

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

OMNIVISION TECHNOLOGIES, INC.,
Petitioner,

v.

RE SECURED NETWORKS, LLC,
Patent Owner.

Case No. IPR2025-01019

U.S. Patent No. 6,838,651

Issue Date: January 4, 2005

Title: HIGH SENSITIVITY SNAP SHOT CMOS IMAGE SENSOR

**DECLARATION OF ALBERT THEUWISSEN, PH.D.
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 6,838,651**

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I. Introduction

1. My name is Dr. Albert Theuwissen. I submit this declaration in support of Petitioner OmniVision Technologies, Inc. ("OmniVision").

2. I have been retained by OmniVision as an independent expert consultant in this proceeding before the United States Patent and Trademark Office ("USPTO") to offer my opinions regarding U.S. Patent No. 6,838,651 ("the '651 patent") (Ex. 1001).

3. I have been asked to consider whether certain references disclose or suggest the features recited in claims 1-5 and 18-22 of the '651 patent and the Declaration of R. Jacob Baker, Ph.D, P.E. submitted in support of the January 15, 2021 Petition of Inter Partes Review of the '651 patent submitted by Samsung Electronics, Inc. (Ex. 1014; Ex. 1015.) This declaration sets forth my opinions relating to the technology discussed in the '651 patent, whether certain references disclose or suggest the features recited in claims 1-5 and 18-22, and whether I agree with the Mr. Baker's Declaration.

II. Qualifications and Experience

4. I am the CEO and founder of Harvest Imaging and professor emeritus at the Delft University of Technology, where I have taught for more than 20 years.

5. I received my M.Sc. in Electrical Engineering from K.U. Leuven in 1977 and earned my Ph.D. in Electrical Engineering from K.U. Leuven in 1983.

6. I have previously worked as a Chief Scientist and Chief Technology Officer at DALSA Semiconductor. I have also previously worked as a research and development manager at Philips Research Labs.

7. In 2007, I co-founded ImageSensors, Inc., a non-profit public benefit organization that addresses the needs of the image sensor community. In 2007, I founded my current company, Harvest Imaging.

8. My current research focuses on the development of smart image sensors for the acquisition of data from light signals. I have extensive experience specifically with the design and development of CMOS image sensors, including low-noise and low-power CMOS image sensors. I have also taught numerous courses on image sensors to both undergraduate and graduate engineering students. Similarly, I have extensive experience in the development and design of semiconductor circuitry for image sensors, including various CCD architectures and technologies.

9. I have also had numerous achievements over the course of my career. For example, I helped implement the first single-chip combination CCD and CMOS in 1985, I helped develop an imager capable of recording 1 million frames per second in 2001, and I have created imaging devices with ultralow noise levels and world-record dark current levels.

10. My research has been funded by numerous leading organizations, such as the European Community and the Dutch Technology Foundation as well as other industrial partners. I also serve, or have served, on the editorial board of several leading peer-reviewed journals, including Photonics Spectra and various publications of the Institute of Electronics and Engineers (“IEEE”) involving special issues relating to image sensors and digital imaging. I have also served as a reviewer for peer-reviewed journals including the IEEE Journal on Solid-State Circuits, IEEE Transactions on Electron Devices, IEEE Electron Device Letters, and MDPI Sensors.

11. I have also authored or co-authored more than 270 publications in the field of imaging and related fields. I have also authored the textbook, “Solid-State Imaging with Charge-Coupled Devices,” and co-edited 3 books and several book chapters. I have

been listed as an inventor on over 30 families of patents and patent applications in the United States and abroad. I have given over 50 invited seminars at scientific symposia and education institutions.

12. Within Harvest Imaging, I have conducted over 280 courses, public and in-house, all over the world. Such customers include, for example, Sony, Panasonic, Philips, ASML, Nokia, Motorola, Sony-Ericsson, Google, Facebook, the European and United States Patent Offices, and many others.

