in a second subframe end minus." Did I read that last part correctly?

A Yes, and that's what figure 12 shows.

Q You told me that you cannot determine the level of the signals applied from figure 12, correct?

A No, there's no indication. I mean it should be on the figure itself.

Q But it's not, right?

A But it's not, and that's why I say these are highly idealized teaching curves, there are no real scientific data can be derived from them, but a concept can be taught.

Q So from figure 12, is there any disclosure that allows you to conclude that rolling back to an originally desired target value means underdriving?

A Well, I don't know how else you would do it.

Q But you can't determine the level of the signal being applied to the second subframe?

A Why do I have to? The curve makes it very clear what's going on.

Q What is it from the curve that indicates

in the second subframe that it must be underdriving?
A Well, the fact you are decreasing the voltage from whatever level it maximized at down to T2.
Q Why does that require underdrive?
A How else would you get down to T2?
Q Are you saying there's no other way to do it?
A In an LCD? Nothing occurs to me.
Q What about driving to the originally desired target value, would that get you there?
A Well, if you could do it. But as I have explained several times, that's a very hard thing to do because of the RC nature of the circuitry.
Q So Dr. Zech, I want to make sure I understand. Your testimony is that driving with the overshot value rolled back to an originally desired target value means underdriving; is that right?
A It's equivalent to underdriving, yes.
Q Is there anything in the Lee reference that tells you that that's the case?
A I don't recall. I'll happily go through

it, but Lee is very clear about what he's doing and why and anyone with ordinary skill in the art would be able to readily interpret and understand what he's saying.

Q Turn to page 28, please.

A Which one, sir?

Q 28.

A That's in the Lee?

Q Yes, sir.

A Okay.

Q At the very bottom of this page actually beginning on line 18, Lee is discussing the second embodiment of the data gray level signal compensation portion. Do you see that?

A Yes.

Q Bottom of page 28 is going to carry over to 29. At the top of this paragraph on page 29 -- I'll give you a moment, you are reading --

A Okay, I have read to line 9.

Q Thank you, Dr. Zech. Beginning at the end of line 4, Lee is discussing the first compensated gray level signal, correct?

A Yes.
Q It says, "the first compensated gray level signal is an overshoot compensated gray level signal in case of the gray level signal of the current frame greater than the gray level signal of the previous frame and is an undershoot compensated gray level signal in case of the gray level signal of the current frame less than the gray level signal of the previous frame." Did I read that correctly?
A Okay.
Q Is that correct, Dr. Zech?
A Yes, it is.
Q So Lee tells us that the first compensated gray level signal is either an overshoot or an undershoot compensated gray level signal, correct?
A Okay.
Q That's what it says here, correct?
A Okay.
Q Is that right?
A Yes.
Q Okay. Let's move to the next paragraph beginning line 10. Do you see that paragraph?

A Yes.
Q It's talking about the second compensated gray level signal, correct?
A Yes, it is.
Q Please read through this paragraph and tell me if it ever says that the second compensated gray level signal is an overshoot or an undershoot compensated gray level signal.
A Well, it could have been written better and I certainly would not have used since he's talking about -- okay, I would have called it undershot rather than overshot, but it seems to describe figure 12 correctly.
Q Does it say that the second compensated gray level signal is an overshoot or undershoot compensated gray level signal?
A Well, he calls it overshot.
Q Does he?
A Yes, he does, in line 11.
Q What does he say, please tell me --
A "By making an overshot value down to an originally desired target value." That's exactly

what we see in figure 12.

Q Isn't that overshot value the overshot value as a result of the first compensated gray level signal?

A Oh, do you mean it's needed because of the overshot?

Q I'm just asking you if that's what Lee is talking about.

A I am trying to understand your question. Yes, you need it because, as I explained before and Lee honestly portrays, these driving voltages tend to get out of hand and go past where you want them to go. You don't have a braking system, in other words.

Q You go past where you want to go as a result of an overshoot compensated gray level signal in the first subframe N plus, correct?

A Yes, and that came from overdriving.

Q In the first subframe, correct?

A Yes, in the first.

Q In the second frame the second compensated gray level signal is applied, correct?

A Yes.

Q And that second compensated gray level signal takes that overshot value down to an originally designed target value, correct?

A Exactly as the figure shows, yes, correct.

Q And does Lee say that the second compensated gray level signal is underdriving?

A He doesn't use those words. In fact, overdriving and underdriving are -- I don't know if he uses them at all anymore. But I explained there is a direct connection between the two concepts, one is the cause, the other is the effect. Lee chose to talk about the effect. Shen chose to talk about the cause.

Q So where does Lee say that the second compensated gray level signal is underdriving or overdriving?

A Well, as I said before, he uses the word over -- wait a minute, let me get this straight. Okay, let's start on line 10. We are talking about the second compensated gray line signal. A compensated gray line signal by making an overshot value -- he should have said undershot there in my opinion, but it's neither here nor there. But the meaning is clear, especially when you look at this with respect to figure 12, down to an originally designed target value. This is the key thing. Getting down to that desired target value that we have chosen to call T2 -- or I have chosen to call it that.

Q So your testimony right now is that overshot value is a typo?

A Well, it could be a typo. I don't really know what was in the mind of Shen. But a more accurate description would be to have said it was undershot rather than overshot.

Q It doesn't say that here, right?

A No. It says overshot.

Q Okay.

A But I think the meaning is clear with reference to figure 12.

Q Dr. Zech, let's take a look at this one more time.

A Okay.

Q I am going to look at the first half of that paragraph beginning on line 10 on page 29. Are you with me?

A Yes.

Q Do you see beginning at the end of line 11 we are talking about "in case of the gray level signal of the current frame greater than the gray level signal of the previous frame"? Does that describe figure 12?

A It strikes me that that paragraph talks about just the opposite of what figure 12 shows.

Q How's that?

A Well, the way I read it is that you are looking at a situation where you have a lower value than what's needed -- or a higher value than what's needed and you want to bring it down. If you reverse the figure 12 and apply the same logic, you'll get the same result in terms of overshooting and undershooting, only instead of overshooting initially, you undershoot and now you have so do a little bit of overshooting to get to the desired T2 level. For the life of me, I don't know why they are describing this in these terms, but you know it's what it is, I can't do anything about it.

Q I am going to take a look at page 24 of your declaration. At the bottom you are showing figure 12. Do you see that?

A Not yet. Now I see it, yes.

Q In figure 12 of Lee as shown in your declaration, page 24, the first subframe N plus --

A Right.

Q -- shows an overshot value at the end of that subframe, correct?

A Yes, it does.

Q And the second subframe shows according to Lee taking that overshot value down to T2, correct?

A Correct.

Q And that T2 is what Lee sees, according to you, is the original desired target value, correct?

A Well, it's the target value.

Q So in the second subframe N minus --

A Yes.

Q -- I believe your testimony is that you have no way of knowing what the level of the voltage being applied in that second subframe is, right, from this figure?

A Nobody would know. No, it's not possible. Needs to be indicated.

Q And on page 29 of Lee, lines 10-15, the first three lines there, "the second compensated gray level signal is a compensated gray level signal by making an overshot value down to an originally desired target value in case of the gray level signal current frame greater than the gray level signal of the previous frame." Is that right?

A That's what it says.

Q And they don't say here in that portion that the second gray level compensated signal is underdrive, do they?

A Well, the word underdriving does not appear there, I can see that. But anybody who looked at figure 12 in the N minus cell frame, you don't have to even be of ordinary skill in the art, just somebody who has had enough math to know what the hell they are looking at.

Q Where does your declaration explain that concept?

A Which concept?

Q That in your view signal level in the second subframe must be underdriving.

A I probably don't explain it because to me it's so obvious that I didn't feel it was necessary, and if you had questions, I'm sure you have an expert who can come and say yes, this is how it works.

Q So you didn't feel it was important to explain that; is that right?

A I didn't say it was not important. I just said it was unnecessary, in my opinion.

Q Is there anything that you felt was unnecessary to explain in your declaration?

A No. I said what I thought was important and needed to be explained and I explained it.

Q So even though you can't determine from figure 12 the level of the signals that are being applied, you felt it wasn't important enough to explain in the declaration; is that right?

A That's right. What difference would it make if you know what the voltages were? Wouldn't make a dime's worth of difference in my opinion. I mean you want to pursue that? Okay. But there is no mention of voltage values, curve values, other than -- timing is not mentioned other than if you have 60 frames per second, you have 16.7 milliseconds per frame to get your work done. Neither patent really goes into details about the actual measurements and numbers. That's not required of a patent, as I understand.

Q Dr. Zech, is it correct that sitting here right now you have no idea whether in the second subframe N minus is performing underdriving or overdriving?

A I do know. He's underdriving.

Q How do you know that?

A By the shape of the curve.

Q Is there anything else that you know that from?

A I don't need to have anything else. The shape of the curve tells me all I need to know.

Q Is rolling back synonymous with

underdriving according to Lee?
A No, I'm not going to -- I don't know what -- I don't necessarily agree with that. I would not necessarily have chosen rolling back in my own writing, but I don't see anything wrong with it either.
Q What does it mean?
A Rolling back?
Q Yes, sir.
A Let's look at curve 12 again. We have a maximum value at the end of N plus, okay. Rolling back in this context means I screwed up or I went too far or the system didn't work for me, now I have got to drive that voltage down in the N minus subframe to T2. Call it rolling back, decreasing, minimizing. You know there are a lot of terms that one could have used.
Q So rolling back refers to the shape of the curve on figure 12, is that right, in the second subframe N minus?
A No. It refers to the function that's performed which is decreasing the voltage from

whatever value it is at the peak here down to T2.
Q Which is the originally desired target value?
A Yes.
Q And your testimony is that rolling back must mean underdriving?
A In the general use of the term, rolling back means go to a previous condition. That's why I would not have used that term myself.
Q What does it mean in Lee?
A In Lee it means decreasing from the maximum value of the overshoot down to the T2 level.
Q So rolling back refers to a result and not --
A No. It refers to a process. The result is a voltage at the T2 level.
Q How do you perform the process of rolling back?
A Whatever signal process that you have tells you how much you have overshot and tells you how much you must roll back, which means decrease the existing. When you look at the end of N plus,

you are looking at a voltage there, that's a maximum voltage that you put on the pixel. Not good. You don't want to be there. You want to be at T2. So you need to apply a negative voltage to bring that back down and that's what he means by rolling back.

Q Applying the negative voltage means underdriving?

A I think so.

Q But Lee doesn't say that, right?

A No, he doesn't use that term. He likes overshooting and undershooting. Right?

Q He doesn't say that in the second subframe N minus that it's undershooting, does he?

A He doesn't use that terminology.

Q Let's take a look at page 25 of your declaration.

A Okay.

Q Sorry, you were on the right document. Sorry, Dr. Zech. Go ahead and turn the page there. There you go, one page. As I understand your testimony, you are saying that overshooting and undershooting are not the same thing as overdrive.

A No. Let me say it again, please. Overdriving or underdriving is a process. Overshooting and undershooting is a result of that process.
Q Okay.
A I can't tell you anything more about it than that.
Q Let's take a look near the top of page 25, paragraph 64.
A Okay.
Q If you go down about a 5 lines there is a beginning of a sentence "thus."
A Yes.
Q You say, "thus the overshoot and rollback occurring respectively in the first and second subframes constitute a plurality of overdriven impulses within a single frame." Is that right?
A Yes, I do.
Q Is it your testimony that rolling back means overdriven or not?
A No. I think I have said several times now that rollback and undershooting or underdriving go

together, depending on what you take -- if you take the definition of overdriving as both the plus and the minus function, then you know if you say overshoot, then it follows that you've got both the increase and decrease values. But in this context we have two subframes. We do overshooting which in this case means overdriving. We get the wrong value so we got to do something about that, and the inventor, Lee, chose to use the term rollback.

Q He chose rollback and not underdrive, right?

A Yes, I guess you could say that. But regardless of the words, his figure speaks for itself.

Q And you say that from the shape of the curve in the second subframe?

A Absolutely. That's what guys like me are trained to do.

MR. HELGE: Break?

MR. BARROW: Fine.

(Off the record 12:40-12:53 p.m.)

BY MR. HELGE:

Q Let's go back on the record. Dr. Zech, can you please turn to page 28 of the English translation of Lee.
A You said 28, sir?
Q Yes, sir. There's a paragraph that begins "moreover." Do you see that paragraph?
A Yes, I do.
Q Do you see that this paragraph is talking about the separator 450. At the very end it says "compensated gray level signal GN minus the second subframe is output to the separator." Do you see that?
A Yes.
Q At any point in this paragraph does it describe the compensated gray level signal GN minus of the second subframe as either overdriven or underdriven?
A It does not say either way.
Q Are you aware of whether Lee describes the compensated gray level signal in the second subframe as overdriven or underdriven anywhere in this reference?

A I don't immediately recall, but if you don't mind, I'd like to just take a quick look at the text of this.

Q Of course.

A On page 29 he talks about -- starting on line 10 -- he talks about the second compensated gray level and again he describes it in terms of compensated gray level signal by making an overshot value down to an originally desired value. Is that the kind of thing you were looking for?

Q Is that your answer that that is describing the compensated gray level signal as either overdriven or underdriven?

A Oh, yes. What else are we doing, counselor, if we don't do that? What is the whole point of the exercise? I mean if he does not do that, then he's doing nothing, as it would be true of Shen. There has to be some kind of action.

Q Isn't Lee in this paragraph in the line you just mentioned, isn't Lee taking the overshot value achieved at the end of the first subframe N plus down to the originally desired target value?

A No question. We have been discussing that for the last hour. Absolutely.
Q As shown in figure 12, correct?
A Absolutely.
Q Okay. And your testimony is that you know in the second subframe that the voltage being applied to the pixel must be underdriven based on the shape of that curve; is that right?
A Basically, yes.
Q Is there any other reason that you know that must be underdriven?
A Oh, I don't know, 50, 55 years of technical work, half my Ph.D. studies were in mathematics. I don't know, I like to think I know something about the subject. But I'm not sure -- I don't know why we need more. I mean we have an absolute answer there in terms of that curve.
Q What is the absolute answer?
A The absolute answer is that the voltage is being driven down.
Q Of the pixel, correct?
A Yes. You see on the N negative or N plus,

I forget, but that second subframe you are applying a negative voltage. The first subframe it was a positive voltage. But you could do it the other way around, inversely, negative voltage in the first frame and positive in the second.

Q And your testimony is you know that based on the shape of that curve, your experience, and that's it, right?

A No. I think that the Lee specification is quite helpful.

Q And is that page 29 from 10-15?

A I'm sure I read that and took it into account.

Q Is there anywhere else that you are relying on Lee to guide your interpretation of figure 12?

A Counselor, if I needed more to guide me on a matter like this, I shouldn't be in the business.

Q And you don't describe in your declaration that the shape of that curve based on your experience means underdriving, correct?

A I do not because as I explained before, I tried to focus only on what I thought were the important things for the litigation. I wasn't writing a tutorial on electrical engineering or optics or mathematics or anything else. These are well known and well understood curves, these are no mysteries.

Q Is it accurate for me to say that based on the shape of that curve on figure 12 of Lee in the second subframe that your testimony is there must be underdriving?

A Relative to that figure, yes. I mean I don't know how you go from this voltage down to the lower voltage (indicating) without this underdriving concept. Remember what you have got there is a negative voltage and in the first subframe you have a positive one.

Q You are talking about polarity inversion?

A You could call it that, from positive to negative, yes.

Q Sir, if you are going from positive to negative, why must there be underdriving in that second subframe?

A Why must there be underdriving is your question?

Q That's right.

A Let me think about that for a minute so I can give you a coherent answer. Everything in the context of the Shen and Lee documents indicate to me very clearly that when you do what you do in figure 12 in subframe 2, you are underdriving and perhaps undershooting as the case may be -- I mean I have nothing else to go on, I have to go on what's on the paper there.

Q And experience, right?

A Well, experience, like I say, I have been -- I'd be an awful dumb electrical engineer if I couldn't look at those curves and tell you what they meant, and anybody with any skill in the art, I think I have defined that person as an electrical engineer and physicist preferably with master's degrees at least. You know this is the simplest solution to all differential equations of that class and exponential. If you take a simple electrical circuit -- your expert can show you this -- with a capacitor resistor in it and you try to determine the constant -- the current, you will come up with a simple exponential solution with a time consonant of 1 over RC.

Q And that background is why there must be underdriving in the second subframe; is that right?

A I believe so. That's my opinion. Correction. The RC constant is not one over RC but is RC. I think.

Q Doctor, based on your interpretation of rollback, is there a reason why you did not include it in your discussion in paragraph 52 in your table that describes the patent terms and Lee's terms?

A No, no particular reason. I probably just didn't get to it. If I had thought about it, if I had more time to do my declaration, I'd probably have gotten them in on the second time through.

Q Do you think your declaration is incomplete because you didn't include that?

A No, not at all. It's not a fundamental term unless I remember how many times Lee uses it, and it's not many.

Q So it's your testimony that rollback is a result of underdriving; is that accurate?

A No, no. It's the other way around. Rollback is a process, it's a process that's accomplished in the case of figure 12 by underdriving.

Q And that's the only way to achieve rollback in figure 12?

A Well, I don't know of any other method. I'd gladly share it with you if I did, but I don't. In the context of these patents, okay? There are other people that do other things, would look up tables and what have you, which are entirely different and foreign to anything we are talking about here.

Q Dr. Zech, also in paragraph 52 of your declaration --

A Yes, sir.

Q -- you also do not provide any analysis of what is meant by controlling the transmission rate according to the '843 patent terms, correct?

A Yes, I didn't really think that was

necessary. Well, that's just my opinion.
Q When you say it wasn't necessary despite the fact that you felt that transmission rates was not a term of art?
A Well, the thing was, at the time I submitted this declaration, I didn't have the epiphany I had a couple of months ago about it being probably a typo or a mistranslation.
Q So you had that epiphany after you submitted the declaration?
A Yes. That's why it's not in there. I was troubled by the term, but I didn't have anything intelligent to say about it.
Q Is it fair to say that you didn't understand it when you submitted this declaration?
A No. I know what the inventor was trying to tell me, I just didn't know why that term was used.
Q You didn't come to that realization of what you think it means now until after you had submitted your declaration?
A That's correct. But we are not talking

about concept, we are just talking about words.
Q Dr. Zech, can you skip ahead to paragraph 70?
A Sure.
Q Specifically the last sentence of this paragraph.
A Okay.
Q Why don't you read that to yourself a moment and let me know when you have completed.
A Did you say last paragraph or last sentence?
Q Last sentence of paragraph 70.
A Thank you. Okay.
Q At the time you submitted this declaration, as I understand from your testimony a moment ago, you did not have the epiphany of what was meant in the '843 patent by transmission rate, right?
A No, that's not right. It's easy enough to figure out what both of the inventors were saying even when they used terms that were not a part of the industry. What I was telling you was that I

couldn't for the life of me figure out why they would use such a dumb term to explain what they were trying to teach. Transmission rate is totally unknown to me. I looked for it in dictionaries, on the Internet, everything, and never found a single example of it. But as I said, a couple of months ago, oh, I've got it, it's a mistranslation. They don't really mean transmission rates, they probably mean transmission ratio or something else. But anyhow, that has no impact on anything else. I just took them at their word. If they want to call it that, it's their right. I can work with it.

Q Dr. Zech, do you know that there is a burden of proof in these cases before the Patent Tral and Appeal Board?

A I have heard that.

Q Do you know what that burden of proof is?

A No. I'm not a lawyer.

Q Did you have to weigh any of this evidence in reaching your conclusions?

A What do you mean weigh the evidence?

Q Did you have to evaluate whether any

concepts were more likely than not disclosed?

MR. BARROW: Objection to form.

A I don't know what that question means. I'm sorry, counselor. It's too early in the day to be getting brain fog, but I just am not following that. I mean what use am I to the process if I don't carefully study and analyze the documentation I'm given? I don't do it from the perspective of a lawyer. I'm an engineer and scientist and I spent 14 years in the university system and I use what they taught me there to this day.

MR. HELGE: Well, with the right to reserve recross, I'll hand him over to you.

MR. BARROW: Can we take a short break?

MR. HELGE: We can, but I put out the prohibition I have already stated.

(Off the record 1:13-1:21 p.m.)

EXAMINATION BY COUNSEL FOR PETITIONER

BY MR. BARROW:

Q Dr. Zech, I have just a few follow-up questions regarding your testimony.

A Yes.

Q You spoke quite a bit about this term transmission rate. Do you recall that?

A Yes.

Q What is your present understanding of the term transmission?

A Well, transmission refers to the ratio of some input to some output. For example, your car has a transmission and you know you get power from the drive shaft and the various gears decide how it's applied. But in this case it seems to me that the term transmission rate is just a misnomer. It means basically transmission, transmitter, whatever.

Q Just to clarify, so you said in your opinion transmission rate essentially means transmission?

A Basically. Just trying to build up the concept in my opinion. You can't match transmission and rate. I think I explained that the rate is something going on per second like the frame rate for example, and the frame rate may or may not have something to do with the transmission, depends on what the frame rate is, how much power.

You know, for example, we look at all of this stuff, Lee and whatever. In my opinion, I as an engineer never implement this stuff because it's too expensive. Frame memory cost a lot of money back in 2003 and they are still expensive. I would have -- the easier solution was to go to 120 hertz technology which people did.

Q Okay. So forgetting transmission rate for a second, but we are still in the context of the '843 patent --

A Okay.

Q -- what is your present understanding of the term transmission, just transmission?

A Well, that was something I knew a definition of 45 and 50 years ago. It's simply the ratio of the output and input. Now in the case of an LCD. The input is either the life value of the back light unit or it's that same light after it passes through the first substrate and it will be greatly diminished down to about 5 percent of the original value. So either one can be the denominator and the numerator, the top value, is the light output. Then, as I said, there were instruments that can measure this.

Q Can you describe what transmission means in the context of the pixel?

A Sure. Every pixel has to transmit light, so therefore it has a transmission ratio.

Q Transmission ratio, okay.

A Simpler just to call it transmission, but I use ratio because I have explained to you there is a numerator and a denominator and by anybody's logic -- you don't have to be a genius -- that's a ratio.

Q And your present understanding is consistent with the term transmission at the time you prepared your declaration?

A Oh, sure.

Q Is transmission the same as transmittance in your opinion?

A Closely related concepts.

Q Sir, earlier you testified regarding your alleged confusion about the term transmission rate. Would it be accurate to say that this alleged confusion pertains to the word rate rather than the word transmission?

MR. HELGE: Objection to leading.

A Let me first of all say I didn't have any confusion. I was just more than anything annoyed by the study of the term and I just you know -- I'm that kind of person, I'm driven, I have to know everything, and you know it was no clear way to find out other than calling Mr. Shen and saying what the hell did you mean by this. But I didn't do that.

Q But did you understand what transmission meant when you read the patent?

A Oh, sure, it's pretty obvious from the context of the spec what the inventor was getting at.

Q In your opinion what does it mean to control the transmission rate?

MR. HELGE: Objection to form.

A To control it means to somehow modulate it so that the output value for a given pixel -- and this applies to all pixels -- achieves the value that you are looking for. So again, to expand that, a pixel has three subpixels, red, green, blue. All of this has to be driven in a way that the brightness and the appropriate color is achieved.

Q Okay. Let's go to figure 12 of the Lee translation.

A Yes, I have it memorized by now.

Q Just give me a moment to find it.

A Sure.

Q If you could put it in front of you.

A Okay, will do. What page is that?

Q I think it's 600.

A Okay, pops right out.

Q Earlier -- correct me if I am wrong -- you testified that this figure does not show specific or say anything about specific voltage values; is that accurate?

MR. HELGE: Object to form.

A Best as I can tell, yes. It's there for illustrative purposes. Forgive me for using this term but quite frequently in a situation like this I refer to these things as cartoons. No scientist or engineer worth his salt would tell you that this is anything but illustrating a concept, an important concept -- don't misunderstand me -- but it's an illustration.

Q So looking at the various subframes here that you spoke about, I would like to refer your attention to the dotted line in between subframe plus, N plus, and N minus?

A Yes.

Q This appears to intersect the peak here of the signal?

A Yes.

Q What does this peak tell you, if anything, about the applied voltage?

MR. HELGE: Objection.

A Well, in absolute terms, nothing. It tells you about the transmission being intelligent, knowledgeable people. We know that that didn't get there except that there was some voltage applied to the pixel, loss, gain. I don't think that's very meaningful. So in a lot of these figures and a lot of the statements, you have to be able to work back from what you are presented with, you know, the people who are supposed to be able to deal with are of ordinary skill in the art. This is a tough art so the skill levels have to be pretty high. Does that answer your question, counselor?

Q Yes. Does this figure tell you anything about relative voltage values?

MR. HELGE: Object to form.

A No, you can't take this too literally. You know one could make a case I suppose that you in conjunction with the specification and maybe you could infer something from it. Now speaking as an engineering manager, if you came to me and told me you could do that from this curve, I would throw you out of my office.

By the way, let me add that in the circuitry that's driving all this stuff that comes before we get to this point, there's not an unlimited rate of voltages, there's some narrow range of positive to negative voltages. But again this is quite specific to the design of a given product and there's hundreds and hundreds of products.

Q Sorry, I didn't want to interrupt --
A I'm done.
Q Okay. So you said here at this line in the 29 plus and the minus 2 subframes you overshot the target value.
A Yes, getting too much transition.
Q And then in the subframe N minus, you said this is where we do this rollback, right?
A Correct, we make an adjustment to get us to the transmission level which we call T2 -- or I call T2 in any event. You know that's the whole purpose of the patent, it's to gain some control over what's going on there. Believe me, it's far more complicated than these patents reveal, the overall process. You could go nuts trying to figure out everything.
Q I believe before you stated that at this point, this intersection, at this peak --
A Yes.
Q -- you mentioned you are driving the voltage down. Is that what you said?
MR. HELGE: Object to form.

A Yes, you have to -- at the peak, if you want to get down to T2, you have to apply a negative voltage.

Q So just if you could clarify this for me. So this plots transmission against the frame, right?

A Yes.

Q Now you talked a little bit before about voltage and now you are talking about voltage in the context of this figure. Can you explain to me how you are getting to voltage?

A Well, the transmission is determined by the voltage applied to the pixel. I may not know exactly what that voltage is, but I know it's positive and the duration of the given voltage pulse has already been determined by the network design. I don't know what else to tell you. I mean there's a direct correlation, one-to-one relationship between transmission and voltage.

Q So you said there was a positive voltage. Are you referring to the P --

A The upward curve, it looks like an exponential, upward curve is positive. You know it doesn't really matter. This could be negative and this could be positive.

Q So you are saying this curve reflects application of a voltage?

A Of a voltage, sure.

Q What's going on on the down, on the rollback?

MR. HELGE: Object to form.

A Application of the negative voltage.

Q So a positive voltage on the ramp up?

A Yes, that's a good way to put it.

Q And a negative voltage on the rollback?

A Rollback, sure. That's as good a term as any. See, as I have tried to make clear, because of the RC nature of the circuitry involved, the pixels in particular, you can't just arbitrarily say stop here because a pixel will laugh at you, yeah, I'm going to do what I want to do, well, within limits, so you do tend to get this overshooting. But that overshooting came from overdriving and the other way around you, want to do some -- you get -- well, you don't get any undershooting really. That's bringing it right in on target, but it's in the context of these patents it could be called underdriving.

Q Sir, I believe the term that you used earlier today, you said cartoon, you said these are illustrations, these are attempts to illustrate what's going on.

A Yes.

Q The context of overshooting is we are trying to get the target value, but these things don't behave like we would like them to so sometimes we overshoot --

A Yes, we don't have precision of control over where the voltages end up in value.

Q Would this also occur on the rollback?

A Sure. You can see you have an exponential here. Now you have to make some better decisions than you made in N plus, in N minus. Fortunately the value that you need to change is relatively small. So you know what, doesn't show it here, but I bet this tail runs a little bit further than is shown here. But again, it's an illustration, it's trying to make a point, trying to teach us something, and this is Lee's perception of how things would go on in two subframes of a particular pixel.

Q One of ordinary skill in the art looking at this figure and perhaps the disclosure would understand that it might end up undershooting its target value a little bit?

MR. HELGE: Object to form.

A You might. You know that's hard to go back to 2003 and figure out whether or not, but a good engineer or physicist knows his math, he knows what goes on with this stuff.

Q Let's go back to your declaration.

A Okay.

Q Let's go to paragraph 64, please.

A I'm there.

Q I direct your attention to the middle of that paragraph. "Thus the overshoot and rollback occurring respectively in the first and second subframes constitute a plurality of overdriven impulses within a single frame." Do you see that?

A Yes, I do.

Q This paragraph, is it addressing the rollback scenario that Mr. Helge discussed with you earlier?

A In the main it does.

Q And is this still your opinion that the overshoot and rollback constitutes a plurality of overdriven impulses within a single frame; is that still your opinion?

A Yes.

Q Can we go back to the '843 patent, please?

A Sure.

Q I direct your attention to column 2, line 2. I'll read this to into the record as well. "In order to improve that, some conventional LCD are overdriven, which means applying a higher or a lower data impulse to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules so that the pixel can reach the predetermined gray level in a predetermined frame period." Do you see that?

A Yes.

Q Do you consider this description, the term overdriven, in your analysis of the Lee patent?

A I'm not sure I know what that question means. Did I consider it? I read it, I analyzed it, I think I understood it. When I looked at Lee, there were some differences in terminology, but basically the novel concepts in both were clear to me. Have I answered your question? I'm not sure what point you are trying to make and what question you are trying to ask.

Q Is Shen providing sort of a description or definition of overdriven in this sentence that I read?

MR. HELGE: Object to the form.

A More or less.

Q So what I was asking is did you consider that in your analysis of overdrive.

A Absolutely.

MR. BARROW: No further questions.

FURTHER EXAMINATION BY COUNSEL FOR PATENT OWNER

BY MR. HELGE:

Q Dr. Zech, do you agree that in figure 12 of the Lee reference, the second subframe N minus,

there was no undershoot occurring?
A No undershoot occurring. Well, the illustration in fact shows another idealization showing that the N -- in fact in frame N minus 1, that that negative descending exponential curve just perfectly matches up to T2, probably not in this universe but close enough, close approximation.
Q And Lee describes that as the original target value, correct?
A Yes.
MR. HELGE: No further questions.
MR. BARROW: I have no further questions.
MR. HELGE: Let's get this on the record. Will Dr. Zech review and sign the transcript?
MR. BARROW: Yes.
THE WITNESS: I hope so. I would be very disappointed. I have done a lot of depositions. I have always gotten the transcript to review and to make corrections. I'm not allowed to make additions, though many times I wish I could have.
MR. HELGE: I know that Planet Depos also wants the order on the record. So we'd like

delivery on Monday.

MR. BARROW: And you will provide a copy to me.

MR. HELGE: I would like to have these three exhibits attached too because Dr. Zech has marked T2 on a couple of those and we need that to be a part of this record.

THE WITNESS: Here you are, all three of them.

(The deposition concluded at 1:46 p.m.)

CERTIFICATE OF SHORTHAND REPORTER - NOTARY PUBLIC

I, Marilyn J. Feldman, Certified Reporter and Notary Public within and for the District of Columbia do hereby certify that RICHARD ZECH, PH.D., the witness whose deposition is hereinbefore set forth, was duly sworn by me before the commencement of such deposition and that such deposition was taken before me and is a true record of the testimony given by such witness.

I further certify that the adverse party was was represented by counsel at the deposition.

I further certify that the deposition of RICHARD ZECH, PH.D. occurred at the offices of Mayer Brown LLP on Friday, November 13, 2015, commencing at 9:30 a.m. to 1:46 p.m.

I further certify that I am not related to any of the parties to this action by blood or marriage, I am not employed by or an attorney to any of the parties to this action, and that I am in no way interested, financially or otherwise, in the outcome of this matter.

IN WITNESS WHEREOF, I have hereunto set my hand this 16th day of November 2015.

My commission expires:

December 14, 2016

NOTARY PUBLIC IN AND FOR

THE DISTRICT OF COLUMBIA

IPR2015-00885
Exhibit 2007
Page 168 of 374

US007202843B2

(12) **United States Patent**
Shen et al.

(10) **Patent No.:** **US 7,202,843 B2**
(45) **Date of Patent:** **Apr. 10, 2007**

(54) **DRIVING CIRCUIT OF A LIQUID CRYSTAL DISPLAY PANEL AND RELATED DRIVING METHOD**

(75) Inventors: **Yung-Hung Shen**, Hsin-Chu (TW); **Shih-Chung Wang**, Kao-Hsiung (TW); **Yuh-Ren Shen**, Tai-Nan (TW); **Cheng-Jung Chen**, Miao-Li Hsien (TW)

(73) Assignee: **Vastview Technology Inc.**, Hsin-Chu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 602 days.

(21) Appl. No.: **10/707,741**

(22) Filed: **Jan. 8, 2004**

(65) **Prior Publication Data**

US 2005/0104824 A1 May 19, 2005

(30) **Foreign Application Priority Data**

Nov. 17, 2003 (TW) .... 92132122 A

(51) **Int. Cl.**
G09G 3/36 (2006.01)

(52) **U.S. Cl.** **345/87**; 345/89

(58) **Field of Classification Search** 345/87, 345/88, 89, 90, 91, 93, 98, 99, 100, 204, 345/589, 596, 600–605
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2001/0038372 A1* 11/2001 Lee 345/89
2002/0044115 A1 4/2002 Jinda et al.
2003/0058264 A1 3/2003 Takako et al.
2004/0119730 A1* 6/2004 Ham et al. 345/692
2004/0196229 A1* 10/2004 Ham 345/87
2004/0246224 A1* 12/2004 Tsai et al. 345/100
2005/0073630 A1* 4/2005 Chen et al. 349/87

FOREIGN PATENT DOCUMENTS

EP	0539185	A1	4/1993
EP	0660297	A2	6/1995
EP	0660297	A3	6/1995
EP	1122711	A2	8/2001
EP	1122711	A3	8/2001

OTHER PUBLICATIONS

Baek-Woon Lee, et al.; Reducing Gray-Level Response to One Frame: Dynamic Capacitance compensation; Samsung Electronics Corp.; ISSN00010966X, 2001.

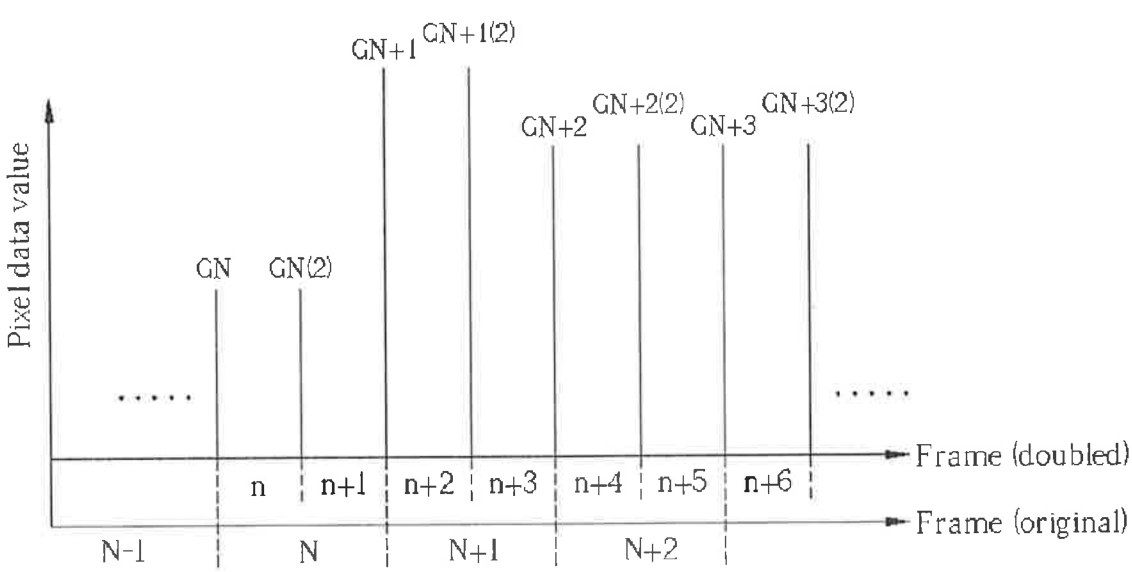
* cited by examiner

Primary Examiner—Nitin Patel
(74) *Attorney, Agent, or Firm*—Winston Hsu

(57) **ABSTRACT**

A method for driving a liquid crystal display (LCD) panel includes receiving continuously a plurality of frame data, generating a plurality of data impulses for each pixel every frame period according to the frame data, and applying the data impulses to a liquid crystal device of a pixel within a frame period via the data line connected to the pixel in order to control a transmission rate of the liquid crystal device.

9 Claims, 10 Drawing Sheets



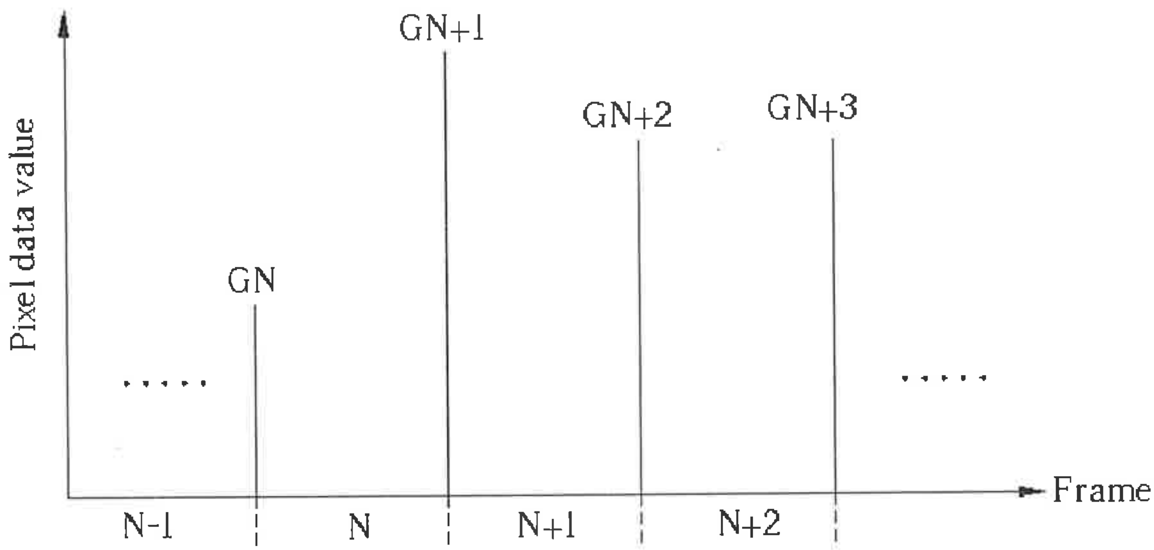


Fig. 1 Prior art

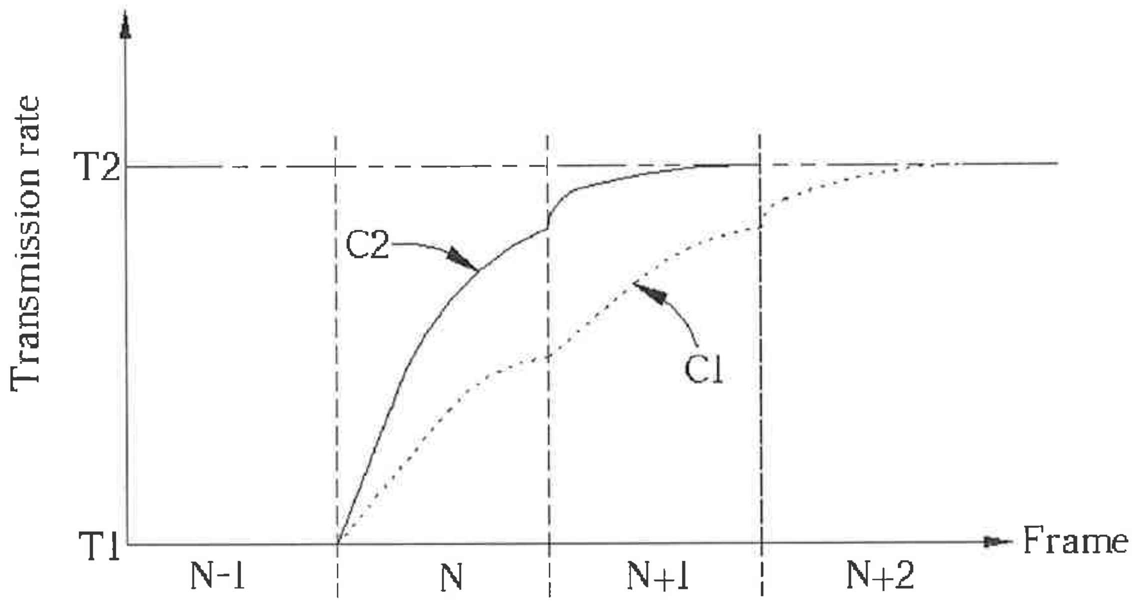


Fig. 2 Prior art

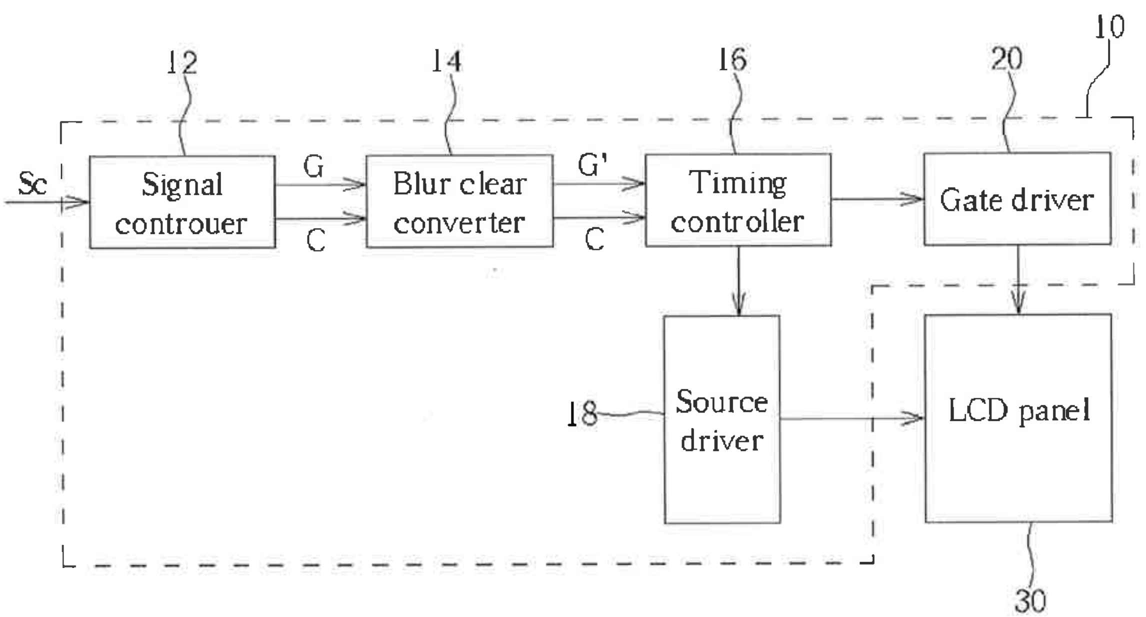

10
12
14
16
20
Sc
Signal controuer
G
C
Blur clear converter
G'
C
Timing controller
Gate driver
18
Source driver
LCD panel
30

Fig. 3

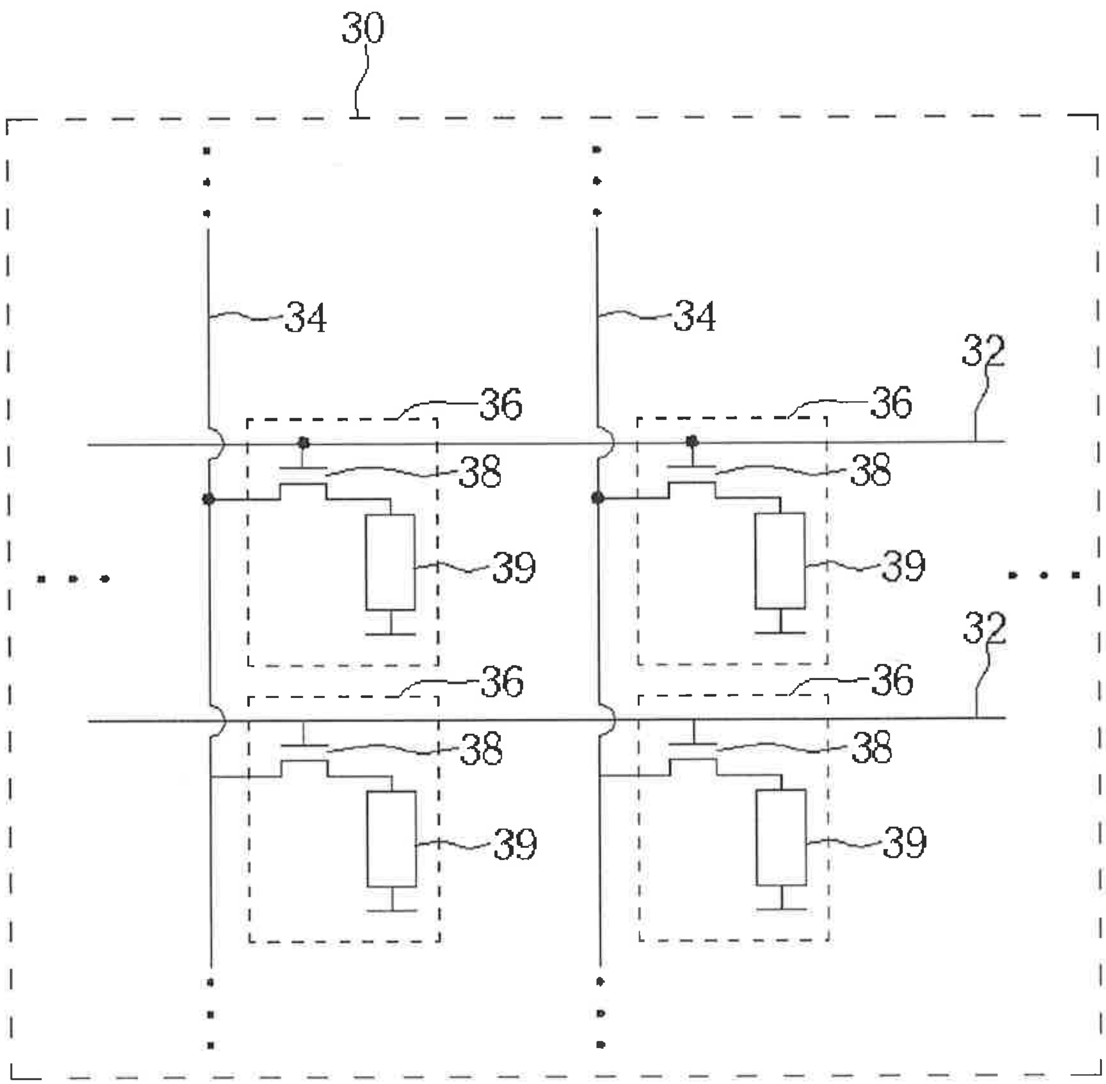


Fig. 4

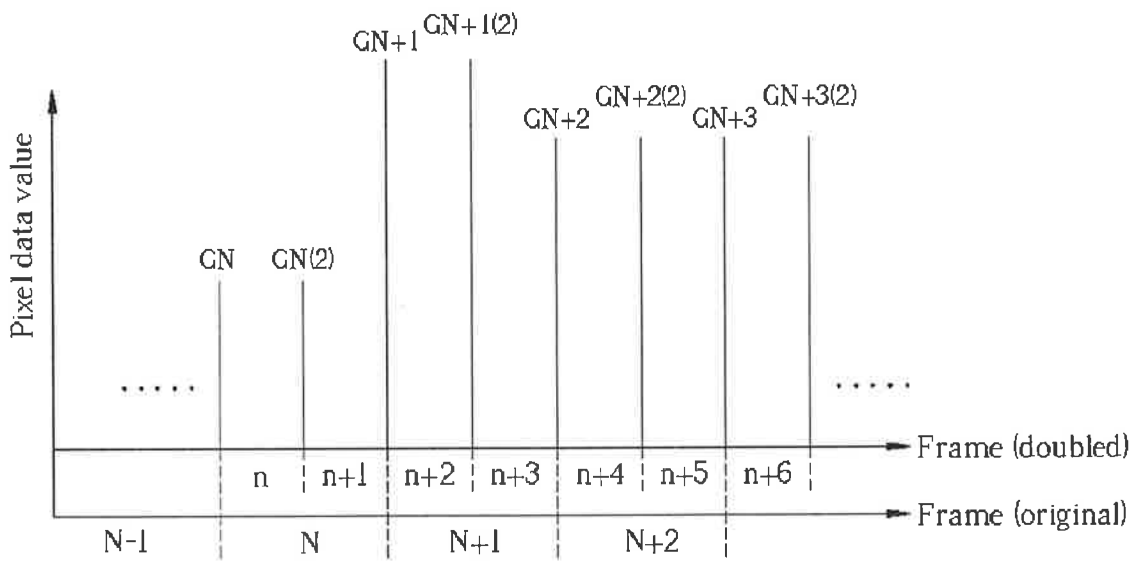

Pixel data value
GN
GN(2)
GN+1
GN+1(2)
GN+2
GN+2(2)
GN+3
GN+3(2)
Frame (doubled)
n
n+1
n+2
n+3
n+4
n+5
n+6
Frame (original)
N-1
N
N+1
N+2

Fig. 5

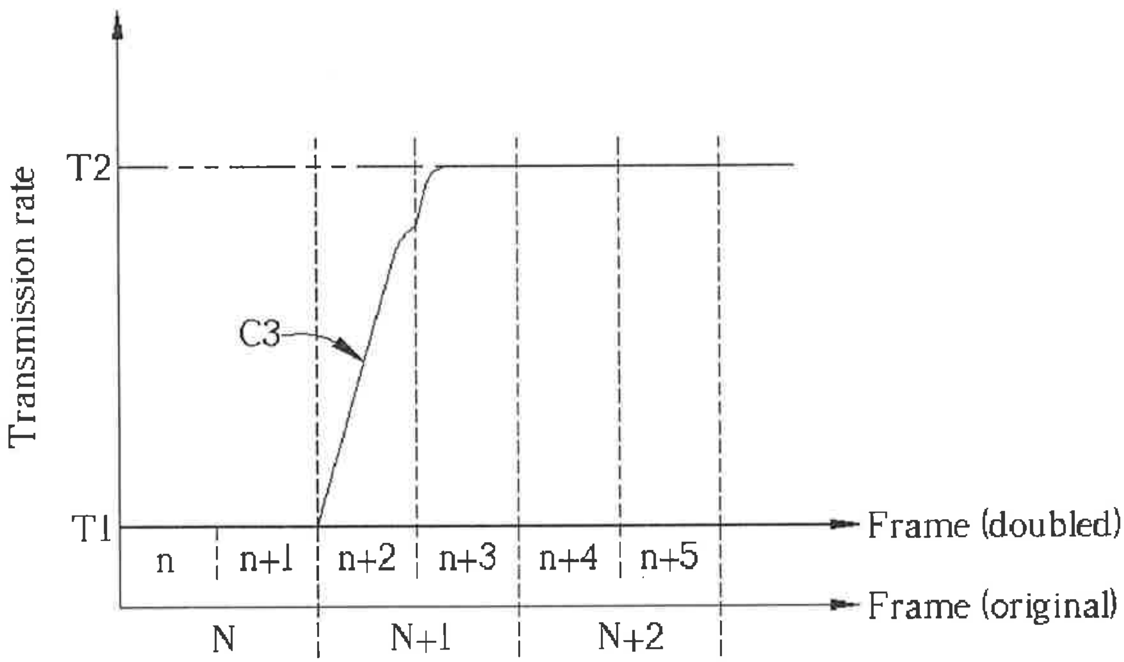

Transmission rate
T2
T1
C3
Frame (doubled)
n
n+1
n+2
n+3
n+4
n+5
Frame (original)
N
N+1
N+2

Fig. 6

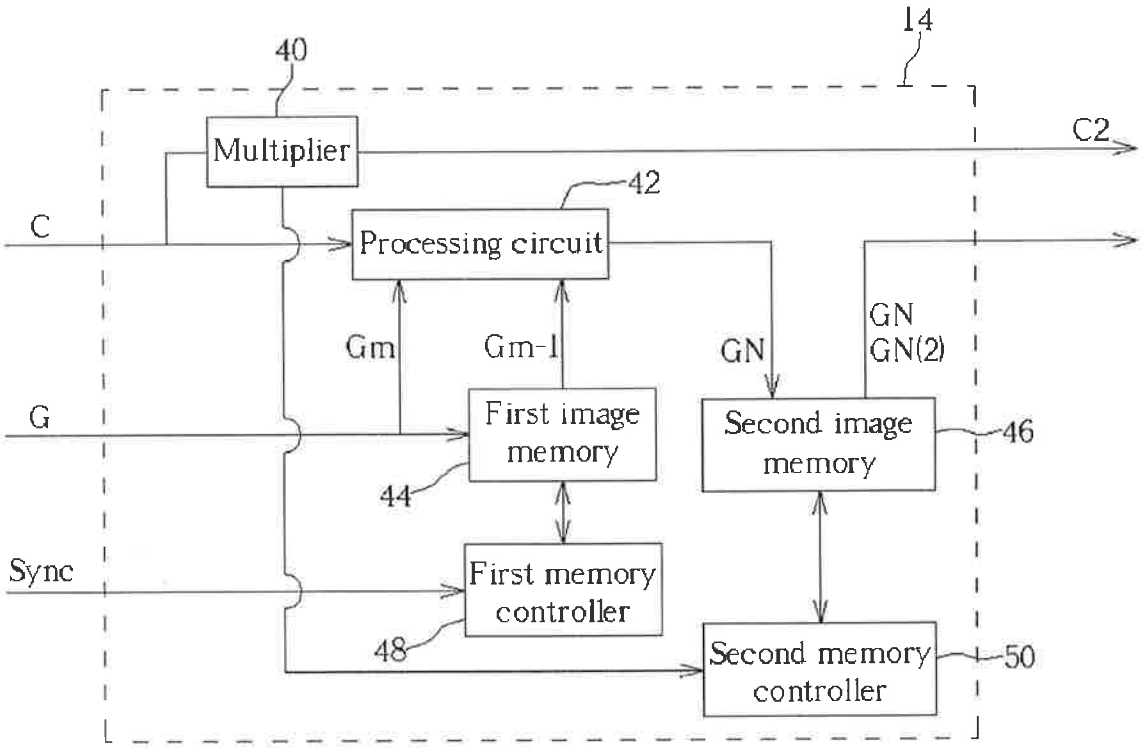

14
40
Multiplier
C2
42
C
Processing circuit
Gm
Gm-1
GN
GN
GN(2)
G
First image memory
Second image memory
46
44
Sync
First memory controller
48
Second memory controller
50

Fig. 7

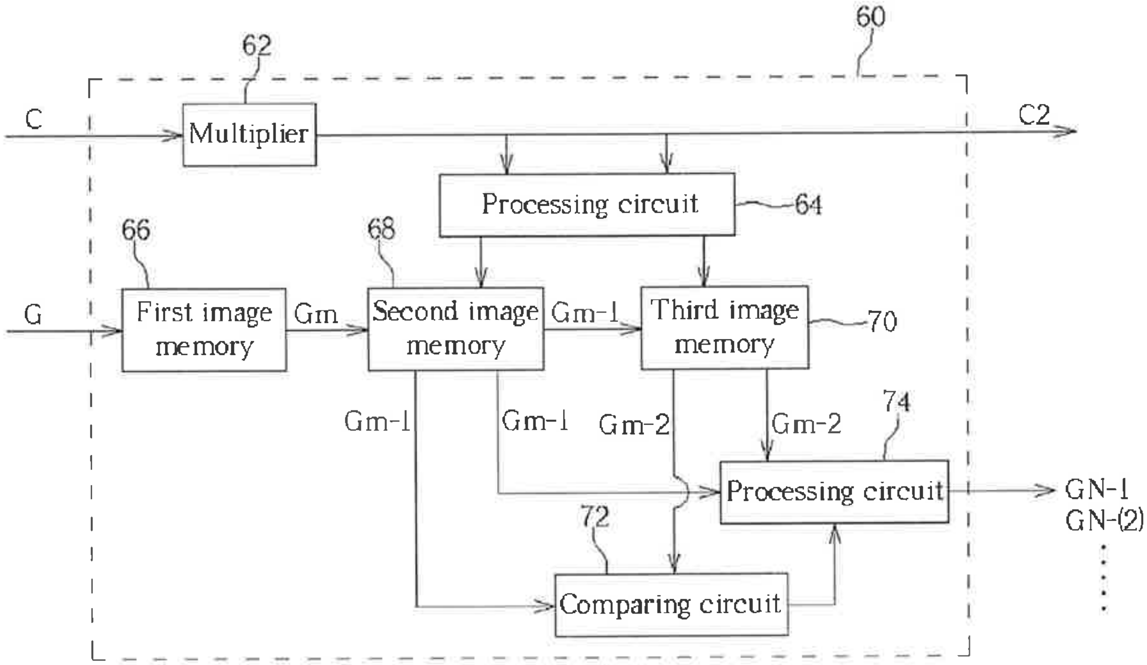

60
62
C
Multiplier
C2
Processing circuit
64
66
68
G
First image memory
Gm
Second image memory
Gm-1
Third image memory
70
Gm-1
Gm-1
Gm-2
Gm-2
74
Processing circuit
GN-1
GN-(2)
72
Comparing circuit

Fig. 8

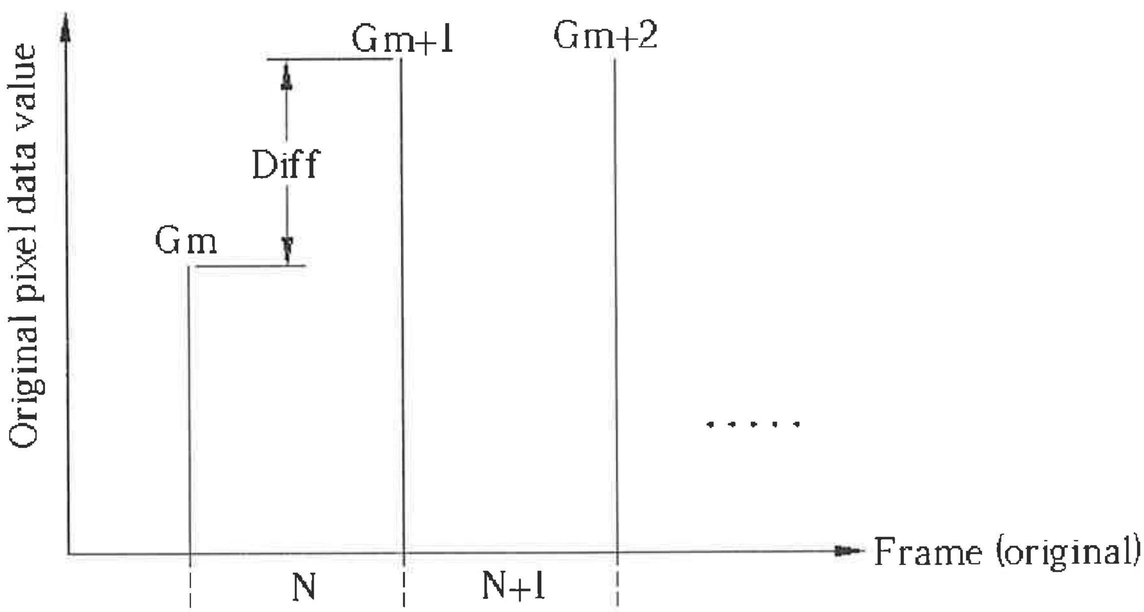

Original pixel data value
Gm+1
Gm+2
Diff
Gm
.....
Frame (original)
N
N+1

Fig. 9

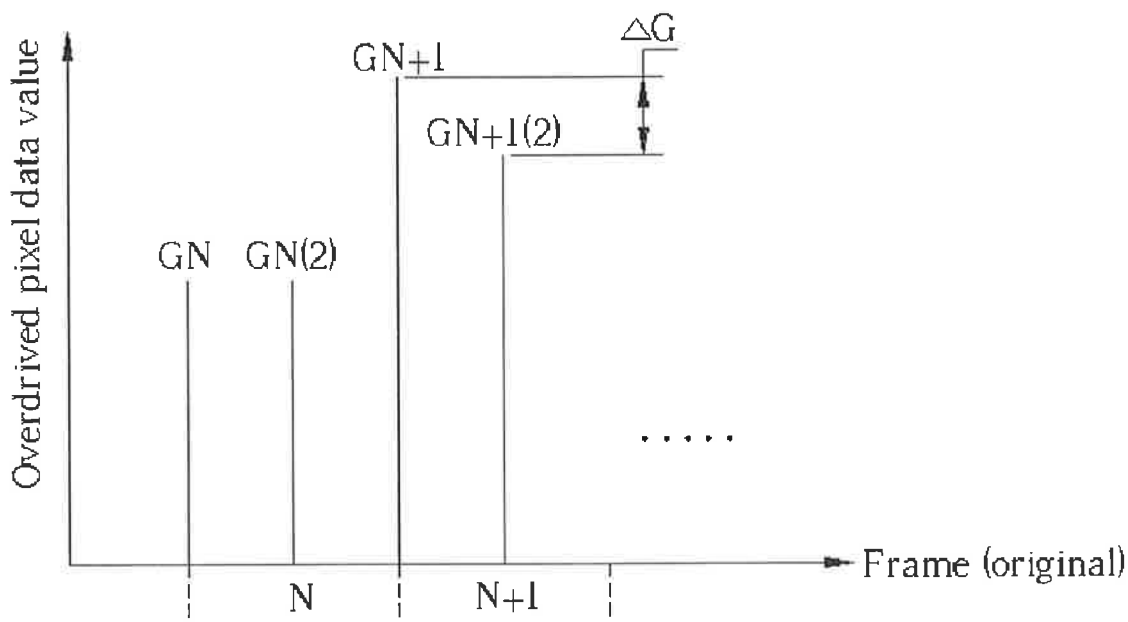

△G
GN+1
GN+1(2)
GN GN(2)
Overdrived pixel data value
.....
Frame (original)
N
N+1

Fig. 10

DRIVING CIRCUIT OF A LIQUID CRYSTAL DISPLAY PANEL AND RELATED DRIVING METHOD

BACKGROUND OF INVENTION

1. Field of the Invention

The invention relates to a driving circuit of a liquid crystal display (LCD) panel and its related driving method, and more particularly, to a driving circuit for applying over two data impulses to a pixel electrode within one frame period, and its related driving method.

2. Description of the Prior Art

A liquid crystal display (LCD) has advantages of light-weight, low power consumption, and low divergence and is applied to various portable equipment such as notebook computers and personal digital assistants (PDAs). In addition, LCD monitors and LCD televisions are gaining in popularity as a substitute for traditional cathode ray tube (CRT) monitors and televisions. However, an LCD does have some disadvantages. Because of the limitations of physical characteristics, the liquid crystal molecules need to be twisted and rearranged when changing input data, which can cause the images to be delayed. For satisfying the rapid switching requirements of multimedia equipment, improving the response speed of liquid crystal is desired.

Generally when driving an LCD, a driving circuit receives a plurality of frame data and then generates corresponding data impulses, scan voltages, and timing signals, according to the frame data, in order to control pixel operation of the LCD. Each of the frame data includes data for refreshing all of the pixels within a frame period; thus each of the frame data can be regarded as including a plurality of pixel data, and each of the pixel data is for defining the gray level that a pixel is required to reach within a frame period. In the general standard, each pixel can switch among 256 (2^8) gray levels, thus each of the pixel data is 8 bits in length.

Please refer to FIG. 1 showing a timing diagram of pixel data values varying in accordance with the frames. When driving a pixel, the driving circuit receives a plurality of pixel data used for driving the pixel in sequence. As shown in FIG. 1, GN, GN+1, GN+2 are the pixel data received in frame periods N, N+1, N+2, and the driving circuit determines the gray level of the pixel in the frame periods N, N+1, N+2 according to the values of the pixel data GN, GN+1, GN+2. In general, the larger the value of the pixel data is, the larger the gray level is. The driving circuit generates a data impulse corresponding to a frame period according to the pixel data GN, GN+1, GN+2, and applies the pulse to a pixel electrode of the corresponding pixel to have the pixel be in the appropriate gray level as required within each frame period.

Please refer to FIG. 2 showing a timing diagram of different transmission rates of a pixel, varying in accordance with the frames. Two curves C1, C2 are measured when the driving circuit changes the transmission rate from T1 to T2 beginning at frame period N. The curve C1 shows the transmission rate of a pixel not overdriven corresponding to the frames, and the curve C2 shows the transmission rate of the pixel overdriven corresponding to the frames. The U.S. published application No. 2002/0050965 is one of the references of the conventional overdriving method. There is a time delay when charging liquid crystal molecules, so that they cannot twist at a predetermined angle at a predetermined transmission rate. As shown by the curve C1, in the case of not being overdriven, the transmission rate cannot reach a predetermined level in the frame period N but has to wait until the frame period N+2. Such a delay causes blurring. In order to improve that, some conventional LCD are overdriven, which means applying a higher or a lower data impulse to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules, so that the pixel can reach the predetermined gray level in a predetermined frame period. As shown by the curve C2, in the case of being overdriven, although the reaction speed of the liquid crystal molecules is faster than in case of not being overdriven, the transmission rate has to wait until frame period N+1 to reach T2. Thus, the requirement of reaching T2 in the frame period N still remains unsatisfied.

SUMMARY OF INVENTION

It is therefore a primary objective of the claimed invention to provide a driving circuit of an LCD panel and its relating driving method to solve the problem mentioned above.

Briefly, the present invention provides a method for driving an LCD panel. The LCD panel includes a plurality of scan lines, a plurality of data lines, and a plurality of pixels. Each pixel is connected to a corresponding scan line and a corresponding data line, and each pixel includes a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device. The method includes receiving continuously a plurality of frame data, generating a plurality of data impulses for each pixel in every frame period according to the frame data and applying the data impulses to the liquid crystal device of one of the pixels within one frame period via the data line connected to the pixel in order to control the transmission rate of the liquid crystal device of the pixel.

The present invention further provides a driving circuit for driving an LCD panel including a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel, the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data in every frame period for each pixel; a source driver for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel in order to control the transmission rate of the liquid crystal device; and a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a timing diagram of the pixel data values varying in accordance with the frames according to the prior art.

FIG. 2 is a timing diagram of different transmission rates of the pixel varying in accordance with the frames.

FIG. 3 is a block diagram of a driving circuit and an LCD panel according to the present invention.

FIG. 4 is a circuit diagram of the LCD panel.

FIG. 5 is a timing diagram of pixel data values varying in accordance with frames.

FIG. 6 is a timing diagram of the transmission rate of the pixel varying in accordance with the frames.

FIG. **7** is a block diagram of the blur clear converter according to the first embodiment of the present invention.

FIG. **8** is a block diagram of the blur clear converter according to the second embodiment of the present invention.

FIG. **9** is a timing diagram of original pixel data received by the blur clear converter varying in accordance with the frames.

FIG. **10** is a timing diagram of overdriven pixel data generated by the blur clear converter varying in accordance with the frames.

DETAILED DESCRIPTION

Please refer to FIG. **3** showing a block diagram of a driving circuit **10** and an LCD panel **30** according to the present invention. The driving circuit **10** is for driving the LCD panel **30**, which includes a signal controller **12**, a blur clear converter **14**, a timing controller **16**, a source driver **18**, and a gate driver **20**. The signal controller **12** is for receiving composite video signals Sc, which includes frame data and timing data for driving the LCD panel **30**, and processing the composite video signals Sc to separate them into frame signals G and control signals C. Subsequently, the blur clear converter **14** continuously receives the control signals C and the frame data included in the frame signals G and generates processed frame signals G including a plurality of overdriven data according to the frame data. The timing controller **16** controls the source driver **18** and the gate driver **20** according to the frame signals G and the control signals C so that the source driver **18** and the gate driver **20** generate corresponding data line voltages and scan line voltages according to the plurality of overdriven data included in the frame signals G in order to drive the LCD panel **30** to generate images corresponding to the composite video signals Sc.

Please refer to FIG. **4** showing a circuit diagram of the LCD panel **30**. The LCD panel **30** includes a plurality of scan lines **32**, a plurality of data lines **34**, and a plurality of pixels **36**. Each pixel **36** is connected to a corresponding scan line **32** and a corresponding data line **34**, and each pixel **36** has a switching device **38** and a liquid crystal device **39** a.k.a. a pixel electrode. The switching device **38** is connected to the corresponding scan line **32** and the corresponding data line **34**, and the source driver **18** and the gate driver **20** control the operation of each pixel **36** via the scan line **32** and the data line **34**. To drive the LCD **30**, scan voltages are applied to the scan lines **32** to turn on the switching devices **38**, and data voltages are applied to the data lines **34** and transmitted to the pixel electrodes **30** through the switching devices **38**. Therefore, when the scan voltages are applied to the scan lines **32** to turn on the switching devices **38**, the data voltages on the data lines **34** will charge the pixel electrodes **39** through the switch devices **38**, thereby twisting the liquid crystal molecules. When the scan voltages on the scan lines **32** are removed to turn off the switching devices **38**, the data lines **34** and the pixels **36** will disconnect, and the pixel electrodes **39** will remain charged. The scan lines **32** turn the switching devices **38** on and off repeatedly so that the pixel electrodes **39** can be repeatedly charged. Different data voltages cause different twisting angles and show different transmission rates. Hence, the LCD **30** displays various images.

Please refer to FIG. **5** showing a timing diagram of pixel data values varying in accordance with frames. According to the present invention, when driving any pixel **36** of the LCD panel **30**, the driving circuit **10** generates a plurality of pixel data used for driving the pixel in sequence. As shown in FIG. **5**, GN, GN(**2**), GN+1, GN+1(**2**), GN+2, GN+2(**2**), GN+3, GN+3(**2**) are the pixel data generated in frame periods N, N+1, N+2, N+3. The driving circuit **10** generates two pieces of pixel data for each pixel **36** in every frame period. The driving circuit **10** drives the pixel to reach gray levels in the frame periods N, N+1, N+2, N+3 according to the values of the pixel data GN–GN+2(**2**). For instance, when the pixel data GN, GN(**2**) are generated, the source driver of the driving circuit **10** converts the pixel data GN, GN(**2**) into two corresponding data impulses and then applies them to the liquid crystal device **39** via the data line **32** in the frame period N in order to control the transmission rate of the liquid crystal device **39**. Similarly, data impulses corresponding to the pixel data GN+1–GN+3(**2**) are applied respectively to corresponding pixel electrodes **39** every half a frame period. Same as the prior art, the larger the value of the pixel data is, the higher the voltage of the corresponding data impulse is, and the larger the gray level value is.

Please refer to FIG. **6** showing a timing diagram of the transmission rate of the pixel **36** varying in accordance with the frames. As described above, the driving circuit **10** generates two pieces of pixel data in each frame period, and then the source driver **18** generates two corresponding data impulses according to the two pieces of pixel data and applies them to the pixel electrode **39** of the corresponding pixel **36** in order to control the transmission rate and gray level of the pixel electrode **39**. As shown in FIG. **6**, the driving circuit **10** changes the transmission rate of the pixel electrode **39** of a pixel **36** from **T1** to **T2** in the frame period N+1. The pixel electrode **39** is applied with two data impulses corresponding to the pixel data GN+1, GN+1(**2**) in the frame period N+1 at a time interval of half a frame period. As shown in FIG. **6**, although the transmission rate of the pixel electrode **39** cannot reach **T2** in the first half period n+2 of the frame period N+1, in the later half period n+3 of the frame period N+1, the pixel electrode **39** is applied with another data impulse, so that the transmission rate can reach **T2** in the frame period N+1 as required. Therefore, blurring will not occur.

In the present embodiment, the two pieces of pixel data of each pixel in every frame period are generated by the blur clear converter **14**. Please refer to FIG. **7** showing a block diagram of the blur clear converter **14**. The blur clear converter **14** includes a multiplier **40**, a processing circuit **42**, a first image memory **44**, a second image memory **46**, a first memory controller **48**, and a second memory controller **50**. The multiplier **40** is for doubling the frequency of the control signal C to generate a multiplied signal C2. The first image memory **44** is controlled by the first memory controller **48** to delay current pixel data Gm for a frame period to generate delayed pixel data Gm−1 according to the control signal C. The processing circuit **42** generates a plurality of overdriven pixel data GN according to the current pixel data Gm and the delayed pixel data Gm−**1**. The second image memory **46** stores the overdriven pixel data GN, and the second memory controller **50** controls the second image memory **46** to output two overdriven pixel data GN, GN(**2**) to each pixel **36** within a frame period according to the multiplied signal C2 in order to have the source driver **18** apply two data impulses to a specific pixel **36** within a frame period according to the two overdriven pixel data GN, GN(**2**).

Please refer to FIG. **8** showing a block diagram of the blur clear converter **60** according to the second embodiment of the present invention. The blur clear converter **60** functions the same as the blur clear converter **14**, which includes a multiplier **62**, a first image memory **66**, a second image memory **68**, a third image memory **70**, a memory controller **64**, a processing circuit **74**, and a comparing circuit **72**. The multiplier **62** is for doubling the frequency of the control signal C to generate a multiplied signal C**2**. The first image memory **66** is for receiving and temporarily storing a plurality of pixel data G. The second image memory **68** delays the plurality of pixel data G for a frame period to generate delayed pixel data Gm−1. The third image memory **70** delays the pixel data Gm−1 for a frame period to generate delayed pixel data Gm−2. Thus the pixel data Gm−2 lags the pixel data Gm−1 for a frame period, and so does the pixel data Gm−1 with respect to the pixel data Gm. The memory controller **64** controls the second image memory **68** and the third image memory **70** to output two overdriven pixel data in each frame period according to the multiplied signal C2. The processing circuit **74** generates two pieces of overdriven pixel data GN1, GN−1(**2**) for each pixel **36** in every frame period according to the pixel data Gm−1, Gm−2. The comparing circuit **72** compares the pixel data Gm−1 with the pixel data Gm−2 to determine the values of the overdriven pixel data GN−1, GN−1(**2**).

Please refer to FIG. **9** showing a timing diagram of original pixel data received by the blur clear converter **60** varying in accordance with the frames, and FIG. **10** showing a timing diagram of overdriven pixel data generated by the blur clear converter **60** varying in accordance with the frames. As shown in FIG. **9**, the original pixel data received by the blur clear converter **60** in the frame periods N and N+1 are respectively Gm and Gm+1, with a difference Diff between each other. The blur clear converter **60** generates the two overdriven pixel data GN+1, GN+1(2) with a difference ΔG between each other according to the original pixel data Gm, Gm+1. The difference ΔG is determined by the comparing circuit **72** in FIG. **8** for driving the pixels **36** according to difference conditions. The difference ΔG is determined according to the difference Diff between the original pixel data Gm and Gm+1. For instance, when the difference Diff is less than a specific value, the comparing circuit **72** determines the difference ΔG as 0, that is equating the overdriven pixel data GN+1 to the overdriven pixel data GN+1(**2**). Or when the difference Diff is larger than a specific value, the comparing circuit **72** modulates the difference ΔG to drive the LCD panel **30** properly.

In contrast to the prior art, the present invention discloses a driving circuit and relating driving method to generate two pieces of pixel data in each frame period for every pixel on an LCD panel and then to generate two data impulses according to the two pieces of pixel data and to apply them to each pixel within a frame period in order to change the transmission rate of a pixel electrode. Thus, each of the pixels of the LCD panel is applied of a plurality of data impulses within a frame period, so that liquid crystal molecules of the pixels can twist to reach a predetermined gray level within a frame period, and blurring will not occur.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

The invention claimed is:

1. A driving circuit for driving an LCD panel, the LCD panel comprising:

a plurality of scan lines;

a plurality of data lines; and

a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device,

the driving circuit comprising:

a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel, the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel;

a source driver for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device; and

a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel.

2. The driving circuit of claim **1** wherein the blur clear converter further comprises:

a multiplier for multiplying a frequency of a control signal to generate a multiplied signal;

a first image memory for delaying the pixel data for a frame period;

a processing circuit for generating the plurality of overdriven pixel data according to the pixel data and the pixel data delayed by the first image memory;

a second image memory for storing the overdriven pixel data;

a memory controller for controlling the second image memory according to the multiplied signal to output the plurality of overdriven pixel data to any pixel so that the source driver generates the data impulses to each pixel within one frame period according to the overdriven pixel data output by the second image memory.

3. The driving circuit of claim **1** wherein the blur clear converter further comprises:

a multiplier for multiplying a frequency of a control signal to generate a multiplied signal;

a first image memory for receiving and temporarily storing the pixel data;

a second image memory for delaying the pixel data stored and output by the first image memory for a frame period;

a third image memory for delaying the pixel data stored and output by the second image memory for a frame period;

a memory controller for controlling the second image memory and the third image memory according to the multiplied signal;

a processing circuit for generating the plurality of overdriven pixel data according to the pixel data delayed and output by the second image memory and the third image memory; and

a comparing circuit for comparing the pixel data delayed by the second image memory with the pixel data delayed by the third image memory in order to determine data values of the overdriven pixel data generated by the processing circuit.

4. A method for driving a liquid crystal display (LCD) panel, the LCD panel comprising:

a plurality of scan lines;

a plurality of data lines; and

a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device, and

the method comprising:

receiving continuously a plurality of frame data;

generating a plurality of data impulses for each pixel within every frame period according to the frame data; and

applying the data impulses to the liquid crystal device of one of the pixels within one frame period via the data line connected to the pixel in order to control a transmission rate of the liquid crystal device of the pixel.

5. The method of claim 4 further comprising:

delaying the frame data to generate a plurality of corresponding delayed frame data; and

comparing current frame data and corresponding delayed data to determine voltage values of the data impulses when generating the data impulses.

6. The method of claim 5 wherein the data impulses are a first data impulse and a second data impulse applied to the liquid crystal device of the pixel in sequence within the frame period.

7. The method of claim 6 further comprising:

determining a difference between the first data impulse and the second data impulse according to the current frame data and the corresponding delayed frame data.

8. The method of claim 4 further comprising:

applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel.

9. The method of claim 4 wherein each frame data comprises a plurality of pixel data, and each pixel data corresponds to a pixel.

* * * * *

(19) 대한민국특허청(KR)
(12) 등록특허공보(B1)

(45) 공고일자 2007년12월07일
(11) 등록번호 10-0783697
(24) 등록일자 2007년12월03일

(51) Int. Cl.
G09G 3/36 (2006.01)
(21) 출원번호 10-2000-0073673
(22) 출원일자 2000년12월06일
심사청구일자 2005년11월11일
(65) 공개번호 10-2002-0044673
(43) 공개일자 2002년06월19일
(56) 선행기술조사문헌
JP04204593 A
JP06189232 A
JP07056532 A
JP10039837 A
전체 청구항 수 : 총 21 항

(73) 특허권자
삼성전자주식회사
경기도 수원시 영통구 매탄동 416
(72) 발명자
이백운
경기도성남시분당구서현동96우성아파트210동1307호
(74) 대리인
김원근, 팬코리아특허법인

심사관 : 이병우

(54) 동화상 보정 기능을 갖는 액정 표시 장치와 이의 구동장치 및 방법

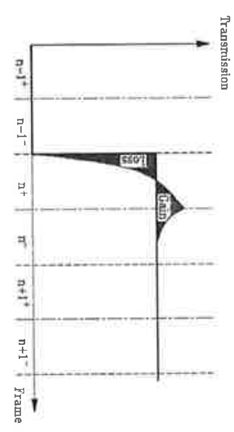
(57) 요 약

본 발명은 동화상 보정 기능을 갖는 액정 표시 장치와 이의 구동 장치 및 방법이 개시된다.

본 발명에 따르면, 데이터 계조 신호 보정부는 데이터 계조 신호 소스로부터 제공되는 화상 신호의 계조 데이터 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하고, 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교에 따라 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 출력하고, 데이터 드라이버부는 데이터 계조 신호 보정부로부터 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 제공받아 상기 보정된 계조 데이터에 대응하는 데이터 전압으로 변경하여 액정 표시 패널의 데이터 라인에 화상 신호를 출력한다.

그 결과, 액정 표시 장치의 동화상 표현시 하나의 프레임을 시분할한 2개의 서브 프레임을 이용하여 이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우에는 첫 번째 서브 프레임의 구동시에는 오버슈트 구동을 수행한 후 두 번째 서브 프레임의 구동시에는 목표치 수준으로 다운 구동하므로써, 액정 표시 장치의 동영상 구현시 화면 끌림 현상을 제거 할 수 있다.

대표도 - 도12



특허청구의 범위

청구항 1

데이터 계조 신호 소스로부터 제공되는 화상 신호의 계조 데이터 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하고, 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교에 따라 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 출력하는 데이터 계조 신호 보정부;

상기 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 제공받아 상기 보정된 계조 데이터에 대응하는 데이터 전압으로 변경하여 화상 신호를 출력하는 데이터 드라이버부;

주사 신호를 순차적으로 공급하는 게이트 드라이버부; 및

상기 주사 신호를 전달하는 다수의 게이트 라인과, 상기 화상 신호를 전달하며 상기 게이트 라인과 절연되어 교차하는 다수의 데이터 라인과, 상기 게이트 라인과 상기 데이터 라인에 의해 둘러싸인 영역에 형성되며 각각 상기 게이트 라인과 상기 데이터 라인에 연결되어 있는 스위칭소자를 가지는 매트릭스 형태로 배열된 다수의 화소를 포함하는 액정 표시 패널

을 포함하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 2

제1항에 있어서, 상기 데이터 계조 신호 보정부는,

이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우에는 제1 서브 프레임에서는 오버슈트 구동을 통해 제1 보정된 계조 데이터를 출력하고, 상기 제1 서브 프레임에 후행하는 제2 서브 프레임에서는 상기 오버슈트된 값을 목표값으로의 다운 구동을 통해 제2 보정된 계조 데이터를 출력하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 3

제1항에 있어서, 상기 데이터 계조 신호 보정부는,

이전 프레임의 계조 신호보다 작은 현재 프레임의 계조 신호가 입력되는 경우에는 제1 서브 프레임에서는 언더슈트 구동을 통해 제3 보정된 계조 데이터를 출력하고, 상기 제1 서브 프레임에 후행하는 제2 서브 프레임에서는 상기 언더슈트된 값을 목표값으로의 업 구동을 통해 제4 보정된 계조 데이터를 출력하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 4

제1항에 있어서, 상기 데이터 계조 신호 보정부는 비월 주사 방식을 이용하여 상기 보정된 계조 데이터를 상기 데이터 드라이버부에 제공하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 5

제4항에 있어서, 상기 데이터 계조 신호 보정부는,

제1 서브 프레임 구동시에는 계조 데이터의 기록 및 판독을 위한 제1 제어 신호를 출력하고, 제2 서브 프레임 구동시에는 계조 데이터의 기록 및 판독을 위한 제2 제어 신호를 출력하는 컨트롤러;

상기 제1 서브 프레임 구동시, 상기 컨트롤러로부터 제1 제어 신호가 입력되는 경우에 데이터 계조 소스로부터 제공되는 현재 프레임의 계조 데이터를 저장하고, 상기 제2 서브 프레임 구동시, 상기 현재 프레임의 계조 데이터를 출력하는 제1 메모리;

상기 제1 및 제2 서브 프레임 구동시, 상기 컨트롤러로부터 제2 제어 신호가 입력되는 경우에 이전 프레임의 계조 데이터를 출력하는 제2 메모리; 및

상기 제1 서브 프레임 구동시에는, 상기 데이터 계조 신호 소스로부터 현재 프레임의 계조 데이터를 제공받고, 상기 제2 메모리로부터 이전 프레임의 계조 데이터를 제공받아 보정된 계조 데이터를 출력하고, 상기 제2 서브 프레임 구동시에는, 상기 제1 메모리로부터 현재 프레임의 계조 데이터를 제공받고, 상기 제2 메모리로부터 이

전 프레임의 계조 데이터를 제공받아 보정된 계조 데이터를 출력하는 상기 데이터 드라이버부에 출력하는 데이터 계조 신호 변환기

를 포함하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 6

제1항에 있어서, 상기 데이터 계조 신호 보정부는 순차 주사 방식을 이용하여 상기 보정된 계조 데이터를 상기 데이터 드라이버부에 제공하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 7

제6항에 있어서, 상기 데이터 계조 신호 보정부는,

n번째 프레임 구동시 기저장된 (n-2)번째 프레임의 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 (n+1)번째 프레임의 계조 데이터를 저장하며, (n+2)번째 프레임 구동시 기저장된 (n+1)번째 프레임의 계조 데이터를 출력하는 제1 메모리;

n번째 프레임 구동시 계조 데이터를 저장하고, (n+1)번째 프레임 구동시 기저장된 n번째 프레임의 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 기저장된 n번째 프레임의 계조 데이터를 출력하는 제2 메모리;

n번째 프레임 구동시 기저장된 (n-1)번째 프레임의 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 기저장된 (n-1)번째 프레임 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 (n+2)번째 프레임의 계조 데이터를 저장하는 제3 메모리;

상기 제1 내지 제3 메모리의 계조 데이터 기록 및 판독을 제어하는 컨트롤러; 및

n번째 프레임 구동시 상기 제1 및 제3 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 상기 제2 및 제3 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 상기 제1 및 제2 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하는 데이터 계조 신호 변환기

를 포함하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 8

제7항에 있어서, 상기 제1 내지 제3 메모리에 저장되는 계조 데이터의 저장 주파수는 제1 주파수로 저장되고, 상기 제1 내지 제3 메모리로부터 출력되는 계조 데이터의 출력 주파수는 상기 제1 주파수의 2배수인 제2 주파수인 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 9

제5항 또는 제7항에 있어서, 상기 메모리는 프레임 메모리인 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치.

청구항 10

.데이터 계조 신호 소스로부터 화상 신호의 계조 데이터를 제공받아 액정 표시 모듈에 출력하는 액정 표시 장치의 구동 장치에 있어서,

데이터 계조 신호 소스로부터 제공되는 화상 신호의 계조 데이터 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하고, 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교에 따라 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 상기 액정 표시 모듈에 출력하여 액정의 응답 속도를 고속화하는 데이터 계조 신호 보정부

를 포함하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 11

제10항에 있어서, 상기 데이터 계조 신호 보정부는,

이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우에는 제1 서브 프레임에서는 오버슈

트 구동을 통해 제1 보정된 계조 데이터를 출력하고, 상기 제1 서브 프레임에 후행하는 제2 서브 프레임에서는 상기 오버슈트된 값을 목표값으로의 다운 구동을 통해 제2 보정된 계조 데이터를 출력하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 12

제10항에 있어서, 상기 데이터 계조 신호 보정부는,

이전 프레임의 계조 신호보다 작은 현재 프레임의 계조 신호가 입력되는 경우에는 제1 서브 프레임에서는 언더슈트 구동을 통해 제3 보정된 계조 데이터를 출력하고, 상기 제1 서브 프레임에 후행하는 제2 서브 프레임에서는 상기 언더슈트된 값을 목표값으로의 업 구동을 통해 제4 보정된 계조 데이터를 출력하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 13

제10항에 있어서, 상기 데이터 계조 신호 보정부는 비월 주사 방식을 이용하여 상기 보정된 계조 데이터를 상기 액정 표시 모듈에 제공하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 14

제13항에 있어서, 상기 데이터 계조 신호 보정부는,

제1 서브 프레임 구동시에는 계조 데이터의 기록 및 판독을 위한 제1 제어 신호를 출력하고, 제2 서브 프레임 구동시에는 계조 데이터의 기록 및 판독을 위한 제2 제어 신호를 출력하는 컨트롤러;

상기 제1 서브 프레임 구동시, 상기 컨트롤러로부터 제1 제어 신호가 입력되는 경우에 데이터 계조 소스로부터 제공되는 현재 프레임의 계조 데이터를 저장하고, 상기 제2 서브 프레임 구동시, 상기 현재 프레임의 계조 데이터를 출력하는 제1 메모리;

상기 제1 및 제2 서브 프레임 구동시, 상기 컨트롤러로부터 제2 제어 신호가 입력되는 경우에 이전 프레임의 계조 데이터를 출력하는 제2 메모리; 및

상기 제1 서브 프레임 구동시에는, 상기 데이터 계조 신호 소스로부터 현재 프레임의 계조 데이터를 제공받고, 상기 제2 메모리로부터 이전 프레임의 계조 데이터를 제공받아 보정된 계조 데이터를 출력하고, 상기 제2 서브 프레임 구동시에는, 상기 제1 메모리로부터 현재 프레임의 계조 데이터를 제공받고, 상기 제2 메모리로부터 이전 프레임의 계조 데이터를 제공받아 보정된 계조 데이터를 출력하는 상기 데이터 드라이버부에 출력하는 데이터 계조 신호 변환기

를 포함하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 15

제10항에 있어서, 상기 데이터 계조 신호 보정부는 순차 주사 방식 이용하여 상기 보정된 계조 데이터를 상기 액정 표시 모듈에 제공하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 16

제15항에 있어서, 상기 데이터 계조 신호 보정부는,

n번째 프레임 구동시 기저장된 (n-2)번째 프레임의 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 (n+1)번째 프레임의 계조 데이터를 저장하며, (n+2)번째 프레임 구동시 기저장된 (n+1)번째 프레임의 계조 데이터를 출력하는 제1 메모리;

n번째 프레임 구동시 계조 데이터를 저장하고, (n+1)번째 프레임 구동시 기저장된 n번째 프레임의 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 기저장된 n번째 프레임의 계조 데이터를 출력하는 제2 메모리;

n번째 프레임 구동시 기저장된 (n-1)번째 프레임의 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 기저장된 (n-1)번째 프레임 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 (n+2)번째 프레임의 계조 데이터를 저장하는 제3 메모리;

상기 제1 내지 제3 메모리의 계조 데이터 기록 및 판독을 제어하는 컨트롤러; 및

n번째 프레임 구동시 상기 제1 및 제3 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하고, (n+1)번째 프레임 구동시 상기 제2 및 제3 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하며, (n+2)번째 프레임 구동시 상기 제1 및 제2 메모리로부터 제공되는 계조 데이터를 제공받아 보정된 계조 데이터를 출력하는 데이터 계조 신호 변환기

를 포함하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 17

제16항에 있어서, 상기 제1 내지 제3 메모리에 저장되는 계조 데이터의 저장 주파수는 제1 주파수로 저장되고, 상기 제1 내지 제3 메모리로부터 출력되는 계조 데이터의 출력 주파수는 상기 제1 주파수의 2배수인 제2 주파수인 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 18

제14항 또는 제16항에 있어서, 상기 메모리는 프레임 메모리인 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치.

청구항 19

다수의 게이트 라인과, 상기 게이트 라인에 절연되어 교차하는 다수의 데이터 라인과, 상기 게이트 라인 및 데이터 라인에 의해 둘러싸인 영역에 형성되며 각각 상기 게이트 라인 및 데이터 라인에 연결되어 스위칭 소자를 가지는 매트릭스 타입으로 배열된 다수의 화소를 포함하는 액정 표시 장치의 구동 방법에 있어서,

(a) 상기 게이트 라인에 주사 신호를 순차적으로 공급하는 단계;

(b) 외부의 데이터 계조 신호 소스로부터 제공되는 하나의 화상 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하는 단계;

(c) 현재 프레임의 계조 신호가 입력됨에 따라 현재 프레임의 계조 신호와 이전 프레임의 계조 신호를 비교하는 단계;

(d) 상기 단계(c)에서 이전 프레임의 계조 신호보다 현재 프레임의 계조 신호가 크다고 체크되는 경우에는 제1 서브 프레임의 구동시에는 오버슈트 구동을 수행하여 제1 데이터 구동 전압을 생성하고, 상기 제1 서브 프레임에 후행하는 제2 서브 프레임의 구동시에는 상기 오버슈트된 값을 목표값으로의 다운 구동을 수행하여 제2 데이터 구동 전압을 생성하는 단계;

(e) 상기 단계(c)에서 이전 프레임의 계조 신호가 현재 프레임의 계조 신호보다 작다고 체크되는 경우에는 상기 제1 서브 프레임의 구동시에는 언더슈트 구동을 수행하여 제3 데이터 구동 전압을 생성하고, 상기 제2 서브 프레임의 구동시에는 상기 언더슈트된 값을 목표값으로의 업 구동을 수행하여 제4 데이터 구동 전압을 생성하는 단계;

(f) 상기 단계(d)와 상기 단계(e)에서 생성된 제1 내지 제4 데이터 구동 전압을 상기 데이터 라인에 공급하는 단계

를 포함하여, 액정의 응답 속도를 고속화하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 방법.

청구항 20

제19항에 있어서, 상기 단계(c)에서 이전 프레임의 계조 신호와 현재 프레임의 계조 신호의 크기가 동일하다고 체크되는 경우에는 미보정된 계조 신호를 바이패스하고, 상기 바이패스된 계조 신호에 대응하는 데이터 구동 전압을 상기 데이터 라인에 공급하는 단계를 더 포함하는 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 방법.

청구항 21

제19항에 있어서, 상기 분할된 서브 프레임이 2개인 경우에는,

상기 전반부에 위치하는 서브 프레임은 첫 번째 서브 프레임이고,

상기 후반부에 위치하는 서브 프레임은 두 번째 서브 프레임인 것을 특징으로 하는 동화상 보정 기능을 갖는 액정 표시 장치의 구동 방법.

명 세 서

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

<15> 본 발명은 액정 표시 장치와 이의 구동 장치 및 방법에 관한 것으로, 보다 상세하게는 동화상 구현시 화면의 끌림 현상을 제거하기 위한 액정 표시 장치와 이의 구동 장치 및 방법에 관한 것이다.

<16> 일반적으로 LCD는 두 기판 사이에 주입되어 있는 이방성 유전율을 갖는 액정 물질에 전계(electric field)를 인가하고 이 전계의 세기를 조절하여 기판에 투과되는 빛의 양을 조절함으로써 원하는 화상 신호를 얻는 표시 장치이다. 이러한 LCD는 휴대가 간편한 플랫 패널형 디스플레이 중에서 대표적인 것으로서, 이 중에서도 박막 트랜지스터(Thin Film Transistor: TFT)를 스위칭 소자로 이용하는 TFT LCD가 주로 이용되고 있다.

<17> 최근에는 TFT LCD가 컴퓨터의 디스플레이 장치뿐만 아니라 텔레비전의 디스플레이 장치로 널리 사용됨에 따라 동화상을 구현할 필요가 증가하게 되었다. 그러나, 종전의 TFT LCD는 응답 속도가 느리기 때문에 동화상을 구현하기 어렵다는 단점이 있었다.

<18> 이러한 응답속도 문제를 개선하기 위해 종래에는 OCB(Optically Compensated Band) 모드를 사용하거나, 강유전성 액정(FLC; Ferro-electric Liquid Crystal) 물질을 사용한 TFT LCD를 사용하였다.

<19> 그러나, 이와 같은 OCB 모드나 FLC를 사용하기 위해서는 종래의 TFT LCD 패널이 구조를 바꾸어야 하는 문제점이 있다.

발명이 이루고자 하는 기술적 과제

<20> 이에 본 발명의 기술과 과제는 이러한 종래의 문제점을 해결하기 위한 것으로, 본 발명의 목적은 화상 신호 보정을 통해 동영상 구현시 화면의 끌림 현상을 제거한 동화상 보정 기능을 갖는 액정 표시 장치를 제공하는 것이다.

<21> 또한 본 발명의 다른 목적은 상기한 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치를 제공하는 것이다.

<22> 또한 본 발명의 다른 목적은 상기한 동화상 보정 기능을 갖는 액정 표시 장치의 구동 방법을 제공하는 것이다.