13. Throughout my career I have received numerous honors and awards for my work in the image sensor field. In 2008, I was awarded the Fuji Gold Medal by the Society for Motion Pictures and Television Engineers for my contributions in research, development, and education in the field of solid-state image capturing. I was also elected the Electronic Imaging Scientist of the Year in 2010, and in 2014 I received the SEMI Award, which recognizes contributions to the semiconductor, micro-systems, photovoltaic, and display industries.

14. A more complete summary of my education, experience, publications, awards, honors, patents and patent publications, and presentations is provided in my CV, which is included as Exhibit 1003.

III. Compensation

15. I am being compensated for my time spent on this matter at my usual and customary rate of €550 per hour, plus reasonable expenses. My compensation is not in any way tied to the substance of my opinions or the outcome of this action. I have no financial interest in this proceeding.

IV. Materials Reviewed & Considered

16. In preparing this Declaration, I reviewed and considered at least the following materials, in addition to my general background, expertise and experience described above:

- a. The '651 patent (Ex. 1001);
- b. The prosecution file history for the '651 patent (Ex. 1004);
- c. Japanese Patent Publication 2000-12819 ("*Isogai*") (Ex. 1005);
- d. U.S. Patent No. 5,982,984 to Inuiya et al. ("*Inuiya*") (Ex. 1006);
- e. U.S. Patent No. 7,133,073 to Neter ("*Neter*") (Ex. 1007);
- f. U.S. Patent No. 6,704,049 to Fossum ("*Fossum*") (Ex. 1008);
- g. Loinaz et al., "A 200-mW, 3.3-V, CMOS Color Camera IC Producing 352 x 288 24-b Video at 30 Frames/s," *IEEE Journal of Solid-State Circuits*, Vol. 33, No. 12, December 1998 ("*Loinaz*") (Ex. 1010);
- h. U.S. Patent No. 6,115,065 to Yadid-Pecht et al. ("*Yadid-Pecht*") (Ex. 1011);
- i. U.S. Patent No. 6,882,364 to Inuiya et al. ("*Inuyia-364*") (Ex. 1012);
- j. U.S. Patent No. 5,982,318 to Yiannoulous ("*Yiannoulous*") (Ex. 1013);
- k. Petition for *Inter Partes* Review of U.S. Patent No. 6,838,651; Proceeding No. IPR2021-00437 ("*IPR2021-00437*") (Ex. 1014); and
- l. Declaration of R. Jacob Baker, Ph.D., P.E. in Support of Petition for *Inter Partes* Review of U.S. Patent No. 6,838,651; Proceeding No. IPR2021-00437 ("*Baker Declaration*") (Ex. 1015).

V. Level of Ordinary Skill in the Art

17. Having reviewed the '651 patent and its prosecution history, in my opinion, a person of ordinary skill in the art would have had at least a bachelor's degree in electrical engineering, physics, or materials science, and would have had at least four years of industrial or research experience in CMOS image sensor design or fabrication. Or, alternatively, a POSA would have had a master's degree in the fields referenced, electrical engineering, physics, or materials science, and at least two years of experience of industrial or research experience in image sensor design or fabrication.

18. In IPR2021-00437, Dr. Baker opined that a person of ordinary skill in the art at the time of the alleged invention of the '651 patent would have had at least a bachelor's degree in electrical engineering, computer science, or the equivalent, and two or more years of experience with image processing. More education could supplement practical experience and *vice versa*. (Ex. 1015, ¶ 20.)

19. The same analysis and conclusions reached by Dr. Baker and those that I set forth in this Declaration apply under either my proposed level of skill in the art or that of Dr. Baker.

VI. Additional Technology Background

20. In an image sensor, a pattern of color filters allowing only a limited range of wavelengths of light to pass are placed on top of the pixels. For example, the green filter typically allows only wavelengths of 495–570 nanometers (nm) to pass. Thus, the pixels differ in that wavelengths of light that are absorbed and fall into three categories: red, green, and blue.

21. The filters are necessary because the photoelectric effect provides a signal based on the intensity of light, not the perceived color, of light. In 1976, Bryce Bayer at

Kodak received a patent on what has become so ubiquitous it is now referred to as “the Bayer pattern” (U.S. Patent No. 3,971,065.)