발명의 구성 및 작용

<23> 상기한 본 발명의 목적을 실현하기 위한 하나의 특징에 따른 동화상 보정 기능을 갖는 액정 표시 장치는,

<24> 데이터 계조 신호 소스로부터 제공되는 화상 신호의 계조 데이터 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하고, 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교에 따라 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 출력하는 데이터 계조 신호 보정부;

<25> 상기 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 제공받아 상기 보정된 계조 데이터에 대응하는 데이터 전압으로 변경하여 화상 신호를 출력하는 데이터 드라이버부;

<26> 주사 신호를 순차적으로 공급하는 게이트 드라이버부; 및

<27> 상기 주사 신호를 전달하는 다수의 게이트 라인과, 상기 화상 신호를 전달하며 상기 게이트 라인과 절연되어 교차하는 다수의 데이터 라인과, 상기 게이트 라인과 상기 데이터 라인에 의해 둘러싸인 영역에 형성되며 각각 상기 게이트 라인과 상기 데이터 라인에 연결되어 있는 스위칭소자를 가지는 매트릭스 형태로 배열된 다수의 화소를 포함하는 액정 표시 패널을 포함하여 이루어진다.

<28> 또한 상기한 본 발명의 다른 목적을 실현하기 위한 하나의 특징에 따른 동화상 보정 기능을 갖는 액정 표시 장치의 구동 장치는, 데이터 계조 신호 소스로부터 화상 신호의 계조 데이터를 제공받아 액정 표시 모듈에 출력하는 액정 표시 장치의 구동 장치에 있어서,

<29> 데이터 계조 신호 소스로부터 제공되는 화상 신호의 계조 데이터 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하고, 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교에 따라 오버슈트 또는 언더슈트 구동을 통해 보정된 계조 데이터를 상기 액정 표시 모듈에 출력하여 액정의 응답 속도를 고속화하는 데이터 계조 신호 보정부를 포함하여 이루어진다.

<30> 또한 상기한 본 발명의 또 다른 목적을 실현하기 위한 하나의 특징에 따른 동화상 보정 기능을 갖는 액정 표시 장치의 구동 방법은, 다수의 게이트 라인과, 상기 게이트 라인에 절연되어 교차하는 다수의 데이터 라인과, 상기 게이트 라인 및 데이터 라인에 의해 둘러싸인 영역에 형성되며 각각 상기 게이트 라인 및 데이터 라인에 연결되어 스위칭 소자를 가지는 매트릭스 타입으로 배열된 다수의 화소를 포함하는 액정 표시 장치의 구동 방법에 있어서,

<31> (a) 상기 게이트 라인에 주사 신호를 순차적으로 공급하는 단계;

<32> (b) 외부의 데이터 계조 신호 소스로부터 제공되는 하나의 화상 프레임을 적어도 두 개 이상의 서브 프레임으로 분할하는 단계;

<33> (c) 현재 프레임의 계조 신호가 입력됨에 따라 현재 프레임의 계조 신호와 이전 프레임의 계조 신호를 비교하는 단계;

<34> (d) 상기 단계(c)에서 이전 프레임의 계조 신호보다 현재 프레임의 계조 신호가 크다고 체크되는 경우에는 상기 분할한 서브 프레임 중 전반부에 위치하는 서브 프레임의 구동시에는 오버슈트 구동을 수행하여 제1 데이터 구동 전압을 생성하고, 상기 분할한 서브 프레임 중 후반부에 위치하는 서브 프레임의 구동시에는 상기 오버슈트된 값을 목표값으로의 다운 구동을 수행하여 제2 데이터 구동 전압을 생성하는 단계;

<35> (e) 상기 단계(c)에서 이전 프레임의 계조 신호가 현재 프레임의 계조 신호보다 작다고 체크되는 경우에는 상기 분할한 서브 프레임 중 전반부에 위치하는 서브 프레임의 구동시에는 언더슈트 구동을 수행하여 제3 데이터 구동 전압을 생성하고, 상기 분할한 서브 프레임 중 후반부에 위치하는 서브 프레임의 구동시에는 상기 언더슈트된 값을 목표값으로의 업 구동을 수행하여 제4 데이터 구동 전압을 생성하는 단계;

<36> (f) 상기 단계(c)와 상기 단계(d)에서 생성된 제1 내지 제4 데이터 구동 전압을 상기 데이터 라인에 공급하는 단계를 포함하여, 액정의 응답 속도를 고속화한다.

<37> 이러한 동화상 보정 기능을 갖는 액정 표시 장치와 이의 구동 장치 및 방법에 의하면, 액정 표시 장치의 동화상 표현시 하나의 프레임을 시분할한 2개의 서브 프레임을 이용하여 이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우에는 첫 번째 서브 프레임의 구동시에는 오버슈트 구동을 수행한 후 두 번째 서브 프레임의 구동시에는 목표치 수준으로 다운 구동하므로써, 액정 표시 장치의 동영상 구현시 화면 끌림 현상을 제거 할 수 있다.

<38> 또한, 시분할한 2개의 서브 프레임을 이용하여 이전 프레임의 계조 신호보다 작은 현재 프레임의 계조 신호가 입력되는 경우에는 첫 번째 서브 프레임의 구동시에는 언더슈트 구동을 수행한 후 두 번째 서브 프레임의 구동시에는 목표치 수준으로 업 구동하므로써 액정 표시 장치의 동영상 구현시 화면 끌림 현상을 제거할 수 있다.

<39> 그러면, 통상의 지식을 지닌 자가 본 발명을 용이하게 실시할 수 있도록 실시예에 관해 설명하기로 한다.

<40> 일반적으로 LCD는 주사 신호를 전달하는 다수의 게이트 라인과 이 게이트 라인에 교차하여 형성되며 데이터 전압을 전달하는 데이터 라인을 포함한다. 또한 LCD는 이들 게이트 라인과 데이터 라인에 의해 둘러싸인 영역에 형성되며 각각 게이트 라인 및 데이터 라인과 스위칭 소자를 통해 연결되는 행렬 형태의 다수의 화소를 포함한다.

<41> LCD에서 각 화소는 액정을 유전체로 가지는 커패시터 즉, 액정 커패시터로 모델링할 수 있는데, 이러한 LCD에서의 각 화소의 등가회로는 도 1과 같다.

<42> 도 1에 도시한 바와 같이, 액정 표시 장치의 각 화소는 데이터 라인(Dm)과 게이트 라인(Sn)에 각각 소스 전극과 게이트 전극이 연결되는 TFT(10)와 TFT의 드레인 전극과 공통전압(Vcom) 사이에 연결되는 액정 커패시터(Cl)와 TFT의 드레인 전극에 연결되는 스토리지 커패시터(Cst)를 포함한다.

<43> 도 1에서, 게이트 라인(Sn)에 게이트 온 신호가 인가되어 TFT(10)가 턴 온되면, 데이터 라인에 공급된 데이터 전압(Vd)이 TFT를 통해 각 화소 전극(도시하지 않음)에 인가된다. 그러면, 화소 전극에 인가되는 화소 전압(Vp)과 공통 전압(Vcom)의 차이에 해당하는 전계가 액정(도 1에서는 등가적으로 액정 커패시터로 나타내었음)에

인가되어 이 전계의 세기에 대응하는 투과율로 빛이 투과되도록 한다. 이때, 화소 전압(Vp)은 1 프레임 동안 유지되어야 하는데, 도1에서 스토리지 커패시터(Cst)는 화소 전극에 인가된 화소 전압(Vp)을 유지하기 위해 보조적으로 사용된다.

<44> 한편, 액정은 이방성 유전율을 갖기 때문에, 액정의 방향에 따라 유전율이 다른 특성이 있다. 즉, 전압이 인가됨에 따라 액정의 방향자가 변하면 유전율도 따라서 변하고 이에 따라 액정 커패시터의 커패시턴스 값(이하 액정 커패시턴스)도 변하게 된다. 일단 TFT가 온되는 구간동안 액정 커패시터에 전하를 공급한 후, TFT가 오프 상태로 되는데, Q=CV이므로 액정 커패시턴스가 변하면 액정에 걸리는 화소 전압(Vp)도 또한 변하게 된다.

<45> 노멀리 화이트 모드(Normally white mode) TN(twisted Nematics) LCD를 예를 들면, 화소에 공급되는 화소 전압이 0V인 경우에는 액정 분자가 기판에 평행한 방향으로 배열되어 있으므로 액정 커패시턴스는 $C(0V)=\varepsilon_{\perp}A/d$가 된다. 여기서, $\varepsilon_{\perp}$는 액정 분자가 기판에 평행한 방향으로 배열된 경우 즉, 액정 분자가 빛의 방향과 수직한 방향으로 배열된 경우의 유전율을 나타내며, A와 d는 각각 LCD 기판의 면적과 기판 사이의 거리를 나타낸다. 풀 블랙(full black)을 구현하기 위한 전압이 5V라 하면 액정에 5V가 인가되는 경우 액정 분자가 기판에 수직한 방향으로 배열되므로 액정 커패시턴스는 $C(5V)=\varepsilon_{\parallel}A/d$가 된다. TN 모드에 사용되는 액정의 경우에는 $\varepsilon_{\parallel}-\varepsilon_{\perp}>0$이므로 액정에 인가되는 화소 전압이 높아질수록 액정 커패시턴스가 더 커지게 된다.

<46> n 번째 프레임에서 풀 블랙을 만들기 위해 TFT가 충전시켜야 하는 전하량은 C(5V)×5V이다. 그러나, 바로 전 프레임인 n-1 번째 프레임에서 풀 화이트(Vn-1= 0V)였다고 가정하면 TFT의 턴온 시간 동안에는 액정이 미처 응답하기 전이므로 액정 커패시턴스는 C(0V)가 된다. 따라서, 풀 블랙을 만들기 위해 n 번째 프레임에서 5V의 데이터 전압(Vd)을 인가하더라도 실제 화소에 충전되는 전하량은 C(0V)×5V가 되고, C(0V) < C(5V)이므로 액정에 실제 공급되는 화소 전압(Vp)은 5V에 못 미치게 되는 화소 전압(예를 들어 3.5V)이 인가되어 풀 블랙이 구현되지 않는다. 또한, 다음 프레임인 n+1 번째 프레임에서 풀 블랙을 구현하기 위해 데이터 전압(Vd)을 5V로 인가한 경우에는 액정에 충전되는 전하량은 C(3.5V)×5V가 되고, 결국 액정에 공급되는 전압(Vp)은 3.5V와 5V 사이가 된다. 이와 같은 과정을 되풀이하면 결국 몇 프레임 후에 화소 전압(Vp)이 원하는 전압에 도달하게 된다.

<47> 즉 이를 계조의 관점에서 설명하면, 임의의 화소에 인가되는 신호(화소전압)가 낮은 계조에서 높은 계조로(또는 높은 계조에서 낮은 계조로) 바뀌는 경우, 현재 프레임의 계조는 이전 프레임의 계조의 영향을 받기 때문에 바로 원하는 계조에 도달하지 못하고, 몇 프레임이 경과된 후에야 비로소 원하는 계조에 도달하게 된다. 마찬가지로, 현재 프레임의 화소의 투과율은 이전 프레임의 화소의 투과율의 영향을 받아 몇 프레임의 경과된 후에야 원하는 투과율을 얻을 수 있다.

<48> 한편, n-1 프레임이 풀 블랙이고 즉, 화소 전압(Vp)이 5V이고, n 프레임에서 풀 블랙을 구현하기 위해 5V의 데이터 전압이 인가되었다고 하면, 액정 커패시턴스는 C(5V)이므로 화소에는 C(5V)×5V에 해당하는 전하량이 충전되고 이에 따라 액정의 화소 전압(Vp)은 5V가 된다.

<49> 이와 같이, 액정에 실제 공급되는 화소 전압(Vp)은 현재 프레임에 공급되는 데이터 전압뿐만 아니라 이전 프레임의 화소 전압(Vp)에 의해서도 결정된다.

<50> 도 2는 종래의 구동방식으로 인가되는 경우의 데이터 전압 및 화소 전압을 나타내는 도면이다.

<51> 도 2에 도시한 바와 같이, 종래에는 이전 프레임의 화소 전압(Vp)을 고려하지 않고, 목표 화소 전압(Vw)에 해당하는 데이터 전압(Vd)을 매 프레임마다 인가하였다. 따라서, 실제 액정에 인가되는 화소 전압(Vp)은 앞서 설명한 바와 같이, 이전 프레임의 화소 전압에 대응하는 액정 커패시턴스에 의해 목표 화소 전압 보다 낮게 또는 높게 된다. 따라서, 몇 프레임이 지난 후에야 비로소 목표 화소 전압에 도달하게 된다.

<52> 도 3은 이와 같은 종래의 구동 방법에 따른 액정 표시 장치의 투과율을 나타내는 도면이다.

<53> 도 3에 도시한 바와 같이, 종래에는 앞서 설명한 바와 같이 실제 화소 전압이 목표 화소 전압 보다 낮게 되기 때문에 액정의 응답시간이 1프레임 이내인 경우에도 몇 프레임이 지난 후에야 비로소 목표 투과율에 도달하게 된다.

<54> 본 발명의 실시예는 현재 프레임의 화상 신호(Sn)를 이전 프레임의 화상 신호(Sn-1)와 비교하여 다음과 같은 보정 신호(Sn')를 생성한 후, 보정된 화상 신호(Sn')를 각 화소에 인가한다. 여기서, 화상 신호(Sn)는 아날로그 구동 방식인 경우에는 데이터 전압을 의미하나, 디지털 구동 방식의 경우에는 데이터 전압을 제어하기 위하여

이진화된 계조 신호를 사용하므로 실제 화소에 인가되는 전압의 보정은 계조 신호의 보정을 통해서 이루어진다.

<55> 첫째, 현재 프레임의 화상 신호(계조 신호 또는 데이터전압)가 이전 프레임의 화상 신호와 동일하면 보정을 행하지 않는다.

<56> 둘째, 현재 프레임의 화상 신호(계조 신호 또는 데이터 전압)가 이전 프레임의 계조 신호(데이터 전압)보다 높은 경우에는 현재의 계조 신호(데이터 전압) 보다 더 높은 보정된 계조 신호(데이터 전압)를 출력하고, 현재 프레임의 계조 신호(데이터 전압)가 이전 프레임의 계조 신호(데이터 전압)보다 낮은 경우에는 현재의 계조 신호(데이터 전압) 보다 더 낮은 보정된 계조 신호(데이터 전압)를 출력한다. 이때, 보정이 이루어지는 정도는 현재의 계조 신호(데이터 전압)와 이전 프레임의 계조 신호(데이터 전압)와의 차에 비례한다.

<57> 셋째, 데이터 계조 신호 소스로부터 인가되는 계조 신호중 일부 비트만을 보정하여 보정된 계조 신호를 구한다. 이때, 보정되지 않는 나머지 비트는 바이패스된다. 즉, 데이터 계조 신호 소스로부터 n비트의 계조 신호가 수신되면, n비트의 계조 신호중 일부 비트(m)만을 이용하여 보정된 계조 신호를 구한다. 이때, m비트는 n비트의 계조 신호중에서 LSB(Least Significant Bit)에서부터 i(i=1, 2, ..., n-1)개의 비트(bits)를 제외한 나머지이다. 즉, m비트는 (n-i)비트이다.

<58> 이하에서는 본 발명의 실시예에 따른 데이터 전압 보정 방법을 개략적으로 설명한다.

<59> 도 4는 액정 표시 장치의 전압-유전율간의 관계를 간단하게 모델링(modeling)한 도면이다.

<60> 도 4에서, 가로축은 화소 전압이며, 세로 축은 특정 화소 전압 v에서의 유전율($\varepsilon(v)$)과 액정이 기판에 평행한 방향으로 배열된 경우 즉, 액정이 빛의 투과 방향과 수직한 경우의 유전율($\varepsilon_{\perp}$)의 비를 나타낸다.

<61> 도 4에서는, $\varepsilon(v)/\varepsilon_{\perp}$의 최대값 즉, $\varepsilon_{\parallel}/\varepsilon_{\perp}$을 3이라 가정하였고, Vth와 Vmax를 각각 1V, 4V로 가정하였다. 여기서, Vth와 Vmax는 각각 풀 화이트 및 풀 블랙(또는 그 반대)에 해당하는 화소 전압을 나타낸다.

<62> 스토리지 커패시터의 커패시턴스(이하에서는 이를 '스토리지 커패시턴스'라 한다.)가 액정 커패시턴스의 평균값 〈Cst〉 와 같다고 하고, LCD 기판의 넓이 및 기판 사이의 거리를 각각 A와 d라 하면, 스토리지 커패시턴스 Cst는 다음의 수학식 1로 나타낼 수 있다.

수학식 1

<63> $$Cst = \langle Cl \rangle = 1/3\ (\varepsilon_{\parallel} + 2\varepsilon_{\perp})\ A/d = 5/3\ \varepsilon_{\perp} A/d = 5/3\ C0$$

<64> 여기서, $C0 = \varepsilon_{\perp} A/d$이다.

<65> 도 4로부터, $\varepsilon(v)/\varepsilon_{\perp}$는 다음의 수학식 2로 나타낼 수 있다.

수학식 2

<66> $$\varepsilon(v)/\varepsilon_{\perp} = 1/3(2V + 1)$$

<67> LCD의 총 커패시턴스 C(V)는 액정 커패시턴스와 스토리지 커패시턴스의 합이므로, LCD의 커패시턴스는 C(V)는 수학식 1 및 2로부터 다음의 수학식 3으로 나타낼 수 있다.

수학식 3

<68> $$C(V) = Cl + Cst = \varepsilon(v)\ A/d + 5/3\ C0 = 1/3(2V + 1)C0 + 5/3\ C0$$

<69> $$= 2/3(V+3)C0$$

<70> 화소에 인가되는 전하량 Q는 보존되므로, 다음의 수학식 4가 성립한다.

수학식 4

<71> Q = C(Vn)Vn = C(Vf)Vf

<72> 여기서, Vn은 현재 프레임에 인가될 데이터 전압(반전 구동식의 경우에는 데이터 전압의 절대값)을 나타내며, C(Vn-1)는 이전 프레임(n-1 프레임)의 화소 전압에 대응하는 커패시턴스를 나타내며, C(Vf)는 현재 프레임(n 프레임)의 실제 화소 전압(Vf)에 대응하는 커패시턴스를 나타낸다.

<73> 수학식 3 및 수학식 4로부터 다음의 수학식 5가 유도될 수 있다.

수학식 5

<74> C(Vn-1)Vn = C(Vf)Vf = 2/3(Vn-1 + 3)Vn = 2/3(Vf+3)Vf

<75> 따라서, 실제 화소 전압 Vf는 다음의 수학식 6으로 나타낼 수 있다.

수학식 6

$$Vf=\frac{-3+\sqrt{9+4V_n(V_{n-1}+3)}}{2}$$

<76>

<77> 위의 수학식 6으로부터 명확히 알 수 있듯이, 실제 화소 전압 Vf는 현재 프레임에 인가된 데이터 전압(Vn)과 이전 프레임에 인가된 화소 전압(Vn-1)에 의해서 결정된다.

<78> 한편, n 프레임에서 화소 전압이 목표 전압(Vn)에 도달하도록 하기 위해 인가되는 데이터 전압을 Vn'라고 하면, Vn'는 수학식 5로부터 다음의 수학식7로 나타낼 수 있다.

수학식 7

<79> (Vn-1 + 3)Vn' = (Vn+3)Vn

<80> 따라서, Vn'는 다음의 수학식 8로 나타낼 수 있다.

수학식 8

$$Vn'=\frac{V_{n+3}}{V_{n-1}+3}V_n=V_n+\frac{V_n-V_{n-1}}{V_{n-1}+3}V_n$$

<81>

<82> 이와 같이, 현재 프레임의 목표 화소 전압(Vn)과 이전 프레임의 화소 전압(Vn-1)을 고려하여 상기 수학식 8에 의해 구해지는 데이터 전압(Vn')을 인가하면, 목표로 하는 화소 전압 Vn에 바로 도달할 수 있다.

<83> 위의 수학식 8은 도4에 도시한 도면 및 몇몇 기본 가정으로부터 유도된 식이며, 일반적인 LCD에서 적용되는 데이터 전압 Vn'는 다음의 수학식 9로 나타낼 수 있다.

수학식 9

$$|V_n'|=|V_n|+f(|V_n|-|V_{n-1}|)$$

<84>

<85> 여기서, 함수 f는 LCD의 특성에 의해 결정된다. 함수 f는 기본적으로 다음의 성질을 갖는다.

<86> 즉, $|Vn|$과 $|Vn-1|$이 같은 경우에 f=0이 되며, $|Vn|$이 $|Vn-1|$ 보다 큰 경우 f는 0 보다 크고, $|Vn|$이 $|Vn-1|$ 보다 작은 경우 f는 0 보다 작다.

<87> 다음은 본 발명의 실시예에 따른 데이터 전압 인가방법을 설명한다.

<88> 도 5는 본 발명의 따른 데이터 전압 인가방법을 나타내는 도면이다.

<89> 도 5에 도시한 바와 같이, 본 발명의 제1 실시예에서는 현재 프레임의 목표 화소 전압과 이전 프레임의 화소 전압(데이터 전압)을 고려하여 보정된 데이터 전압 Vn'을 인가하여, 화소 전압(Vp)이 바로 목표 전압에 도달하도록 한다.

<90> 즉, 본 발명의 제1 실시예에서는 현재 프레임의 목표 전압과 이전 프레임의 화소 전압이 다른 경우, 현재 프레

임의 목표 전압 보다 더 높은 전압(또는 더 낮은 전압)을 보정된 데이터 전압으로서 인가하여 첫 번째 프레임에서 바로 목표 전압 레벨에 도달하도록 한 후 이후의 프레임에서는 목표 전압을 데이터 전압으로 인가한다. 이와 같이 함으로써 액정의 응답속도를 개선할 수 있다.

<91> 이때, 보정된 데이터 전압(전하량)은 이전 프레임의 화소 전압에 의해 결정되는 액정 커패시턴스를 고려하여 결정한다. 즉, 본원 발명은 이전 프레임의 화소 전압 레벨을 고려하여 전하량(Q)을 공급함으로써 첫 번째 프레임에서 바로 목표 전압 레벨에 도달하도록 한다.

<92> 도 6은 본 발명의 제1 실시예에 따라 데이터 전압을 인가한 경우의 액정 표시 장치의 투과율을 나타내는 도면이다. 도 6에 도시한 바와 같이, 본 발명의 제1 실시예에 따르면 보정된 데이터 전압을 인가하기 때문에, 현재 프레임에서 바로 목표 투과율에 도달한다.

<93> 한편, 본 발명의 제2 실시예에서는 목표 전압보다 약간 높은 보정된 전압 Vn'을 화소 전압으로 인가한다. 이와 같이 구동하는 경우에는 도 7에 도시한 바와 같이 액정의 응답 시간의 약 1/2 이전에서는 투과율이 목표치보다 작게 되나 그 이후에서는 목표치보다 과도하게 되어(overcompensate) 평균적인 투과율이 목표 투과율과 같아진다.

<94> 다음에는 본 발명의 실시예에 따른 액정 표시 장치를 설명한다.

<95> 도 8은 본 발명의 실시예에 따른 액정 표시 장치를 나타내는 도면으로, 본 발명의 실시예에 따른 액정표시장치는 디지털 구동 방법을 사용한다.

<96> 도 8에 도시한 바와 같이, 본 발명의 실시예에 따른 액정 표시 장치는 액정 표시 장치 패널(100), 게이트 드라이버부(200), 데이터 드라이버부(300) 및 데이터 계조 신호 보정부(400)를 포함한다.

<97> 액정 표시 장치 패널(100)에는 게이트 온 신호를 전달하기 위한 다수의 게이트 라인(S1, S2, S3, ..., Sn)이 형성되어 있으며, 보정된 데이터 전압을 전달하기 위한 데이터 라인(D1, D2, ..., Dm)이 형성되어 있다. 게이트 라인과 데이터 라인에 의해 둘러싸인 영역은 각각 화소를 이루며, 각 화소는 게이트 라인과 데이터 라인에 각각 게이트 전극 및 소스 전극이 연결되는 박막 트랜지스터(110)와 박막 트랜지스터(110)의 드레인 전극에 연결되는 화소 커패시터(Cl)와 스토리지 커패시터(Cst)를 포함한다.

<98> 게이트 드라이버부(200)는 게이트 라인에 순차적으로 게이트 온 전압을 인가하여, 게이트 온 전압이 인가된 게이트 라인에 게이트 전극이 연결되는 TFT를 턴온시킨다.

<99> 데이터 계조 신호 보정부(400)는 데이터 계조 신호 소스(예를 들면, 그래픽 제어기)로부터 n비트의 데이터 계조 신호(Gn)를 수신한 후, 앞서 설명한 바와 같이 m비트의 현재 프레임의 데이터 계조 신호와 m비트의 이전 프레임의 데이터 계조 신호를 고려하여 보정된 m비트의 데이터 계조 신호(Gn')을 출력한다.

<100> 이때, 계조 신호 보정부는 스탠드 얼론(stand-alone) 유닛으로 존재할 수도 있고, 그래픽 카드나 LCD 모듈에 통합될 수도 있다.

<101> 데이터 드라이버부(300)는 데이터 계조 신호 보정부(400)로부터 수신된 보정된 계조 신호(Gn')를 해당 계조 전압(데이터 전압)으로 바꾸어 각각 데이터 라인에 인가한다.

<102> 도 9는 본 발명에 따른 데이터 계조 신호 보정부의 제1 실시예를 설명하기 위한 도면이다.

<103> 도 9에 도시한 바와 같이, 본 발명에 따른 데이터 보정신호 보정부(400), 즉 화상 신호 보정 회로(DCC; Dynamic Capacitance Compensation)의 제1 실시예는 프레임 메모리(410), 컨트롤러(controller)(420), 및 데이터 계조 신호 변환기(430)를 포함하며, 데이터 계조 신호 소스로부터 R(red), G(green), B(blue) 각각에 대한 n비트의 계조 신호(Gn)를 수신하여 보정된 계조 신호(Gn')를 출력한다. 따라서, 데이터 계조 신호 보정부(430)로 수신되는 계조 신호는 총 (3×n)비트이다. 여기서, 당업자는 데이터 계조 신호 소스로부터 (3×n)비트의 계조 신호가 동시에 데이터 계조 신호 보정부(430)에 인가되도록 할 수 있고, n비트의 R, G, B 계조 신호 각각이 순차적으로 인가되도록 할 수 있다.

<104> 도 9에서, 프레임 메모리(410)는 보정될 계조 신호의 비트를 결정하는데, 데이터 계조 신호 소스로부터 수신되는 R(red), G(green), B(blue)에 대한 n비트의 계조 신호 중에서 m비트만을 입력하고, 이를 R, G, B에 대응하는 소정 어드레스에 저장하며, 한 프레임 지연후 데이터 계조 신호 변환기(430)로 출력한다. 즉, 프레임 메모리(410)는 현재 프레임의 m비트 계조 신호(Gn)를 수신하고, 이전 프레임의 m비트 계조 신호(Gn-1)를 출력한다.

<105> 데이터 계조 신호 변환기(430)는 데이터 계조 신호 소스로부터 수신되는 n비트 중에서, 보정을 거치지 않고 바이패스되는 현재 프레임(Gn)의 (n-m)비트와, 보정을 위해 수신되는 현재 프레임(Gn)의 m비트와, 프레임 메모리(410)에 의해 지연된 이전 프레임(Gn-1)의 m비트를 수신한 후, 현재 및 이전 프레임의 m 비트를 고려한 보정된 계조 신호(Gn')를 생성한다.

<106> 상기한 화상 신호 보정 회로를 통하여 액정의 응답 시간을 1 프레임 내로 낮출 수 있고, 이로 인해 LCD 패널의 능동 콘트라스트 비율의 저하 현상이나 스트로보스코픽 모션(Stroboscopic motion) 현상을 완전 제거할 수 있다.

<107> 그러나, LCD 패널에서 망막 잔상 시간이 짧아짐에도 끌림 현상이 여전히 관찰되어 끌림 현상이나 가장 자리의 블러링(blurring) 현상은 완전히 없엘 수는 없다.

<108> 이러한 응답 시간이 망막 잔상 시간, 예를 들어 40ms보다 훨씬 짧아짐에도 끌림 현상이 여전히 관찰되는 이유를 하기와 같이 설명한다.

<109> LCD 화면을 가로질러서 움직이는 사각형을 일례로 하는 동화상 구현을 설명한다.

<110> 도 10은 일반적인 LCD 화면의 끌림 현상을 설명하기 위한 도면이다.

<111> 도 10에 도시한 바와 같이, 사각형의 블랙 컬러가 LCD 화면상의 좌측에서 우측으로 움직일 때 (n-1)번째 프레임에서는 블랙 컬러를 유지하나, n번째 프레임에서 블랙 컬러 사각형의 A 영역은 백 그라운드(background) 컬러에서 포어그라운드(foreground) 컬러로 색상이 바뀌게 되고, 블랙 컬러 사각형의 B 영역은 포어그라운드 그대로 유지되며, 블랙 컬러 사각형의 C 영역은 포어그라운드에서 백 그라운드로 바뀌게 된다.

<112> 따라서 n번째 프레임 동안 B 영역은 계속 블랙을 나타내고 있지만, A, B 영역은 화이트와 블랙이 혼합되어 있으므로 회색을 나타내게 된다.

<113> 그 다음 프레임인 (n+1)번째 프레임에도 상기한 n번째 프레임과 동일하게 사각형의 B' 영역은 색상이 변화하지 않고 그대로 유지하며, 사각형의 A' 및 B'은 화이트와 블랙이 혼합되어 있으므로 회색을 나타내게 된다.

<114> 만일 관찰자가 LCD 화면의 한 곳을 고정해서 본다면 이러한 변환 영역(A, C)(A',C')은 큰 문제가 되지 않지만, 화면상에 움직이는 물체가 있으면 관찰자의 눈은 움직이는 물체를 따라 가게 된다. 즉, B, B', B", ... 영역이 망막의 한 고정된 위치에 계속 이미지가 되고, 마찬가지로 A, A', A", ... 영역도 한 위치에 고정되어 이미지가 되며, C, C', C", ... 영역도 마찬가지이다.

<115> LCD 패널이 도 11의 (a)처럼 1 프레임내로 반응한다고 할 때, 사각형의 각 부분 A, B, C를 인지하는 망막에 투사되는 빛은 (b)과 같다.

<116> 관찰자의 눈은 16ms 정도의 속도로 변화하는 것은 감지하지 못하고 평균값을 인식하게 된다.

<117> 도 11의 (b)에서 실선 부분이 실제로 눈에 느껴지는 응답이다. 이상적으로는 A 영역은 풀 블랙이, C 영역은 풀 화이트가 되어야만 화면상에서 블러링(blurring)없는 선명한 사각형이 인식이 되겠지만 도 11에서 도시한 바와 같이, A 영역에서는 어느 정도 빛이 투과되고, C 영역에서는 최대치 휘도에 도달하지 못한다. 이 오차를 줄이기 위해서는 액정의 응답 속도가 더욱 빨라져야 한다.

<118> 예를 들어, 5% 정도의 오차는 허용한다고 하면, 액정의 응답 시간은 대략 1 프레임(frame)의 1/10이 되어야 한다. 즉, 60frame/sec이면, 1.67ms내에, 30frame/sec이면 3.33ms 내에 액정이 응답하여야 화면상에서 블러링이 없는 선명한 화면을 인식할 수 있다.

<119> 그러나, 모든 계조 레벨(gray level) 사이에서 이렇게 빠른 시간 내에 응답하는 네마틱(Nematics) 액정은 현재 미개발된 상태이다.

<120> 그러면 이하에서는 화상 신호의 보정을 통해 끌림이 없는 LCD 화면을 구현하기 위한 예를 설명한다. 이를 위해서 도 12에 도시한 바와 같이, 하나의 화상 프레임을 두 개의 서브프레임으로 나누어 구동한다.

<121> 도 12는 본 발명의 실시예에 따라 서브 프레임을 이용한 데이터 전압을 인가한 경우의 액정 표시 장치의 투과율을 나타내는 도면이다.

<122> 도 12에 도시한 바와 같이, 이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우는 분할한 화상 프레임 중 첫 번째 서브프레임(n^+)에서는 오버슈트 구동을 수행하고, 두 번째 서브프레임(n^-)에서는 상

기 오버슈트된 값을 원래 원하는 목표값으로 끌어내려 구동을 수행한다.

<123> 이러한 방식의 오버슈트를 통해 액정이 응답하는 시간동안 잃어버린 광량을 만회하고, 마치 액정의 응답 속도가 무한히 빠른 것 같은 효과를 얻을 수 있어 움직이는 영상의 가장자리가 또렷하게 인식된다. 이때 오버슈트해주는 값은 현재 프레임의 계조 레벨과 과거 프레임의 계조 레벨에 의존하는 함수이다.

<124> 상기한 도 12에서는 이전 프레임의 계조 신호와 현재 프레임의 계조 신호와의 비교를 통해 현재 프레임의 계조 신호가 더 크다고 체크되는 경우에는 첫 번째 서브 프레임에서는 오버슈트 구동을 수행하고, 두 번째 서브 프레임에서는 목표값으로 다운(down) 구동하는 것을 그 일례로 설명하였으나, 그 역도 가능하다.

<125> 즉, 이전 프레임의 계조 신호보다 작은 현재 프레임의 계조 신호가 입력되는 경위에는 첫 번째 서브 프레임에서는 언더슈트 구동을 수행하고, 두 번째 서브 프레임에서는 목표값으로 업(up) 구동하므로써 액정 표시 장치의 동화상 구현시 발생하는 화면의 끌림 현상을 제거할 수 있다.

<126> 도 13a 내지 도 13b는 본 발명에 따른 데이터 계조 신호 보정부의 제2 실시예를 설명하기 위한 도면으로서, 도 13a는 첫 번째 서브 프레임에 따른 데이터 계조 신호 보정부를 설명하기 위한 도면이고, 도 13b는 두 번째 서브 프레임에 따른 데이터 계조 신호 보정부를 설명하기 위한 도면이다.

<127> 도 13a 내지 도 13b에 도시한 바와 같이, 본 발명에 따른 데이터 보정신호 보정부(400), 즉 화상 신호 보정 회로(DCC; Dynamic Capacitance Compensation)의 제2 실시예는 합성기(410), 프레임 메모리부(420), 컨트롤러(430), 데이터 계조 신호 변환기(442) 및 분리기(450)를 포함하며, 상기한 도 11과 중복되는 부분은 그 설명을 생략한다.

<128> 프레임 메모리부(420)는 제1 프레임 메모리(422)와 제2 프레임 메모리(424)를 포함하여, 컨트롤러(430)로부터 제공되는 제어신호(write/read)에 따라 합성기(410)로부터 제공되는 계조 신호의 저장 및 이전 프레임의 계조 신호를 데이터 계조 신호 변환기(442)에 출력하는 동작을 수행하거나, 현재 프레임의 계조 신호와 이미 저장된 이전 프레임의 계조 신호를 데이터 계조 신호 변환기(442)에 출력하는 동작을 수행한다.

<129> 보다 상세히는, 제1 메모리(422)는 첫 번째 서브 프레임 구동시 컨트롤러(430)로부터 라이트 신호(write)가 입력됨에 따라 합성기(410)로부터 제공되는 현재 프레임의 계조 신호(G_n)를 저장하고, 두 번째 서브 프레임 구동시 컨트롤러(430)로부터 리드 신호(read)가 입력됨에 따라 기저장된 현재 프레임의 계조 신호(G_n)를 데이터 계조 신호 변환기(442)에 출력한다.

<130> 제2 메모리(424)는 첫 번째 서브 프레임 구동시 컨트롤러(430)로부터 리드 신호(read)가 입력됨에 따라 기저장된 이전 프레임의 계조 신호(G_{n-1})를 데이터 계조 신호 변환기(442)에 출력하고, 두 번째 서브 프레임 구동시 컨트롤러(430)로부터 리드 신호(read)가 입력됨에 따라 기저장된 이전 프레임의 계조 신호(G_{n-1})를 데이터 계조 신호 변환기(442)에 출력한다.

<131> 데이터 계조 신호 변환기(442)는 컨트롤러(430)로부터 제공되는 프레임 감지신호(431)에 따라 합성기(410)로부터 제공되는 현재 프레임의 계조 신호(G_n)와 프레임 메모리부(420)로부터 제공되는 현재 프레임의 계조 신호(G_n) 또는 이전 프레임의 계조 신호(G_{n-1})를 제공받아 제1 보정된 계조 신호($G_n^{+'}$) 또는 제2 보정된 계조 신호($G_n^{-'}$)를 분리기(450)에 출력한다.

<132> 보다 상세히는, 컨트롤러(430)로부터 제공되는 프레임 감지신호(431)가 첫 번째 서브 프레임이라 체크되는 경우에는 합성기(410)로부터 제공되는 현재 프레임의 계조 신호(G_n)를 제공받고, 프레임 메모리부(420)의 제2 프레임 메모리(424)로부터 제공되는 이전 프레임의 계조 신호(G_{n-1})를 제공받아 첫 번째 서브 프레임의 보정된 계조 신호($G_n^{+'}$)를 분리기(450)에 출력한다.

<133> 또한 컨트롤러(430)로부터 제공되는 프레임 감지신호(431)가 두 번째 서브 프레임이라 체크되는 경우에는 제1 프레임 메모리(422)로부터 제공되는 현재 프레임의 계조 신호(G_n)를 제공받고, 제2 프레임 메모리(424)로부터 제공되는 이전 프레임의 계조 신호(G_{n-1})를 제공받아 두 번째 서브 프레임의 보정된 계조 신호($G_n^{-'}$)를 분리기(450)에 출력한다.

<134> 이상에서 설명한 바와 같이, 본 발명에 따른 데이터 계조 신호 보정부의 제2 실시예에서는 현재 프레임의 계조 신호(G_n)와 프레임 메모리부(420)로부터 출력되는 이전 프레임의 계조 신호(G_{n-1})가 들어오면, 첫 번째 서브 프레임(n^+)에서는 도 13a에 도시한 바와 같이 제1 보정된 계조 신호(G_{n^+}')를 출력하고, 두 번째 서브 프레임(n^-)에서는 도 13b에 도시한 바와 같이 제2 보정된 계조 신호(G_{n^-}')를 출력한다. 이때 제1 보정된 계조 신호는 현재 프레임의 계조 신호가 이전 프레임의 계조 신호보다 큰 경우에는 오버슈트 보정된 계조 신호이고, 현재 프레임의 계조 신호가 이전 프레임의 계조 신호보다 작은 경우에는 언더슈트 보정된 계조 신호이다.

<135> 또한 제2 보정된 계조 신호는 현재 프레임의 계조 신호가 이전 프레임의 계조 신호보다 큰 경우에는 오버슈트된 값을 원래의 원하는 목표값으로 다운시킨 보정된 계조 신호이고, 현재 프레임의 계조 신호가 이전 프레임의 계조 신호보다 작은 경우에는 원래의 원하는 목표값으로 업시킨 보정된 계조 신호이다.

<136> 본 발명의 제2 실시예에서 설명한 바와 같이, 두 개의 필드 동안 동일 그림이 반복되어 출력되는 비월 주사 방식을 이용하는 DVD나 TV 및 기타 영상 신호의 경우, 그 구동은 60field/sec 이지만 그 내용은 30frame/sec이다.

<137> 그러므로 프레임의 변경 여부를 통보하는 신호, 본 발명에서는 프레임 신호(frame signal)를 컨트롤러가 데이터 계조 신호 변환기에 제공하고, 상기 데이터 계조 신호 변환기는 컨트롤러로부터 제공되는 프레임 신호에 따라 첫 번째 서브 프레임 구동에 따른 보정된 계조 데이터를, 또는 두 번째 서브 프레임 구동에 따른 보정된 계조 데이터를 각각 출력한다.

<138> 한편, 프레임 메모리에 기록하는 동작은 정극성(+) 프레임, 즉 첫 번째 서브 프레임에서만 수행한다. 즉, 화면이 바뀌는 순간에는 프레임 메모리에 기록해주고, 데이터 계조 신호 변환기에서는 첫 번째 계조 데이터를 출력하고, 다음 서브 프레임에서는 프레임 메모리에 기록은 하지 않으며, 데이터 계조 신호 변환기에서 두 번째 서브 프레임의 계조 데이터를 출력하며, 이 과정을 반복한다.

<139> 이상의 본 발명의 제2 실시예에서는 하나의 화상 프레임을 두 개의 서브 프레임으로 시분할하고, 시분할된 첫 번째 서브 프레임과 두 번째 서브 프레임의 구동시 이전 프레임과 현재 프레임의 계조 신호를 비교하여 동화상 보정 동작을 수행하는 것을 설명하였으나, 시분할하는 서브 프레임을 3개 이상으로 분리하여도 본 발명의 요지는 벗어나지는 않을 것이다. 예를 들어, 3개의 서브 프레임으로 분할한 경우에 첫 번째 서브 프레임을 하나의 서브 프레임으로, 두 번째와 세 번째 서브 프레임을 다른 하나의 서브 프레임으로 이용할 수도 있다.

<140> 도 14a 내지 도 14c는 본 발명에 따른 데이터 계조 신호 보정부의 제3 실시예를 설명하기 위한 도면이다.

<141> 도 14a 내지 도 14c에 도시한 바와 같이, 본 발명에 따른 데이터 보정신호 보정부(400), 즉 화상 신호 보정 회로(DCC; Dynamic Capacitance Compensation)의 제3 실시예는 합성기(410), 프레임 메모리부(420), 컨트롤러(430), 데이터 계조 신호 변환기(444) 및 분리기(450)를 포함하며, 상기한 도 11과 중복되는 부분은 그 설명을 생략한다.

<142> 프레임 메모리부(420)는 제1 프레임 메모리(A)(426), 제2 프레임 메모리(B)(427), 제3 프레임 메모리(C)(428)를 포함하여, 컨트롤러(430)의 제어에 의해 합성기(410)로부터 현재 프레임의 계조 신호를 제공받아 상기 프레임 메모리(426)(427)(428)중 어느 하나에 기록하고, 상기 현재 프레임의 계조 신호가 기록됨에 따라 기록 동작이 수행되지 않는 2개의 프레임 메모리에 기저장된 계조 신호를 데이터 계조 신호 변환기(444)에 출력한다.

<143> 보다 상세히는, 도 14a에 도시한 바와 같이, 제2 프레임 메모리(427)에 현재 프레임의 계조 신호(G_n)가 기록됨에 따라 제1 프레임 메모리(426)는 기저장된 2프레임 이전의 계조 신호(G_{n-2})를 데이터 계조 신호 변환기(444)에 출력하고, 제3 프레임 메모리(428)는 기저장된 1프레임 이전의 계조 신호(G_{n-1})를 데이터 계조 신호 변환기(444)에 출력한다.

<144> 이때 각 프레임 메모리의 저장동작 수행시 이용될 수 있는 주파수가 30Hz인 경우에는 그 출력동작 수행시 이용되는 주파수는 60Hz이고, 각 프레임 메모리의 저장 동작 주파수가 60Hz인 경우에는 그 출력동작 주파수는 120Hz이다.

<145> 이상에서 설명한 바와 같이, 1초당 필드 수와 프레임 수가 일치하는 순차 주사 방식을 이용하는 컴퓨터 영상 신호의 경우, 1초당 필드의 수를 2배로 하고, 1프레임을 복제하여 2필드가 출력되도록 한다. 예를 들어 60frame/sec인 경우, 매 프레임을 복제하여 1초당 120필드를 생성한 후 120Hz로 LCD 패널을 구동한다.

<146> 이때의 프레임 메모리는 총 3개로 구성할 수 있는데, 제1 메모리(426)에는 현재 프레임에서 입력되는 화상 신호를 60Hz로 기록하고, 제2 메모리(427)에는 1프레임 이전에 기록된 화상 신호가 저장되고, 제3 메모리(428)에는 2프레임 이전에 기록된 화상 신호가 저장되어 있다.

<147> 컨트롤러(430)는 현재 프레임에서 제2 메모리(427)와 제3 메모리(428)로부터 120Hz(1프레임에 두 번)로 읽어들여 데이터 계조 신호 변환기(444)에 출력하고, 다음 프레임에는 입력되는 신호를 제3 메모리(428)가 받아들이며, 컨트롤러(430)는 제1 및 제2 메모리(426)(427)로부터 화상 신호를 읽어들여 데이터 계조 신호 변환기(444)에 출력한다. 이러한 방식으로 제1, 제2, 제3 메모리(426)(427)(428)가 순차적으로 기록 및 출력 동작을 수행한다. 여기서, 분류한 메모리는 물리적 개념으로 분할된 메모리일 수도 있고, 논리적 개념으로 분할된 메모리일 수도 있다.

<148> 이상에서 설명한 바와 같이, 하나의 프레임을 분할한 두 개의 서브 프레임중 첫 번째 서브프레임(n^+)이든지, 또는 두 번째 서브프레임(n^-)이든지와 무관하게 데이터 계조 신호 변환기(444)에 입력되는 계조 신호는 현재 프레임의 계조 신호(G_n)와 이전 프레임의 계조 신호(G_{n-1})로 동일하다.

<149> 따라서 컨트롤러(430)로부터 출력되는 프레임 감지 신호(431)에 따라 상기한 두 계조 신호(G_n, G_{n-1}) 중 어느 하나를 출력할지 결정하는 것은 데이터 계조 신호 변환기(444)의 각 단계중 어느 곳에나 들어갈 수 있다.

<150> 예를 들어, 데이터 계조 신호 변환기를 정극성(+) 서브 프레임용 데이터 계조 신호 변환기와 부극성(-) 서브 프레임용 데이터 계조 신호 변환기로 별도 구성하여 프레임 검출 신호를 받아들여 어느 경로로 출력할지를 결정하고 그 특정 경로를 따라 보정 계조값을 출력하는 방식을 이용할 수 있다.

<151> 또한 이와는 반대되는 일례로서, 별도의 데이터 계조 신호 변환기를 구성하지 않고, 하나의 데이터 계조 신호 변환기에서 두 보정값을 동시에 출력하여 상기 출력을 프레임 신호에 따라 선별적으로 내보내는 방식을 이용할 수도 있으며, 상기한 두 방식의 혼합 방식을 이용할 수도 있다.

<152> 상기에서는 본 발명의 바람직한 실시예를 참조하여 설명하였지만, 해당 기술 분야의 숙련된 당업자는 하기의 특허청구범위에 기재된 본 발명의 사상 및 영역으로부터 벗어나지 않는 범위 내에서 본 발명을 다양하게 수정 및 변경시킬 수 있음을 이해할 수 있을 것이다.

발명의 효과

<153> 이상 설명한 바와 같이, 본 발명에 따라 액정 표시 장치의 동화상 표현시 하나의 프레임을 시분할한 2개의 서브 프레임을 이용하여 이전 프레임의 계조 신호보다 큰 현재 프레임의 계조 신호가 입력되는 경우에는 첫 번째 서브 프레임의 구동시에는 오버슈트 구동을 수행한 후 두 번째 서브 프레임의 구동시에는 목표치 수준으로 다운 구동하므로써, 액정 표시 장치의 동영상 구현시 화면 끌림 현상을 제거 할 수 있다.

<154> 또한 시분할한 2개의 서브 프레임을 이용하여 이전 프레임의 계조 신호보다 작은 현재 프레임의 계조 신호가 입력되는 경우에는 첫 번째 서브 프레임의 구동시에는 언더슈트 구동을 수행한 후 두 번째 서브 프레임의 구동시에는 목표치 수준으로 업 구동하므로써 액정 표시 장치의 동영상 구현시 화면 끌림 현상을 제거할 수 있다.

도면의 간단한 설명

<1> 도 1은 액정 표시 장치에서 각 화소의 등가회로를 나타내는 도면이다.

<2> 도 2는 종래 구동 방식으로 인가되는 데이터 전압 및 화소 전압을 나타내는 도면이다.

<3> 도 3은 종래 구동 방식에 따른 액정 표시 장치의 투과율을 나타내는 도면이다.

<4> 도 4는 액정 표시 장치의 전압-유전율간의 관계를 모델링한 도면이다.

<5> 도 5는 본 발명의 일 실시예에 따른 데이터 전압 인가방법을 나타내는 도면이다.