22. Bayer pattern operates as a repeating square pattern of 2x2 pixels, in which two pixels are green, one is red, and one is blue. The pixels are arranged so that the color filters allow green and red in every other row and the blue and green in the other alternating rows. The same is true also in column direction. The Bayer pattern is shown below.

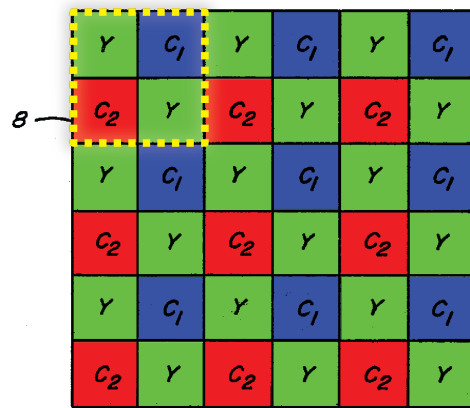


FIG. 1B

(*Id.*, Fig. 1B, annotated.)

23. A person of ordinary skill as of the 2000’s would be well-aware of the Bayer pattern and its benefit in distributing green filters in a uniform way in both dimensions to maximize spatial resolution for luminance sampling. (See, e.g., *id.* at Abstract, 2:18–25, 4:24–31.) Green pixels are placed twice to correspond to the human eye’s greater number of receptors for green light, and thus higher resolution for green information.

24. The 2x2 arrangement, an example of which is within the yellow box annotation, can be referred to as a “unit cell.” The green pixels are arranged on the opposite corners of the 2x2 square to produce uniform sampling of the luminance.

25. Although only a single color’s intensity is measured for each pixel, an outputted color for the pixel requires all three: red, green, and blue (RGB). In other words, when outputted as a digital image, the color value for the pixel consists of three colors, red, green, and blue. For example, a typical color scheme uses values from 0 to 255 for each other: (0,0,0) is black; (255, 255, 255) is white; (255, 0, 0) is red; (0, 255, 0) is green; (0, 0, 255) is blue; and over 16 million other combinations are available. What we perceive as bright yellow can be represented as (255, 255, 0), employing the highest intensity red and green wavelengths only.

26. To accomplish the task for converting each pixel to a usable color value, a CMOS image sensor will employ color interpolation to fill in an estimate of what the other wavelengths of photons would have been if they were not blocked by the color filter. For example, if a single pixel has a green color filter, the only wavelength that was incident on the pixel was a range of wavelengths around 550 nanometers (nm). That pixel does not measure the red wavelength range of around 650 nm or the blue wavelength range of around 450 nm. But a neighboring pixel will instead have a blue color filter that will only allow the blue wavelength range, and another will have a red color filter to only allow the red wavelength range. By also considering certain neighboring pixels, the image sensor can estimate what the original red, green, and blue wavelengths of the incident light would have been. This is called “color interpolation.”

27. Interpolation in which one estimates two missing color values for each pixel was well-known as of the early 2000's in a variety of forms. Color interpolation could range from very simple, such as using the measured value for the nearest neighbors for the two missing colors, averaging multiple neighbors, or other more advanced techniques such as cubic weighting of multiple pixels. Averaging or employing other weighting techniques may improve the results based on the designer's parameters, but the interpolation process is at its core about providing the missing color values that are not included when the pixel measures only a single color. (See, e.g., U.S. Patent No. 5,629,734.)

28. It was well-known and understood as of the early 2000s that color interpolation could be accomplished with a single integrated circuit, i.e. without the use of a separate general processor running software. (See Ex. 1010.) An example of a specialized hardware configuration for performing color interpolation is shown in Loinaz and reproduced below.

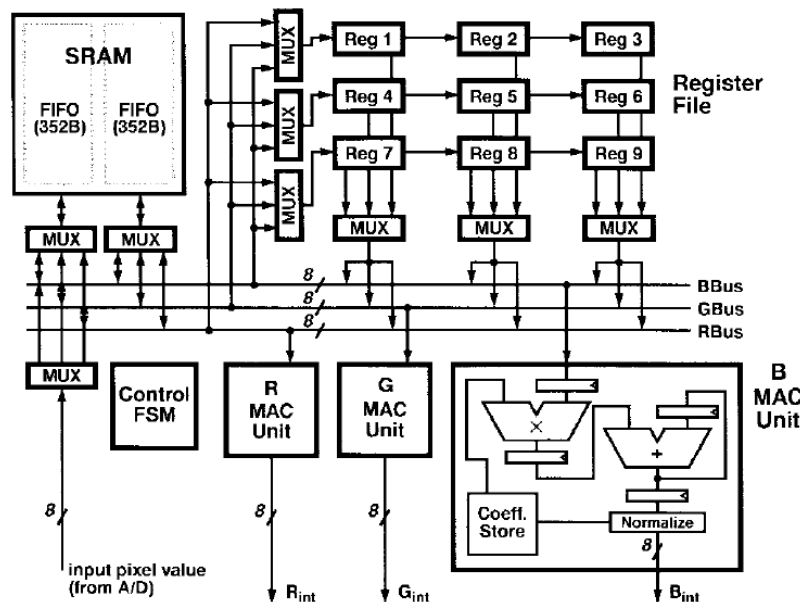


Fig. 10. Color interpolation unit.

(Id.)

29. Further, as of this time, performing **all** of the tasks of a digital camera could be accomplished on a single integrated circuit. For example, Lucent announced and published this capability. A block diagram showing components in a single chip is reproduced below:

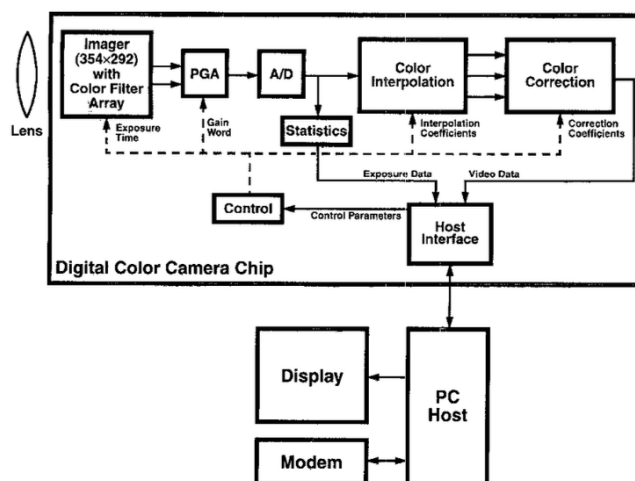


Figure 1: Multimedia camera system block diagram.

(Ex. 1010, Fig. 1)

VII. Overview of the '651 Patent

30. U.S. Patent No. 6,838,651 ("the '651 patent") is titled "High Sensitivity Snap Shot CMOS Image Sensor." The '651 patent issued on January 4, 2005 from U.S. Patent Application No. 10/113,545, which was filed on March 28, 2002.

31. The '651 patent states that the invention "relates to a solid-state imaging device implementing multiple analog-to-digital ('A/D') converters to obtain high frame rates." (Ex. 1001 at 1:8– 11.)

32. The '651 patent discloses a “red pixel, a blue pixel, a first green pixel, a second green pixel, two analog-to-digital converters and a color interpolation circuit.” (*Id.* at Abstract). The four pixels correspond to “four color channels (one red, one blue, and two greens),” (*id.* at 3:1–4), and while “it is natural to use a separate A/D converter for each of the color channels ... two A/D converters may be employed, where one A/D converter is used for the red and blue channels and the second A/D converter is used for the green channels.” (*Id.* at 3:6–10.)

33. Instead of using four A/D converters, one for each color channel, “first analog-to-digital converter converts the outputs of the red pixel and the blue pixel into digital signals,” and the “second analog-to-digital converter converts the outputs of the first green pixel and the second green pixel into digital signals.” (*Id.* at 3:33–37.) These four digital signals are then combined by the color interpolation circuit. (*Id.* at 3:37–38.)