<6> 도 6은 본 발명의 일 실시예에 따라 데이터 전압을 인가한 경우의 액정 표시 장치의 투과율을 나타내는 도면이다.

<7> 도 7은 본 발명의 다른 실시예에 따라 데이터 전압을 인가한 경우의 액정 표시 장치의 투과율을 나타내는 도면이다.

<8> 도 8은 본 발명의 실시예에 따른 액정 표시 장치를 나타내는 도면이다.

<9> 도 9는 본 발명에 따른 데이터 계조 신호 보정부의 제1 실시예를 설명하기 위한 도면이다.

<10> 도 10은 일반적인 LCD 화면의 끌림 현상을 설명하기 위한 도면이다.

<11> 도 11은 이동하는 사각형을 통해 화면의 끌림 현상을 설명하기 위한 도면이다.

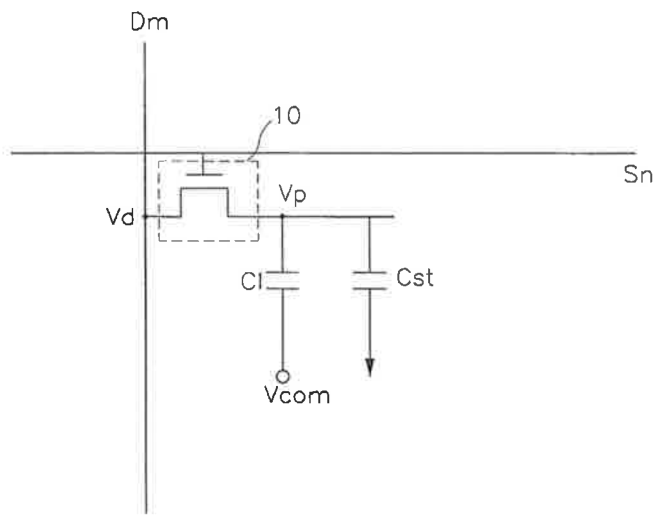
<12> 도 12는 본 발명의 실시예에 따라 서브 프레임을 이용한 데이터 전압을 인가한 경우의 액정 표시 장치의 투과율을 나타내는 도면이다.

<13> 도 13a 내지 도 13b는 본 발명에 따른 데이터 계조 신호 보정부의 제2 실시예를 설명하기 위한 도면이다.

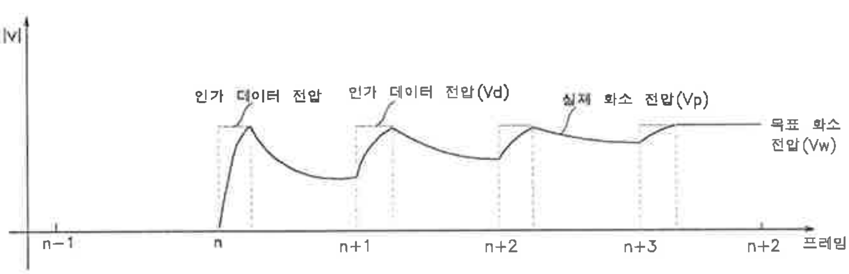
<14> 도 14a 내지 도 14c는 본 발명에 따른 데이터 계조 신호 보정부의 제3 실시예를 설명하기 위한 도면이다.

도면

도면1



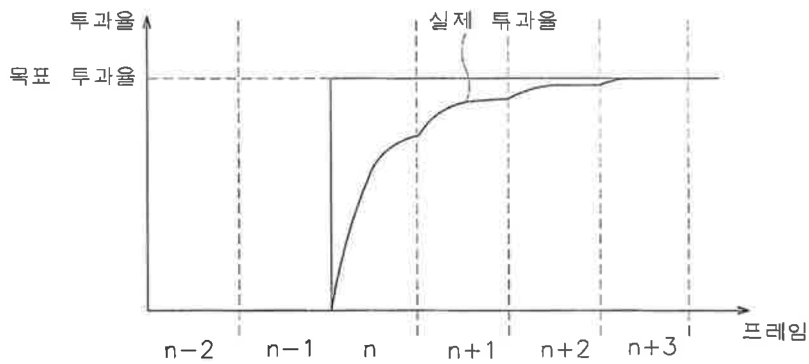
도면2



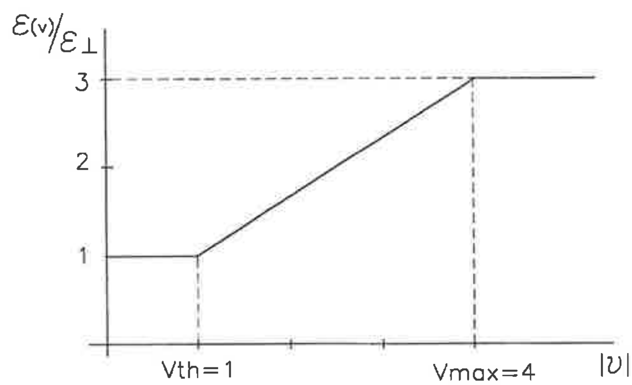
LGD_000529

IPR2015-00885
Exhibit 2007
Page 220 of 374

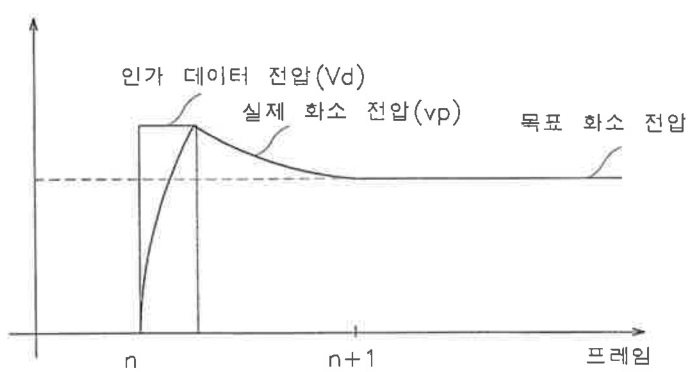
도면3



도면4

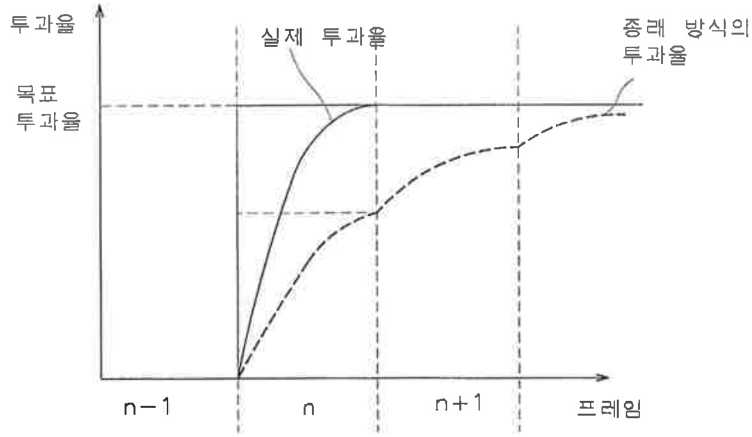


도면5

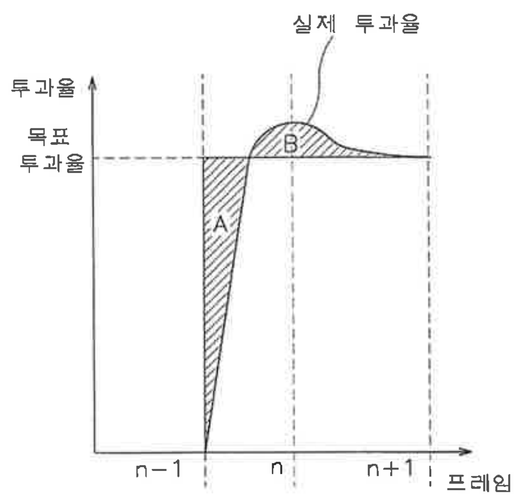


LGD_000530

도면6

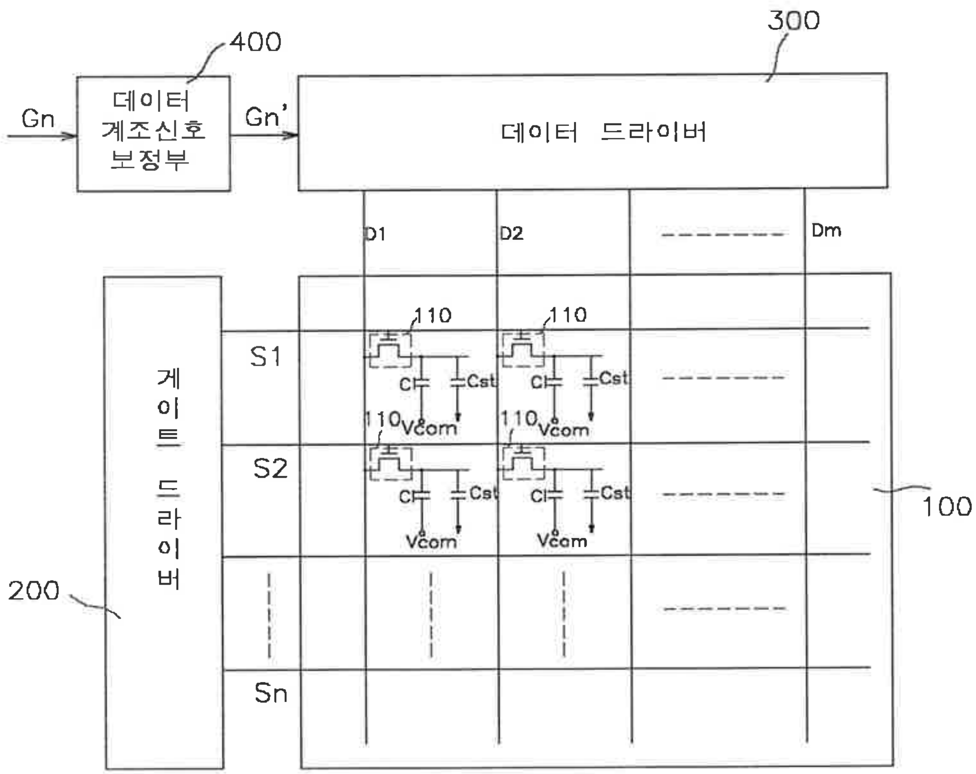


도면7

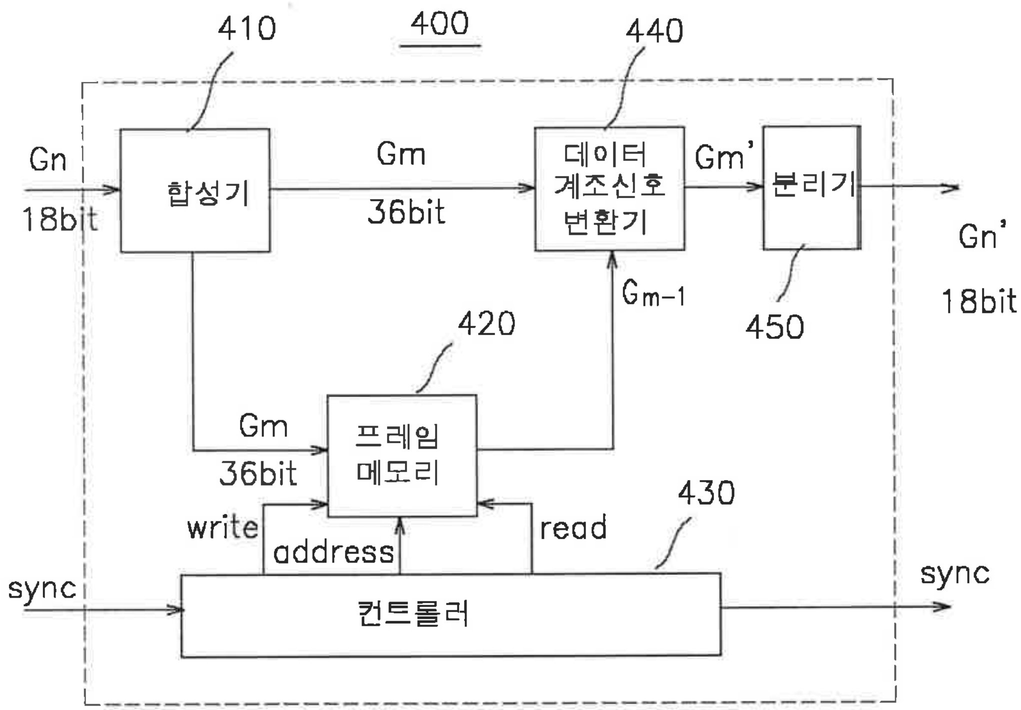


LGD_000531

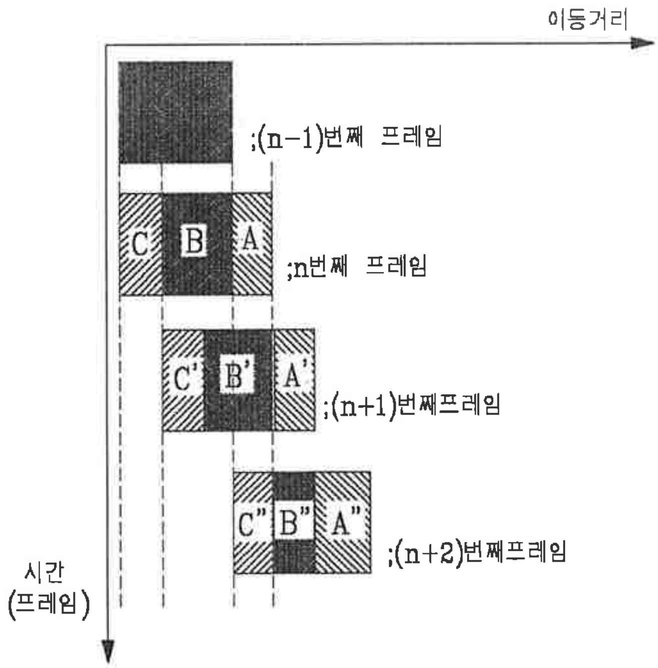
도면8


400
데이터
계조신호
보정부
Gn
Gn'
300
데이터 드라이버
D1
D2
Dm
110
S1
S2
Sn
Cl
Cst
Vcom
게
이
트
드
라
이
버
200
100

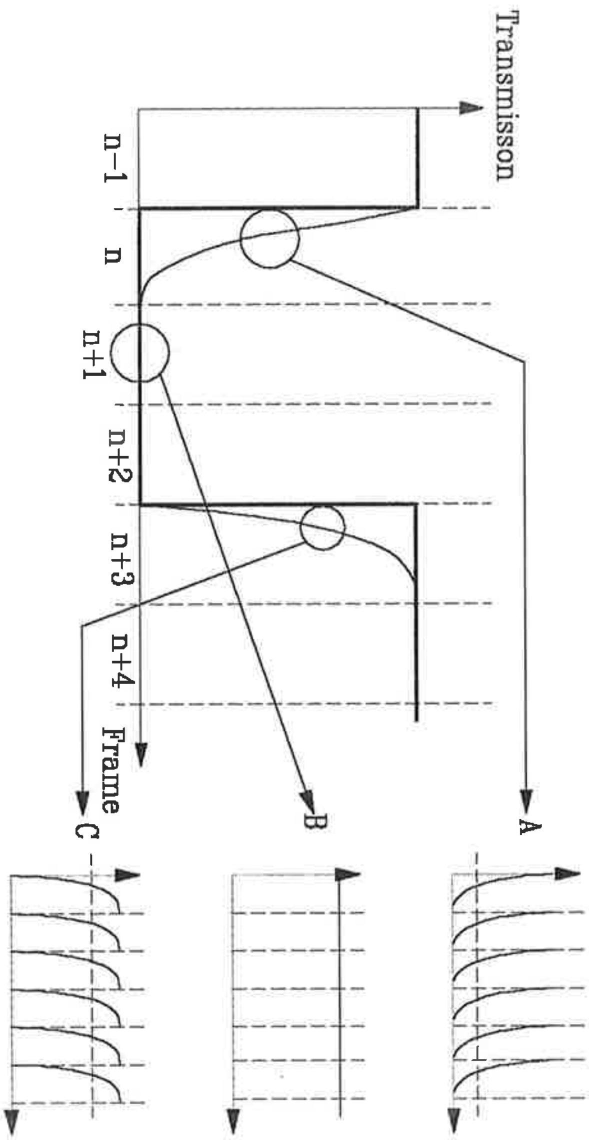
도면9


400
410
440
Gn
18bit
합성기
Gm
36bit
데이터
계조신호
변환기
Gm'
분리기
Gn'
18bit
Gm-1
450
420
Gm
36bit
프레임
메모리
430
write
address
read
sync
컨트롤러
sync

도면10

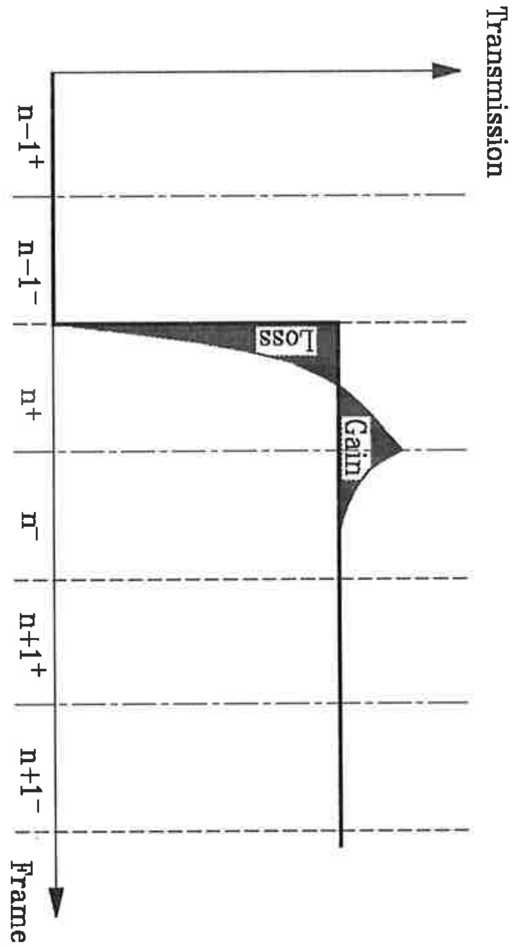


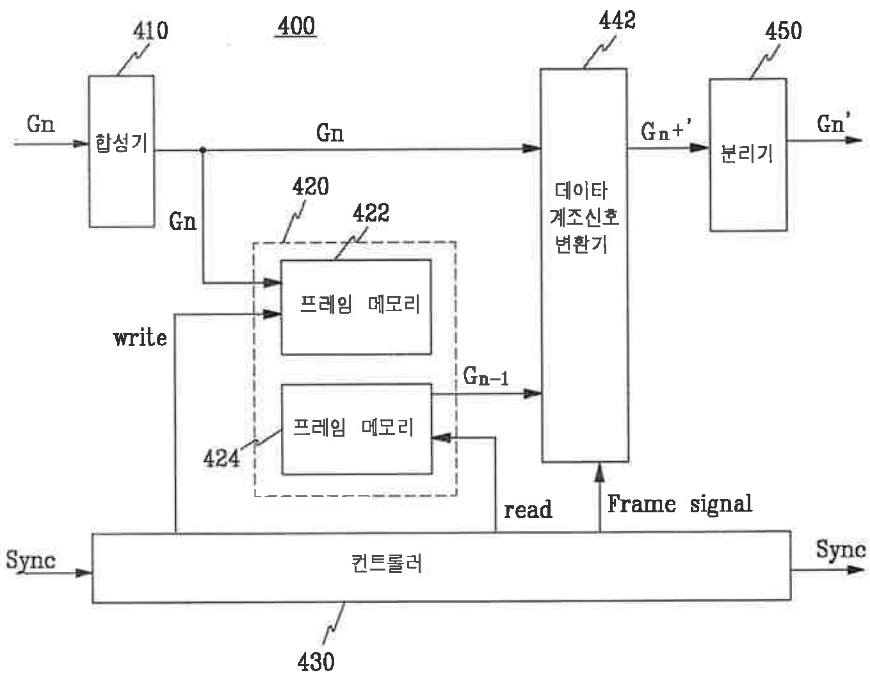
도면11



LGD_000535

도면12

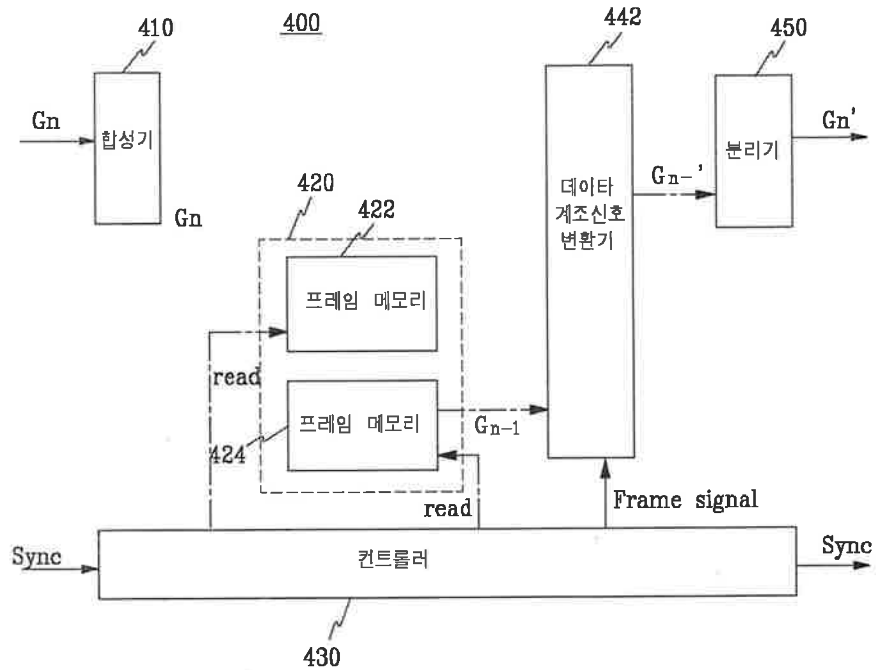




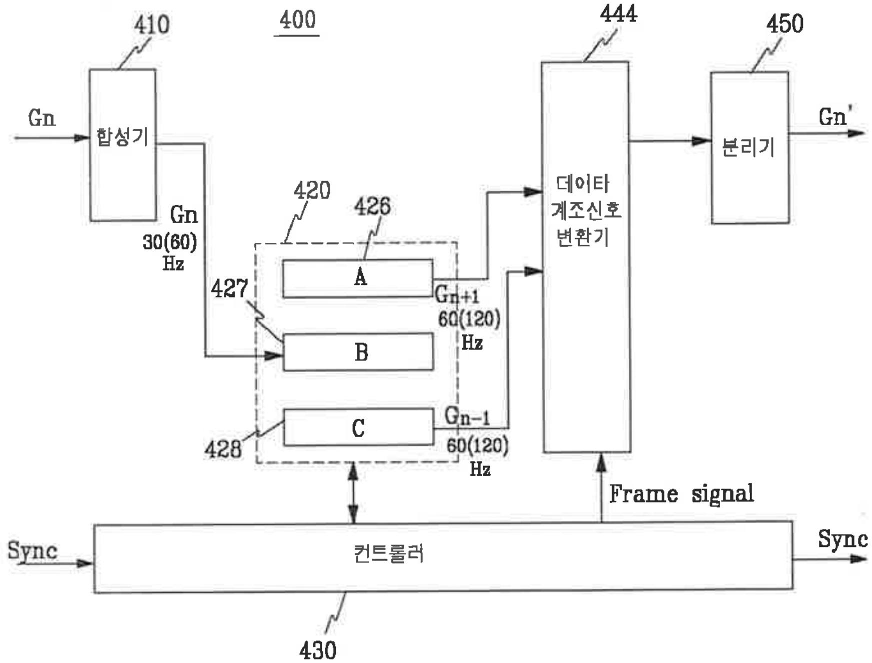
400
410
Gn
합성기
Gn
Gn
442
데이타
계조신호
변환기
Gn+'
450
분리기
Gn'
420
422
프레임 메모리
write
Gn-1
프레임 메모리
424
read
Frame signal
Sync
컨트롤러
Sync
430

도면13a

도면13b

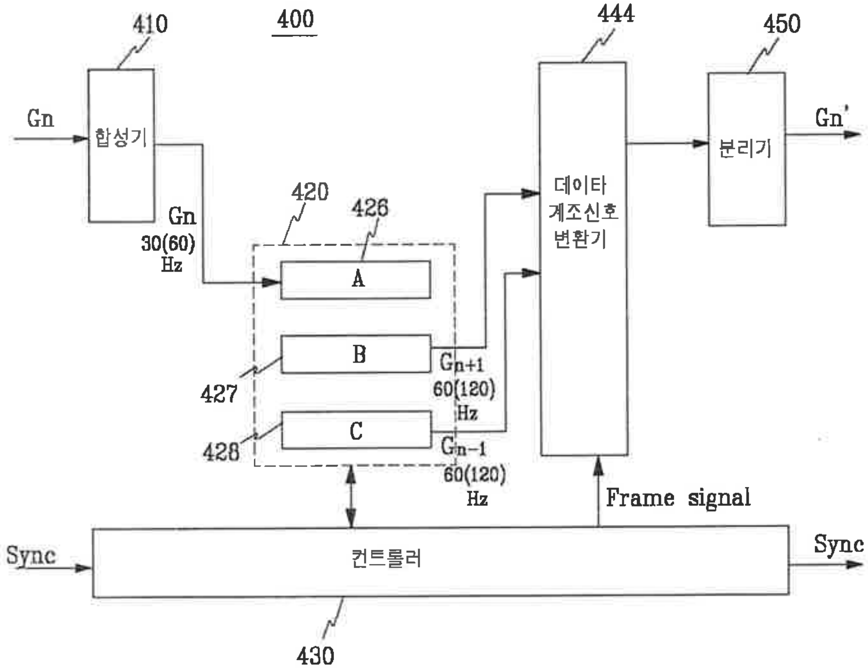

400
410
Gn
합성기
Gn
420
422
프레임 메모리
read
프레임 메모리
424
read
G_{n-1}
442
데이타
계조신호
변환기
G_{n-}'
450
분리기
Gn'
Frame signal
Sync
컨트롤러
Sync
430

도면14a

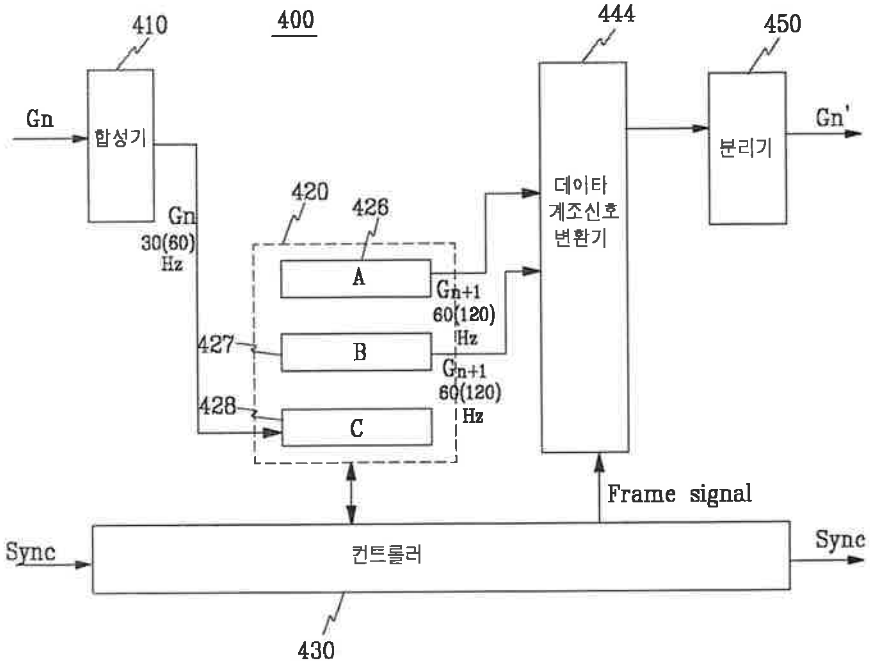


400
410
합성기
Gn
Gn
30(60)
Hz
420
426
427
428
A
B
C
Gn+1
60(120)
Hz
Gn-1
60(120)
Hz
444
데이타
계조신호
변환기
450
분리기
Gn'
Frame signal
Sync
컨트롤러
Sync
430

도면14b


400
410
Gn
합성기
Gn
30(60)
Hz
420
426
A
B
C
427
428
Gn+1
60(120)
Hz
Gn-1
60(120)
Hz
444
데이타
계조신호
변환기
450
분리기
Gn'
Frame signal
Sync
컨트롤러
Sync
430

도면14c


400
410
Gn
합성기
Gn
30(60)
Hz
420
426
A
Gn+1
60(120)
Hz
427
B
Gn+1
60(120)
Hz
428
C
444
데이타
계조신호
변환기
450
분리기
Gn'
Frame signal
Sync
컨트롤러
Sync
430

CERTIFICATION OF TRANSLATION

This is to certify that I, Tae-Ho HA, a Patent Attorney of NEIT INTERNATIONAL PATENT AND LAW FIRM, am well acquainted with both the Korean and English languages, and that the attached document is an accurate and complete translation from Korean to English of Korean Laid-Open Patent No. 2002-0044673 to the best of my knowledge and ability.

Signature: ____________________ Date: March 10, 2015

LGD_000542

(19) KOREA PATENT OFFICE (KR)

(12) GAZETTE OF PATENT PUBLICATION (A)

(11) PUBLICATION NUMBER OF PATENT APPLICATION 2002-0044673

(43) DATE OF PUBLICATION June 19, 2002

(51) Int. Cl. 5

G02F 1/1333

(21) APPLICATION NUMBER 10-2000-0073673

(22) APPLICATION DATE December 6, 2000

(71) APPLICANT Samsung Electronics Co., Ltd., Jong-Yong YUN

416, Maetan 3-dong, Paldal-gu, Suwon, Gyunggi-do, Republic of Korea

(72) INVENTOR Baek-Woon LEE

210-1307 Woosung Apt., 96, Seohyun-dong, Bundang-gu, Gyunggi-do, Republic of Korea

(74) AGENT Won-Keun KIM, YUMI Patent Law Firm

REQUEST OF EXAMINATION: UNREQUESTED

(54) LIQUID CRYSTAL DISPLAY DEVICE HAVING MOVING PICTURE COMPENSATION FUNCTION AND DRIVING DEVICE AND METHOD THEREOF

[ABSTRACT]

The present invention discloses a liquid crystal display device having a moving picture compensation function, and driving device and method thereof.

According to the present invention, a data grey level signal compensation portion divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame, and a data driver portion is supplied with the compensated grey level data through the overshoot or undershoot driving, converts the compensated grey level data into a data voltage corresponding to the compensated grey level data, and outputs a picture signal to a data line of a liquid crystal panel.

As a result, using two sub frames which one frame is time-divided into in displaying a moving picture, in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, an overshoot driving is conducted in a first sub frame and then a down driving to a target value level is conducted in a second sub frame, and thus a screen dragging phenomenon in realizing a moving picture of a liquid crystal display can be removed.

[REPRESENTATIVE FIGURE]

FIG. 4

[REPRESENTATIVE WORD(S)]

Liuiqid crystal, response speed, frame, sub frame, division, retina, grey, memory

[SPECIFICATION]

[BRIEF EXPLANATION OF FIGURES]

FIG. 1 is a view showing an equivalent circuit of each pixel of a liquid crystal display device.

FIG. 2 is a view showing a data voltage and a pixel voltage applied in the prior art driving method.

FIG. 3 is a viewing showing a transmittance of a liquid crystal display device according to the prior art method.

FIG. 4 is a view modeling a relation of voltage to dielectric constant of a liquid crystal display device.

FIG. 5 is a view showing a method of applying a data voltage according to an embodiment of the present invention.

FIG. 6 is a view showing a transmittance of a liquid crystal display device in case of applying a data voltage according to an embodiment of the present invention.

FIG. 7 is a view showing a transmittance of a liquid crystal display device in case of applying a data voltage according to another embodiment of the present invention.

FIG. 8 is a view showing a liquid crystal display device according to an embodiment of the present invention.

FIG. 9 is a view for explaining a first embodiment of a data grey level signal compensation portion according to the present invention.

FIG. 10 is a view for explaining a general LCD screen dragging phenomenon.

FIG. 11 is a view for explaining a screen dragging phenomenon with a moving quadrangle.

FIG. 12 is a view showing a transmittance of a liquid crystal display device in case of applying a data voltage using a sub frame according to an embodiment of the present invention.

FIGs. 13a and 13b are view for explaining a second embodiment of a data grey level signal compensation portion according to the present invention.

FIGs. 13a to 14c are view for explaining a third embodiment of a data grey level signal compensation portion according to the present invention.

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[TECHNICAL FIELD OF THE INVENTION AND PRIOR ART OF THE FIELD]

The present invention relates to a liquid crystal display device, and driving device and method thereof, and in more detailed, to a liquid crystal display device, and driving device and method thereof to remove a dragging phenomenon of a screen in realizing a moving picture.

Generally, an LCD are a display device obtaining a desired picture signal by applying an electric field to a liquid crystal material, which is injected between two substrates and has an anisotropic dielectric constant, adjusting intensity of the electric field to adjust amount of light transmitting the substrates. The LCD is a representative one among flat panel type displays that are easy to carry, and among the LCDs, a TFT LCD that uses a thin film transistor (TFT) as a switching element is mostly used.

Recently, since the TFT LCD is used as not only a display device of a computer but also a display device of a television widely, a demand for realizing moving pictures increases. However, the prior TFT LCD had disadvantage of difficulty in realizing moving pictures because the response speed of the LCD is slow.

To improve the problem of the response speed, a TFT LCD using an OCB (Optically Compensated Band) mode, or a ferro-electric liquid crystal (FLC) material was used.

However, there was a problem of changing a structure of the prior TFT LCD panel in order to use the OCB mode or FLC.

[TECHNICAL SUBJECT TO BE ACHIEVED BY INVENTION]

The technical subject of the present invention is to solve the above prior problem, and an object of the present invention is to provide a liquid crystal display device having a moving picture compensation function that removes a picture dragging phenomenon in realizing moving picture through picture signal compensation.

Moreover, another object of the present invention is provide a driving device of the liquid crystal display device having the moving picture compensation function.

Moreover, yet another object of the present invention is provide a driving method of the liquid crystal display device having the moving picture compensation function.

[CONSTRUCTION AND OPERATION OF THE INVENTION]

A liquid crystal display device having a moving picture compensation function according to one characteristic to achieve the aforementioned object of the present invention includes, a data grey level signal compensation portion that divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame;

a data driver portion that is supplied with the compensated grey level data through the overshoot or undershoot driving, converts the compensated grey level data into a data voltage corresponding to the compensated grey level data, and outputs a picture signal;

a gate driver portion that supplies scanning signals sequentially; and

a liquid crystal display panel that includes a plurality of gate lines transferring the scanning signals, a plurality of data lines transferring the picture signals, and isolated from and crossing the gate lines, and a plurality of pixels formed at regions surrounded by the gate lines, the data lines and each having a switching element connected to the gate line and the data line, and arranged in a matrix form.

A driving device of a liquid crystal display device having a moving picture compensation function according to one characteristic to achieve the aforementioned another object of the present invention, the driving device supplied from a data grey level signal source with a grey level data of a picture signal and outputting the grey level data to a liquid crystal display module, wherein the driving device includes,

a data grey level signal compensation portion that divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs to the liquid crystal display panel a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame, thereby making a response speed of liquid crystal high.

A method of driving a liquid crystal display device having a moving picture compensation function according to one characteristic to achieve the aforementioned yet another object of the present invention, the device including a plurality of gate lines, a plurality of data lines insulated from and crossing the gate lines, and a plurality of pixels formed at regions surrounded by the gate lines and the data lines, each having a switching element connected to the gate line and the data line, and arranged in a matrix form, the method includes,

(a) a step of supplying scanning signals to the gate lines sequentially;

(b) a step of dividing one picture frame supplied from an external data grey level signal source into at least two sub frames;

(c) a step of comparing a grey level signal of a current frame and a grey level signal of a previous frame according to a grey level signal of a current frame being input;

(d) a step of, in case that a grey level signal of a current frame is check greater than a grey level of a previous frame in the step (c), conducting an overshoot driving and generating a first data driving voltage when driving a sub frame located at a first half portion out of the divided sub frames, and conducting a down driving to a target value from the overshot value and generating a second driving voltage when driving a sub frame located at a second half portion out of the divided sub frames;

(e) a step of, in case that a grey level signal of a current frame is check less than a grey level of a previous frame in the step (c), conducting an undershoot driving and generating a third data driving voltage when driving a sub frame located at a first half portion out of the divided sub frames, and conducting an up driving to a target value from the undershot value and generating a fourth driving voltage when driving a sub frame located at a second half portion out of the divided sub frames; and

(f) a step of supplying the first to fourth driving voltages generated in the steps (c) and (d) to the data line, thereby making a response speed of liquid crystal high.

According to the liquid crystal display device, and the driving device and method thereof, using two sub frames which one frame is time-divided into in displaying a moving picture, in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, an overshoot driving is conducted in a first sub frame and then a down driving to a target value level is conducted in a second sub frame, and thus a screen dragging phenomenon in realizing a moving picture of a liquid crystal display can be removed.

Moreover, using the time-divided two sub frames, in case that a grey level signal of a current frame less than a grey level signal of a previous frame is input, an undershoot driving is conducted in a first sub frame and then an up driving to a target value level is conducted in a second sub frame, and thus a screen dragging phenomenon in realizing a moving picture of a liquid crystal display can be removed.

An embodiment is explained such that one of ordinary skill in the art can easily embody the present invention.

Generally, an LCD includes a plurality of gate lines transferring scan signals and data lines crossing the gate lines and transferring data voltages. Moreover, the LCD includes a plurality of pixels in a matrix form that are each formed in a region surroudned by the gate and data lines, and are each connected to the gate and data lines through a switching element.

In the LCD, each pixel is modelled with a capacitor having a liquid crystal as a dielectric i.e., a liquid crystal capacitor, and an equivalent circuit of each pixel in the LCD is as shown in FIG. 1.

As shown in FIG. 1, each pixel of the liquid crystal display device includes a

TFT 10, a source electrode and a gate electrode of which are connected to a data line Dm and a gate line Sn, respectively, a liquid crystal capacitor Cl connected between a drain electrode of the TFT and a common voltage Vcom, and a storage capacitor Cst connected to the drain electrode of the TFT.

In FIG. 1, when a gate on signal is applied to the gate line Sn and the TFT 10 is turned on, a data voltage Vd supplied to the data line is applied to each pixel electrode (not shown) through the TFT. Then, an electric field, which corresponds to a difference between a pixel voltage Vp applied to the pixel electrode and the common voltage Vcom, is applied to the liquid crystal (equivalently shown as the liquid crystal capacitor in FIG. 1), and light transmits the liquid crystal with transmittance corresponding to intensity of the electric field. In this regard, the pixel voltage Vp should be maintained during one frame, and in FIG. 1, the storage capacitor Cst is auxiliarily used to maintain the pixel voltage Vp applied to the pixel electrode.

Meanwhile, since the liquid crystal has an anisotropic dielectric constant, there is property of different dielectric constants according to directions of the liquid crystal. In other words, when a liquid crystal director changes according to application of voltage, dielectric constant changes accordingly, and thus a capacitance value of the liquid crystal capacitor (hereinafter, a liquid crystal capacitance) also changes. Charges are supplied to the liquid crystal capacitance during a period the TFT is turned on and then the TFT is in off state, and because of Q = "CV", when the liquid crystal capacitance changes, the pixel voltage Vp also changes.

In a normally white mode TN (Twisted Nematics) LCD as an example, when a pixel voltage applied to a pixel is 0V, since liquid crystal molecules are arranged along a direction parallel with a substrate, a liquid crystal capacitance is $C(0V) = \varepsilon\perp A/D$. The $\varepsilon\perp$ indicates a dielectric constant when the liquid crystal molecules are arranged along the direction parallel with the substrate i.e., when the liquid crystal molecules are arranged along a direction perpendicular to direction of light, and the A and d indicate an area of a substrate of the LCD, and a distance between substrates of the LCD, respectively. Assuming that a voltage to realize a full black is 5V, when 5V is applied to the liquid crystal, since the liquid crystal molecules are arranged along a direction perpendicular to the substrate, a liquid crystal capacitance is $C(5V) = \varepsilon \parallel A/D$. Because of $\varepsilon\perp - \varepsilon\parallel > 0$ in a liquid crystal used in a TN mode, the higher the pixel voltage applied to the liquid crystal is, further the liquid crystal capacitance increases.

To make a full black in a n^{th} frame, a quantity of charge that the TFT should charge is C(5V)*5V. However, assuming that a full white (Vn-1 = 0V) is in a $(n-1)^{th}$ frame of the immediately previous frame, the liquid crystal capacitance becomes C(0V) during a time the TFT is turned on because the liquid crystal does not make a response until the time the TFT is turned on. Thus, even though the data voltage Vd of 5V is applied in the n^{th} frame in order to make a full black, an actual quantity of charge charged in the pixel becomes C(0V)*5V, and because of C(0V) < C(5V), the actual pixel voltage Vp supplied to the liquid crystal becomes below 5V (e.g., 3.5V), and thus a full black is not made. Moreover, in case that the data voltage Vd of 5V is applied in a $(n+1)^{th}$ frame of a next frame in order to make a full black, a quantity of charge charged in the liquid crystal becomes C(3.5V)*5V, and the voltage Vp supplied to the liquid crystal finally becomes between 3.5V and 5V. This process being repeated, the pixel voltage Vp finally reaches a desired voltage after several frames.

In other words, this being explained in view of grey level, in case that a signal (pixel voltage) applied to a certain pixel changes from a low grey level to a high grey level (or from a high grey level to a low grey level), since a grey level of a current frame is influenced by a grey level of a previous frame, a desired grey level is not reached immediately, and the desired grey level is reached only after several frames. Likewise, a transmittance of pixel of a current frame is influenced by a transmittance of pixel of a previous frame, and thus a desired transmittance can be obtained after several frames.

Meanwhile, assuming that a full black is in a $(n-1)^{th}$ frame i.e., the pixel voltage Vp is 5V, and the data voltage of 5V is applied in a n^{th} frame in order to make a full black, since the liquid crystal capacitance is C(5V), a quantity of charge of C(5V)*5V is charged in the pixel, and accordingly, the pixel voltage Vp of the liquid crystal becomes 5V.

Like this, the pixel voltage Vp actually applied to the liquid crystal is determined by not only the data voltage applied in the current frame but also the pixel voltage Vp of the previous frame.

FIG. 2 is a view showing a data voltage and a pixel voltage applied according to the prior art driving method.

As shown in FIG. 2, the prior art did not consider the pixel voltage Vp of the previous frame and applied the data voltage Vd corresponding to a target pixel voltage Vw every frame. Thus, as explained above, the pixel voltage Vp actually applied to the liquid crystal becomes lower or higher than the target pixel voltage because of the liquid crystal capacitance corresponding to the pixel voltage of the previous frame. Thus, the target pixel voltage is reached only after several frames.

FIG. 3 is a view showing a transmittance of the liquid crystal display device according to the prior art driving method.

As shown in FIG. 3, as explained above, in the prior art, since the actual pixel voltage is lower than the target pixel voltage, even in case that a response time of liquid crystal is within 1 frame, a target transmittance is reached only after several frames.

The embodiment of the present invention compares a picture signal Sn of a current frame with a picture signal Sn-1 of a previous frame and generates a compensation signal Sn' as follows, and then applies the compensated picture signal Sn' to each pixel. The picture signal Sn means a data voltage in case of an analog driving mode, and in case of a digital driving mode, since a binary-coded grey signal should be used to control a data voltage, a compensation of a voltage applied to an actual pixel is made through a compensation of a grey level signal.

First, when a picture signal (grey level signal or data voltage) of a current frame is equal to a picture signal of a previous frame, a compensation is not made.

Second, when a picture signal (grey level signal or data voltage) of a current frame is higher than a grey level signal (data voltage) of a previous frame, a compensated grey level signal (data voltage) higher than the current grey level signal (data voltage) is output, and when a grey level signal (data voltage) of a current frame is lower than a grey level signal (data voltage) of a previous frame, a compensated grey level signal (data voltage) lower than the current grey level signal (data voltage) is output. In this regard, an extent of compensation is proportional to a difference between the current grey level (data voltage) and the grey level (data voltage) of the previous frame.

Third, a compensated grey level signal is obtained by compensating partial bit(s) among a grey level signal applied from a data grey level signal source. In this regard, other bits not compensated bypass. In other words, when a n-bit grey level signal is received from the data grey level signal source, the compensated grey level signal is obtained using only partial bits (m bits) among the grey level of n bits. In this regard, the m bits are the rest except i (i = "1", 2, ..., n-1) bits from LSB (Least Significant Bit) among the grey level signal of the n bits. In other words, the m bits are (n-i) bits.

Hereinafter, a compensation method of a data voltage according to the embodiment of the present invention is schematically explained.

FIG. 4 is a view simply modeling a relation of voltage to dielectric constant of a liquid crystal display.

In FIG. 4, a horizontal axis is a pixel voltage, and a vertical axis indicates a ratio of a dielectric constant $\varepsilon(v)$ at a specific pixel voltage v to a dielectric $\varepsilon\perp$ constant when liquid crystal is arranged along a direction parallel with a substrate i.e., liquid crystal is perpendicular to transmission direction of light.

In FIG. 4, it is assumed that a maximum of $\varepsilon(v)/\varepsilon\perp$ i.e., $\varepsilon\parallel/\varepsilon\perp$ is 3, and Vth and Vmax are 1V and 4V, respectively. The Vth and Vmax indicates pixel voltages corresponding to full white and full black (or otherwise), respectively.

Assuming that a capacitance of the storage capacitor (hereinafter, referred to as a storage capacitance) is equal to an average of the liquid crystal capacitance <Cst>, and an area of the substrate of the LCD and a distance between the substrates of the LCD are A and d, respectively, the storage capacitance Cst can be expressed by a following math formula 1:

$$Cst = \langle Cl \rangle = 1/3(\varepsilon\parallel + 2\varepsilon\perp)A/d = 5/3\,\varepsilon\perp A/d = 5/3C0,$$

Where $C0 = \varepsilon\perp A/d$.

From FIG. 4, $\varepsilon(v)/\varepsilon\perp$ can be expressed by a following math formula 2:

$$\varepsilon(v)/\varepsilon\perp = 1/3(2V + 1).$$

Since a total capacitance C(V) of the LCD is the sum of the liquid crystal capacitance and the storage capacitance, the capacitance C(V) of the LCD can be expressed by a following math formula 3:

$$C(V) = Cl + Cst = \varepsilon(v)A/d + 5/3C0 = 1/3(2V+1)C0 + 5/3C0 = 2/3(V+3)C0.$$

Since a quantity of charge Q applied to the pixel is preserved, a following math formula is established:

$$Q = C(Vn)Vn = C(Vf)Vf,$$

where Vn indicates a data voltage (an absolute value of a data voltage in case of an inverse driving method) to be applied in a current frame, C(Vn-1) indicates a capacitance corresponding to a pixel voltage of a previous frame ($(n-1)^{th}$ frame), and C(Vf) indicates a capacitance corresponding to an actual pixel voltage (Vf) of a current frame (n^{th} frame).

A following math formula 5 is induced from the math formula 3 and the math formula 4:

C(Vn-1)Vn = C(Vf)Vf = 2/3(Vn-1 + 3)/Vn = 2/3(Vf + 3)Vf.

Thus, the actual pixel voltage Vf can be expressed by a following math formula 6:

$$Vf = \frac{-3 + \sqrt{9 + 4V_n(V_{n-1} + 3)}}{2}.$$

As clearly known from the above math formula 6, the actual pixel voltage Vf is determined by the data voltage Vn applied in the current frame and the pixel voltage Vn-1 applied in the previous frame.

Meanwhile, assuming that a data voltage, which is applied in the n^{th} frame in order that the pixel voltage reach the target voltage Vn, is Vn', Vn' can be expressed by a following math formula 7 from the math formula 5:

V(n-1 +3)Vn' = (Vn +3)Vn.

Thus, Vn' can be expressed by a following math formula 8:

$$Vn' = \frac{V_{n+3}}{V_{n-1}+3} V_n = V_n + \frac{V_n - V_{n-1}}{V_{n-1}+3} V_n.$$

Like this, when the data voltage Vn' obtained by the formula 8 is applied considering the target pixel voltage Vn of the current frame and the pixel voltage Vn-1 of the previous frame, the pixel voltage Vn as a target can be immediately reached.

The math formula 8 is a formula induced from the drawing of FIG. 4 and some basic assumptions, and a data voltage Vn' applicable to a general LCD can be expressed in a following math formula 9:

$$|Vn'| = |Vn| + f(|Vn| - |Vn\text{-}1|),$$

where the function f is determined by a property of an LCD. The function f basically has a following property.

In other words, f = "0" in case that |Vn| and |Vn-1| are the same, f is over 0 in case that |Vn| is greater than |Vn-1|, and f is below 0 in case that |Vn| is less than |Vn-1|.

A method of applying a data voltage according to the embodiment of the present invention is explained as below.

FIG. 5 is a view showing a method of applying a data voltage according to the embodiment of the present invention.

As shown in FIG. 5, in a first embodiment of the present invention, by applying a compensated data voltage Vn' considering a target pixel voltage of a current frame and a pixel voltage (data voltage) of a previous frame, a pixel voltage immediately reaches a target voltage.

In other words, in the first embodiment of the present invention, in case that the target voltage of the current frame is different from the pixel voltage of the previous frame, a voltage higher (or a voltage lower) than the target voltage of the current frame is applied as a compensated data voltage so that a target voltage level is immediately reached in a first frame, and then the target voltage is applied as the data voltage in a next frame. By doing so, response speed of liquid crystal can be improved.

In this regard, the compensated data voltage (quantity of charge) is determined considering a liquid crystal capacitance determined by the pixel voltage of the previous frame. In other words, the present invention supplies the quantity of charge Q considering the pixel voltage level of the previous frame, and thus the target voltage is immediately reached in the first frame.

FIG. 6 is a view showing a transmittance of a liquid crystal display device in case of application of a data voltage according to the first embodiment of the present invention. As shown in FIG. 6, according to the first embodiment of the present invention since the compensated data voltage is applied, a target transmittance is immediately reached in the first frame.

Meanwhile, in a second embodiment of the present invention, a compensated voltage Vn' that is a little higher than a target voltage is applied as a pixel voltage. When driving so, as shown in FIG. 7, a transmittance is below a target value before about 1/2 of a response time of liquid crystal and is overcompensated after then, and thus an average transmittance becomes the same as the target transmittance.

A liquid crystal display device according to the embodiment of the present invention is explained as below.

FIG. 8 is a view showing a liquid crystal display device according to the embodiment of the present invention, which uses a digital driving method.

As shown in FIG. 8, the liquid crystal display device according to the embodiment of the present invention includes a liquid crystal display device panel 10, a gate driver portion 200, a data driver portion 300, and a data grey level signal compensation portion 400.

In the liquid crystal display device panel 100, a plurality of gate lines S1, S2, S3, ..., Sn to transfer gate on signals are formed, and data lines D1, D2, ..., Dm to transfer compensated data voltages are formed. Regions surrounded by the gate lines and the data lines each form a pixel, and each pixel includes a thin film transistor 110, a gate electrode and a source electrode of which are connected to the gate line and the data line, respectively, and a pixel capacitor Cl and a storage capacitor Cst that are connected to a drain electrode of the thin film transistor 110.

The gate driver portion 200 applies gate on voltages to the gate lines sequentially, and thus turns on the TFT the gate electrode of which is connected to the gate line which the gate on voltage is applied to.

The data grey level signal compensation portion 400 receives a data grey level signal Gn of n bits from a data grey level signal source (e.g., graphic controller), and then outputs a data grey level signal Gn' of m bits compensated considering a data grey level signal of m bits of a current frame and a data grey level signal of m bits of a previous frame, as explained above.

In this regard, the grey level signal compensation portion may exist as a stand-alone unit, or may be integrated into a graphic card or LCD module.

The data driver portion 300 changes the compensated grey level signal Gn', which is received from the data grey level signal compensation portion 400, into the corresponding grey level voltage (data voltage) and applies the voltage to the data line.

FIG. 9 is a view showing a first embodiment of a data grey level signal compensation portion according to the present invention.

As shown in FIG. 9, a first embodiment of a data grey level signal compensation portion 400 according to the present invention i.e., a picture signal compensation circuit (DCC: Dynamic Capacitance Compensation) includes a frame memory 410, a controller 420, and a data grey level signal converter 430, and receives a grey level signal of n bits for each of R(red), G(green), and B(blue) and a compensated grey level signal Gn'. Thus, the grey level signals, which the data grey level signal compensation portion 430 receives, are totally 3*n bits. One of ordinary skill in the art can let grey level signals of (3*n) bits simultaneously applied from the data grey level signal source to the data grey level signal compensation portion 430, or let R, G, and B grey level signals sequentially applied.

In FIG. 9, the frame memory 410 determines bits of the grey level to be compensated, has m bits among the grey level signals of the n bits for R (red), G (green), and B (blue), which are received from the data grey level signal source, input thereto, stores the m bits in predetermined addresses corresponding to R, G and B, and outputs the m bits to the data grey level converter 430 after one frame delay. In other words, the frame memory 410 receives a m-bit grey level signal (Gn) of a current frame, and outputs a m-bit grey level signal (Bn-1) of a previous frame.

The data grey level converter 430 receives (n-m) bits of the current frame (Gn) not passing through compensation and bypassing, and n bits of the current frame (Gn) being received for compensation, among n bits being received from the data grey level signal source, and m bits of the previous frame (Gn-1) delayed by the frame memory 410, and then generates a compensated grey level signal considering the m bits of the current frame and the previous frame.

A response time of a liquid crystal can be reduced to less than one frame through the picture signal compensation circuit, and thus phenomenon of reduction of dynamic contrast ratio of an LCD panel and a stroboscopic motion phenomenon can be completely removed.

However, despite retina after image time shortened at the LCD panel, a dragging phenomenon is still observed, and the dragging phenomenon and a blurring phenomenon at an edge cannot be completely removed.

The reason that the dragging phenomenon is still observed even though such the response time is much shorter than the retina after image time e.g., 40ms is explained as follows.

Realization of a moving picture is explained with a quadrangle moving across an LCD screen as an example.

FIG. 10 is a view for explaining a general dragging phenomenon of an LCD screen.

As shown in FIG. 10, when a quadrangular black color moves from a left side to a right side on a LCD screen, a black color is maintained in a $(n-1)^{th}$ frame, but in a n^{th} frame, a region A of the black color quadrangle changes from a background color into a foreground color, a region B of the black color quadrangle is maintained as the foreground, and a region C of the black color quadrangle changes from the foreground into the background.

Thus, during the n^{th} frame, the region B still appears black while the regions A and B appear grey because white and black are mixed.

Even in a $(n+1)^{th}$ frame of a next frame, identical to the n^{th} frame, the quadrangular region B' is still maintained without change of color, and the quadrangular regions A' and C' appear grey because white and black are mixed.

If an observer focuses on one point of the LCD screen, the changed regions (A, C)(A', C') do not a big problem, but when there is an moving object on a screen, observer's eyes follow the moving object. In other words, the regions B, B', B",... continue to become image at a fixed position of a retina, and likewise, the regions A, A', A", ... are fixed at a position and become image, and the regions C, C', C", ... are also the same.

When the LCD panel responds within one frame like FIG. 11(a), lights projected on a retina recognizing the parts A, B and C of the quadrangle are the same as (b).

The observer's eyes does not detect a thing changing at a speed of approximately 16ms, and recognizes an average value.

A solid line in FIG. 11(b) is a response felt in the eyes. Ideally, if the A region were to become a full black and the region C were to become a full white, a clear quadrangle without blurring would be perceived on the screen, but as shown in FIG. 11, light transmits somewhat at the region A, and a maximum brightness cannot be reached at the region C. To reduce this error, a response speed of liquid crystal needs to be faster.

For example, when 5% error is allowable, a response time of liquid crystal needs to be about 10/1 of one frame. In other words, only if the liquid crystal responds within 1.67ms at 60 frame/sec or within 3.33ms at 30 frame/sec, a clear screen without blurring can be recognized.

However, a nematics liquid crystal responding within such the fast time among all grey levels is not developed currently.

Hereinafter, an example of realizing an LCD screen without dragging through a picture signal compensation is explained. To do this, as shown in FIG. 12, operation is conducted with one picture frame divided into two sub frames.

FIG. 12 is a view showing a transmittance of a liquid crystal display device in case of applying a data voltage using a sub frame according to the embodiment of the present invention.

As shown in FIG. 12, in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, an overshoot driving is conducted in a first sub frame n+ out of the divided picture frame, and a driving with the overshot value rolled back to an originally desired target value is conducted in a second sub frame n-.

Through the overshoot of this mode, a quantity of light lost during a time a liquid crystal responds is recovered, and an effect can be obtained as if a response time of liquid crystal was infinitely fast and thus an edge of a moving image is clearly recognized. In this regard, the value for the overshoot is a function depending on a grey level of a current frame and a grey level of a previous frame.

It is explained in the above FIG. 12 that in case that the grey level of the current frame is checked greater through comparing the grey level of the previous frame with the grey level of the current frame, the overshoot driving is conducted in the first sub frame, and the down driving to the target value is conducted in the second sub frame, but the reverse is possible.

In other words, in case that the grey level signal of the current frame less than the grey level signal of the previous frame is input, an undershoot driving is conducted in the first sub frame, and an up driving to a target value is conducted in the second sub frame, and thus a screen dragging phenomenon occurring in realizing a moving picture of a liquid crystal display device can be removed.

FIGs. 13a and 13b are views for explaining a second embodiment of a data grey level signal compensation portion according to the present invention, FIG. 13a is a view for explaining the data grey level signal compensation portion according to a first sub frame, and FIG. 13b is a view for explaining the data grey level signal compensation portion according to a second sub frame.

As shown in FIGs. 13a and 13b, a second embodiment of a data compensation signal compensation portion 400 i.e., a picture signal compensation circuit (DCC: Dynamic Capacitance Compensation) includes a synthesizer 410, a frame memory portion 420, a controller 430, a data grey level signal converter 442 and a separator 450, and explanations of parts overlapping with the above FIG. 11 are omitted.

The frame memory portion 420 includes a first frame memory 422 and a second frame memory 424, and, according to control signals (write/read) supplied from the controller 430, conducts an operation of storing a grey level signal supplied from the synthesizer 410 and outputting a grey level signal of a previous frame to the data grey level signal converter 442, or an operation of outputting a grey level signal of a current frame and a grey level signal of a previous frame already stored to the data grey level signal converter 442.

In more detail, the first memory 422 stores a grey level signal Gn of a current frame supplied from the synthesizer 410 according to a write signal being input from the controller 430 when driving the first sub frame, and outputs the grey level signal Gn of the current frame already stored to the data grey level signal converter 442 according to a read signal being input from the controller 430 when driving the second sub frame.

The second memory 424 outputs a grey level signal Gn-1 of a previous frame already stored to the data grey level signal converter 442 according to a read signal being input from the controller 430 when driving the first sub frame, and outputs a grey level signal Gn-1 of a previous frame already stored to the data grey level signal converter 442 according to a read signal being input from the controller 430 when driving the second sub frame.

The data grey level signal converter 442 is, according to a frame detection signal 431 supplied from the controller 430, supplied with the grey level signal Gn of the current frame from the synthesizer 410 and the grey level signal Gn of the current frame or the grey level signal Gn-1 of the previous frame from the frame memory portion 420, and outputs a first compensated grey level signal Gn+' or a second compensated grey level signal Gn-' to the separator 450.

In more detail, in case that the frame detection signal 431 supplied from the controller 430 is checked as a first sub frame, the grey level signal Gn of the current frame is supplied from the synthesizer 410 and the grey level signal Gn-1 of the previous frame is supplied from the second frame memory 424 of the frame memory portion 420, and the compensated grey level signal Gn+' of the first sub frame is output to the separator 450.

Moreover, in case that the frame detection signal 431 supplied from the controller 430 is checked as the second sub frame, the grey level signal Gn of the current frame is supplied from the first frame memory and the grey level signal Gn-1 of the previous frame is supplied from the second frame memory 424, and the compensated grey level signal Gn-' of the second sub frame is output to the separator 450.

As explained above, in the second embodiment of the data grey level signal compensation portion according to the present invention, when the grey level signal Gn of the current frame and the grey level signal Gn-1 of the previous frame output from the frame memory portion 420 enter, the first compensated grey level signal Gn+' is output in the first sub frame (+) as shown in FIG. 13a, and the second compensated grey level signal Gn-' is output in the second sub frame (-) as shown in FIG. 13b. In this regard, the first compensated grey level signal is an overshoot compensated grey level signal in case of the grey level signal of the current frame greater than the grey level signal of the previous frame, and is an undershoot compensated grey level signal in case of the grey level signal of the current frame less than the grey level signal of the previous frame.

Moreover, the second compensated grey level signal is a compensated grey level signal by making an overshot value down to an originally desired target value in case of the grey level signal of the current frame greater than the grey level signal of the previous frame, and is a compensated grey level signal by making up to an originally desired target value in case of the grey level signal of the current frame less than the grey level signal of the previous frame.

Therefore, the controller supplies a signal notifying whether a program changes or not, a frame signal in the present invention to the data grey level signal converter, and the data grey level signal converter outputs, in accordance with the frame signal supplied from the controller, a compensated grey level data according to the first sub frame driving, or a compensated grey level data according to the second sub frame driving.

Meanwhile, an operation of writing on the frame memory is conducted only in a positive polarity (+) frame i.e., the first sub frame. In other words, at the moment a screen changes, it is wrote on the frame memory and the data grey level signal converter outputs a first grey level data, and in a next sub frame, it is not wrote on the frame memory and the data grey level signal converter outputs a grey level data of a second sub frame, and this process is repeated.

It is explained in the above second embodiment that one picture frame is time-divided into two sub frames, and when driving the time-divided first sub frame and second sub frame, the grey level signals of the previous frame and the current frame are compared and a moving picture compensation operation is conducted, and time-dividing into even 3 or more sub frames is not beyond the gist of the present invention. For example, in case of dividing into 3 sub frames, a first sub frame may be used as one sub frame, and second and third sub frames may be used as the other sub frame.

FIGs. 14a to 14c are views for explaining a third embodiment of a grey level signal compensation portion according to the present invention.

As shown in FIGs. 14a to 14c, a third embodiment of a data grey level signal compensation portion 400 according to the present invention i.e., a picture signal compensation circuit (DCC: Dynamic Capacitance Compensation) includes a synthesizer 410, a frame memory portion 420, a controller 430, a data grey level signal converter 444, and a separator 450, and explanations of parts overlapping with the above FIG. 11 are omitted.

The frame memory portion 420 includes a first frame memory (A) 426, a second frame memory (B) 427, and a third frame memory (C) 428, and, by control of the controller 430, is supplied with a grey level signal of a current frame from the synthesizer 410 and writes the grey level signal on one of the frame memories 426, 427 and 428, and outputs grey level signals already stored in the two frame memories, which are not conducting a writing operation according to the writing of the grey level signal of the current frame, to the data grey level signal converter 444.

In more detail, as shown in FIG. 14a, according to the grey level signal Gn of the current frame being wrote on the second frame memory 427, the first frame memory 426 outputs a grey level signal Gn-2 already stored of 2 frames before to the data grey level signal converter 444, and the third frame memory 428 outputs a grey level signal Gn-1 of 1 frame before to the data grey level signal converter 444.

In this regard, in case that a frequency, which can be used in conducting a storing operation of each frame memory, is 30Hz, a frequency used in conducting an output operation of it is 60Hz, and in case that a frequency of a storing operation of each frame memory is 60Hz, a frequency of an output operation of it is 120Hz.

As explained above, in case of a computer picture signal using a progressive scanning mode in which a number of field and a number of frame per 1 second are equal to each other, a number of field per 1 second is made twice, and 1 frame is made duplicated so that 2 fields are output. For example, in case of 60 frame/sec, every frame is duplicated to generate 120 fields per 1 second, and then the LCD panel is driven at 120Hz.

The frame memory in this case can be configured totally with 3 frame memories, a picture signal input in the current frame is wrote on the first frame memory 426 at 60Hz, a picture signal wrote 1 frame before is stored in the second memory 427, and a picture signal wrote 2 frames before is stored in the third memory 428.

The controller 430 reads at 120 Hz from the second memory 427 and the third memory 428 and outputs to the data grey level signal converter 444 in the current frame, and in a next frame, the third memory 428 receives a signal being input, and the controller 430 reads a picture signal from the first and second memories 426 and 427 and outputs the picture signal to the data grey level signal converter 444. In this manner, the first, second and third memories 426, 427 and 428 conduct writing and output operations sequentially. In this regard, the classified memories may be memories partitioned in physical concept, or memories partitioned in logical concept.

As explained above, regardless of the first sub frame n+ or the second sub frame n- out of two sub frames which one frame is divided into, the grey level signal input to the data grey level signal converter 444 is equal to the grey level signal Gn or the current frame or the grey level signal Gn-1 of the previous frame.

Thus, determining which one of the two grey level signals Gn and Gn-1 is output according to the frame detection signal output from the controller 430 enters any step among steps of the data grey level signal converter 444.

For example, used can be a method of configuring a data grey level signal converter with a data grey level signal converter for a positive polarity (+) sub frame and a data grey level signal converter for a negative polarity (-) sub frame separately, receiving a frame detection signal, determining which path to output, and outputting a compensation grey level value along a specific path.

Moreover, as the contrary example, used can be a method of not configuring a separate data grey level signal converter, simultaneously outputting two compensation values from one data grey level signal converter and exporting the outputs selectively according to the frame signal, and a mixture method of the above two methods can be used.

Even though explanations are made above with reference to the desirable embodiments of the present invention, it can be understood that a skilled person in the art can variously modify and alter the present invention within a range not departing from the thought and region of the present invention recited in the below range of claims.

[EFFECT OF THE INVENTION]

As explained above, according to the present invention, using two sub frames which one frame is time-divided into in displaying a moving picture, in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, an overshoot driving is conducted in a first sub frame and then a down driving to a target value level is conducted in a second sub frame, and thus a screen dragging phenomenon in realizing a moving picture of a liquid crystal display can be removed.

Moreover, using the time-divided two sub frames, in case that a grey level signal of a current frame less than a grey level signal of a previous frame is input, an undershoot driving is conducted in a first sub frame and then an up driving to a target value level is conducted in a second sub frame, and thus a screen dragging phenomenon in realizing a moving picture of a liquid crystal display can be removed.

[RANGE OF CLAIMS]

[CLAIM 1]

A liquid crystal display device having a moving picture compensation function, the device comprising:

a data grey level signal compensation portion that divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame;

a data driver portion that is supplied with the compensated grey level data through the overshoot or undershoot driving, converts the compensated grey level data into a data voltage corresponding to the compensated grey level data, and outputs a picture signal;

a gate driver portion that supplies scanning signals sequentially; and

a liquid crystal display panel that includes a plurality of gate lines transferring the scanning signals, a plurality of data lines transferring the picture signals, and isolated from and crossing the gate lines, and a plurality of pixels formed at regions surrounded by the gate lines, the data lines and each having a switching element connected to the gate line and the data line, and arranged in a matrix form.

[Claim 2]

The device according to claim 1, wherein in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, the data grey level signal compensation portion outputs a first compensated grey level data through an overshoot driving in a sub frame located at a first half portion out of the divided picture frame, and outputs a second compensated grey level data through a down driving to a target value from the overshot value in a sub frame located at a second half portion out of the divided picture frame.

[Claim 3]

The device according to claim 1, wherein in case that a grey level signal of a current frame less than a grey level signal of a previous frame is input, the data grey level signal compensation portion outputs a third compensated grey level data through an undershoot driving in a sub frame located at a first half portion out of the divided picture frame, and outputs a fourth compensated grey level data through an up driving to a target value from the downshot value in a sub frame located at a second half portion out of the divided picture frame.

[Claim 4]

The device according to claim 1, wherein the data grey level signal compensation portion supplies the compensated grey level data to the data driver portion using an interlaced scanning method.

[Claim 5]

The device according to claim 4, wherein the data grey level signal compensation portion includes:

a controller that outputs a first control signal for writing and reading of a grey level data when driving the first sub frame, and outputs a second control signal for writing and reading of a grey level data when driving the second sub frame;

a first memory that stores a grey level data of a current frame supplied from a data grey level source, in case that the first control signal is input from the controller, when driving the first sub frame, and outputs the grey level data of the current frame when driving the second sub frame;

a second memory that outputs a grey level data of a previous frame, in case that the second control signal is input from the controller, when driving the first sub frame and the second sub frame; and

a data grey level signal converter that, when driving the first sub frame, is supplied with a grey level data of a current frame from the data grey level signal source, is supplied with a grey level data of a previous frame from the second frame memory, and outputs a compensated grey level data, and, when driving the second sub frame, is supplied with a grey level data of a current frame from the first frame memory, is supplied with a grey level data of a previous frame from the second frame memory, and outputs a compensated grey level data to the data driver portion.

[Claim 6]

The device according to claim 1, wherein the data grey level signal compensation portion supplies the compensated grey level data to the data driver portion using a progressive scanning method.

[Claim 7]

The device according to claim 6, wherein the data grey level signal compensation portion includes:

a first memory that outputs a grey level data of a $(n-2)^{th}$ frame already stored when driving a n^{th} frame, stores a grey level data of a $(n+1)^{th}$ frame when driving a $(n+1)^{th}$ frame, and outputs a grey level data of a $(n+1)^{th}$ frame already stored when driving a $(n+2)^{th}$ frame;

a second memory that stores a grey level data when driving a n^{th} frame, outputs a grey level data of a n^{th} frame already stored when driving a $(n+1)^{th}$ frame, and outputs a grey level data of a n^{th} frame already stored when driving a $(n+2)^{th}$ frame;

a third memory that outputs a grey level data of a $(n-1)^{th}$ frame already stored when driving a n^{th} frame, outputs a grey level data of a $(n-1)^{th}$ frame already stored when driving a $(n+1)^{th}$ frame, and stores a grey level data of a $(n+2)^{th}$ frame already stored when driving a $(n+2)^{th}$ frame;

a controller that controls writing and reading of grey level data of the first to third memories; and

a data grey level signal converter that, when driving a n^{th} frame, is supplied with grey level data from the first and third memories and outputs a compensated grey level data, and, when driving a $(n+1)^{th}$ frame, is supplied with grey level data from the second and third memories and outputs a compensated grey level data, and, when driving a $(n+2)^{th}$ frame, is supplied with grey level data from the first and second memories and outputs a compensated grey level data.

[Claim 8]

The device according to claim 6, wherein a storing frequency of grey level data stored in the first to third memories is stored as a first frequency, and an output frequency of grey level data output from the first to third memories is a second frequency that is twice of the first frequency.

[Claim 9]

The device according to claim 5 or 7, wherein the memory is a frame memory.

[Claim 10]

A driving device of a liquid crystal display device having a moving picture compensation function, the driving device supplied from a data grey level signal source with a grey level data of a picture signal and outputting the grey level data to a liquid crystal display module, the driving device comprising:

a data grey level signal compensation portion that divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs to the liquid crystal display panel a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame, thereby making a response speed of liquid crystal high.

[Claim 11]

The driving device according to claim 10, wherein in case that a grey level signal of a current frame greater than a grey level signal of a previous frame is input, the data grey level signal compensation portion outputs a first compensated grey level data through an overshoot driving in a sub frame located at a first half portion out of the divided picture frame, and outputs a second compensated grey level data through a down driving to a target value from the overshot value in a sub frame located at a second half portion out of the divided picture frame.

[Claim 12]

The driving device according to claim 10, wherein in case that a grey level signal of a current frame less than a grey level signal of a previous frame is input, the data grey level signal compensation portion outputs a third compensated grey level data through an undershoot driving in a sub frame located at a first half portion out of the divided picture frame, and outputs a fourth compensated grey level data through an up driving to a target value from the downshot value in a sub frame located at a second half portion out of the divided picture frame.

[Claim 13]

The driving device according to claim 10, wherein the data grey level signal compensation portion supplies the compensated grey level data to the data driver portion using an interlaced scanning method.

[Claim 14]

The driving device according to claim 13, wherein the data grey level signal compensation portion includes:

a controller that outputs a first control signal for writing and reading of a grey level data when driving the first sub frame, and outputs a second control signal for writing and reading of a grey level data when driving the second sub frame;

a first memory that stores a grey level data of a current frame supplied from a data grey level source, in case that the first control signal is input from the controller, when driving the first sub frame, and outputs the grey level data of the current frame when driving the second sub frame;

a second memory that outputs a grey level data of a previous frame, in case that the second control signal is input from the controller, when driving the first sub frame and the second sub frame; and

a data grey level signal converter that, when driving the first sub frame, is supplied with a grey level data of a current frame from the data grey level signal source, is supplied with a grey level data of a previous frame from the second frame memory, and outputs a compensated grey level data, and, when driving the second sub frame, is supplied with a grey level data of a current frame from the first frame memory, is supplied with a grey level data of a previous frame from the second frame memory, and outputs a compensated grey level data to the data driver portion.

[Claim 15]

The driving device according to claim 10, wherein the data grey level signal compensation portion supplies the compensated grey level data to the data driver portion using a progressive scanning method.

[Claim 16]

The driving device according to claim 15, wherein the data grey level signal compensation portion includes:

a first memory that outputs a grey level data of a $(n-2)^{th}$ frame already stored when driving a n^{th} frame, stores a grey level data of a $(n+1)^{th}$ frame when driving a $(n+1)^{th}$ frame, and outputs a grey level data of a $(n+1)^{th}$ frame already stored when driving a $(n+2)^{th}$ frame;

a second memory that stores a grey level data when driving a n^{th} frame, outputs a grey level data of a n^{th} frame already stored when driving a $(n+1)^{th}$ frame, and outputs a grey level data of a n^{th} frame already stored when driving a $(n+2)^{th}$ frame;

a third memory that outputs a grey level data of a $(n-1)^{th}$ frame already stored when driving a n^{th} frame, outputs a grey level data of a $(n-1)^{th}$ frame already stored when driving a $(n+1)^{th}$ frame, and stores a grey level data of a $(n+2)^{th}$ frame already stored when driving a $(n+2)^{th}$ frame;

a controller that controls writing and reading of grey level data of the first to third memories; and

a data grey level signal converter that, when driving a n^{th} frame, is supplied with grey level data from the first and third memories and outputs a compensated grey level data, and, when driving a $(n+1)^{th}$ frame, is supplied with grey level data from the second and third memories and outputs a compensated grey level data, and, when driving a $(n+2)^{th}$ frame, is supplied with grey level data from the first and second memories and outputs a compensated grey level data.

[Claim 17]

The driving device according to claim 16, wherein a storing frequency of grey level data stored in the first to third memories is stored as a first frequency, and an output frequency of grey level data output from the first to third memories is a second frequency that is twice of the first frequency.

[Claim 18]

The driving device according to claim 14 or 16, wherein the memory is a frame memory.

[Claim 19]

A method of driving a liquid crystal display device having a moving picture compensation function, the device including a plurality of gate lines, a plurality of data lines insulated from and crossing the gate lines, and a plurality of pixels formed at regions surrounded by the gate lines and the data lines, each having a switching element connected to the gate line and the data line, and arranged in a matrix form, the method comprising:

(a) a step of supplying scanning signals to the gate lines sequentially;

(b) a step of dividing one picture frame supplied from an external data grey level signal source into at least two sub frames;

(c) a step of comparing a grey level signal of a current frame and a grey level signal of a previous frame according to a grey level signal of a current frame being input;

(d) a step of, in case that a grey level signal of a current frame is check greater than a grey level of a previous frame in the step (c), conducting an overshoot driving and generating a first data driving voltage when driving a sub frame located at a first half portion out of the divided sub frames, and conducting a down driving to a target value from the overshot value and generating a second driving voltage when driving a sub frame located at a second half portion out of the divided sub frames;

(e) a step of, in case that a grey level signal of a current frame is check less than a grey level of a previous frame in the step (c), conducting an undershoot driving and generating a third data driving voltage when driving a sub frame located at a first half portion out of the divided sub frames, and conducting an up driving to a target value from the undershot value and generating a fourth driving voltage when driving a sub frame located at a second half portion out of the divided sub frames; and

(f) a step of supplying the first to fourth driving voltages generated in the steps (c) and (d) to the data line, thereby making a response speed of liquid crystal high.

[Claim 20]

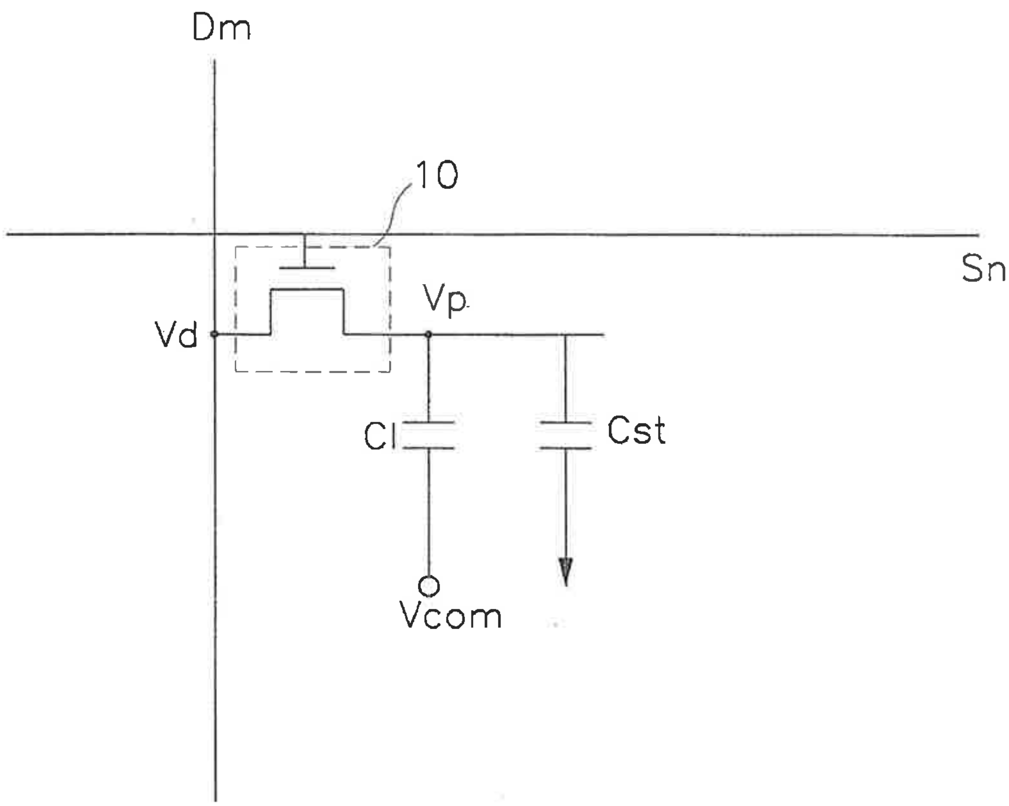
The method according to claim 19, further comprising a step of, in case that a grey level signal of a current frame is check equal to a grey level of a previous frame in the step (c), bypassing a non-compensated grey level signal and supplying a data voltage corresponding to the bypassed grey level signal to the data line.

[Claim 21]

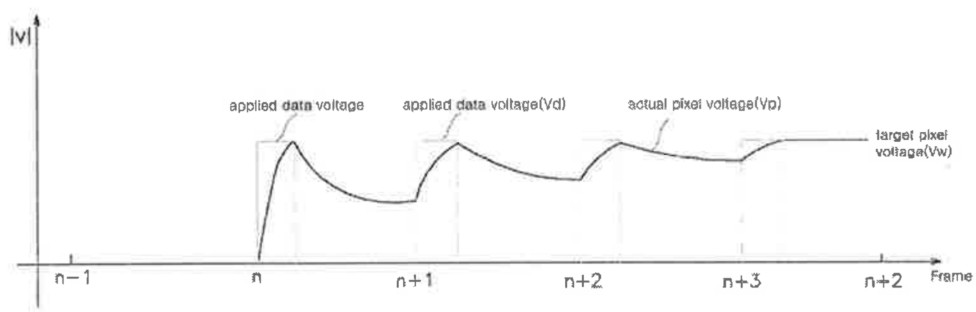
The method according to claim 19, wherein in case that the divided sub frames are two, the sub frame located at the first half portion is a first sub frame, and the sub frame located at the second half portion is a second sub frame.

[DRAWINGS]

[FIG. 1]

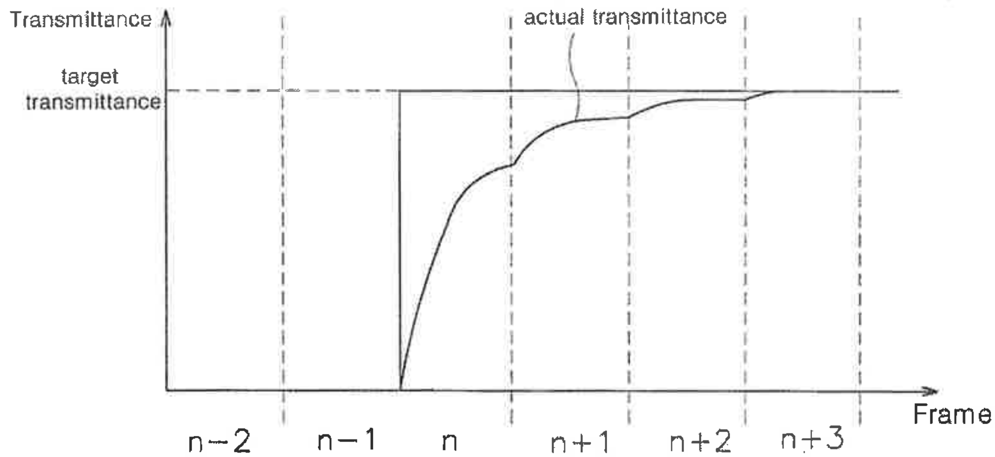


[FIG. 2]

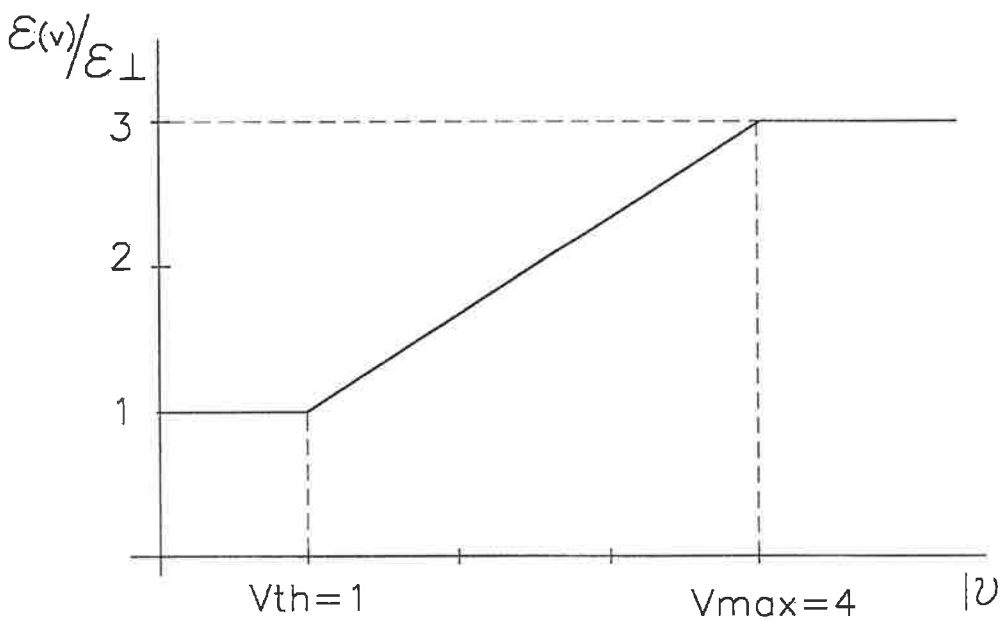


LGD_000592

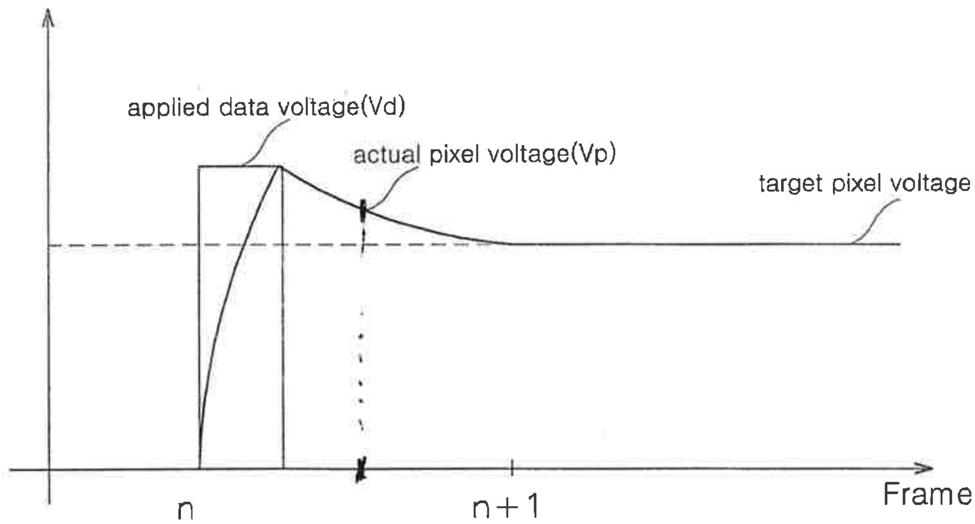
[FIG. 3]


Transmittance
actual transmittance
target transmittance
Frame
n−2
n−1
n
n+1
n+2
n+3

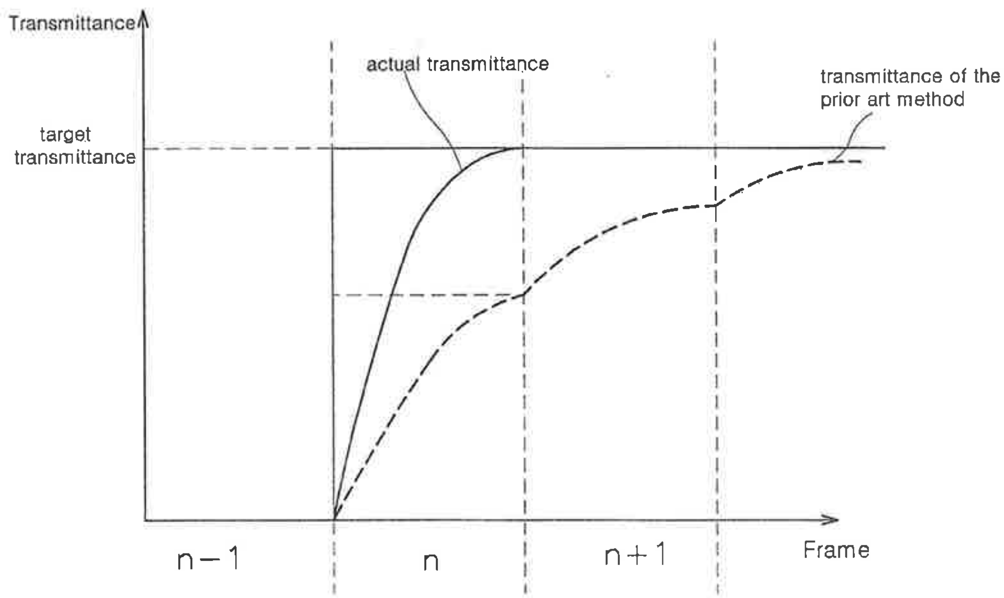
[FIG. 4]


ε(v)/ε⊥
3
2
1
Vth=1
Vmax=4
|v|

[FIG. 5]

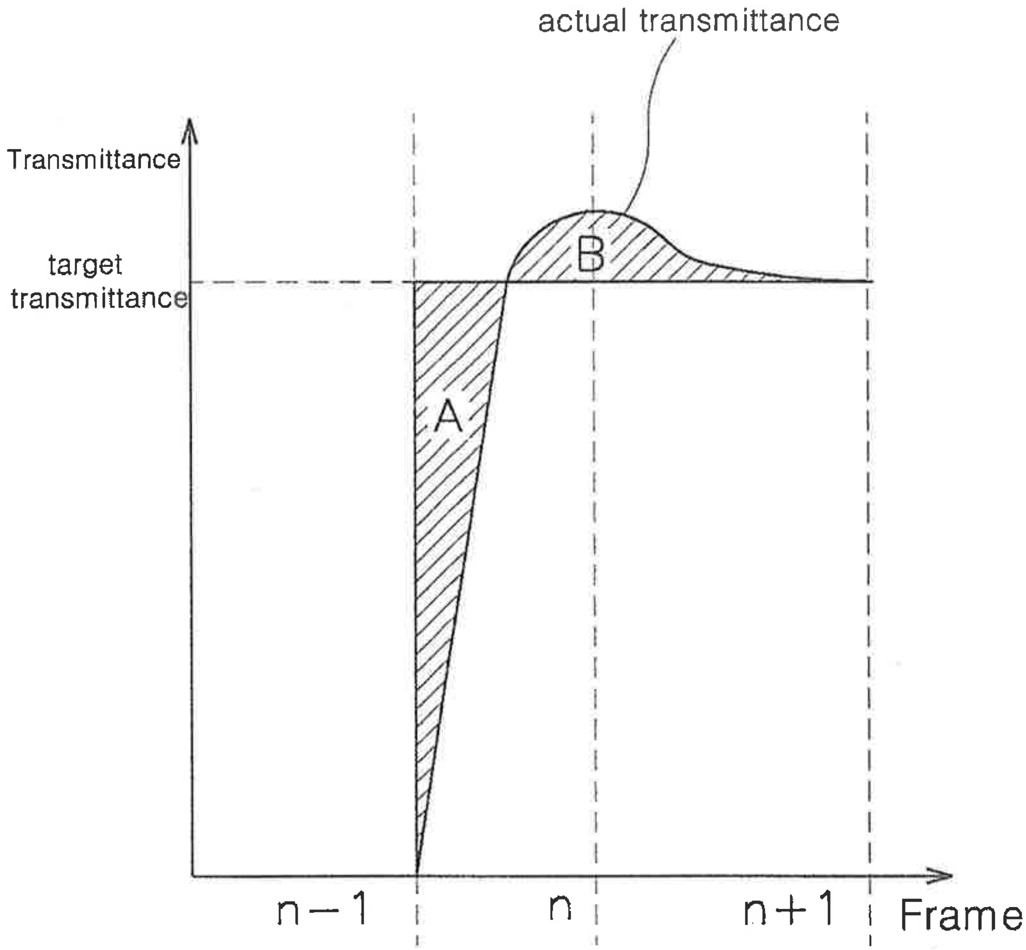


[FIG. 6]



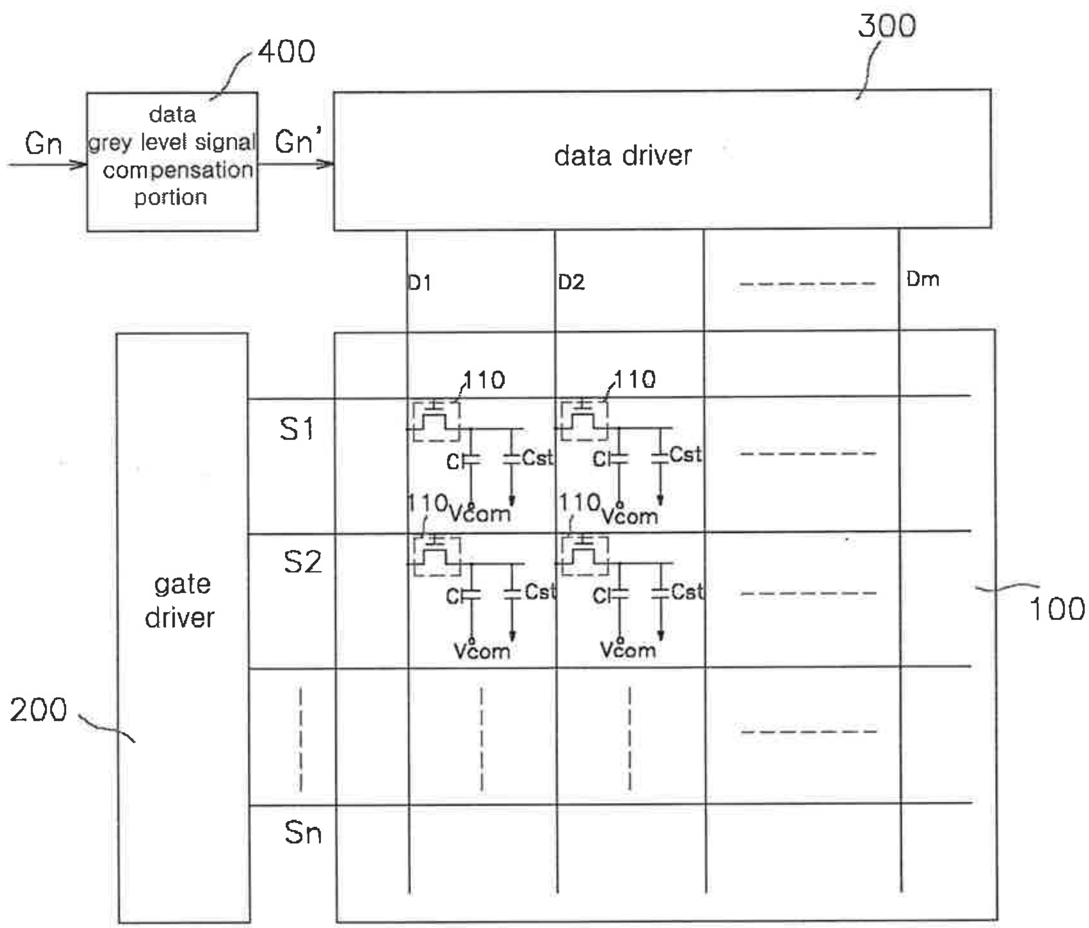
LGD_000594

[FIG. 7]