34. The four color channels are “used to define a color image based upon the Bayer Pattern of color filters.” (*Id.* at 3:1–4; *see also id.* at 4:51–53 (“The solid state imaging device of the present invention defines a color image based upon the Bayer pattern of color filters.”).)

35. Figure 1 of the '651 patent is reproduced below with annotated colors to highlight the Bayer filter color pattern.

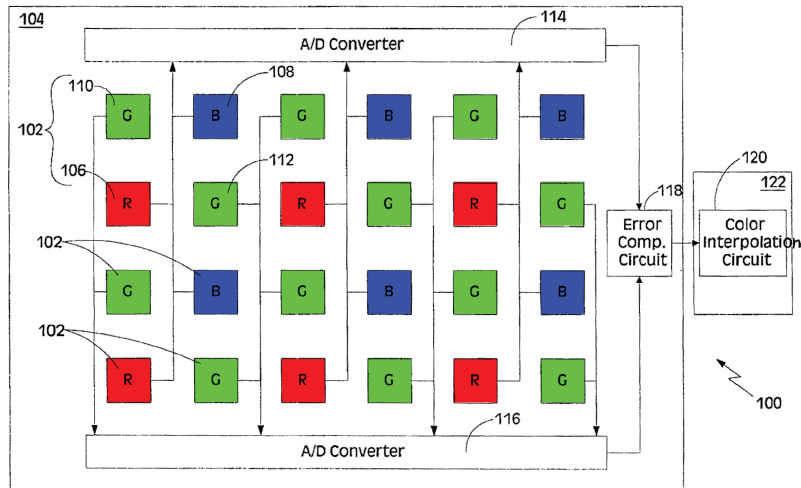


FIG. 1

36. Figure 1 is further annotated below to depict how the different pixels are connected to the A/D converters. The green pixels are connected to the bottom A/D converter. The red and blue pixels are connected to the top A/D converter.

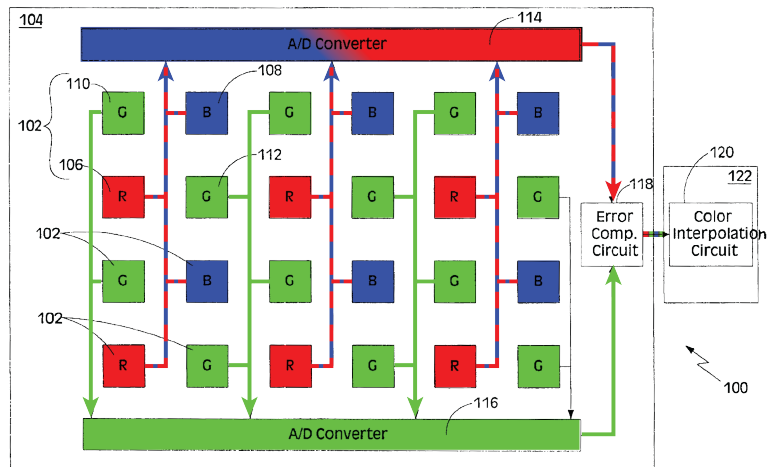


FIG. 1

37. Independent claims 1 and 18 of the '651 patent are reproduced below:

1. A solid state imaging device, comprising:

a red pixel having an output;

a blue pixel having an output;

a first green pixel having an output;

a second green pixel having an output;

a first analog-to-digital converter connected to the output of the red pixel for converting the output of the red pixel into a first digital signal and connected to the output of the blue pixel for converting the output of the blue pixel into a second digital signal;

a second analog-to-digital converter connected to the output of the first green pixel for converting the output of the first green pixel into a third digital signal and connected to the output of the second green pixel for converting the output of the second green pixel into a fourth digital signal; and

a color interpolation circuit for combining the first, second, third and fourth digital signals.