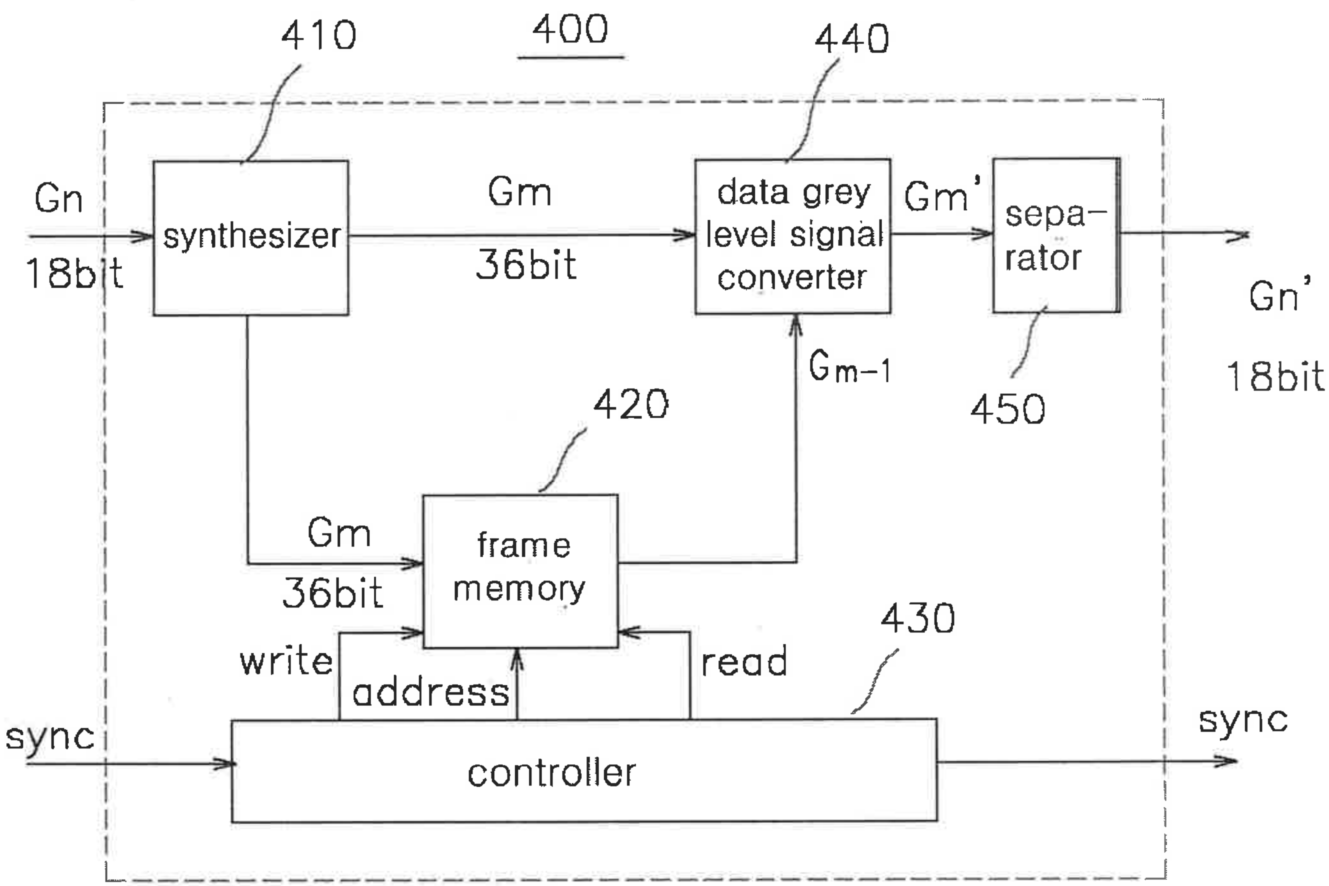
actual transmittance
Transmittance
target
transmittance
B
A
n−1
n
n+1
Frame

[FIG. 8]



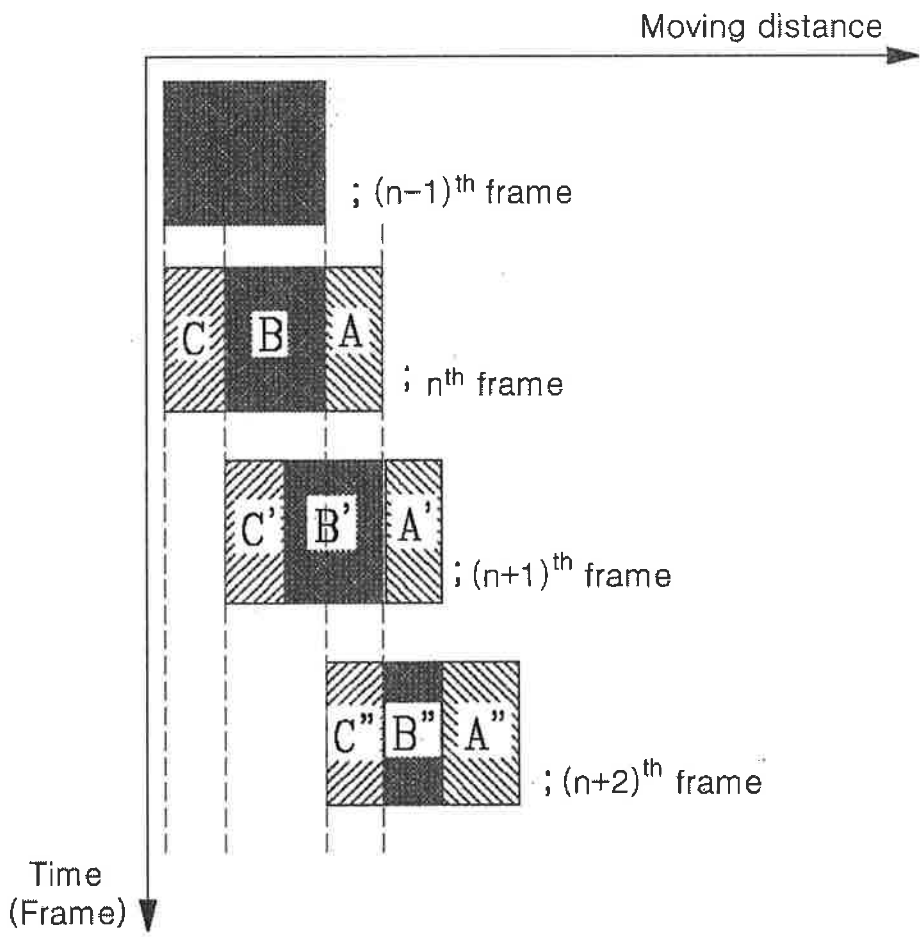
LGD_000596

[FIG. 9]



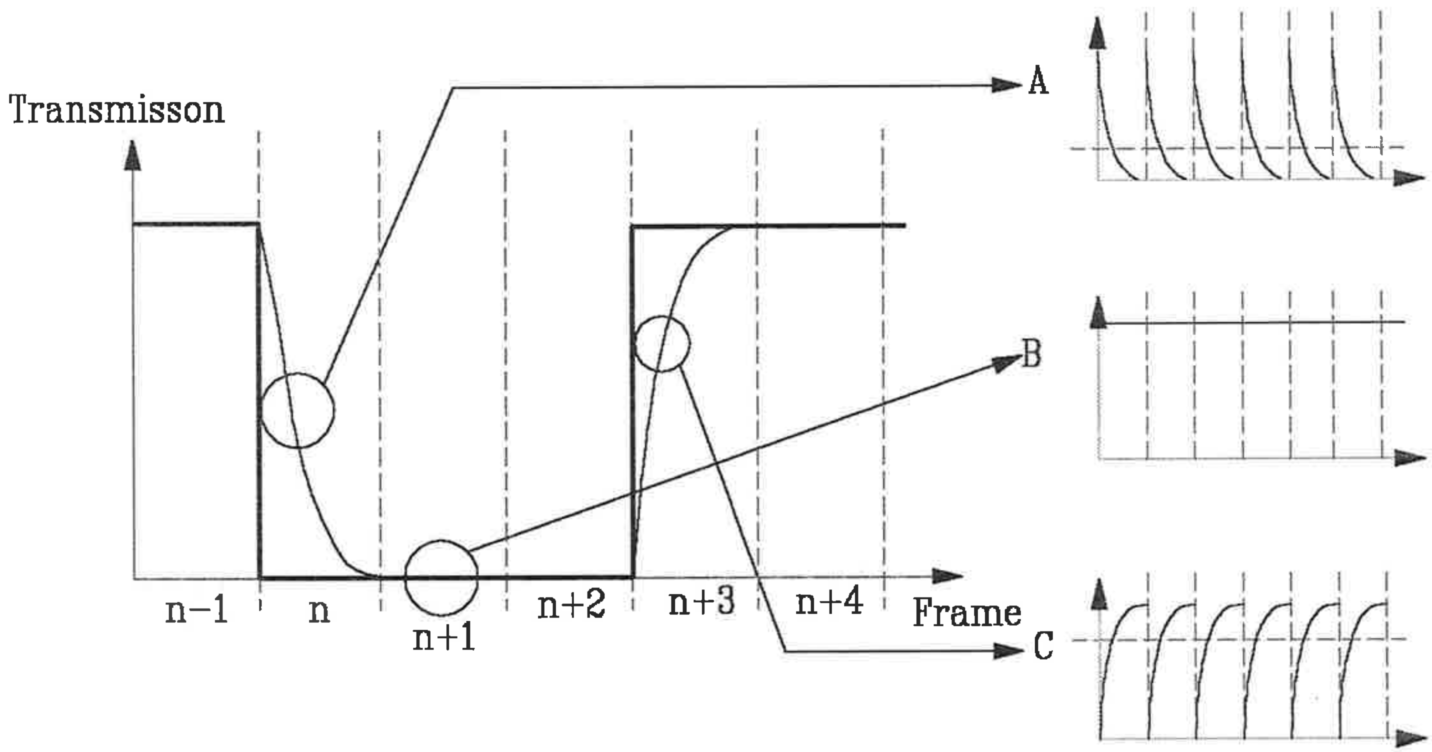
LGD_000597

[FIG. 10]



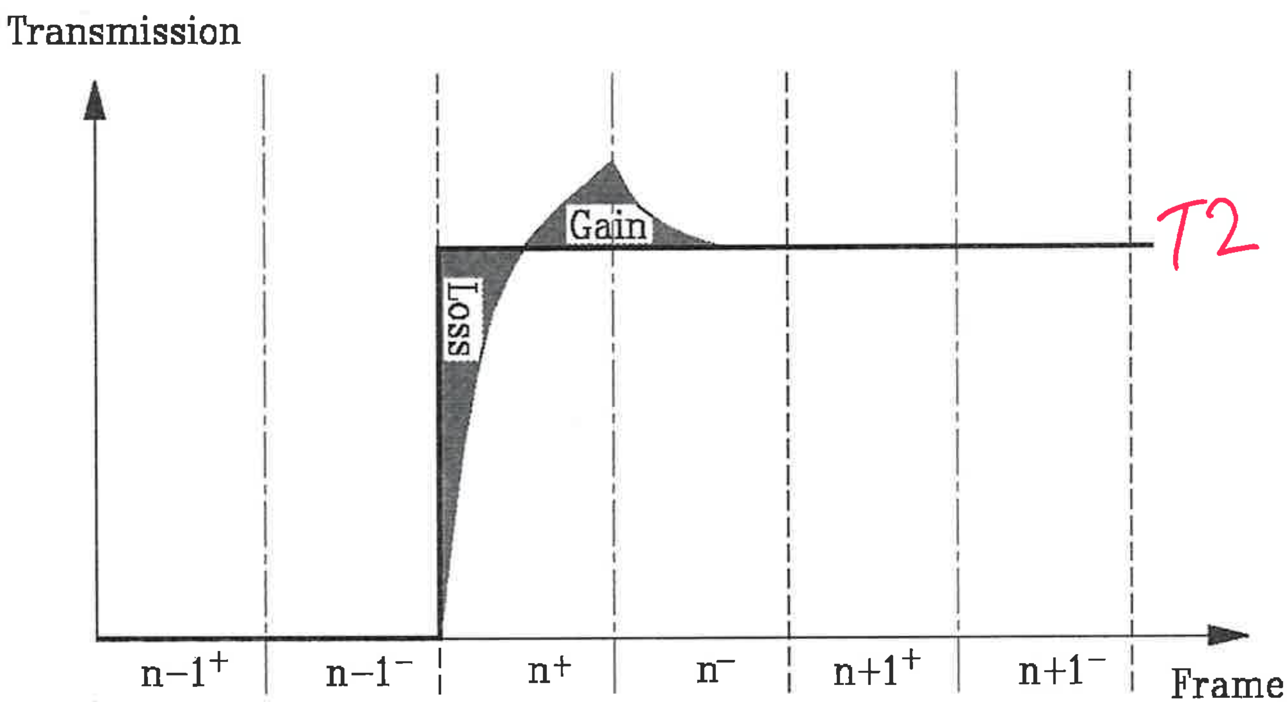
LGD_000598

[FIG. 11]

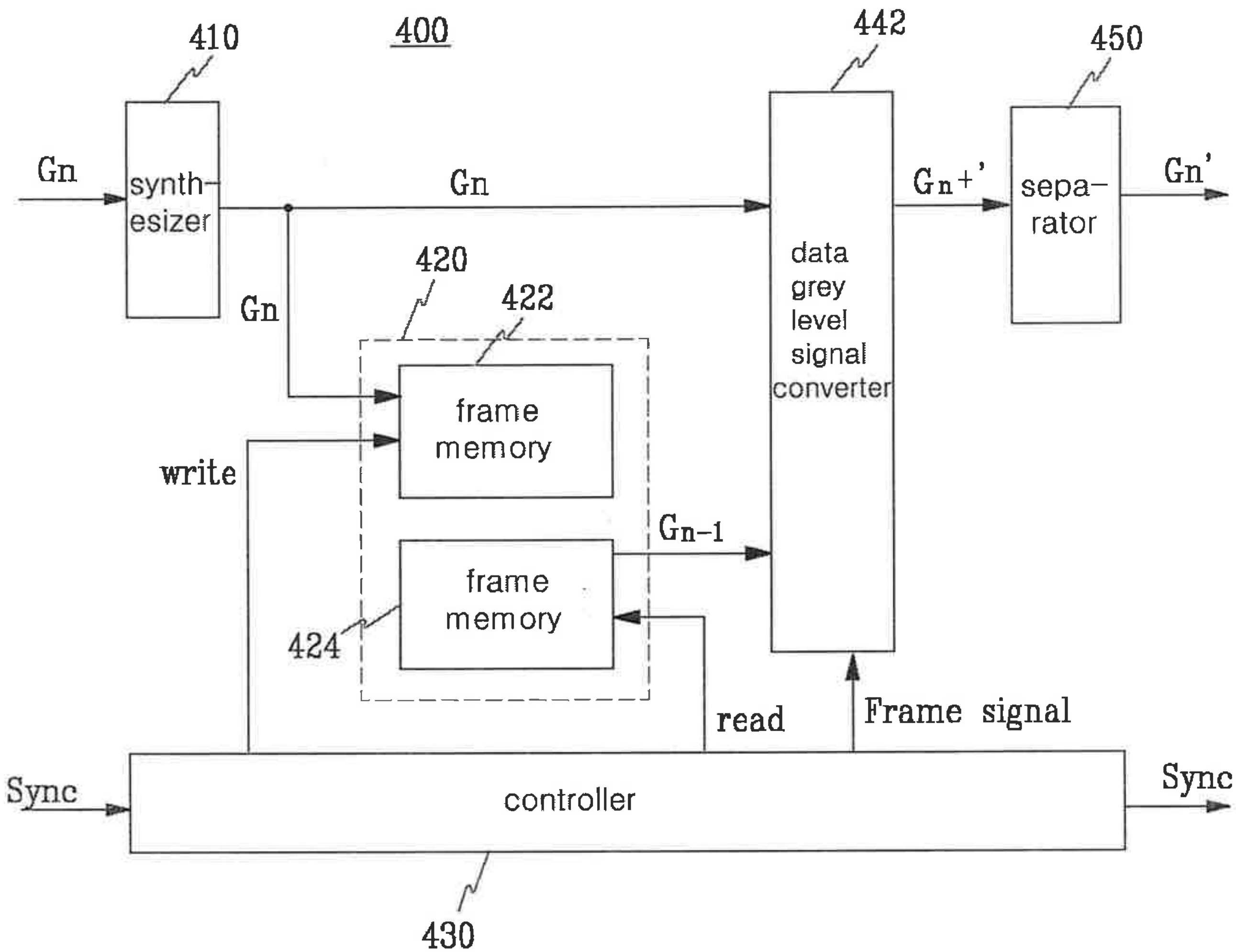


LGD_000599

[FIG. 12]

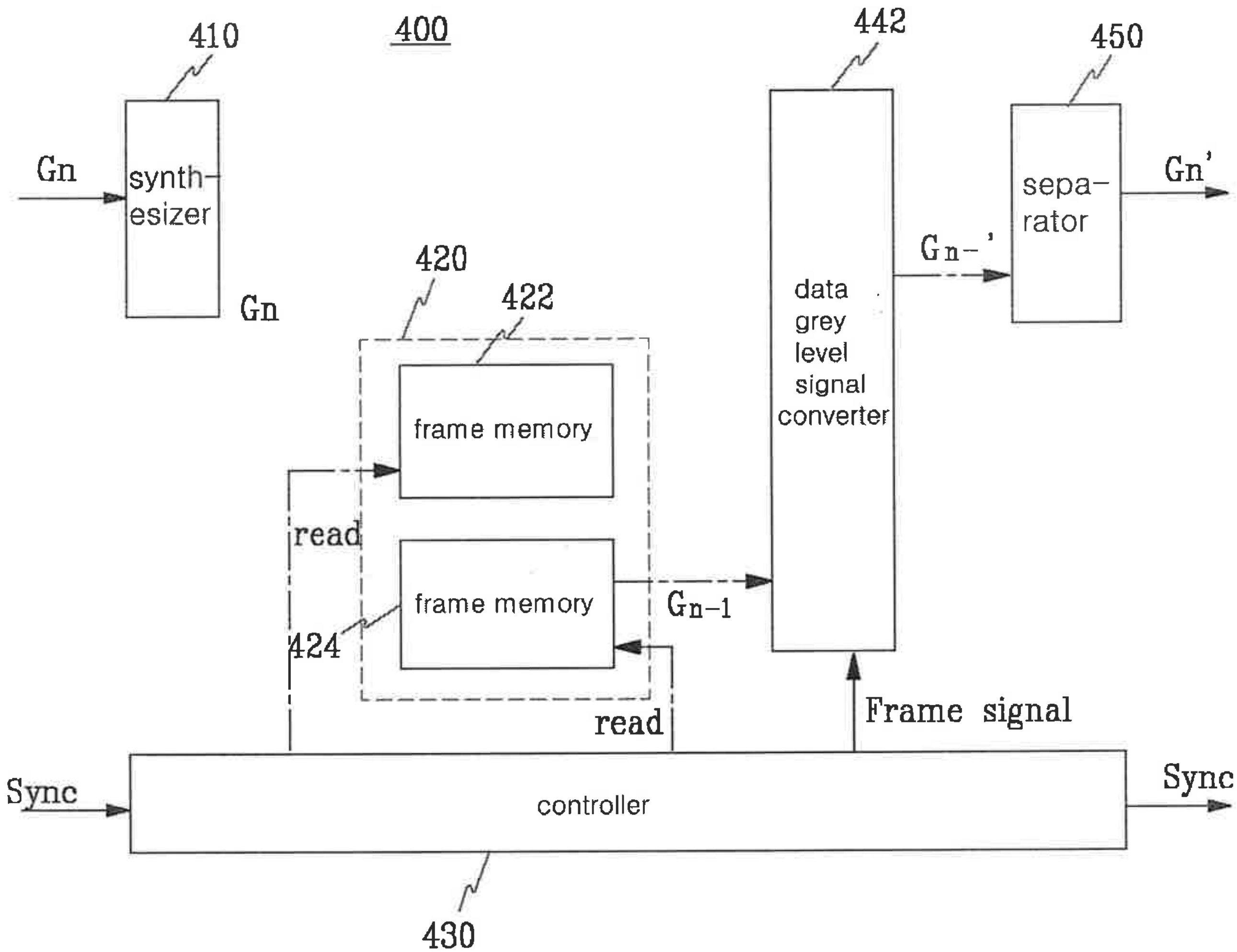


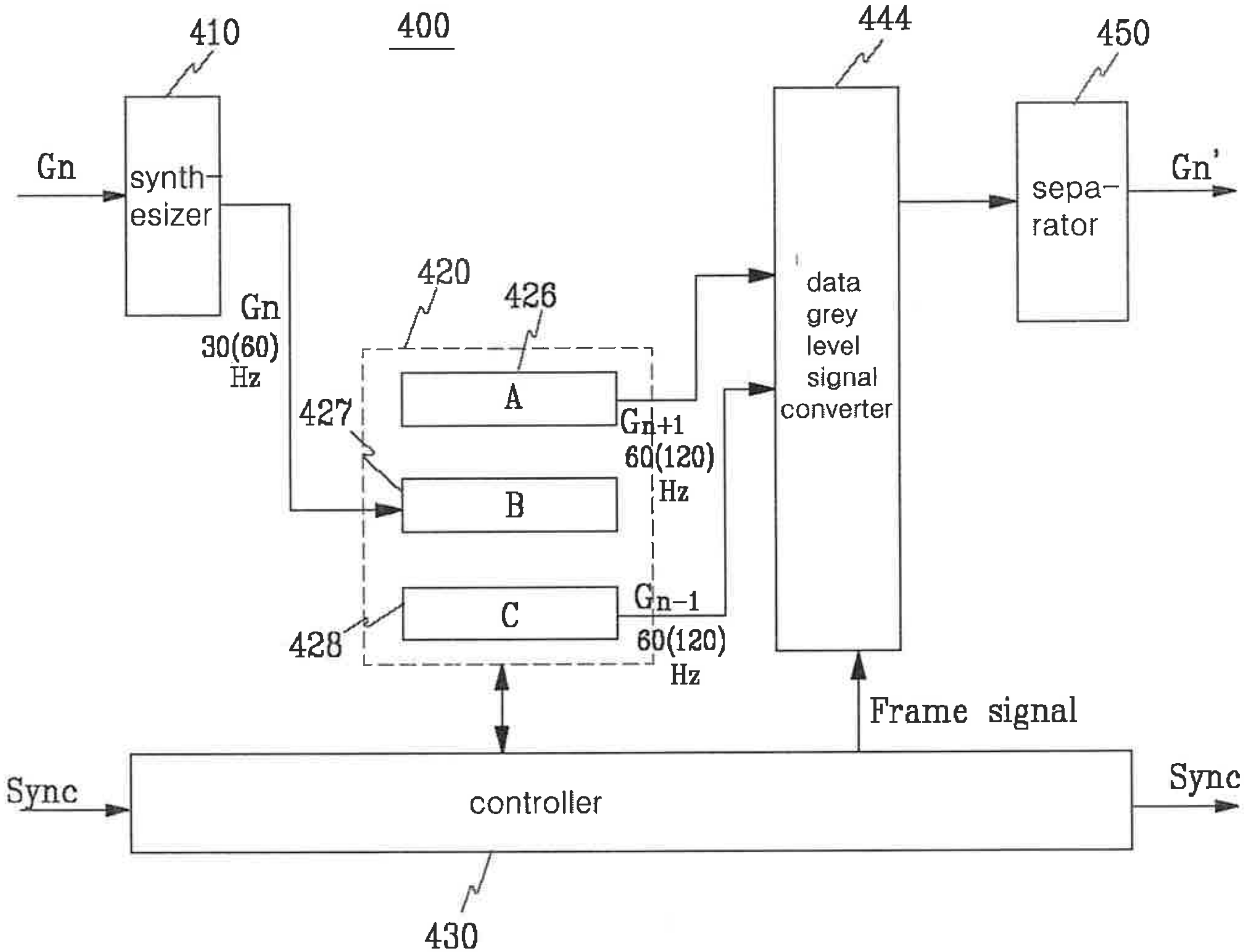
[FIG. 13a]



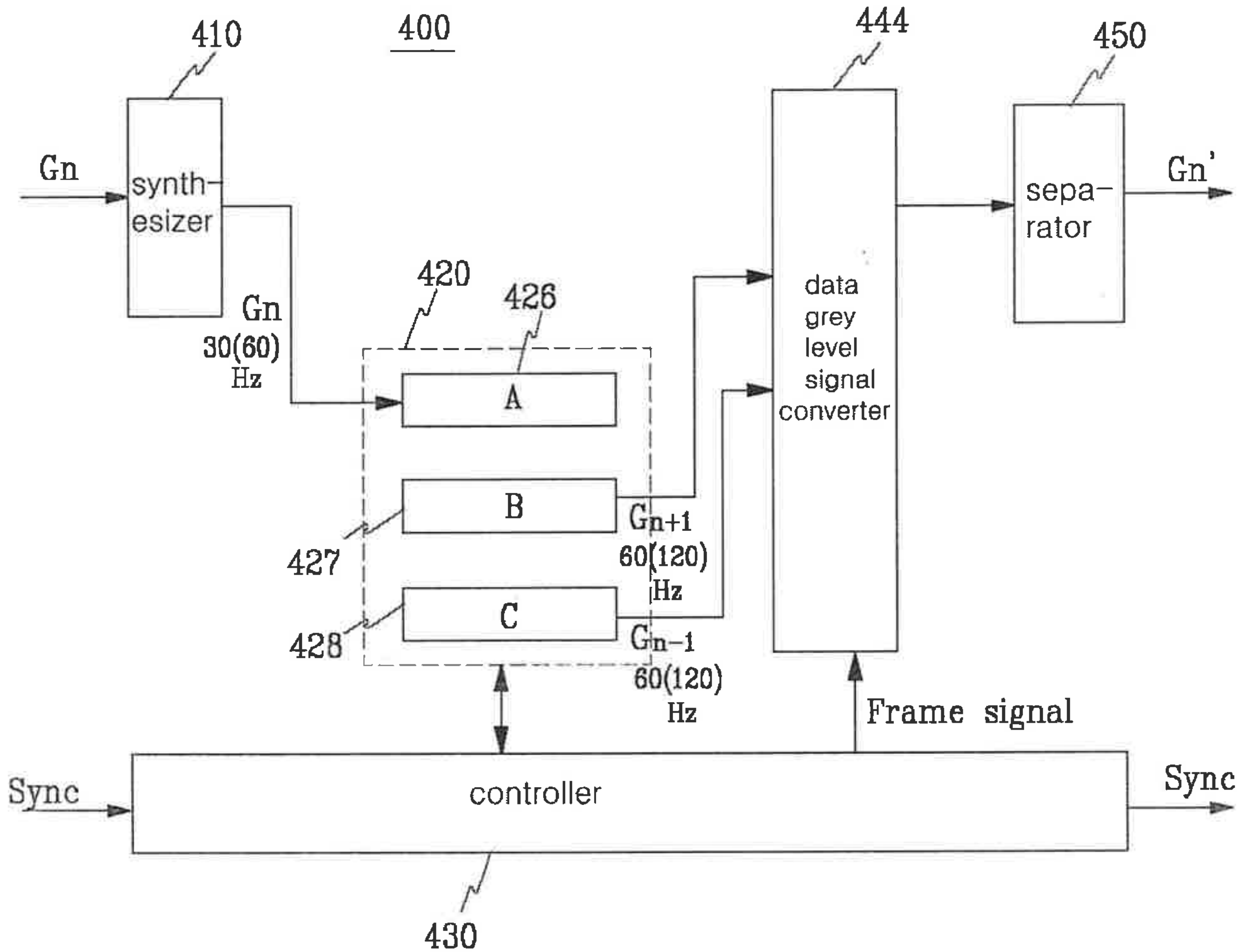
LGD_000601

[FIG. 13b]


400
410
Gn
synth-
esizer
Gn
420
422
frame memory
read
frame memory
424
Gn-1
read
442
data
grey
level
signal
converter
Gn-'
450
sepa-
rator
Gn'
Frame signal
Sync
controller
Sync
430

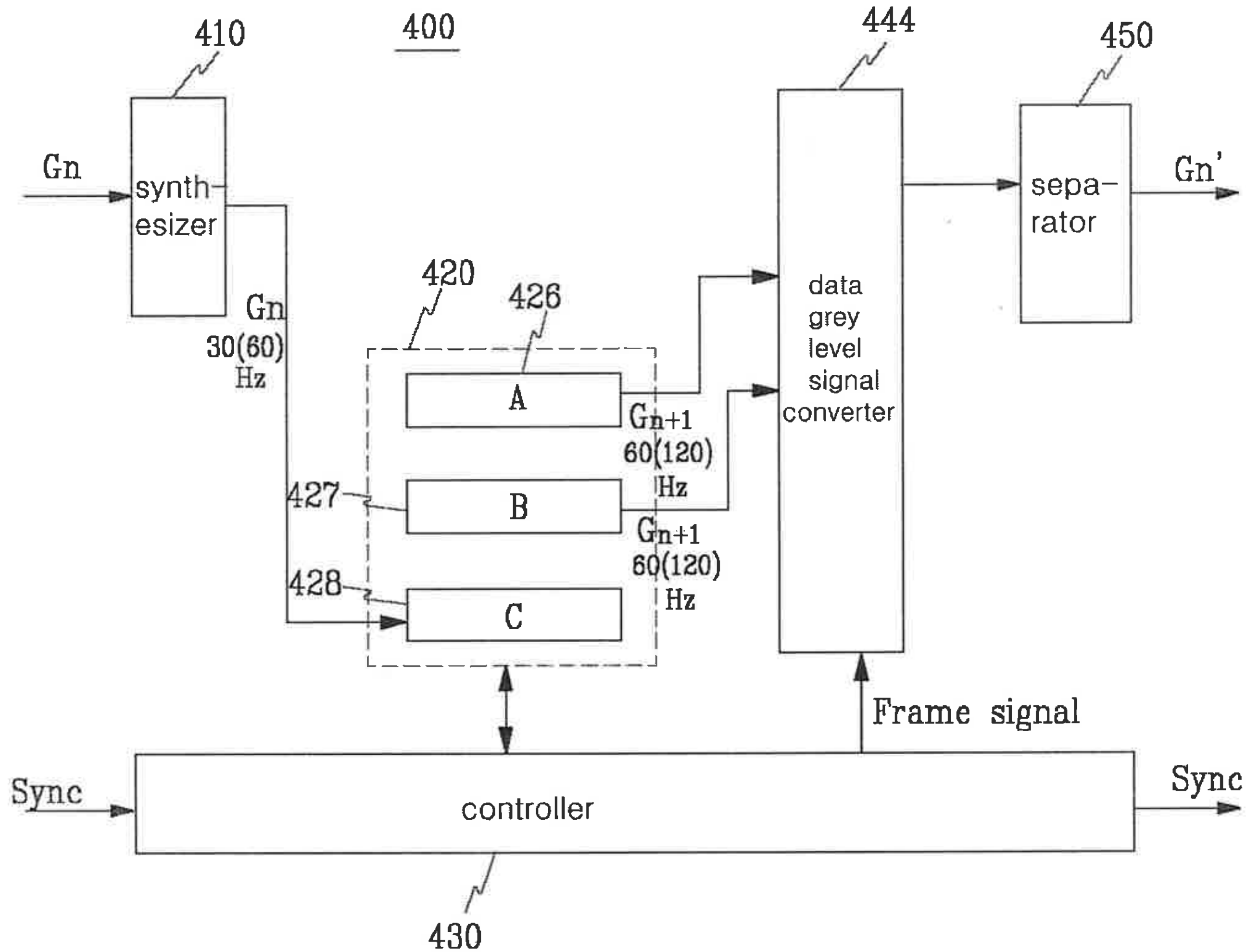

400
410
Gn
synth-
esizer
Gn
30(60)
Hz
420
426
A
427
B
C
428
Gn+1
60(120)
Hz
Gn-1
60(120)
Hz
444
data
grey
level
signal
converter
450
sepa-
rator
Gn'
Frame signal
Sync
controller
Sync
430

[FIG. 14a]


400
410
420
426
427
428
430
444
450
Gn
synth-esizer
Gn
30(60) Hz
A
B
C
Gn+1
60(120) Hz
Gn-1
60(120) Hz
data grey level signal converter
sepa-rator
Gn'
Frame signal
Sync
controller
Sync

[FIG. 14b]

[FIG. 14c]



LGD_000605

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG DISPLAY CO., LTD.
Petitioner

v.

SURPASS TECH INNOVATION LLC
Patent Owner

Case: IPR2015-00885

Patent 7,202,843

DECLARATION OF RICHARD ZECH, PH.D.

I. INTRODUCTION

1. My name is Dr. Richard G. Zech, and I have been retained by the law firm of Mayer Brown LLP on behalf of LG Display Co. Ltd. and LG Display America, Inc. as an expert in the relevant art.

2. I have been asked to provide my opinions and views on the materials I have reviewed in this case related to Ex. 1001, U.S. Patent No. 7,202,843 ("the '843 Patent") ("the patent-at-issue"), and the scientific and technical knowledge regarding the same subject matter before and for a period following the date of the first application for the patent-at-issue was filed.

3. I am compensated at a rate of $250 per hour for my work, plus reimbursement for expenses. My compensation does not depend on the outcome of this proceeding, nor has it influenced any of my opinions in this matter.

4. My opinions and underlying reasoning for this opinion are set forth below.

A. Background And Qualifications

5. A detailed record of my professional qualifications is set forth in the attached Appendix A (my curriculum vitae), including a list of publications, awards, research grants, and professional activities. A list of my previous testimony by deposition and at trial is included in my curriculum vitae (CV).

6. I graduated from Lawrence Institute of Technology (now Lawrence University)

in 1965 with a B.S. in Electrical Engineering, being a Founder's Scholar each year of my undergraduate studies. I then graduated from University of Michigan in December 1966 with an MSEE degree and in May 1974 with a Ph.D. in Electrical Engineering with Computer Science and Photonics minors. While at the University of Michigan, I studied under leading modern optical science information processing pioneers, including Prof. Dr. E. N. Leith, Dr. A. Kozma, Dr. A. Vander Lugt, and Prof. Dr. Dennis Gabor (1971 Nobel laureate in physics).

7. I am currently President and Managing Principal of the ADVENT Group, which provides forensic consumer electronics test and evaluation, market research, product development, R&D, engineering, and technology assessment services in the areas of optical and computer storage, flat panel displays, digital cameras, nanotechnology, microelectromechanical systems (MEMS), and photonics. ADVENT Group's main areas of expertise include consumer electronic technologies, such as digital cameras and imaging, displays (monitors and TVs), scanners, small computer systems and components, and optical drive and media technologies. I have held VP positions in Engineering, Marketing and Sales, and Strategic Planning. In 1990 I was President and COO of the New Interfile Corporation. I therefore have both a knowledge of and perspective on the industries in which I have expertise, including flat panel displays.

8. At the University of Michigan I began a lifetime of research and development

in the highly specialized areas of optical data and image storage, processing, computing, and communications, as well as image capture and display. While completing my Masters and Doctorate education at the University of Michigan, I performed research in the areas of holography, optical data processing and storage, light-sensitive materials, lasers, displays, and grating ruling engines. I also worked on research and development of pioneering recording and processing systems for optical storage and image correction and enhancement.

9. I have extensive experience with displays of various types. In the 1960s and 1970s, I worked with liquid crystal displays for numerous applications. The primary ones being as page composers (input devices) for prototype 3D holographic memories for NASA and large (up to 4x5 foot) monochrome and color displays for data fusion analysis (classified USAF contract; an early part of the 30-minute war scenario project). By today's standards, this was all very crude. I also worked on head-up displays for USAF fighter aircraft and holographic optical elements (HOE) for FLIR (forward looking infrared) sensors. In the 1980s my interests turned to plasma displays, which were well developed, for example, by IBM. In 1995 at the National Association of Broadcasters (NAB) Show I saw the future thanks to a demonstration at the Toshiba booth: real high-definition TV shown on a large (1920x1080) liquid crystal display (LCD). From that time to the present, LCDs have been an important part of my consulting practice.

10. I have nearly 50 years of electrical and computer engineering experience in research and development, product development, systems engineering, and program management, including being principal investigator role. My work experience relates to advanced technologies for capturing, processing, and storing large data sets, such as LandSAT satellite data for NASA and the Department of Defense. I have been involved with pioneering work in the fields of holography, 3D holographic memories, optical data storage on disc, tape, and card, flat panel displays, lasers, materials science, and input/output devices. Since my graduation from the University of Michigan, I have taken numerous courses and seminars to increase my technical knowledge, and I have published nearly 200 papers and reports.

11. In the 1980s, as part of my modernization plan while Director of Communications systems (later, VP/Chief Technology Officer) at McGraw-Hill, I introduced personal computers (PCs), local area networks (LANs), document image management systems with an emphasis on displays for electronic information products. Starting in the 1990s, I have been researching ways to improve the performance, reliability, and lower the cost of high-performance of LCD and other types of displays.

12. I also have considerable experience with light emitting diodes (LEDs) and CCD and CMOS (complementary metal oxide semiconductor) image sensors through my work in 3D holographic memories (in which the image sensor is the output

device, and digital cameras). LEDs are now the preferred light source for backlighting LCDs.

B. Information Considered

13. In addition to my general knowledge gained as a result of my education and experience in this field, I have reviewed and considered, among other things, the '843 Patent, its prosecution history, the prior art of record, and certain other prior art references as discussed in this declaration.

14. The full list of information that I have considered in forming my opinions for this report is set forth throughout the report and listed in the attached Appendix B.

II. Legal Standards

15. In forming my opinions and considering the patentability of the claims of the '843 Patent, I am relying upon certain legal principles that counsel has explained to me.

16. I understand that for an invention claimed in a patent to be found patentable, it must be, among other things, new and not obvious in light of what came before it. Patents and publications which predated the invention are generally referred to as "prior art."

17. I understand that in this proceeding the burden is on the party asserting unpatentability to prove it by a preponderance of the evidence. I understand that "a

preponderance of the evidence" is evidence sufficient to show that a fact is more likely than not.

18. I understand that in this proceeding, the claims must be given their broadest reasonable interpretation consistent with the specification. The claims after being construed in this manner are then to be compared to information that was disclosed in the prior art.

A. Person of Ordinary Skill in the Art

19. I have been informed that the claims of a patent are judged from the perspective of a hypothetical construct involving "a person of ordinary skill in the art." The "art" is the field of technology to which the patent is related. I understand that the purpose of using a person of ordinary skill in the art's viewpoint is objectivity. Thus, I understand that the question of validity is viewed from the perspective of a person of ordinary skill in the art, and not from the perspective of (a) the inventor, (b) a layperson, or (c) a person of extraordinary skill in the art. I have been informed that the claims of the patent-at-issue are interpreted as a person of ordinary skill in the art would have understood them in the relevant time period (*i.e.*, when the patent application was filed or earliest effective filing date).

20. It is my opinion that a one of ordinary skill in the art would be an electrical engineer with at least a BS degree (preferably a MS degree) and 3-5 years of circuit design experience.

21. I understand that a "person of ordinary skill is also a person of ordinary creativity, not an automaton" and that would be especially true of anyone developing technology for LCD panels.

B. Anticipation

22. I understand that the following standards govern the determination of whether a patent claim is "anticipated" by the prior art. I have applied these standards in my analysis of whether claims of the '843 Patent were anticipated at the time of the invention.

23. I understand that a patent claim is "anticipated" by a single prior art reference if that reference discloses each element of the claim in a single embodiment. A prior art reference may anticipate a claim inherently if an element is not expressly stated, if the prior art *necessarily* includes the claim limitations.

24. I understand that the test for anticipation is performed in two steps. First, the claims must be interpreted to determine their meaning. Second, a prior art reference is analyzed to determine whether every claim element, as interpreted in the first step, is

present in the reference. If all the elements of a patent claim are present in the prior art reference, then that claim is anticipated and is invalid.

25. I understand that it is acceptable to examine extrinsic evidence outside the prior art reference in determining whether a feature, while not expressly discussed in the reference, is necessarily present within that reference.

C. Obviousness

26. I understand that a claim can be invalid in view of prior art if the differences between the subject matter claimed and the prior art are such that the claimed subject matter as a whole would have been "obvious" at the time the invention was made to a person having ordinary skill in the art.

27. I understand that the obviousness standard is defined at 35 U.S.C. § 103(a). I understand that a claim is obvious over a prior art reference if that reference, combined with the knowledge of one skilled in the art or other prior art references discloses each and every element of the recited claim.

28. I also understand that the relevant inquiry into obviousness requires consideration of four factors:

a. The scope and content of the prior art;

b. The differences between the prior art and the claims at issue;

c. The knowledge of a person of ordinary skill in the pertinent art; and

d. Objective factors indicating obviousness or non-obviousness may be present in any particular case, such factors including commercial success of products covered by the patent claims; a long-felt need for the invention; failed attempts by others to make the invention; copying of the invention by others in the field; unexpected results achieved by the invention; praise of the invention by the infringer or others in the field; the taking of licenses under the patent by others; expressions of surprise by experts and those skilled in the art at the making of the invention; and that the patentee proceeded contrary to the accepted wisdom of the prior art.

29. I understand that when combining two or more references, one should consider whether a teaching, suggestion, or motivation to combine the references exists so as to avoid impermissible hindsight. I have been informed that the application of the teaching, suggestion or motivation test should not be rigidly applied, but rather is an expansive and flexible test. For example, I have been informed that the common sense of a person of ordinary skill in the art can serve as motivation for combining references.

30. I understand that the content of a patent or other printed publication should be interpreted the way a person of ordinary skill in the art would have interpreted the reference as of the effective filing date of the patent application for the '843 Patent. I have assumed that the person of ordinary skill is a hypothetical person who is presumed to be aware of all the pertinent information that qualifies as prior art. In

addition, the person of ordinary skill in the art makes inferences and creative steps. He or she is not an automaton, but has ordinary creativity.

31. I have been informed that the application that issued as the '843 patent was filed in 2004. However, the application claims priority to a foreign parent application that was filed on November 17, 2003. As a result, I will assume the relevant time period for determining what one of ordinary skill in the art knew is November 17, 2003, the effective filing date for purposes of this proceeding.

D: Claim Construction

32. I have been informed that a claim subject to *Inter Partes* Review is given its "broadest reasonable construction in light of the specification of the patent in which it appears." I have been informed that this means that the words of the claim are given their plain meaning from the perspective of one of ordinary skill in the art unless that meaning is inconsistent with the specification. I understand that the "plain meaning" of a term means the ordinary and customary meaning given to the term by those of ordinary skill in the art at the time of the invention and that the ordinary and customary meaning of a term may be evidenced by a variety of sources, including the words of the claims, the specification, drawings, and prior art.

33. I understand that in construing claims "[a]ll words in a claim must be considered in judging the patentability of that claim against the prior art." (MPEP § 2143.03, citing *In re Wilson*, 424 F.2d 1382, 1385 (CCPA 1970)).

34. I understand that extrinsic evidence may be consulted for the meaning of a claim term as long as it is not used to contradict claim meaning that is unambiguous in light of the intrinsic evidence. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1324 (Fed. Cir. 2005) (citing *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1583-84 (Fed. Cir. 1996)).

35. I also understand that in construing claim terms, the general meanings gleaned from reference sources must always be compared against the use of the terms in context, and the intrinsic record must always be consulted to identify which of the different possible dictionary meanings is most consistent with the use of the words by the inventor. *See, e.g., Ferguson Beauregard/Logic Controls v. Mega Systems*, 350 F.3d 1327, 1338 (Fed. Cir. 2003) (citing *Brookhill-Wilk 1, LLC v. Intuitive Surgical, Inc.*, 334 F.3d 1294, 1300 (Fed. Cir. 2003)).

III. THE '843 PATENT

A. Specification Of The '843 Patent

36. The '843 Patent generally relates to circuits and methods for driving a liquid crystal display ("LCD") panel. The LCD panel 30 described in the '843 Patent includes a number of well-known components common in prior art LCD panels,

including a plurality of scan lines 32 (also called gate lines), a plurality of data lines 34, and a plurality of pixels 36. Ex. 1001, at 1:27-31, 3:37-40.

37. Each pixel 36 includes a switching device 38 (e.g., a thin-film transistor, also known as a "TFT") and a liquid crystal device 39 (also called a "pixel electrode"). *Id.* at 3:40-43. These components are shown in Fig. 4 of the '843 Patent (annotated and reproduced below), which also shows that the gate of the switching device 38 in each pixel is connected to the corresponding scan line 32, while the source of the switching device in the pixel is connected to the corresponding data line 34. *Id.* at 3:43-47.

38. The LCD panel 30 is driven by applying scan line voltages to the scan lines 32 to turn on the switching devices 38 and applying data impulses to the data lines 34 to charge the liquid crystal devices 39 via the switching devices 38. *Id.*

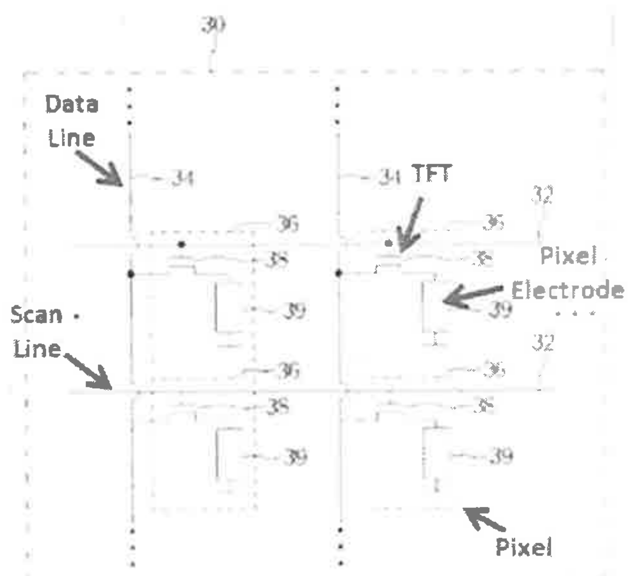


Fig. 4

The time that the pixel electrode needs to react to a driving voltage is called "response time." As was well known prior to November 17, 2003 (the effective filing date for the '843 Patent), the quality of a video image shown on an LCD panel is dependent, in part, on this response time; the faster the response time, the better the image quality. In this regard, the '843 Patent explains that a delay in the response time in an LCD panel causes image defects such as blurring, and describes the need for improving the LCD response speed. *Id.* at 1:21-26, 1:62-2:2.

39. The '843 Patent discusses and claims two previously known techniques for improving the response time – and resultant image quality – of LCDs: (1) "overdriving" the signal data; and (2) increasing the refresh rate (e.g., doubling the refresh rate) of the individual pixels.

40. As the '843 Patent explains, "overdriving" involves "applying a higher or a lower data impulse to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules, so that the pixel can reach the predetermined gray level in a predetermined frame period." *Id.* at 2:2-7.

41. In simple terms, overdriving enables a pixel to change from one gray level (i.e., shade of color) to another more quickly by either boosting or decreasing the requested pixel value (i.e., voltage). The intended effect is to increase the difference in

signal between the before and after pixel values such that the boosted signal will achieve the actual desired level of change (i.e., the non-boosted difference) more quickly.

42. In other words, by pushing (or pulling) the gray level harder (boosting the signal), the desired pixel value is obtained faster. The faster change in pixel value, because it takes less time, reduces the amount of time required for the pixel to change state, meaning the LCD has a faster response time.

43. The '843 Patent admits that the overdriving was known in the prior art. According to the '843 Patent, "***[s]ame as the prior art***, ***the larger*** the value of the ***pixel data*** is [i.e. overdriving], the higher the voltage of the corresponding data impulse is, and ***the larger the gray level value*** is." *See id.* at 4:17-19 (emphases added). In this regard, the '843 Patent acknowledges that the "conventional overdriving method" taught in the prior art could be used to increase LCD response speed. *Id.* at 1:60-2:11.

44. The '843 Patent identified U.S. Patent Application Publication No. 2002-0050965 A1 to Oda et al. as "one of the references of the conventional overdriving method." *Id.* Generally, an overdrive value – i.e., the amount to boost or decrease the data value – is computed by comparing a given pixel's ***previous*** gray level (also

referred to as "transmission rate") with the pixel's ***current*** gray level in order to predict whether and how much the gray level is increasing or decreasing. *Id.* at 5:34-44. The '843 Patent does not add anything new to this already known method for computing the overdrive value.

45. The '843 Patent alleges that, while capable of improving response time to a certain extent, overdriving alone does not achieve adequate performance, namely reaching a desired transmission rate within a single frame period. *See id.* at 2:7-12, Fig. 2. As shown in Figure 2 of the '843 Patent (reproduced below), a single overdriven signal C2 is purportedly unable to reach a target transmission rate T2 within a single frame period N. Rather, according to this Figure, in the prior art, C2 would only reach T2 in the next frame period, N+1. According to the disclosure, since the pixels are unable to reach predetermined grey levels within a given frame period, the image could experience blurring. *Id.* at 1:21-37.