18. An imaging method comprising:

converting an output of a red pixel into a first digital signal using a first analog-to-digital converter;

converting an output of a blue pixel into a second digital signal using the first analog-to-digital converter;

converting an output of a first green pixel into a third digital signal using a second analog-to-digital converter;

converting an output of a second green pixel into a fourth digital signal using the second analog-to-digital converter; and

combining the first, second, third and fourth digital signals using a color interpolation circuit.

VIII. Declaration of Dr. Jacob Baker Submitted in Support of IPR2021-00437

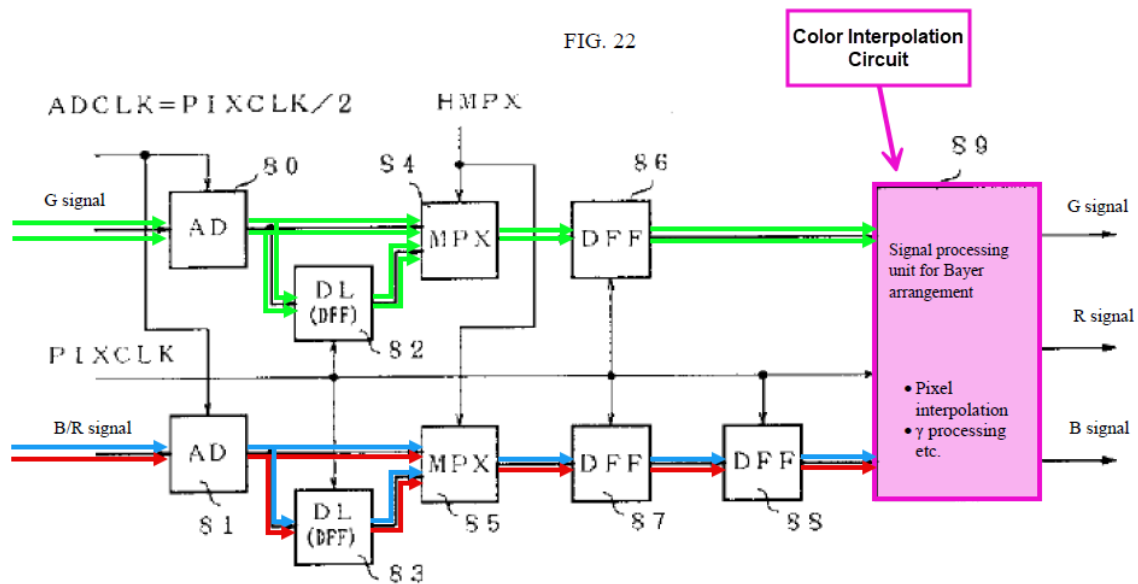
38. I have reviewed the contents and opinions set forth in the “Declaration of R. Jacob Baker, PH.D., P.E. in Support of Petition for *Inter Partes* Review of U.S. Patent No. 6,638,651” (Ex. 1015.) I agree with Dr. Baker’s opinion and incorporate the contents of Dr. Baker’s Declaration in its entirety as if fully set forth herein.

39. Where I render additional opinions to those set forth by Dr. Baker, I have provided those opinions below.

40. I agree with Dr. Baker’s analysis and conclusions that: (1) Isogai discloses or suggests the features of Claims 1 and 18; (2) Isogai in combination with Neter discloses or suggests the features of Claims 2-5 and 19-22; (3) Isogai in combination with Fossum discloses or suggests the features of Claims 2-5 and 19-22; (4) Inuiya discloses the features of Claims 1-3 and 18-20; (5) Inuiya in combination with Neter discloses or suggests the features of Claims 4-5 and 21-22; and (6) Inuiya in combination with Fossum discloses or suggests the features of Claims 4-5 and 21-22.