46. To enable a signal to reach a target transmission rate T2 within a single frame period, the '843 Patent suggests applying two or more overdriven impulses to each pixel within the given frame period. *Id.* at 4:20-40. For example, as shown in Figure 6

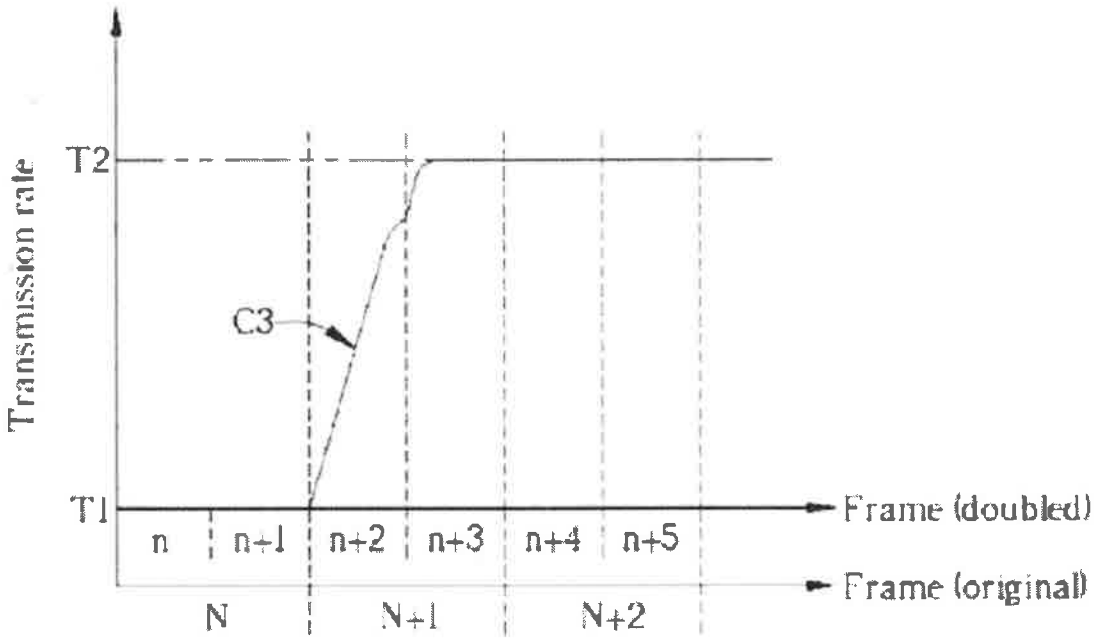


Fig. 6

of the '843 Patent (reproduced below), each single frame period is divided into two segments. The Frame N+1 is divided into the segments n+2 and n+3. Two overdriven data impulses are then applied to these two segments (e.g., one impulse during n+2 and a second during n+3) to the pixel within the given frame period (e.g., N+1). This method allegedly allows the signal to reach a target transmission rate (T2) within a single frame period (e.g., N+1). *Id.* at 1:39-41, 3:15-4:43, 5:45-55.

47. Figure 3 (reproduced below, left) schematically illustrates an embodiment of the circuit for driving the LCD panel 30. The driving circuit 10 includes a blur clear

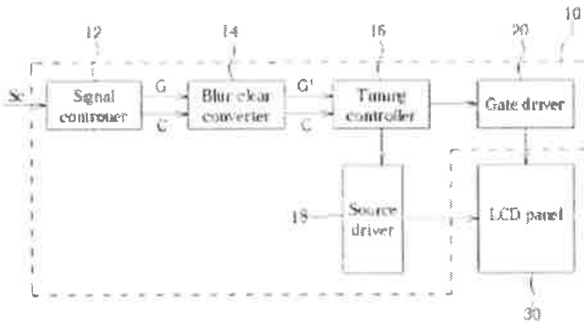


Fig. 3

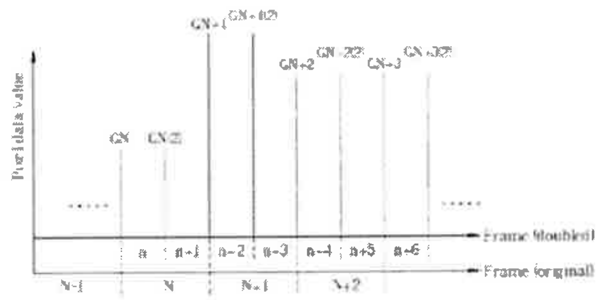


Fig. 5

converter 14, a source driver 18, and a gate driver 20. The blur clear converter 14 continuously receives, through a signal controller 12, a plurality of frame data G. The frame data includes the data necessary to drive all of the pixels of the panel 30. The blur clear converter 14 then generates the overdriven pixel data for each pixel within each frame period based on the frame data. *Id.* at 3:24-28. Figure 5 (reproduced below, right) shows two overdriven pixel data GN+1 and GN+1(2) generated by the blur clear converter 14 for each pixel in the frame period N+1.

48. The source driver 18 then converts the overdriven pixel data (e.g., GN+1 and GN+1(2)) into the corresponding data impulses. *Id.* at 3:28-36. The data impulses are applied to the liquid crystal device 39 of a pixel within the frame period (e.g., at each half of the frame period N+1) via the data line 34 in order to control the transmission rate of the liquid crystal device 39. *Id.* at 4:8-14. The gate driver 20 generates the

corresponding scan line voltage and applies it to the scan line 32 to turn on the switching device 38 of the pixel so that the data impulses from the source driver 18 can be applied to the liquid crystal device 39 of the pixel. *Id.* at 3:28-36.

B. Claims 1, 4, 8, and 9 Of The '843 Patent

49. Independent Claim 1 of the '843 Patent is an apparatus claim directed to a driving circuit for driving an LCD panel. The claimed driving circuit "generat[es] a ***plurality of overdriven*** pixel data within every frame period for each pixel." (*Id.* at Claim 1) (emphasis added). Thus, Claim 1 (and Claims 2 and 3 depending therefrom) requires circuitry for applying ***two or more overdriven*** impulses to each pixel within a frame period, as shown in Figures 5 and 6 above.

50. Independent Claim 4 is a method claim directed to driving an LCD display. In contrast to Claim 1, Claim 4 (and claims 5-9 depending therefrom) merely require "generating a ***plurality*** of data impulses for each pixel within every frame period according to the frame data." (*Id.* at Claim 4) (emphasis added). Thus, Claims 4-9 do not require performing the overdrive technique.

IV. PRIOR ART ANALYSIS

51. I now turn to the references applied in the grounds for rejections discussed in the Petition for *inter partes* review. In my analysis, I will specifically address the following references:

Exhibit Nos.	Reference	Referred To As
1010	Korean Patent Application No. 2000-0073673 ("Lee")	Lee
1008	U.S. Patent Application Publication No. 2002/0044115 ("Jinda")	Jinda
1009	Japanese Laid Open Application Publication JPH0662355A ("Miyai")	Miyai

52. I also provide the following table to demonstrate how terms used in the prior art relate to the terms used in the '843 Patent. For example, as I mentioned above, a gate line is also called a scan line and a switching device is also called a TFT.

'843 Patent Terms	Lee Terms	Jinda Terms
Scan line	Gate line/scanning signal	
Data line	Data line/picture signal	Data line/Image signal
Switching device	Thin-film transistor (TFT)	
Liquid crystal device	Liquid crystal capacitor (Cl) and storage capacitor (Cst)	Liquid crystal display device
Overdrive	Overshoot and/or undershoot	Voltage increase
Gate driver	Gate driver	
Source driver	Data driver	

A. Korean Patent Application No. 2000-0073673 ("Lee")

53. Lee discloses a liquid crystal display device including an LCD panel, data and gate driver portions, and a data grey level signal compensation portion. Ex. 1010, at pp. 5-6; Fig. 8. The gate driver portion "supplies scanning signals sequentially" (*id.* at 35:14) and the data driver portion "data driver portion 300 changes the compensated

grey level signal Gn'…into the corresponding grey level voltage (data voltage) and applies the voltage to the data line" (*id.* at 21:4-6). "Regions surrounded by the gate lines and the data lines each form a pixel," each of which includes "a thin film transistor 110, a gate electrode and a source electrode of which are connected to the gate line and the data line, respectively, and a pixel capacitor Cl and a storage capacitor Cst that are connected to a drain electrode of the thin film transistor 110." *Id.* at 20:6-12.

54. The data grey level signal compensation portion "divides a grey level data frame of a picture signal supplied from a data grey level signal source into at least two sub frames, and outputs to the liquid crystal display panel a compensated grey level data through an overshoot or undershoot driving according to comparing a grey level signal of a previous frame and a grey level signal of a current frame, thereby making a response speed of liquid crystal high." *Id.* at 40:12-17; s*ee also* Figs. 13a and 13b.

55. Lee discloses that the frame memory "can be configured totally with 3 frame memories, a picture signal input in the current frame is wrote on the first frame memory 426 at 60Hz, a picture signal wrote 1 frame before is stored in the second memory 427, and a picture signal wrote 2 frames before is stored in the third memory 428." *Id.* at 32:8-11.

1. Claim 1 Is Anticipated By Lee

Claim 1

56. Claim 1 of the '843 Patent recites:

> 1. A driving circuit for driving an LCD panel, the LCD panel comprising:
>
> a plurality of scan lines;
>
> a plurality of data lines; and
>
> a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device,
>
> the driving circuit comprising: a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel,
>
> the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel;
>
> a source driver for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device; and
>
> a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel.

57. It is my opinion that Lee discloses each and every element of Claim 1 of the

'843 Patent.

58. Lee discloses the scan lines of Claim 1, referring to them as "gate lines." Lee discloses a liquid crystal display and driving device. Ex. 1010, at 4:2-3. More specifically, Lee discloses a liquid crystal display device panel 100 that includes a plurality of gate lines S1-Sn for supplying scanning signals provided by gate driver 200. *Id.* at 20:6-7, 35:13-15. Thus, Lee discloses an LCD panel comprising "a plurality of scan lines," as required by Claim 1.

59. Next, Lee discloses data lines. Lee discloses that the liquid crystal display device panel 100 includes a plurality of data lines D1-Dm, which transfer data or picture signals. *Id.* at 20:6-7; 35:13-15; Fig. 8. Thus, Lee discloses an LCD panel comprising "a plurality of data lines," as required by Claim 1.

60. Lee discloses that the scan lines and data lines are connected to pixels Specifically, Lee discloses "[r]egions surrounded by the gate lines and the data lines each form a pixel." *Id.* at 20:8-12; Fig. 8. Each pixel includes "a thin film transistor 110 [switching device], a gate electrode and a source electrode of which are connected to the gate line and the data line, respectively, and a pixel capacitor Cl and a storage capacitor Cst [collectively, liquid crystal device] that are connected to a drain electrode of the thin film transistor 110." *Id.* at 20:9-12. Thus, Lee discloses "a plurality of pixels, each pixel being connected to a corresponding scan line and a

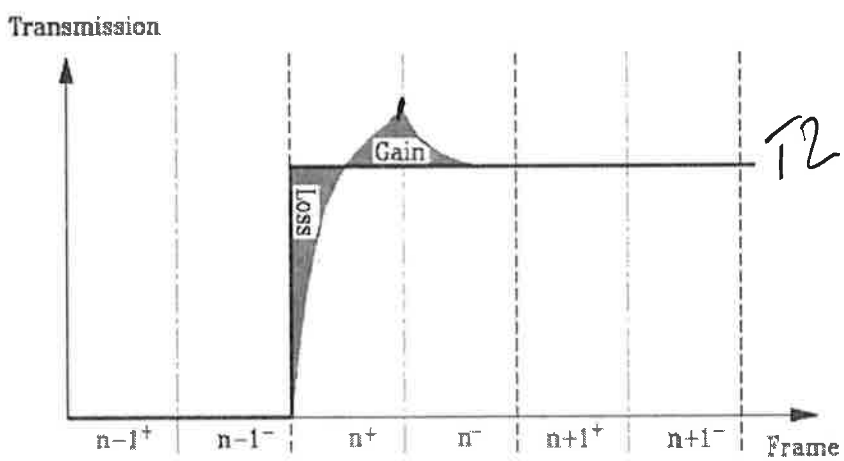
corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device," as required by Claim 1.

61. Lee discloses that the liquid crystal display device includes a data grey level compensation portion 400 (i.e., picture signal compensation circuit) that provides data for the data driver 300. As shown in Figures 13a and 13b, the data compensation signal portion 400 includes a frame memory portion 420 (including first and second frame memories 422 and 424), synthesizer 410, controller 430, data grey level signal converter 442, and a separator 450. *Id.* at 26:15 – 28:17. The frame memory portion 420 stores grey level signals for a plurality of pixels during each frame period. *Id.* at 27:1-7. Thus, Lee discloses a "driving circuit comprising: a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel," as required by Claim 1.

62. Lee discloses that the frame memory portion 420 outputs a grey level signal of a previous frame to the data grey level signal converter 442, or outputs a grey level signal of a current frame and a grey level signal of a previous frame already stored to the data grey level signal converter 442. *Id.* at 27:1-7. As shown in Fig. 13a, "when the grey level signal Gn of the current frame and the grey level signal Gn-1 of the previous frame output from the frame memory portion 420…the first compensated

grey level signal Gn+' is output in the first sub frame (+)...and the second compensated grey level signal Gn-' is output in the second sub frame (-)." *Id.* at 28:19 – 29:4.

63. Lee discloses that "the first compensated grey level signal is an **overshoot** compensated grey level signal . . . [if] the grey level signal of the current frame [is] greater than the grey level signal of the previous frame, and is an **undershoot** compensated grey level signal . . . [if] the grey level signal of the current frame [is] less than the grey level signal of the previous frame." *Id.* at 29:5-9 (emphases added). As shown in Figure 12 below, "an overshoot driving is conducted in a first sub frame n+ out of the divided picture frame, and a driving with the overshot value rolled back to an originally desired target value is conducted in a second sub frame n-." *Id.* at 25:10-13.



Ex. 1010, Lee, Fig. 12.

64. The '843 Patent defines overdriving as "**applying a higher or a lower data impulse** to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules, **so that the pixel can reach the predetermined gray level in a predetermined frame period.**" Ex. 1001, '843 Patent, 2:3-7 (emphases added). Thus, the "overshoot" and "roll back," occurring respectively in the first and second sub-frames constitute a plurality of overdriven impulses within a single frame. Lee therefore discloses "the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel," of Claim 1.

65. Lee discloses a data driver portion 300 that converts the compensated grey level signal (received from data grey level signal compensation portion 400) "into the corresponding grey level voltage (data voltage) and applies the voltage to the data line." Ex. 1010, at 21:5-6. Thus, Lee discloses a "**source driver** for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device," as required by Claim 1.

66. Lee discloses a gate driver 200 for supplying scanning signals to the gate lines of the liquid crystal display panel. *See id.* at 20:2-8; 20:13-15. Thus, Lee discloses "a

gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel," as required by Claim 1.

67. Thus, Lee discloses all of the limitations of Claim 1 of the '843 Patent.

2. Claim 4 Is Anticipated By Lee

Claim 4

68. Claim 4 of the '843 Patent recites:

> 4. A method for driving a liquid crystal display (LCD) panel, the LCD panel comprising:
>
> a plurality of scan lines;
>
> a plurality of data lines; and
>
> a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device, and
>
> the method comprising: receiving continuously a plurality of frame data;
>
> generating a plurality of data impulses for each pixel within every frame period according to the frame data; and
>
> applying the data impulses to the liquid crystal device of one of the pixels within one frame period via the data line connected to the pixel in order to control a transmission rate of the liquid crystal device of the pixel.

69. Lee discloses each and every element of Claim 4 of the '843 Patent. Claim 4 recites nearly identical functionality to that of the apparatus in Claim 1, with the

exception of "overdriving," which is required by Claim 1 but **not** Claim 4. As a result, the disclosure identified in Lee above meets all limitations of Claim 4.

70. For example, Lee Figure 8 (and accompanying disclosure) meets the "plurality of scan line," "plurality of data line," "and plurality of pixel" limitations of Claim 4. Lee also discloses "receiving continuously a plurality of frame data," via the frame memories of the data grey level signal compensation portion 8, which also "generat[es] a plurality of impulses for each pixel within every frame period according to the frame data." These pulses are then applied by the data driver 300 (i.e., source driver) to the liquid crystal display device of the pixels (i.e., capacitors Cl and Cst) to "control the transmission rate of the liquid crystal display device," per Figure 12, which depicts a plurality of data impulses within a single frame period (i.e., a faster frame rate).

71. Thus, Lee discloses all of the limitations of Claim 4 of the '843 Patent.

3. Claim 8 Is Anticipated By Lee

Claim 8

72. Claim 8 of the '843 Patent recites:

> 8. The method of claim 4 further comprising:
>
> applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel.

73. Lee discloses each and every element of claim 8. As discussed above, Lee discloses "a gate driver portion that supplies scanning signals sequentially." *Id.* at 35:14. Lee discloses that each pixel includes a gate electrode "connected to the gate line." *Id.* at 20:14-15. Thus, Lee discloses the step of "applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel," of Claim 8.

74. Thus, Lee discloses all of the limitations of Claim 8 of the '843 Patent.

4. Claim 9 Is Anticipated By Lee

Claim 9

75. Claim 9 of the '843 Patent recites:

> 9. The method of claim 4 wherein each frame data comprises a plurality of pixel data, and each pixel data corresponds to a pixel.

76. Lee discloses each and every element of Claim 9. As discussed above, Lee discloses a frame memory portion 420 that stores grey level signals for a plurality of pixels during each frame period, and outputs a grey level signal of a previous or current frame. *Id.* at 27:1-7. Thus, Lee discloses "each frame data compris[ing] a plurality of pixel data, and each pixel data correspond[ing] to a pixel," as required by Claim 9.

77. Thus, Lee discloses all of the limitations of Claim 9 of the '843 Patent.

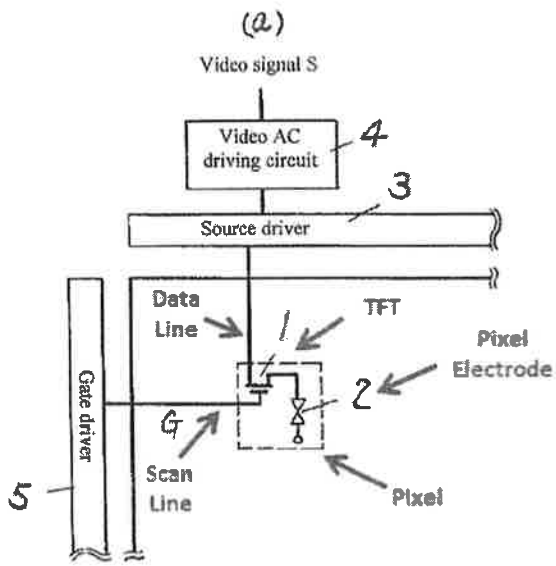
B. U.S. Patent Application Publication No. 2002/0044115 ("Jinda") And Japanese Laid Open Application Publication JPH0662355A ("Miyai")

78. I understand that Jinda was published on April 18, 2002 and is prior art to the '843 Patent under pre-AIA 35 U.S.C. § 102(b). Jinda was cited by the Applicant during prosecution of the '843 Patent, but was not referred to or discussed by the Examiner. As discussed below, the EPO found that Jinda anticipated virtually identical claims to those in question here, but the Applicant never told the USPTO about the EPO's findings.

79. Like the '843 Patent, Jinda discloses a method for "improving the response characteristic of liquid crystals and further improving the display quality of dynamic images" in "matrix type" liquid crystal displays. Ex. 1008, Jinda, ¶ [0007], *see also* ¶ [0002]. For example, Jinda incorporates Japanese Laid Open Application Publication JPH0662355A ("Miyai") by reference, and identifies various issues with "conventional" LCDs, including the LCD disclosed in Miyai.

80. Miyai, which I understand was published on March 4, 1994 and is prior art to the '843 Patent under pre-AIA 35 U.S.C. § 102(b), discloses a conventional LCD panel that includes a matrix of pixels, each of which includes a liquid crystal device and a switching device. Ex. 1009, Miyai, ¶ [0003], Fig. 3(a). Each switching device is connected to a gate (or scan) line and a data line. *Id.* Given the commonality of the components, it is unsurprising that the LCD panel of Miyai (below, left) is identical

to that of the '843 Patent (below, right):



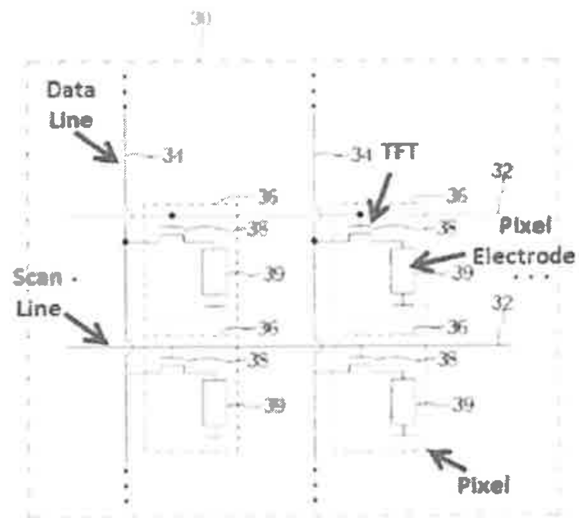
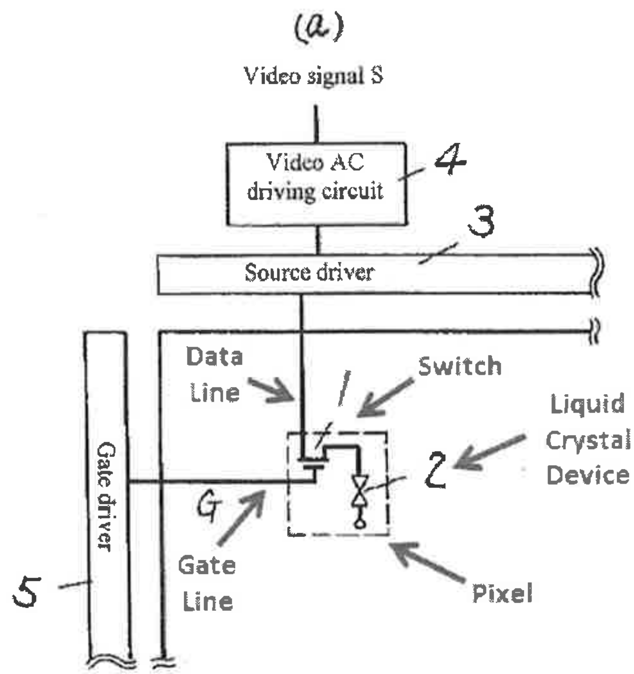


Fig. 4

81. The "conventional liquid crystal panel" referenced in Jinda (and discussed in greater detail in Miyai) includes a matrix of pixels 2, each of which includes a liquid crystal device 2 and a switching device 1 (i.e., a TFT). Ex. 1009, English Translation ¶ [0003]. The switching device is connected to a gate line and a data line. This arrangement is shown in Figure 3(a) of the incorporated Miyai reference, which is reproduced and annotated below:

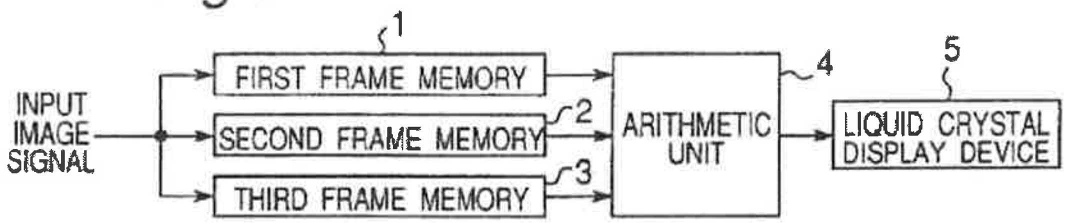
LGD_000636



82. Jinda discloses the same two techniques as the '843 Patent for improving image quality of a conventional LCD panel (e.g., the LCD Panel of Miyai), namely, (1) overdriving the signal data; and (2) increasing the refresh rate of the pixels.

83. Jinda discloses a circuit for receiving an input image signal comprising multiple frames of video. Ex. 1008, Jinda, ¶ [0036], Fig. 1. Frame data is sequentially written into one of the first, second, or third frame memories, as shown in Figure 1 below. *Id.* ¶ [0036]. At any given point in time, one frame memory will contain the current frame data, a second will contain the previous frame data, and a third is available to receive new frame data. *Id.* ¶¶ [0037]-[0038], Figs. 1-3.

Fig. 1



84. "Arithmetic unit 4" retrieves data from the frame memory (1, 2, or 3) and compares the "data value of the previous image signal and the data value of the current image signal" to output overdriven pixel data. *Id.* ¶ [0039]. In this regard, Jinda explains: (a) "a data value of a value greater than the data value of the current image signal is written when the data value of the current image signal is greater than the data value of the previous image signal"; and (b) "a data value of a value smaller that the data value of the current image signal is written when the data value of the current image signal is smaller than the data value is smaller than the data value of the previous image signal." *Id.* In other words, the output data for a given frame is overdriven based on the prior frame's image signal.

85. This is illustrated in the look-up table of Figure 4 of Jinda (reproduced below). When the data value of the previous image signal is 20 and the data value of the current image signal is 10, a lower (overdriven) signal value of 8 will be outputted. By contrast, when the data value of the previous image signal is 10 and the data value of the current image signal is 20, a higher (overdriven) signal value of 22 will be outputted. According to Jinda, this overdriving technique is necessary to "to make

the liquid crystals have a rapid response." *Id.* ¶ [0006].

Fig.4

		DATA VALUE OF PREVIOUS IMAGE SIGNAL					
		10	20	30	40	50	60
DATA VALUE OF CURRENT IMAGE SIGNAL	10	10	8	6	4	2	0
	20	22	20	18	16	14	12
	30	34	32	30	28	26	24
	40	46	44	42	40	38	36
	50	58	56	54	52	50	48
	60	70	68	66	64	62	60

86. In addition, Jinda teaches applying the overdriven image data to each pixel a "plurality of times within one vertical synchronization interval" (i.e., within one frame period). *See, e.g., id.* ¶ [0010]; *see also* ¶¶ [0041]-[0042]. Jinda explains "that the repetitive input of the data value (b) is effective for the improvement of the rise of the light transmittance (c) of the [LCD] device," which reduces blurring and increases image quality. *Id.* ¶ [0042]; *see also* ¶ [0046]). In one embodiment, the transmission rate of the LCD input data is doubled (*Id.* ¶ [0041], Fig. 5), while, in another embodiment, the transmission rate of the LCD input data is tripled (*Id.* ¶ [0067], Fig. 16). This enables "achievement of high-speed image display and the improvement of the dynamic image display quality." *Id.* ¶ [0045].

87. Figure 5 of Jinda shows the application of two overdriven data impulses in each frame period. Figure 5 of Jinda is noticeably indistinguishable from Figure 6 of the

'843 Patent.

1. Jinda, Either Alone Or In Combination With Miyai, Discloses All Elements Of Claim 1

Claim 1

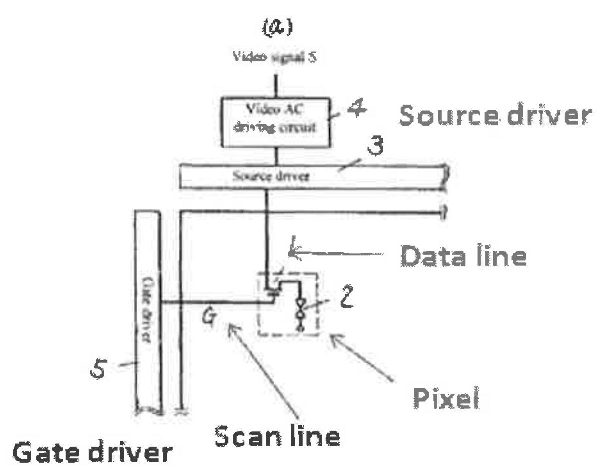
88. Claim 1 of the '843 Patent recites:

> 1. A driving circuit for driving an LCD panel, the LCD panel comprising:
>
> a plurality of scan lines;
>
> a plurality of data lines; and
>
> a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device,
>
> the driving circuit comprising: a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel,
>
> the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel;
>
> a source driver for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device; and
>
> a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device

of the pixel.

89. It is my opinion that Jinda, either alone or in combination with Miyai, discloses each and every element of Claim 1.

90. Jinda discloses a driving circuit for a liquid crystal display device. Ex. 1008, ¶ [0019]; Fig. 1. Jinda incorporates by reference the disclosure of Miyai, which discloses a liquid crystal panel 2, including scan lines provided by a gate driver 5, which is shown in annotated Figure 3a below:



Miyai, Fig. 3a. *See also* Ex. 1009, Miyai Trans, ¶3. Though only one pixel, scan line, and data line are expressly depicted in Figure 3a, in order for the LCD to function properly as a display device, the panel would necessarily have included a pixel array, including a plurality of scan and data lines. Thus, Miyai inherently discloses an LCD panel comprising "a plurality of scan lines," as required by Claim 1.

91. Miyai discloses a liquid crystal display including a plurality of data lines. Jinda

incorporates Miyai by reference, which discloses data lines provided by source driver 3. Ex. 1009, Miyai, Fig. 3a. Though only a single line is expressly depicted in Miyai, Figure 3a, the panel would necessarily have included a pixel array, including a plurality of scan and data lines. Thus, Miyai inherently discloses an LCD panel comprising "a plurality of data lines," as required by Claim 1.

92. Miyai discloses a pixel intersecting the scan and data lines, and including a switching element (thin-film transistor) and liquid crystal device. *See* Ex. 1009, Miyai, Fig. 3a. Though only a single pixel is expressly depicted in Miyai, Figure 3a, the panel would necessarily have included a pixel array. Thus, Miyai inherently discloses "a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device," as required by Claim 1.

93. Jinda discloses a "drive circuit for materializing the liquid crystal display device," in which "[d]igital image signals R, G and B of pixels sequentially read from video equipment or the like are inputted as input image signals to a first frame memory 1, a second frame memory 2 and a third frame memory 3." Ex. 1008, Jinda, ¶ [0036]. Thus, Jinda discloses a "driving circuit comprising: a blur clear converter for receiving frame data every frame period, each frame data comprising a plurality of pixel data and each pixel data corresponding to a pixel," as required by Claim 1.

94. As noted above, the '843 Patent defines overdriving as "**applying a higher or a lower data impulse** to the pixel electrode to accelerate the reaction speed of the liquid crystal molecules, **so that the pixel can reach the predetermined gray level in a predetermined frame period**." Ex. 1001, '843 Patent, 2:3-7 (emphases added). As explained, this essentially means that the system determines a higher (or lower) data value that the actual desired gray level in order to push (or pull) the system to the actual desired gray level faster. In this vein, Jinda discloses an "arithmetic unit 4, which has a look-up table, refers to the look-up table on the basis of the data values (voltage values) of the image signals inputted from the two frame memories and transfers an image signal constituted of the obtained data value (voltage value) to a liquid crystal display device 5." *Id.* at ¶ [0038]. The look-up table in Figure 4 of Jinda (below) shows the determination of the higher or lower (i.e., overdriven) pixel data. *Id.* at ¶ [0038]. The data values for the current and previous signals are compared and the data value is determined as follows: When the data value of the previous image signal is 20 and the data value of the current image signal is 10, a lower (overdriven) signal value of 8 will be outputted. By contrast, when the data value of the previous image signal is 10 and the data value of the current image signal is 20, a higher (overdriven) signal value of 22 will be outputted. According to Jinda, this overdriving technique is necessary to "to make the liquid crystals have a rapid response." *Id.* ¶ [0006].

Fig.4

		DATA VALUE OF PREVIOUS IMAGE SIGNAL					
		10	20	30	40	50	60
DATA VALUE OF CURRENT IMAGE SIGNAL	10	10	8	6	4	2	0
	20	22	20	18	16	14	12
	30	34	32	30	28	26	24
	40	46	44	42	40	38	36
	50	58	56	54	52	50	48
	60	70	68	66	64	62	60

95. Jinda continues: "It is to be noted that the voltage of the data value is applied to the pixel electrode (not shown) of the desired pixel by the image signal thus transferred to the liquid crystal display device 5 although no detailed description is provided. Then, the orientation of the liquid crystal molecules is changed by the applied voltage to change the light transmittance, displaying the pixel." *Id.* at ¶ [0038]. Thus, Jinda discloses "the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel," as required by Claim 1.

96. Jinda discloses "driving a liquid crystal display device by supplying image data to be written into each pixel of the liquid crystal display device to the liquid crystal display device a plurality of times in one vertical synchronization interval." *Id.* at ¶ [0008]. Thus, Jinda discloses a "**source driver** for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by

the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device," as required by Claim 1.

97. The drive circuit of Jinda inherently includes a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel. For the LCD in Jinda to operate, the pixel data must be applied to the pixels, which is done through data impulses. *Id.* Therefore, in order for the LCD in Jinda to operate, it must inherently disclose a gate driver for applying the data impulses. *Id.* Moreover, Miyai, Figure 3a, discloses a gate driver 5 for supplying a scan line to each pixel. Thus, Jinda and Miyai both disclose "a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel," as required by Claim 1.

98. Thus, Jinda in view of Miyai disclose all of the limitations of Claim 1 of the '843 Patent.

2. Jinda, Either Alone Or In Combination With Miyai, Discloses All Elements Of Claim 4

Claim 4

99. Claim 4 of the '843 Patent recites:

> 4. A method for driving a liquid crystal display (LCD) panel, the LCD panel comprising:
>
> a plurality of scan lines;
>
> a plurality of data lines; and
>
> a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device, and
>
> the method comprising: receiving continuously a plurality of frame data;
>
> generating a plurality of data impulses for each pixel within every frame period according to the frame data; and
>
> applying the data impulses to the liquid crystal device of one of the pixels within one frame period via the data line connected to the pixel in order to control a transmission rate of the liquid crystal device of the pixel.

100. Jinda and Miyai disclose each and every element of Claim 4 of the '843 Patent. As noted above, Claim 4 recites nearly identical functionality to that of the apparatus in Claim 1, with the exception of "overdriving," which is required by Claim 1 but **not** Claim 4. As a result, the disclosure identified in Jinda and Miyai above meets all limitations of Claim 4 of the '843 Patent.

3. Jinda, Either Alone Or In Combination With Miyai, Discloses All Elements Of Claim 8

Claim 8

101. Claim 8 of the '843 Patent recites:

> 8. The method of claim 4 further comprising:

> applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel.

102. Jinda and Miyai disclose each and every element of Claim 8. As discussed above, Jinda inherently discloses a gate driver for applying scan line voltages. For the LCD in Jinda to operate, the pixel data must be applied to the pixels, which is done through data impulses. *Id.* Therefore, in order for the LCD in Jinda to operate, it must inherently disclose a gate driver for applying the data impulses. *Id.* Moreover, Miyai, Figure 3a, discloses a gate driver 5 for supplying a scan line to each pixel. Thus, Jinda and Miyai disclose the step of "applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel," as required by Claim 8.

103. Thus, Jinda in view of Miyai disclose all of the limitations of Claim 8 of the '843 Patent.

4. Jinda, Either Alone Or In Combination With Miyai, Discloses All Elements Of Claim 9

Claim 9

104. Claim 9 of the '843 Patent recites:

> 9. The method of claim 4 wherein each frame data comprises a plurality of pixel data, and each pixel data corresponds to a pixel.

105. Jinda discloses each and every element of claim 9. Jinda discloses a system for

generating overdrive frame data for multiple "pixels," for example "R, G and B of **pixels** sequentially read from video equipment or the like." Ex. 1008, Jinda, ¶ [0036]frame. Thus, Jinda discloses "each frame data compris[ing] a plurality of pixel data, and each pixel data correspond[ing] to a pixel," as required by Claim 9.

106. Thus, Jinda discloses al of the limitations of Claim 9 of the '843 Patent.

5. Motivation to Combine Jinda and Miyai

107. As discussed above, Miyai is discussed in the background section of Jinda. (Ex. 1002, Jinda, ¶¶ [0004], [0006]). Specifically, Jinda identifies various shortcomings of the LCD display of Miyai, upon which it seeks to improve. Accordingly, Jinda ***expressly*** teaches one of ordinary skill the art to combine the disclosed driving circuit with the LCD panel of Miyai. In addition, one of ordinary skill in the art would have been motivated to combine the teachings of Jinda and Miyai because both references focused on the exact same problem – improving the image quality of LCD displays and, more particularly, improving the response time of the display. Jinda discloses that "the object of the present invention is to provide a liquid crystal display device driving method capable of improving the response characteristic of liquid crystals and further improving the display quality . . . ." Ex. 1008, Jinda, ¶ [0007]. Similarly, Miyai discloses that "an object [of the invention] is to improve responsiveness and achieve an improvement in image quality . . . in the driving circuit of display elements with slow response speed, such as liquid crystal

panels." Ex. 1009, Miyai, ¶ [0006].

108. More than just trying to solve the same problem, Jinda purports to improve on the very system disclosed in Miyai (and other prior art LCDs). Jinda did not disclose a complete LCD on its own, but plainly purports to teach an improvement for LCDs. It is even in the title of the publication. Ex. 1008, Jinda, ¶ [Cover (54)] ("Liquid Crystal Display Device Driving Method"). Therefore, one of ordinary skill in the art would have started with the disclosure of an LCD – most likely one of the LCDs referenced in Jinda – and then applied the teachings of Jinda to that structure. *Id*,

6. Jinda Discloses All Elements Of Claims 1, 4, 8, and 9

109. Jinda discloses each and every element of Claims 1, 4, 8, and 9 of the '843 Patent as I demonstrated above and explain in more detail below.

110. Jinda discloses a "liquid crystal display that employs a matrix type liquid crystal display device . . . [for] commercial fields [such] as a display device for a television set . . . ." Ex. 1008, at ¶ [0002]. A liquid crystal display employing a matrix type liquid crystal display device necessarily includes an array of pixels, each connected to a scan line and data line, with each pixel connected to TFT or switching device. In order for the liquid crystal to function properly as a display device, the LCD would necessarily have included a pixel array, including a plurality of scan lines, data lines, pixels, and

TFTs. Thus, Jinda inherently discloses "[a] driving circuit for driving an LCD panel, the LCD panel comprising: a plurality of scan lines; a plurality of data lines; a plurality of pixels, each pixel being connected to a corresponding scan line and a corresponding data line, and each pixel comprising a liquid crystal device and a switching device connected to the corresponding scan line, the corresponding data line, and the liquid crystal device," as required by Claim 1.

111. As discussed above, Jinda discloses "the blur clear converter delaying current frame data to generate delayed frame data and generating a plurality of overdriven pixel data within every frame period for each pixel," as required by Claim 1. *See* Ex. 1008, at ¶ [0038]; *see also id.* at ¶ [0067].

112. As discussed above, Jinda also discloses a "source driver for generating a plurality of data impulses to each pixel according to the plurality of overdriven pixel data generated by the blur clear converter and applying the data impulses to the liquid crystal device of the pixel via the scan line connected to the pixel within one frame period in order to control transmission rate of the liquid crystal device," as required by Claim 1. *See* Ex. 1008, at ¶ [0008]

113. The drive circuit of Jinda inherently includes a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel. For the LCD in Jinda to operate, the pixel

data must be applied to the pixels, which is done through data impulses. *Id.* Therefore, in order for the LCD in Jinda to operate, it must inherently disclose a gate driver for applying the data impulses. *Id.* Thus, Jinda discloses "a gate driver for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel," as required by Claim 1.

114. Thus, Jinda discloses all of the limitations of Claim 1 of the '843 Patent.

115. Jinda discloses each and every element of Claim 4 of the '843 Patent. As noted above, Claim 4 recites nearly identical functionality to that of the apparatus in Claim 1, with the exception of "overdriving," which is required by Claim 1 but **not** Claim 4. As a result, the disclosure identified in Jinda above meets all limitations of Claim 4 of the '843 Patent.

116. Jinda disclose each and every element of Claim 8. As discussed above, Jinda inherently discloses a gate driver for applying scan line voltages. For the LCD in Jinda to operate, the pixel data must be applied to the pixels, which is done through data impulses. *Id.* Therefore, in order for the LCD in Jinda to operate, it must inherently disclose a gate driver for applying the data impulses. *Id.* Thus, Jinda discloses the step of "applying a scan line voltage to the switch device of the pixel via the scan line connected to the pixel in order to have the data impulses be applied to the liquid crystal device of the pixel," as required by Claim 8.

117. Jinda discloses each and every element of claim 9. Jinda discloses a system for generating overdrive frame data for multiple "pixels," for example "R, G and B of **pixels** sequentially read from video equipment or the like." Ex. 1008, Jinda, ¶ [0036]. Thus, Jinda discloses "each frame data compris[ing] a plurality of pixel data, and each pixel data correspond[ing] to a pixel," as required by Claim 9.

7. All Elements Of Claims 1, 4, 8, and 9 are Obvious Over Jinda

118. Claims 1, 4, 8, and 9 of the '843 Patent are obvious over Jinda.

119. At the time of the '843 Patent, it was well-known to those of skill in the art that liquid crystal displays employing a matrix type liquid crystal display would include an array of pixels, each connected to a scan line and data line, with each pixel connected to TFT or switching device. Based on the disclosure in Jinda of a matrix type LCD, it would have been obvious to one of skill in the art to apply the well-known LCD elements of a pixel array, including a plurality of scan lines, data lines, pixels, and TFTs to the LCD device of Jinda. *Id.*; *see also* Ex. 1008, at ¶ [0002]. Furthermore, in order for the LCD device of Jinda to function properly as a display device, one of skill in the art would have known that the LCD device comprised a pixel array.

120. At the time of the '843 Patent, one of skill in the art would also have known that gate drivers were used in LCD devices for applying scanning signals to switching devices (TFTs) of the pixels. Thus, it would have been obvious to one of skill in the

art to include a gate driver in the display device of Jinda for applying a scan line voltage to the switch device of the pixel so that the data impulses can be applied to the liquid crystal device of the pixel. *Id.* One of skill in the art would have known that, for the LCD in Jinda to operate, the pixel data must be applied to the pixels, which is done through data impulses. *Id.* Therefore, in order for the LCD in Jinda to operate, one of skill in the art would have applied a gate driver to the device of Jinda for applying the data impulses. *Id.*

121. Thus, Claims 1, 4, 8, and 9 of the '843 Patent are obvious over Jinda.

V. SUPPLEMENTATION

122. This declaration, along with the attached appendices, is based on my present assessment of material and information currently available to me.

123. I hereby declare that all statements made herein of my own knowledge are true and that all statements made herein on information and belief are believed to be true. Further, these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-identified patent.

Dated: 03/15/2015

Respectfully submitted,

By: Richard G. Zech, Ph.D.

Declaration of Richard Zech, Ph.D.

APPENDIX A

Richard G. Zech, Ph.D.
Curriculum Vitae

Professional Summary

Dr. Dick Zech has nearly 50 years of optical data storage, novel computer storage technologies, and photonics experience (including holography, flat panel displays and digital image processing and cameras). His academic focus was on modern optics, electromagnetic theory, communications and information theory, and advanced mathematics. Starting in 1965 at the University of Michigan, Dr. Zech began a lifetime of research and development in the highly specialized areas of optical data and image storage, processing/computing, and communications and image-capture and display. He studied under E. N. Leith, A. Kozma, A. Vander Lugt, and Dennis Gabor (1971 Nobel laureate in physics), leading modern optical sciences pioneers. Dr. Zech is a well-known expert in the field of advanced data storage, holography, photonics, digital image capture and processing, and small computer systems.

Dr. Zech's main areas of interest are optical storage (CD, DVD, and Blu-ray/Blue-laser-disc formats), 3D holographic memories, lasers, flat panel displays, digital imaging/cameras, renewable energy, fiber optics, LEDs, materials science, nanotechnology, control and processing of light beams, and photonic components and their integration into fully functional systems. He has significant engineering, product and business development, and sales & marketing management experience. Finally, he has been a consultant for over 25 years and an expert witness for over 23 years.

Dr. Zech opened a test and forensics lab in October 2004. The lab is focused on test and evaluation of CD/DVD, Blu-ray Disc, other optical storage, flat panel displays, digital imaging/cameras, small computer systems, and related storage and consumer electronics products. The capabilities of the lab have been successfully used for patent infringement and class action litigations.

Areas of Expertise

- CCD and CMOS Image Sensors
- CD, DVD, and Blu-ray Technologies, Processes and Engineering
- Computer Storage (magnetic optical, and semiconductor)
- Consumer Electronic Products
- Digital Imaging and Cameras
- Document Management Systems
- Flat Panel Displays and TVs
- Fiber Optic/Optical Communications
- Holographic Optical Elements (HOEs)
- Holographic Displays
- Holographic Memories
- Lasers and Laser Technology
- LEDs
- Materials Science
- Nanotech/MEMS
- Optical Data Storage (specializing in read/write channel, storage media, read/write heads, and applications)
- Opto-Electronic/Electro-Optical Systems
- Photonic Components & Technology
- Rewritable Optical Drives and Media Technologies
- Solar Energy/Photovoltaics
- Video Data Storage and Transmission

Richard G. Zech, Ph.D.
Curriculum Vitae

Education

Year	College or University	Degree
1974	University of Michigan	Ph.D. (EE; computer science and photonics minors)
1966	University of Michigan	M.S.E.E.
1965	Lawrence Institute of Technology	B.S.E.E.

- Post graduate studies in computer science, optical communications, electronics, optical systems design, and infrared technology and systems.
- Career advancement and MBA courses (off campus) in general management (Harvard University), international marketing (Columbia University), advanced financial analysis, managing interpersonal relationships, and product development.

Professional Experience

From: 1992
To: Present
Organization: The ADVanced ENTerprises (ADVENT) Group
Title: President, Managing Principal
Summary: The ADVENT Group provides forensic consumer electronics test & evaluation, market research, product development, R&D/engineering, and technology assessment services in the areas of optical/computer storage, holography, flat panel displays, digital cameras, nanotechnology/MEMS, and photonics. Main areas of expertise include photonics-enabled information storage/processing/display, new and evolving technologies, and consumer electronics technologies. Examples include:

- CD, DVD, and Blu-ray and other rewritable optical drive and media technologies and optical storage-enabled applications.
- Consumer electronics products such as flat panel displays, digital cameras and imaging, and small computer systems and components.
- New and evolving technologies such as LEDs, solar energy, and nanotechnology.

Clients range from new ventures to Fortune 500 giants. Extensive contacts with major Asian companies provide early access to new technologies and leading edge components.

Expert witness/technology consultant to law firms; primarily, patent infringement and validity, class action, and breach of contract litigation (1990 to present).

Served as CIO/MIS Director for a financial services company from 19995-2000.

From: 1988
To: 1991
Organization: Independent Consultant, Temporary Executive
Summary:

1991	Vice President Engineering, Optimem, Inc.
1990	President & COO, New Interfile Corporation
1989	Vice President Strategic Planning, Optimem, Inc.
1989	Vice President Marketing & Sales, LaserDrive, Ltd.
1988	Vice President Marketing & Sales, Optimem, Inc.

From: 1987
To: 1988
Organization: Rothchild Consultants, Inc.
Title: Senior Industry Analyst
Summary:

- Responsible for new business development and functioned as chief technology expert for optical and magnetic storage and computer information systems.
- Provided new product development, technology transfer, market research, forecasting, and manufacturing strategy support to both domestic and international clients.
- Met 1-year contract goals of tripling sales and profits and diversifying product line.

From: 1985
To: 1986
Organization: Rugged Optical Storage Systems
Title: President
Summary: Responsible for the general management and principal founder of a new venture to develop and manufacture high-performance, high-reliability 2" and 3.5" form factor, fixed-erasable optical disk drives for military, factory floor/industrial, and portable computer markets. Advanced engineering and design features included a two-laser optical head, a sub-20 ms track accessing mechanism, and an optical media hypervisor subsystem (MEAD: Media Error Analysis and Detection). An innovative subsystem architecture featured the optical drive and its controller mounted on the same PC board and packaged in a removable, secure metal enclosure (an industry first).

From: 1984
To: 1985
Organization: Information Storage, Inc. (ISi)
Title Vice President, Marketing & Sales
Summary:

- Responsible for all elements of marketing and sales for the world's first 5.25" optical disk drive startup.

- Developed prospect base and made sales presentations to all major computer and office automation OEMs, system integrators, computer chains, and distributors in the US and Europe.
- Created a complete product line of systems and services, including ISiDOS (the world's first integrated optical I/O driver and file manager).
- Positioned ISi as the number one OEM manufacturer of optical storage products for small computer systems through a multi-media PR campaign based on direct mailings, telemarketing, trade shows, magazine articles, advertising, and symposia.
- Recruited and trained an international sales force. Sold over 200 evaluation systems at $5,000 each to major prospects to finance the transition to manufacturing, and developed an OEM book of business with an estimated 18-month revenue potential of over $20M.
- Reported to the President and CEO; member of the Executive Committee.