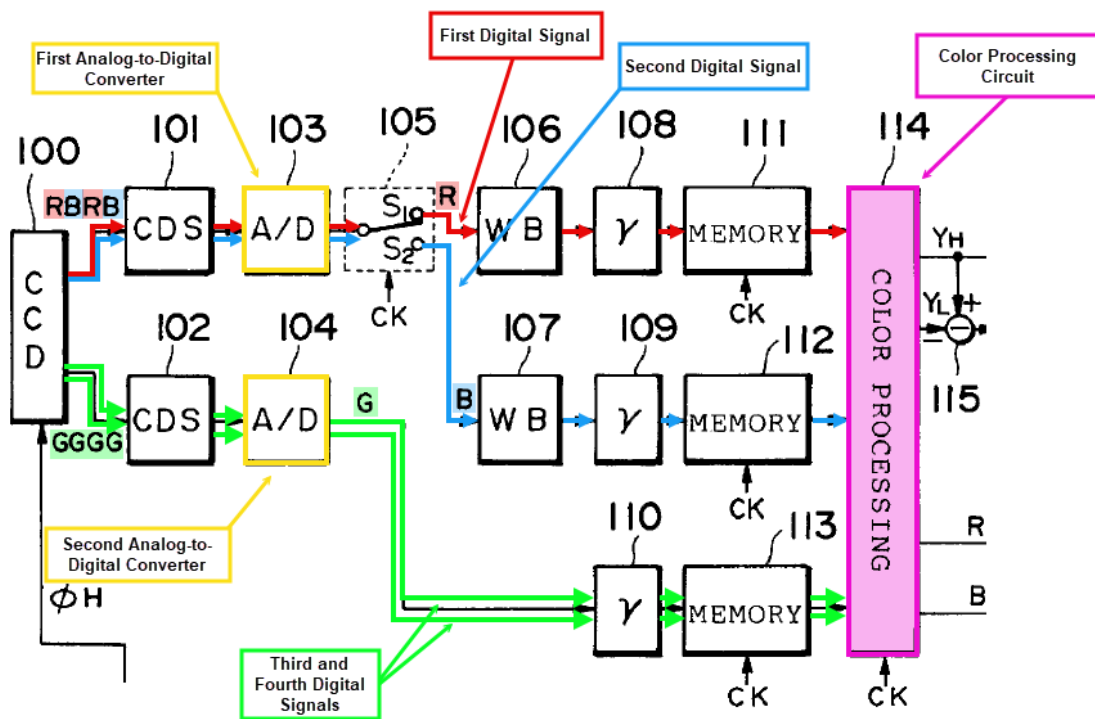
IX. Additional Opinions

41. It is my opinion that signal processing unit for Bayer arrangement 89 shown in Figure 22 of Japanese Patent Publication 2000-12819 ("Isogai") is a dedicated hardware circuit for performing color interpolation of the digital signals for the red, blue, and green pixels. As shown with annotations below, the signal processing unit for Bayer arrangement has inputs receiving two signal paths including first and second analog-to-digital converters in which the first signal path includes two digital signals corresponding to green pixels and the second signal path includes digital signals corresponding to red and blue pixels, and RGB outputs for each pixel after color interpolation is performed.



(Ex. 1005, Fig. 22 (annotated excerpt).)

42. Below is an annotated excerpt of U.S. Patent No. 5,982,984 to Inuiya et al. (“Inuiya”) Figure 18 depicting dedicated input lines and dedicated output lines with respect to the color processing circuit 114. It is my opinion that in the context of entire Figure 18, the dedicated input and output lines corresponding to the color processing circuit 114 indicate that the color processing circuit 114 is also a dedicated hardware circuit for performing color interpolation of the digital signals for the red, blue, and green pixels.



(Ex. 1006, Fig. 18 (annotated excerpt).)

43. It was well understood by a person of skill in the art as of at least 1998 that color interpolation operations could be performed on dedicated hardware circuitry. An example of this is shown in (Ex. 1010, Fig. 10) reproduced below.

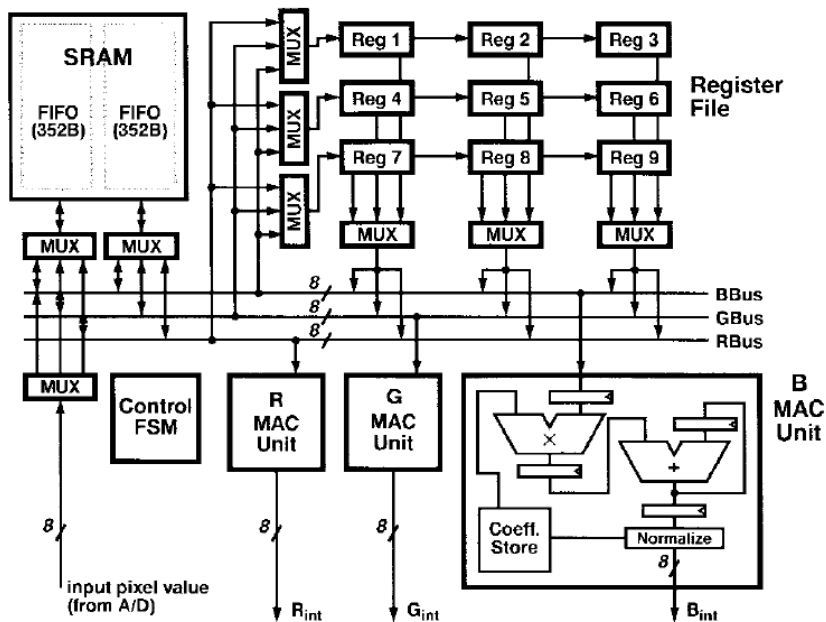


Fig. 10. Color interpolation unit.

44. In my opinion, a person of ordinary skill in the art as of the early 2000's would have understood that a "circuit" is hardware, not software. Based on my decades of experience in image sensor design, "circuit" is a well-known term in the art referring to an interconnection of electrical hardware. A person of ordinary skill in the art would have understood that the term "color interpolation circuit," consistent with the ordinary meaning of "circuit," refers to hardware. For example, the Mc-Graw-Hill Electronics Dictionary, 6th Ed., defines "circuit" as "an interconnected group of active and passive components that accomplishes a desired function such as switching, amplification, filtering or data conversion." In my opinion, a person of ordinary skill in the art as of the filing of the '651 patent in 2002 would have understood that the term "color interpolation circuit," consistent with the ordinary meaning of "circuit," refers to hardware.

45. I have also considered the terms “a color interpolation circuit for combining the first, second, third and fourth digital signals” and “combining the first, second, third and fourth digital signals using a color interpolation circuit” as they would have been understood by a person of ordinary skill in the art at the time of the invention in view of the intrinsic evidence. To a person of ordinary skill in the art, this means that all four signals would be combined.

46. In reviewing Dr. Baker’s Declaration and considering whether cited references disclose “a color interpolation circuit for combining the first, second, third, and fourth digital signals” in claim 1 and “combining the first, second, third, and fourth digitals using a color interpolation circuit” in claim 18 of the ’651 patent, I have applied the understanding of “circuit” and “combining the first, second, third, and fourth digital signals” as applied by a person of ordinary skill in the art as set forth in paragraphs 44 and 45 above.

47. Inuya and Isogai both disclose “a color interpolation circuit for combining the first, second, third, and fourth digital signals” in claim 1 and “combining the first, second, third, and fourth digitals using a color interpolation circuit” in claim 18 of the ’651 patent according to the above constructions. Each discloses dedicated hardware that performs color interpolation. This is evidenced by how each connects to other components and the inclusion of specific input lines for receiving the digital signals and specific output lines for outputting RGB values as discussed above in paragraphs 41 and 42. As confirmed by paragraph 43, a person of skill in the art would know how to build a hardware circuit for color interpolation from a general description or block diagram.

48. To the extent that a broader interpretation of “circuit” or “combining the first, second, third, and fourth digital signals” were adopted, such as if “circuit” were to encompass software running on a microprocessor or in which only some of the four digital signals are combined, Inuya and Isogai would still disclose these claim limitations.

49. To the extent that Patent Owner applies meanings for claim terms that differ from those that I have set forth, I reserve the right to address them in a supplemental opinion.

I hereby attest that the foregoing is true and accurate to the best of my knowledge under penalty of perjury.

May 20th, 2025
Date


Albert Theuwissen, Ph.D.