From: 1979
To: 1984
Organization: McGraw-Hill, Inc. (Information Systems Company)
Title: Vice President for Technology, Business Systems, and Manufacturing
Summary:

- Responsible for new technology (including electronic editing, CD-ROM publishing, and advanced networking for on-line services), computer systems and applications software development, manufacturing operations, technology transfer, strategic planning, and electronically-delivered product development for a $350-million business unit of McGraw-Hill, Inc. Primary corporate mission as functional chief technology officer was to design and build a 21st-century computer and communications architecture.
- Controlled over $80M of operating expenses through budget/expenditure review and approval.
- Managed a staff of 15 senior information system professionals and 20 applications programmers.
- Created the strategic business plan for a market focus organizational structure to rationalize product lines.
- Introduced office automation and microcomputer systems to all business units.
- Automated the production operations of the major divisions, resulting in annualized cost savings of over $8M and the ability to market competitive electronic information products.
- Reported to the President; member of Executive and Operations Committees; Chair of the Corporate Technology, Product Assurance, and Project Evaluation Committees.

From: 1978
To: 1979
Organization: TRW Space and Defense Systems Group

Title: Director, Business Development/Product Line Manager

Summary:

- Responsible for the marketing/sales and technology/product development for the optical processing systems product line (C^3I and ECM applications) comprised of acousto-optic Bragg-cell spectrum analyzers, time and space integrating correlators, and ultra-wideband scanner and recorder systems.
- Marketed programs to defense and intelligence agencies, including CIA, DIA, Hanscomb AFB, MIRADCOM, NASA, NSA, NWL, RADC, and WPAFB.
- Formulated 1-year and 5-year business plans. Initiated marketing efforts that lead to $3M in new business in less than one year, including a classified agency program for an optical drum memory system with 1 TB capacity and a 1 Gbps data rate.
- Managed eight senior scientists and engineers and two marketing specialist.
- Reported to the Division VP/General Manager.

From: 1969
To: 1978
Organization: Harris Corporation, Government Systems Sector, Electro-Optics Division
Title: Research Manager/Principal Engineer

Summary:

- Responsible for R&D and advanced programs/product development in the areas of optical/electronic data recording, processing, storage, and communications using state-of-the-art electronic and laser systems (high-density disk storage, holographic memories, wideband data acquisition and processing, optical computers, and fiber optics).
- Held assignments in research and systems (de facto corporate R&D manager), program management, and marketing. Marketed R&D and systems development programs to DoD, NASA, and other Federal government agencies.
- Developed the technology and sold to NASA the world's largest optical mass storage program (for archiving LandSAT and other remote sensing data; a 1,000 terabyte system with a potential contract value of over $150M).
- Finished all managed programs successfully on schedule and on/under budget for 9 years.
- Managed 15 engineers, scientists, and programmers.

From: 1967
To: 1969
Organization: McDonnell Douglas Corporation, Electronic Systems (Conductron) Division
Title: Section Head/Research Manager

Summary:

- Responsible for R&D and business acquisition in the areas of optical data storage, optical data processing (terminal guidance, feature extraction, synthetic aperture radar, and simulators), large displays, laser systems, light-sensitive media, and holography.
- Invented the "projected real-image" white light hologram, the universal type used

for displays and art.

- Functioned as project engineer and business manager for the largest-ever industrial effort to commercialize CW and pulsed laser holography for display, information storage, and non-destructive testing applications.
- Developed profitable technology and manufacturing methods to achieve these goals, and sold nearly 1 million holograms.
- Managed 25 scientists, engineers, and manufacturing technicians.

From: 1965
To: 1967
Organization: University of Michigan, Institute of Science and Technology
Electro-Optical Sciences Laboratories
Title: Laboratory Supervisor/Research Engineer
Summary:

- Responsible for basic research supported by National Science Foundation (NSF) and Office of Naval Research (ONR) grants in the areas of holography, optical data processing and storage, light-sensitive materials, lasers, and grating ruling engines.
- Pioneered new recording and processing systems for optical storage and image correction and enhancement. Managed four engineers, three technicians, and two R&D laboratories.

Litigation Support Experience

Expert Engagement:

Type of Matter:	Petition for Inter Partes Review
Law Firm:	Knobbe Martens LLC
Case Name:	Intellectual Ventures ILLC v. Canon Inc. - 2
Services Provided:	Consulting expert for Plaintiff on optical scanner technology. Wrote a rebuttal declaration against granting the IPR. Deposition to be scheduled.
Disposition:	TBD
Date:	January 2015 - present

Expert Engagement:

Type of Matter:	Petition for Inter Partes Review
Law Firm:	Mayer Brown LLP
Case Name:	Surpass Tech Innovation LLC v. LG Display Co., Ltd., et al
Services Provided:	Consulting expert for Defendant LG Displays regarding methods for blur reduction or elimination for LCD modules. Drafted a declaration in support of a petition to the PATB for an IPR .
Disposition:	TBD
Date:	December 2014 – present

Expert Engagement:

Type of Matter:	Petition for Inter Partes Review
Law Firm:	Knobbe Martens LLC
Case Name:	Intellectual Ventures ILLC v. Canon Inc. - 1
Services Provided:	Consulting expert for Plaintiff on optical scanner technology. Wrote a rebuttal declaration against granting an IPR. Testified at deposition.
Disposition:	TBD
Date:	November 2014 - present

Expert Engagement:

Type of Matter:	Petition for Inter Partes Review.
Law Firm:	DLA Piper LLC
Case Name:	Optical LLC v. Toshiba
Services Provided:	Consulting expert for Defendant Toshiba on digital optical disc drive servos. Wrote three declarations in support for an IPR. Depositions to be scheduled.
Disposition:	Petitions granted by PATB
Date:	August 2014 – present

Expert Engagement:

Type of Matter:	Patent Infringement. Retroreflectors and optical disc drive controllers.
Law Firm:	O'Melveny & Meyers

Case Name: Optical LLC v. Samsung
Services Provided: Consulting expert for Defendant Samsung on optical components/systems based on a submarined patent and a recent patent on a fully digital optical disc drive controllers.
Disposition: TBD
Date: October - December 2013

Expert Engagement:
Type of Matter: Patent Infringement. Blu-ray Disc player hardware and firmware.
Law Firm: O'Melveny & Meyers
Case Name: Walker Digital v. Samsung, et. al.
Services Provided: Consulting expert for Defendant Samsung on Blu-ray Disc player operation and extensions.
Disposition: TBD
Date: March - June 2012

Expert Engagement:
Type of Matter: Patent Infringement. LCD displays.
Law Firm: O'Melveny & Meyers
Case Name: Samsung v. AU Optronics
Services Provided: Consulting expert for Plaintiff Samsung on LCD displays, including wide angle viewing, TFT substrates, and manufacturing processes.
Disposition: Settled
Date: June 2011 – November 2011

Expert Engagement:
Type of Matter: Patent Infringement. Digital cameras, firmware.
Law Firm: Perkins Coie LLP
Case Name: FlashPoint Technology v. HTC, et al
Services Provided: Lead expert witness for the Defendant HTC on validity. Wrote omnibus invalidity report for three patents related to digital camera image processing. Testified at deposition. This was a litigation before the ITC.
Disposition: TBD
Date: November 2010 – April 12, 2011

Expert Engagement:
Type of Matter: Patent Infringement. Writing to and reading from multiple types of optical discs.
Law Firm: Paul, Hastings, Janofsky & Walker LLP
Case Name: LaserDynamics v. Quanta Computer Inc., Quanta Storage Inc.
Services Provided: Lead expert witness for the Defendant Quanta Computer Inc., Quanta Storage Inc. Wrote opinion and rebuttal expert reports. Testified at deposition. Trial on damages in Eastern District of Texas on January 31, 2011.
Disposition: Verdict for Plaintiff, but damages were limited significantly.
Date: November 2010 – January 2011

Expert Engagement:

Type of Matter:	Patent Infringement. Lens designs, digital cameras, and cell phones.
Law Firm:	Perkins Coie LLP
Case Name:	Fujinon Corp. v. HTC and Largon
Services Provided:	Lead expert witness for the Defendants HTC and Largon.
Disposition:	Trial at ITC; result unknown. Some patents before the PTO for reexamination
Date:	August 2010 – April 2011

Expert Engagement:

Type of Litigation:	Patent Infringement. LCD flat panel displays and TVs. Optics and materials, electronics design and architecture.
Law Firm:	Fish & Richardson
Case Name:	Sharp v. Samsung II
Services Provided:	Consulting expert witness for the Defendant Samsung. Wrote expert report (declaration).
Disposition:	Settled
Date:	December 2009 – February 2010

Expert Engagement:

Type of Matter:	Patent Infringement. Phase change optical discs and CD-RW.
Law Firm:	Paul, Hastings, Janofsky & Walker LLP
Case Name:	Ricoh Company, Ltd. (Ricoh) v. Quanta Computer Inc., QSI, AsusTek Inc., et al
Services Provided:	Lead expert witness for the Defendant Quanta and QSI (Quanta Storage Inc.). On appeal, litigation on two patents was remanded to district court for trial. Testified on validity issues in Federal Court (Madison, WI) re: buffer underrun ("burn proof") and zoned CLV. Originally wrote four invalidity reports that helped win summary judgments.
Disposition:	Verdict for the Plaintiff
Date:	September 2007 – November 2009

Expert Engagement:

Type of Matter:	Patent Infringement. LCD flat panel displays and TVs, optics and materials, electronics design and architecture.
Law Firm:	Fish & Richardson
Case Name:	Sharp v. Samsung
Services Provided:	Consulting expert witness for the Defendant Samsung.
Disposition:	Unknown
Date:	December 2007 – February 2008

Expert Engagement:

Type of Matter:	Patent Infringement. Multi-layer disk optical storage, DVD buffering, spherical aberration correction.
Law Firm:	Connolly Bove Lodge & Hutz LLP
Case Name:	U.S. Philips v. International Norcent Technology, et. al.
Services Provided:	Lead expert witness for the Defendant International Norcent Technology. Wrote invalidity and rebuttal reports and testified at deposition and in Federal District Court.

Disposition:	Jury decision in favor of the Plaintiff
Date:	March – November 2007

Expert Engagement:

Type of Matter:	Patent Infringement. CD-R, CD-RW, DVD±R re background formatting, "burn proof" technology, phase change optical discs, write strategies.
Law Firm:	Paul, Hastings, Janofsky & Walker LLP
Case Name:	Ricoh Company, Ltd. (Ricoh) v. AsusTek Computer Inc. (ASUS), et. al.
Services Provided:	Lead expert witness for the Defendant Quanta Computer Inc. Wrote four invalidity reports.
Disposition:	Summary judgment in favor of Defendant Quanta Computer Inc. for all four patents in litigation; one major patent invalidated.
Date:	February – June 2007

Expert Engagement:

Type of Litigation:	Patent Infringement. DVD media, DVD-9, thin films, metal alloys, phase change media.
Law Firm:	Cooper & Dunham LLP
Case Name:	Target Technology v. Williams Advanced Materials, Cinram International, et al
Services Provided:	Consulting expert witness for the Defendant Cinram International.
Disposition:	Settled
Date:	2006

Expert Engagement:

Type of Matter:	Patent Infringement. DVD parental control mechanisms.
Law Firm:	Monts & Ware LLP
Case Name:	Digital Choice v. Toshiba, Yamaha, et al
Services Provided:	Lead expert witness for the Plaintiff Digital Choice
Disposition:	Settled
Date:	2005 – 2007

Expert Engagement:

Type of Matter:	Class Action. DVD players.
Law Firm:	Heller Erhman White & McAuliffe LLP
Case Name:	Morris et al v. Sony Electronics Inc.
Services Provided:	Lead expert witness for the Defendant Sony Electronics Inc. Designated testifying and consulting expert witness. Forensic evaluation of claimed defective DVD player products, disproved the Plaintiff's claims. Wrote expert report, testified at deposition.
Disposition:	Settled
Date:	2005 – 2006

Expert Engagement:

Type of Matter:	Patent Infringement. DVD technology.
Law Firm:	Fish & Richardson
Case Name:	U.S. Philips v. MRT Technology (Ritek)
Services Provided:	Consulting expert witness for the Defendant MRT Technology (Ritek) .

Disposition: Settled
Date: 2005

Expert Engagement:
Type of Matter: Class Action. DVD players.
Law Firm: Heller Erhman White & McAuliffe LLP
Case Name: Scafuri et al v. Sony Electronics Inc.
Services Provided: Co-Lead expert witness for the Defendant Sony Electronics Inc. (SEL). Designated testifying and consulting expert witness. Performed research and analysis and testified about the design, technology and manufacture of DVD hardware, firmware, and DVD-Video discs. Determined and categorized the modes of DVD-Video product failure by hardware, media and consumer. Used statistical analysis of customer service/repair data to show that product failures after infant mortality were well below industry norms. Provided expertise on consumer electronics products and markets, including service and support strategies. Wrote detailed expert report in response to the Plaintiff's claims and expert report. Testified at deposition.
Disposition: Settled
Date: 2003 – 2005

Expert Engagement:
Type of Matter: Patent Infringement before the ITC. Laptop computers.
Law Firm: Dewey Ballantine LLC
Case Name: Gateway v. HP
Services Provided: Lead expert witness for the Plaintiff Gateway. Subject matter included laptop computers, CD and DVD drives, and Windows and Linux operating systems. Wrote expert and rebuttal reports.
Disposition: Litigation terminated
Date: 2004 – 2005

Expert Engagement:
Type of Matter: Patent Infringement. Optical mice.
Law Firm: Keker & Van Ness LLC
Case Name: PixArt Technology v. Agilent Technologies
Services Provided: Lead expert witness for the Plaintiff PixArt Technology in the following technologies: Optical mouse, photodetector arrays, image processing, optical navigation, LEDs and lasers, and optics.
Disposition: Settled
Date: 2004

Expert Engagement:
Type of Matter: Class Action. DVD players.
Law Firm: Heller Erhman White & McAuliffe LLP
Case Name: Zeigler et al v. Sony Electronics Inc.
Services Provided: Lead expert witness for the Defendant Sony Electronics Inc. Designated testifying and consulting expert witness. Wrote expert report that responded in detail to and disproved the Plaintiff's litigation claims re DVD.

Disposition: Settled
Date: 2004 – 2006

Expert Engagement
Type of Matter: Patent Infringement. Digital and analog cameras.
Law Firm: Lerner, David, Littenberg, Krumholz & Mentlik, LLP
Case Name: Sony v. Eastman Kodak
Services Provided: Consulting expert witness for the Plaintiff Sony. Subject matter included digital and film cameras and processing methods and equipment.
Disposition: Settled
Date: 2004 – 2006

Expert Engagement:
Type of Matter: Patent Infringement. DVD manufacturing.
Law Firm: Weil Gotshal & Manges LLP
Case Name: Matsushita Electric Industrial (MEI) v. Cinram International
Services Provided: Lead expert witness for the Plaintiff MEI (now Panasonic). Designated testifying and consulting expert witness. Performed research and analysis and testified about bonding and substrate molding processes, materials, equipment and manufacturers. Provided expertise on the technology and processes used to design and manufacture DVD discs. Rebutted the Defendant's claims that the patents in litigation lacked validity. Wrote both infringement and validity expert reports. Testified at deposition twice in defense of these reports.
Disposition: Settled
Date: 2003 – 2004

Expert Engagement:
Type of Matter: Copyright Infringement.
Law Firm: Hogan & Hartson LLP
Case Name: ESS Technology Inc. v. MediaTek Inc.
Services Provided: Consulting expert witness for the Defendant MediaTek Inc.. Subject matter included DVD drives and firmware. Submitted initial expert report.
Disposition: Settled
Date: 2003

Expert Engagement:
Type of Matter: Patent Infringement. Xbox related technologies.
Law Firm: Klaquist Sparkman LLP
Case Name: Media Optik v. Microsoft
Services Provided: Consulting expert witness for the Defendant Microsoft in the following technologies; Xbox games, DVD-ROM; optical card systems; virtual memory architectures and bus structures, displays, and image processing.
Disposition: Settled
Date: 2003

Expert Engagement:
Type of Matter: Patent Infringement. DVD hardware and firmware.

Law Firm: Fulbright & Jaworski
Case Name: LaserDynamics v. Acer, et al
Services Provided: Consulting expert witness for the Defendant Acer in the following technologies: DVD-Video and DVD-Recordable, file structures, data access methods, DVD applications software, and displays.
Disposition: Settled
Date: 2002

Expert Engagement:
Type of Matter: Patent Infringement. CD-R optical discs.
Law Firm: Sullivan & Cromwell
Case Name: Philips, et al v. Princo, et al
Services Provided: Consulting expert witness for the Plaintiff Philips
Disposition: Settled
Date: 2002

Expert Engagement:
Type of Matter: Patent Infringement. Non-imaging optics.
Law Firm: Workman, Nydegger & Seeley
Case Name: 3COM v. Xircom
Services Provided: Consulting expert witness for the Plaintiff 3COM on the following technologies: LEDs, fiber optic light pipes, and optical path analysis for laptop modems.
Disposition: Settled
Date: 2001

Expert Engagement:
Type of Matter: Patent Infringement. Technology included architecture, design and implementation of EIDE controller with ATAPI extensions for CD-ROM
Law Firm: Wilson, Sonsini, Goodrich & Rosati
Case Name: Oak Technologies v. UMC, et. al.
Services Provided: Supporting expert witness for the Defendant UMC. Designated testifying and consulting expert witness about the product and market evolution of CD-ROM products, from their invention in 1978 until introduction of universal interface standards in 1995. Performed research and analysis, wrote an expert report, and testified about products, technology, markets, manufacturing, business practices, standards and trends. Testified at deposition and before the ITC.
Disposition: Dr. Zech's market and trends analyses were cited by the judge (Hon. Sidney Harris) in his decision in favor of the client.
Date: 1999

Expert Engagement:
Type of Matter: Patent Infringement. Complex storage architectures.
Law Firm: Chrisman Bynum Johnson
Case Name: Stuff Technology v. Storage Technology Corp.
Services Provided: Lead expert witness for the Defendant Storage Technology Corp. Wrote detailed expert report refuting Plaintiff's claims.
Disposition: Summary judgment in favor of Defendant

Date: 1999

Expert Engagement:

Type of Matter: Theft of Trade Secrets
Law Firm: Oppenheimer Wolff & Donnelly
Case Name: Maxoptix v. TeraStor
Services Provided: Lead expert witness for the Plaintiff Maxoptix. Subject matter included near field optical drives and media.
Disposition: Settled
Date: 1999

Expert Engagement:

Type of Matter: Patent Infringement. Advanced system for cinematic sound reproduction.
Law Firm: Farella Braun & Martel
Case Name: Drexler Technology v. Dolby Laboratories.
Services Provided: Lead expert witness for the Defendant Dolby Laboratories on the following technologies: CCD photodetector arrays, correlation detection, image processing and display, and optical storage for sound reproduction from photographic film.
Disposition: Settled
Date: 1998 – 1999

Expert Engagement:

Type of Matter: Patent Infringement. Optical disc mastering.
Law Firm: Brobeck Phleger & Harrison
Case Name: ODC v. Delmar Electronics
Services Provided: Lead expert witness for the Defendant Delmar Electronics. Subject matter included CD-R optical discs and optimum write strategies.
Disposition: Settled
Date: 1998

Expert Engagement:

Type of Matter: Patent Infringement. Large optical disc system integration.
Law Firm: Gray Cary Ware & Freidenrich
Case Name: ASI v. DataWare
Services Provided: Consulting expert witness for the Defendant DataWare . Subject matter included WORM 12- and 14-inch optical disc drives and media and applications.
Disposition: Settled
Date: 1998

Expert Engagement:

Type of Matter: Breach of Contract. Design and performance of a thermal transfer device.
Law Firm: Sidley & Austin
Case Name: BE Aerospace v. NCR
Services Provided: Consulting expert witness for the Defendant NCR; submitted expert report. Subject matter included thermal analysis and characterization methods and processes.
Disposition: Settled

Date: 1998

Expert Engagement:
Type of Matter: Breach of Contract. Allegations of the failure of PLMS to deliver in quantity and on time 2x-speed CD-ROM drives for Atari's Jaguar game product
Law Firm: Law Offices of Adron Beene
Case Name: JTS/Atari v. Philips Laser Magnetic Storage (PLMS)
Services Provided: Lead expert witness for the Plaintiff JTS/Atari . Designated testifying and consulting expert witness. Performed research and analysis and testified about technology, product development, project management, components and manufacturing. Deconstructed production model of litigated 2x-speed CD-ROM reader. Determined mechanical, optical, and electronic (including R/W channel, ECC, and interface) design aspects. Showed in expert report that (i) Atari's electronics design was stable and manufacturable, and that all components were available and usable and (ii) PLMS had the capability to perform. Testified at deposition
Disposition: Settled
Date: 1997

Expert Engagement:
Type of Matter: Patent Infringement. Optical disc mastering.
Law Firm: Morgan, Lewis & Bockius
Case Name: DiscoVision Associates v. DMI
Services Provided: Consulting expert for the Plaintiff DiscoVision Associates. Subject matter included CD-R discs and master disc formatting.
Disposition: Settled
Date: 1997

Expert Engagement:
Type of Matter: Breach of Contract regarding the development, manufacturing and marketing of a 4 GB 14" WORM disk optical storage product line, comprising drives, disks, and libraries for IBM mainframe computers.
Law Firm: Rothgerber, Appel, Johnson, & Powers
Case Name: Storage Tech Partners II v. Storage Technology Corp. (STC)
Services Provided: Lead expert witness for the Defendant Storage Technology Corp. (STC) . Designated testifying and consulting expert witness. Performed research and analysis and testified about technology, product development, project management, manufacturing, computer storage, markets and applications, and market potential. Interviewed key managers. Analyzed sales forecasts. Testified at deposition
Disposition: Settled
Date: 1990

Non-Litigation Patent Consulting Projects

Consulting Engagement:

Client:	Luminoz, LLC
Services Provided:	Patent application support. Wrote a report responding to patent examiner's objections, refined claims, re-wrote abstract.
Date:	2006

Consulting Engagement:

Client:	AC Troner LP (Melbourne, FL)
Services Provided:	Consulting expert regarding technology and potential economic value of IP. Wrote detailed report outlining areas of potential infringement and licensing opportunities.
Date:	2002 – Present

Consulting Engagement:

Client:	Knobbe, Martens, Olson & Bear
Services Provided:	Consulting expert regarding technology/economic value of IP. Wrote detailed report with recommendations for product development/infringement research.
Date:	1998

Professional Affiliations, Achievements & Awards

- Founder's Scholar, Lawrence Institute of Technology (1960-1965)
- NASA Science and Technology Award for the invention of the DIGIMEM Terabyte Optical Memory System (1982)
- Member, Committee on Preservation for the U.S. National Archives (1981-85)
- Member, Consultants Network of Silicon Valley (CNSV)
- Fellow, Society for Imaging Science and Technology (1983; formerly SPSE)
- Member, DVD Association
- Life Member, IEEE (Institute of Electrical and Electronic Engineers; consumer electronics, holography, and photonics societies)
- Member, International Liquid Crystal Society
- Member, Materials Research Society (MRS)
- Member, OSA (Optical Society of America)
- Member, SID (Society for Information Display)
- Member, SPIE (Society of Photographic and Instrumentation Engineers)
- Charter Member Emeritus, CPIA (Colorado Photonics Industry Association)
- Primary Contributor, 2003 INSIC and author of the 2004 NEMI and 2006, 2010, 2012, and 2014 iNEMI optical storage roadmaps.
- Manuscript Reviewer, Applied Optics and Optics Express (1995 – Present)

Patents & Publications

Patent	Date Issued	Description
4,198,701	1980	Digital Optical Recorder-Reproducer System

Publications

Dr. Zech is the author of over 150 technical papers, reports and presentations (1965-2012); a complete list is attached.

Past 10 Years Papers, Presentations, and Reports

1. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2012.
2. "The Future of Optical Data Storage " (Invited Paper), International Conference on Consumer Electronics, Las Vegas, NV, January 13-16, 2012.
3. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2010.
4. "Optical Data Storage – A Tutorial" (Invited Paper), International Conference on Consumer Electronics, Las Vegas, NV, January 11-14, 2009.
5. A DVD Primer -The DVD-Video Perspective (rev 08), An ADVENT Group Publication, September 2007.
6. Di Chen and R.G. Zech, Optical Data Storage - Technology and Business Outlook, International Forum on Optical Industry IP (Cheng Chan High Tech Center), Shanghai, China, May 19-21 2007.
7. "Computer Storage at the New Technology Tipping Point: The Impact of MEMS and NEMS on Performance (Invited Paper)," International Conference on Consumer Electronics 2007, Las Vegas, NV, January 10-14, 2007.
8. "Focusing on Blu-ray & HD DVD," The 2006 Consumer Electronics Show, Las Vegas, NV, Jan 5-8, 2006.
9. "The Blue-Laser Media Perspective," A CeBIT 2006 Summary Report, Hannover, Germany, March 8-15, 2006.
10. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2006.
11. "The Future Direction of Optical Data Storage: Technologies and Challenges in the 21st Century (Invited Paper)," Media-Tech 2006, Long Beach, CA, October 10-11, 2006.
12. "The Technical Expert Witness in Patent Litigation (Invited Paper)," Optical Sciences Center, University of Arizona, February 17, 2005.
13. "A Bright Future for Optical Storage - The Consumer Electronics Perspective," Storage Visions 2005 (jointly with CES 2005), Las Vegas, NV, January 4-5, 2004.
14. "The Technical Expert Witness: Honest, Objective, and Effective Litigation Support" (Invited Paper), SPIE Annual Meeting, Denver, CO, July 2004.
15. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," National Electronics Manufacturers Initiative (NEMI) Biannual Roadmap, July 2004.
16. The 2005-15 Roadmap: Optical Storage for Consumer Electronics, An ADVENT Special Report, December 2004.

All Papers and Presentations

1. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2012.
2. "The Future of Optical Data Storage " (Invited Paper), International Conference on Consumer Electronics, Las Vegas, NV, January 13-16, 2012.
3. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2010.
4. "Optical Data Storage – A Tutorial," International Conference on Consumer Electronics 2009, Las Vegas, NV, January 11-14, 2009.
5. "A DVD Primer – The DVD Video Perspective (rev 08)," An ADVENT Group Publication, September 2007.
6. Di Chen and R.G. Zech, "Optical Data Storage – Technology and Business Outlook," International Forum on Optical Industry IP (Cheng Chan High Tech Center), Shanghai, China, May 19-21, 2007.
7. "Computer Storage at the New Technology Tipping Point: The Impact of MEMS and NEMS on Performance (Invited Paper)," International Conference on Consumer Electronics 2007, Las Vegas, NV, January 10-14, 2007.
8. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," international National Electronics Manufacturers Initiative (iNEMI) Biannual Roadmap, July 2006.
9. "The Future Direction of Optical Data Storage: Technologies and Challenges in the 21st Century (Invited Paper)," Media-Tech 2006, Long Beach, CA, October 10-11, 2006.
10. A DVD Primer -The DVD-Video Perspective (rev 07), An ADVENT Group Publication, December 2006.
11. "The Technical Expert Witness in Patent Litigation (Invited Paper)," Optical Sciences Center, University of Arizona, February 17, 2005.
12. "A Bright Future for Optical Storage -The Consumer Electronics Perspective," Storage Visions 2005 (jointly with CES 2005), Las Vegas, NV, January 4-5, 2004.
13. "The Technical Expert Witness: Honest, Objective, and Effective Litigation Support" (Invited Paper), SPIE Annual Meeting, Denver, CO, July 2004.
14. "Strategic Assessment of Next Generation and Future Optical Storage Technologies," National Electronics Manufacturers Initiative (NEMI) Biannual Roadmap, July 2004.
15. The 2005-15 Roadmap: Optical Storage for Consumer Electronics, an ADVENT Special Report, December 2004.
16. "UV Futures for Optical Disc (What's Next for DVD after Blu-ray?)," International Storage Industry Consortium (INSIC) 2003 Conference on the Future of Optical Data Storage, San Francisco, CA, January 23-25, 2003.
17. "Technology Analysis: Optical Storage Futures -The Consumer Electronics Perspective (Invited Paper), IIST Workshop XVII, Asilomar Conference on Computer Storage, Monterrey, CA, December 2003.

18. "Where do we go from here?, Digital Media Futures for Consumer Electronics" (Invited Paper), Diskcon 2002, September 17-19, 2002, San Jose, CA.
19. "A Summary Report on Selected Advances in CD/DVD and Other Optical Storage Technologies," ODS 2001, Santa Fe, NM, April 22-25, 2001.
20. "Highlights of Advances in CD/DVD Replication Technology & Content Creation and Delivery Methods," REPLITech Europe 2000, Düsseldorf, Germany, February 22-24, 2000.
21. "Volume Hologram Optical Memories: Mass Storage Future Perfect?," Optics and Photonics News, August 1992, pp. 16-25.
22. "Mass Storage Concepts and Technology for Electronic Image Management: Optical , Magnetic, and Semiconductor," AIIM Annual Show and Conference, April 29 -May 2, 1991, Washington, D.C.
23. "Second Generation Write-Once Disk Optical Storage Subsystems," Proceedings IGC Electronic Imaging'89, Pasadena, CA, April 1989.
24. "The Optical Head/Media Interface -Performance, Systems, and Applications Issues for Magneto-Optic Erasable-Disk Optical Drives," Proceedings of IEEE on Computer Systems, Peripherals and Networks, Santa Clara, CA, May 23-25, 1989.
25. "Systems, Applications, and Implications of Optical Storage," CompCon`88 (23rd IEEE Computer Society International Conference), San Francisco, CA, February 29-March 4, 1988.
26. "The Growth Market for Optical Storage Subsystems," Optical Storage'88, Denver, Colorado, May 16-18, 1988.
27. "Optical Drive Technology and Markets - Light at the End of the Tunnel?" (Invited Paper), IIST Workshop IV, Lake Arrowhead Invitational Conference on Mass Storage, Lake Arrowhead, CA, October 1988.
28. "Matching Optical Storage to the Market," The First Technology Opportunity Conference in Europe, London, England, February 1987.
29. "Optical Memory Technology -Status, Challenges, and Opportunities for Key Components," The First Annual Technology Opportunity Conference and Exhibition on Optical Drive and Media Manufacturing, San Francisco, CA, July 1987.
30. "Important Technology and Manufacturing Issues for Optical Drives and Media," The First Annual Technology Opportunity Conference and Exhibition on Optical Drive and Media Manufacturing, San Francisco, CA, July 1987.
31. "Marketing the Small Computer System Optical Memory Application," Third Annual Technology Opportunity Conference on Optical Storage for Small Systems, October, 1987.
32. "Optical Storage Limitations: Systems and Media Aspects," Symposium on Memory and Advanced Recording Technologies (SMART), Santa Clara, CA, May 1986.
33. "Rugged and Militarized Optical Drives -Technology, Markets, and Applications," The Second International Japan Technology Opportunity Conference, Tokyo, Japan, October 1986.
34. "Will the Real Optical Storage Please Stand Up?" (Invited Paper), IIST Workshop II, Lake Arrowhead Invitational Conference on Mass Storage, Lake Arrowhead, CA, October 1986.
35. "Optical Storage -Technology, Systems and Applications," The Second Annual Technology Opportunity Conference on Optical Storage for Small Systems, Los Angeles, CA, November 1986.

36. "Applications of Optical Memory to Printing and Publishing," Lasers in Graphics Conference Proceedings (Vol. 2), Anaheim, CA, December 1986, pp. 339-40
37. "Optical Data Storage - An Historical Perspective" (Invited Lecture), the University of Texas (Dallas), January 30, 1985.
38. "Optical Mass Storage for Small Computer Systems --- ISI's Philosophy and Products," The First Annual Conference on Optical Storage for Small Systems, Los Angeles, CA, June 5-7, 1985.
39. "Optical Storage: Criteria for Selection, Evaluation, and Integration," Peripherals Forum, Sunnyvale, CA, June 1985.
40. "Comparative Survey of Erasable Optical Disk Media," Technology Opportunity Conference on The Future of Optical Memories, Compact Disks, and Videodisks to the Year 2000, San Francisco, CA, November 13-15, 1985.
41. "Microimaging Technology in an Electronic Information Age," SPSE 3rd International Business Graphics Symposium (Microimaging Technology), Arlington, VA, November 1983.
42. "Optical Data Display, Processing, and Storage II" (Conference Chair and Editor), SPSE Technical Symposium, Las Vegas, Nevada, March 1981.
43. "Technology for Electronic Journalism in the 1980's," SPSE Annual Meeting, New York, NY, May 1981.
44. "Technology for the 1980's --Applications to Real Estate Information Services" (Invited Lecture), Northwest Council of Multiple Listing Services Spring Meeting, Spokane, WA, April 1980.
45. "Optical Data Display, Processing, and Storage I" (Conference Chair and Editor), SPSE Technical Symposium, Orlando, FL, January 1979.
46. "High-Density Optical Data Storage for Military Applications" (Invited Lecture), U.S. Army Missile Research and Development Center, Huntsville, AL, March 1979.
47. "Review of Laser Systems and Materials for Publication Applications," Lasers in Graphics, San Diego, CA, October 1979.
48. "Optical Storage for Cartography" (Invited Speaker) 3rd International Symposium on Computer-Assisted Cartography (Auto-Carto III), San Francisco, California, January 1978.
49. "A Review of Optical Information Handling Systems" (Invited Graduate Seminar Lecture), Florida Institute of Technology, Melbourne, Florida, March 1978.
50. "Optical Data Storage: Technology and Applications," IGC Conference on Promise of Current and Future Imaging Systems, Andover, Massachusetts, March, 1978.
51. "Optical Data Storage for Archiving" (Invited Presentation), Photographic Preservation Branch -National Archives, Washington, D.C., May 1978.
52. "Optical Data Recording and Storage" (Invited Paper), 1978 Gordon Conference on Holography and Coherent Optics, Santa Barbara, California, June 1978.
53. "Overview of Optical Information Storage," IGC Conference on Advances in Optical Information Storage, Andover, MA, July 1978.
54. "Holographic Block-Oriented, Random-Access Memories: Problems and Prospects," IGC Conference on Advances in Optical Information Storage, Andover, MA, July 1978.

55. "Status and Outlook for Storage Media," IGC Conference on Advances in Optical Information Storage, Andover, MA, July 1978.
56. "Applications of Optical Recording and Storage," IGC Conference on Advances in Optical Information Storage, Andover, MA, July 1978.
57. "Design Considerations for Large Online Optical Memories," Annual Meeting of the Optical Society of America, San Francisco, CA, October 1978.
58. "Overview of Magnetic and Optical Storage Technologies" (Invited Presentation), IBM Almaden Research Laboratories, San Jose, CA, November 1978.
59. "Transparent Electrophotographic Films for Optical Data Storage Applications" (coauthor), Applied Optics 16, pp. 1642-51, June 1977.
60. "Experimental Characterization and Evaluation of High-Resolution Electrophotographic Recording Media" (coauthor), Optical Storage Materials and Methods, SPIE Proceeding 23, pp. 61-66, August 1977.
61. "3M and Kodak Dry Silver Recording Materials for Laser Imagery Transmission Applications" (coauthor), Optical Storage Materials and Methods, SPIE Proceeding 23, pp. 10-16, August 1977.
62. "Multichannel Laser Recorder/Reproducer (Optical Memory) for Archival Mass Storage Applications" (coauthor), Annual Meeting of the Optical Society of America, Toronto, Ontario, Canada, October 1977.
63. "Laser Recording at Harris Corporation" (Invited Paper), Annual Meeting of the Optical Society of America, Toronto, Canada, October 1977.
64. "Electrophotographic Films for High-Density Optical Data Storage," 3rd SPSE International Conference on Electrophotography, Washington, D.C., November 1977.
65. "Optical Mass Storage" (coauthor), Proceedings of the DOE/NCAR Mass Storage Workshop, Boulder, Colorado, December 1977.
66. "Optical Storage and Retrieval of Cartographic Information" (coauthor), Annual Meeting of the Optical Society of America, Tucson, AZ, October 1976.
67. "Distortion Minimization in Cartographic Storage and Retrieval" (coauthor), Annual Meeting of the Optical Society of America, Tucson, AZ, October 1976.
68. "The Role of Holography in Micrographics," 16th Annual SPSE Fall Symposium on Business Graphics, Washington, D.C., November 1976.
69. "Applications of Electrophotography to Optical Data Storage," IEEE/IAS Conference Record 51A, pp. 301-308, October 1975.
70. "Angular Orientation Sensitivity of Volume Holograms," Annual Meeting of the Optical Society of America, Boston, MA, October 1975.
71. "Data Storage in Volume Holograms," Ph.D. Thesis, University of Michigan, May 1974 (University Microfilms No. 74-25, 369).
72. "Holographic Data Storage and Retrieval" (coauthor), Optical Engineering 13, pp. 429434, September/October 1974.
73. "Volume Hologram Recording in Photographic Emulsions: Development Effects," SPSE Symposium on Advances in Applied Photographic Processing, Washington, D.C., October 1974.

74. "Incoherent Superposition in Volume Phase Holograms," Annual Meeting of the Optical Society of America, Houston, TX, October 1974.
75. "Experimental Measurement of Aberrations in Holographic Optical Elements" (coauthor), Spring Meeting of the Optical Society of America, Denver, CO, March 1973. "Optical Storage Materials: Basic Concepts and Definitions," University of Michigan Engineering Summer Conference on Optical Processing, Ann Arbor, MI, August 1973.
76. "Heat-Processed Photoresist for Holographic Data Storage" (coauthor), Applied Optics 12, pp. 2822-27, December 1973.
77. "Hologram Recording in Thick Light-Sensitive Polymers," Fall Meeting of the Optical Society of America, San Francisco, CA, October 1972.
78. "Holographic Recording of Retinal Contours" (coauthor), Fall Meeting of the Optical Society of America, Hollywood, FL, September 1970.
79. "Pulsed Laser Holography," Spring Meeting of the Optical Society of America, San Diego, California, March 1969.
80. "A New Holographic Technique for Medical and Biomedical Applications" (coauthor), Biomedical Sciences Instrumentation 6, pp. 66-71, May 1969.
81. "Photographic Realization of an Image-Deconvolution Filter for Holographic Fourier Transform Division" (coauthor), Japanese Journal of Applied Physics 7, pp. 764-66, July 1968.
82. "Pulsed Laser Reflection Holograms" (coauthor), Applied Physics Letters 13, pp. 41718, December 1968.
83. "Holographic Synthesis of Computer-Generated Holograms" (coauthor), Proceedings of the IEEE 55, pp. 109-11, January 1967.
84. "Hand-Held Holography" (coauthor), Journal of the Optical Society of America 57, p. 110, January 1967.
85. "A Posteriori Image-Correcting Deconvolution by Holographic Fourier Transform Division" (coauthor), Physics Letter 25A, pp. 89-90 July 1967.
86. "White-Light Reconstruction of Color Images from Black-and-White Volume Holograms on Sheet Film" (coauthor), Applied Physics Letters 9, pp. 215-17, September 1966.
87. "Advantages and Limitations of van Heerden Wavefront Reconstruction Optical Memories," Institute of Science and Technology Lecture, University of Michigan, Ann Arbor, MI, November 1965.

U.S. Government Contract Research Reports (unclassified only)

1. "Optical Mass Memory Investigation" (Volumes I, II, and III), Final Technical Report, Contract No. NAS 8-30564, G. C. Marshall Space Flight Center, Huntsville, Alabama, June 1977.
2. "Hologram Replication Investigation," Final Technical Report, Contract No. F30602-76C-0382, Rome Air Development Center, Griffiss Air Force Base, New York, September 1977.
3. "Wideband Holographic Digital Recording and Reproduction (Phase III)," Final Technical Report, Contract No. RD-76-6208, September 1977.

4. "Microreduction and Enlargement of Graphic Information Study," Final Technical Report ETL-0063, Contract No. DAAG-53-75-C-0155, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, December 1977.
5. "Investigation of Cartographic Pressplate Recording from Digital Data," Final Technical Report ETL-0043, Contract No. DAAG53-76-C-0021, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, February 1976.
6. "Data Storage in Volume Holograms," Final Technical Report, Contract No. DAAH0173-C-0946, U.S. Army Missile Command, Redstone Arsenal, Huntsville, Alabama, January 1974.
7. "Holographic Optical Elements: Fabrication and Testing," Final Technical Report 1321F-2, Contract No. NAS 8-28949, G. C. Marshall Space Flight Center, Huntsville, Alabama, March 1974.
8. "Holographic Packing Density Evaluation," Final Technical Report, Contract No. DAAB03-72-C-3242, National Security Agency, Fort Meade, Maryland, May 1974.
9. "Holographic Recording Materials," Final Technical Report RADC-TR-74-287, Contract No. F30602-14-C-0030, Rome Air Development Center, Griffiss Air Force Base, New York, July 1974.
10. "Holographic Optical Elements," Final Technical Report AFAL-TR-72-409, Contract No. F33615-72-C-1156, Air Force Systems Command, Wright Patterson Air Force Base, Ohio, January 1973.
11. "Optical Read/Write Memory System Components," Part II, Final Technical Report 8105-F-2, Contract No. NAS 8-26672, G. C. Marshall Space Flight Center, Huntsville, Alabama, March 1973.
12. "Investigation of Uses of Holographic Optical Elements," Final Technical Report 8204-F1, Contract No. NAS 8-28949, G. C. Marshall Space Flight Center, Huntsville, Alabama, May 1973.
13. "Wideband Holographic Digital Recording and Readout," Final Report RADC-TR-73223, Contract No. F30602-71-C-0365, Rome Air Development Center, Griffiss Air Force Base, New York, August 1973.
14. "Updated Optical Read/Write Memory Systems Components," Final Technical Report, Contract No. NAS 8-26672, G. C. Marshall Space Flight Center, Huntsville, Alabama, August 1973.
15. "Large Aperture Holographic Optical Elements," Final Technical Report 6317-F, Contract No. 100071, Environmental Research Institute of Michigan, Ann Arbor, Michigan, September 1973.
16. "Optical Read/Write Memory System Design," Final Technical Report 8104-F-1, Contract No. NAS 8-26360, G. C. Marshall Space Flight Center, Huntsville, Alabama, February 1971.
17. "Holographic Storage/Readout Techniques," Final Technical Report RADC-TR-71-S4, Contract No. F30602-71-C-0100, Rome Air Development Center, Griffiss Air Force Base, New York, June 1971.
18. "Optical Read/Write Memory System Components," Part I, Final Technical Report 8105F-1, Contract No. 8-26672, G. C. Marshall Space Flight Center, Huntsville, Alabama, February 1971.
19. "Investigation of Optical Memory Techniques," Final Technical Report 8101-12-F, Contract No. NAS-12-2200, NASA Electronics Research Center, Cambridge, Massachusetts, October 1970.

Confidential Business and Technology Reports

1. 2-D Diode Laser Array for Ultra High-performance Optical Card Memory System
2. 3.5" and 5.25" Optical Storage Product Distribution in Europe
3. Applications and Markets for 12" MO Multifunctional Optical Storage Products
4. Application/Market Development for High-performance Multimedia Optical Storage
5. Applications and Market Potential for High-density SSD 3.5" MO Optical Storage System
6. Computer Storage for Video-on-Demand/Consumer Interactive Services Applications
7. Computer Security: Technology, Products, and Markets for PCs and Workstations
8. Design/Business Plan for 50 GB WORM Removable-media Optical Drum Memory System
9. Design/Preliminary Business Plan for Rotating Optical Memory Card Based on CD-R
10. Design/Preliminary Business Plan for 2" and 3.5" Fixed-media MIL-SPEC Optical Drives
11. Design/Preliminary Business Plan for 3.5" 1-GB Rewritable Fixed-media Optical Drive
12. Design/Business Plan for a 2 x 512MB 3.5" Phase Change Optical Disk Drive
13. Design/Preliminary Business Plan for 19" Rack-mounted 25-GB 12" Fixed-disk Optical Drive
14. Design/Preliminary Business Plan for Dual CD-ROM/Multifunction 5.25" Optical Disk Drive
15. Design/Preliminary Business Plan for Parallel Architecture Wafer Scale (PAWS) Semiconductor Super High-performance Storage System
16. Design/Preliminary Business Plan for 1 PB 3-D Holographic Memory Server
17. Engineering and Applications Overview of Optical Disk Products
18. Market/Application Assessment: 3-D Hologram Memories for Enterprise Servers
19. Markets and Applications for 5.25" Optical Disk Libraries
20. Marketing Channels for Optical Drives and Media
21. Market Channel Survey of Optical Drive and Disk Resellers
22. Marketing and Sales Strategies for 3.5" and 5.25" MO Optical Disk Products
23. Market and Technology Evaluation of High-end Document Image Servers and Systems
24. Markets and Technologies for High-end Document Image Processing Systems
25. Markets and Technologies for Optical Disk and Magnetic Tape Automated Libraries
26. Militarized Optical Disk Drives: Technology, Markets, and Applications
27. Optical Memory Cards: An Analysis of Markets, Applications, Technologies, and New Business Opportunities
28. Optical Storage Applications for Small Computer Systems
29. Optical Storage Technology and Devices for MIL-SPEC and Rugged Applications
30. Phase Change Media for 5.25" and 12" Multifunction Optical Storage
31. Product Integrator Business Development for the 1990s: A Strategic Advisory
32. Ruggedized Optical Disk Drives: Technology, Markets, and Applications

33. Serial Impact Dot Matrix & Inkjet Printer Markets and Technologies: A General Survey and Analysis
34. Technology, Markets, and Distribution for CCD-based Electronic Imaging Products
35. Technology Assessment/Conceptual Design: 3-D Hologram Memories for Enterprise Server Applications
36. Technology Assessment: 3-D Hologram Memories for Wideband Correlators
37. Technology Assessment: 3-D Hologram Memory for Wideband Video-on-Demand Services
38. Time-to-Market and Manufacturing Considerations for Low-cost Optical Storage

Conference and Trade Show Reports

1. "CeBIT Executive Report PLUS," CeBIT 1988-2001, Hanover, Germany (a total of 14 detailed reports and appendices covering the world's largest IT trade show; focused on CD and DVD since 1995)
2. "COMDEX Executive Report PLUS," COMDEX Fall 1988-1995, Las Vegas, NV (a total of 8 detailed reports and appendices covering the US's largest IT trade show and conference)

Optical Data Storage (ODS) Conferences

1. "Focusing on Blu-ray & HD DVD," The 2006 Consumer Electronics Show, Las Vegas, NV, 2006.
2. "The Blue-Laser Media Perspective," A CeBIT 2006 Summary Report, Hannover, Germany, March 8-15, 2006.
3. "A Summary Report on Selected Advances in CD/DVD and Other Optical Storage Technologies," ODS 2001, Santa Fe, NM, April 22-25, 2001.
4. "Highlights of Advances in CD/DVD Replication Technology & Content Creation and Delivery Methods," REPLITech Europe 2000, Düsseldorf, Germany, February 22-24, 2000.
5. "Highlights and Advances in CD/DVD and High-performance Rewritable Optical Technology," ODS 1998, Aspen, CO, May 10-13, 1998.
6. "An Appreciation of Significant and Strategic Advances in Optical Storage," ODS 1994, Dana Point, CA, May 16-18, 1994.

Other Private/Custom Reports (not in public domain)

1. All-Optical Networking 2001; CABLE (1994 and 1997); CES (2001-2009); CLEO 2002; EMX 2004 (re Blu-ray Disc); MediaTech 2003-2006; NAB 1995; OFC 2002; REPLITech North America (1996-2001).

APPENDIX B

Information Considered

Description
U.S. Patent No. 7,202,843
U.S. Prosecution History of U.S. Patent No. 7,202,843
Petition filed in IPR2015-00021
Preliminary Response filed in IPR2015-00021
Selected Documents from Prosecution History of European Patent Application No. 03029643.8
Selected Documents from Prosecution History of Japanese Laid-Open Patent Publication No. 4199655 and Certified English Translation Thereof History of Thereof
U.S. Patent Application Publication No. 2002/0044115 ("Jinda")
Japanese Laid Open Application Publication JPH0662355A ("Miyai") and Certified English Translation Thereof
Korean Patent Application No. 2000-0073673 ("Lee") and Certified English Translation Thereof