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(54) **Titre : ETALONNAGE DE PIXEL FONDE SUR DES VALEURS DE REFERENCE AMELIOREES**

(54) **Title: CALIBRATION OF PIXEL BASED ON IMPROVED REFERENCE VALUES**

(57) **Abrégé/Abstract:**

What is disclosed are systems and methods of compensation of images produced by active matrix light emitting diode device (AMOLED) and other emissive displays. The electrical output of a pixel is compared with a reference value to adjust an input for the pixel. In some embodiments an integrator is used to integrate a pixel current and a reference current using controlled integration times to generate values for comparison.

ABSTRACT

What is disclosed are systems and methods of compensation of images produced by active matrix light emitting diode device (AMOLED) and other emissive displays. The electrical output of a pixel is compared with a reference value to adjust an input for the pixel. In some embodiments an integrator is used to integrate a pixel current and a reference current using controlled integration times to generate values for comparison.

IGNIS Innovation Inc.

IGNIS PATENTS

CHARGE BASED COMPARATOR

REZA CHAJI

Revision: 1.0

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Contents

1. Introduction

To avoid the error propagation in the calibration of the pixels in an array structure, the best approach is to adjust the input to get the proper output of the pixel.

In one case, the current is the output of the pixel. Here, the current is compared against a reference current and the input is adjusted so that output current is the same as reference current.

The challenge in this case is generating accurate reference current at different levels. This invention presents methods to reduce the complexity of generating low current levels as reference current.

2. Integration Time Ratio

In this method, the pixel current and the reference current are integrated two create two voltages that can be compared or digitalized for making a decision for adjusting the pixel input.

Here, the integration time of the reference current can be shorter than the pixel current. As a result to get similar effect as pixel current, the reference current should be larger than the pixel current. For example, if the integration time of the reference current is K times smaller than that of pixel current, the reference current should be K times larger. This can be also applied to sampling the output charge from the pixel and comparing it with a reference charge created by a reference current.

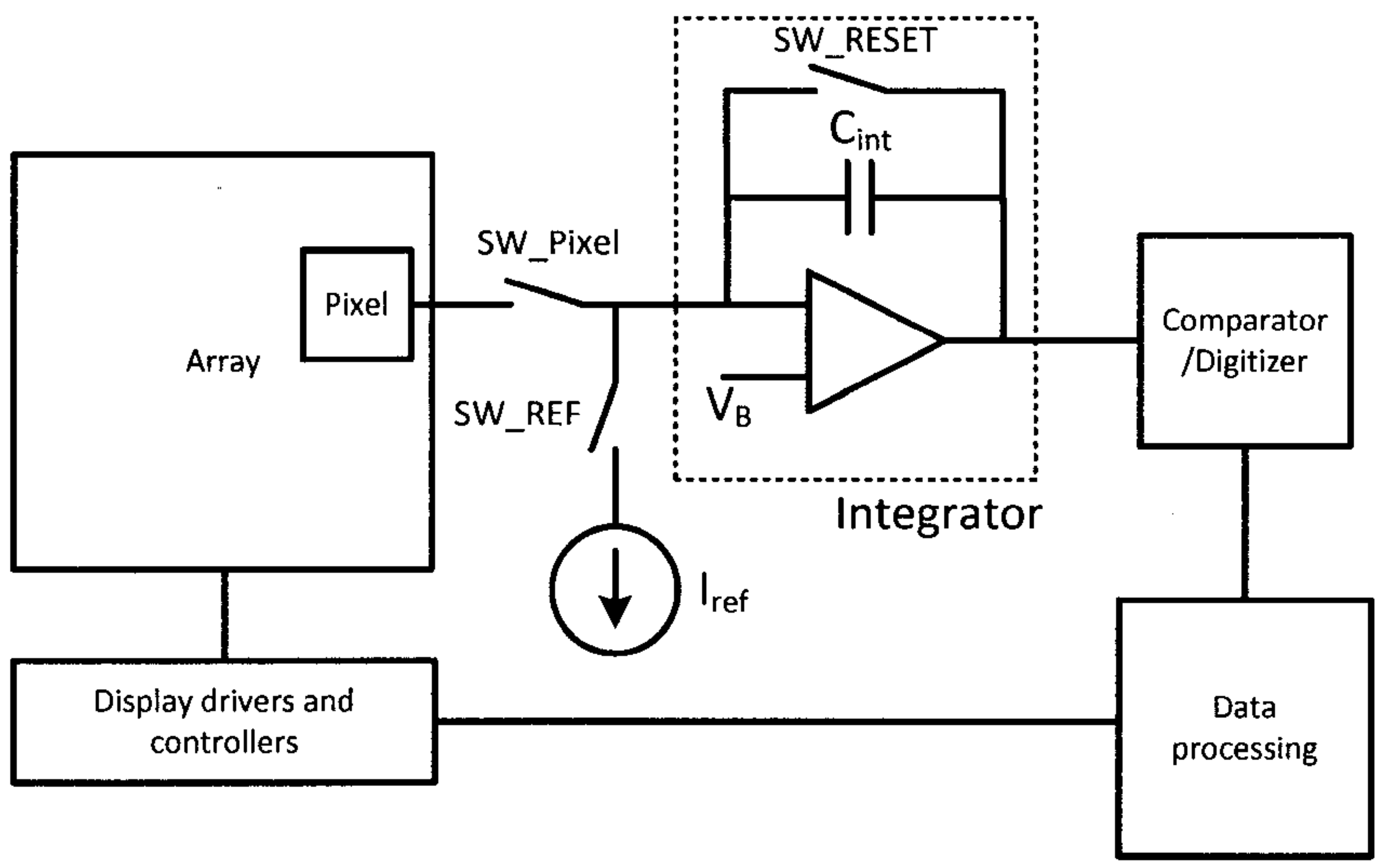


Figure 1: An embodiment for Integration time ratio.

Figure 1 shows a simplified embodiment of the integration capable of having different integration time for pixel and reference current. It is obvious that the integration time ratio can be used with other embodiment as well. Here either one integrator is used and it is time multiplexed between reference and pixel or two integrators can be used. After the integration of reference and pixel current the digitizer/comparator creates a digital value that is used by the data processing unit to adjust the input to the pixel. After, the pixel data is finalized, the input data and/or the reference current can be used to calibrate the input of the pixel circuit. The integration time can be controlled by the switched in series with pixel and current source or by the reset switch. The time that the switch in series with pixel (or current source) is ON and the integrator is in integration mode defines the integration of time of the pixel (or reference current). In case of the reset switch is ON, the integrator is not in integration mode. As a result, the overlap of the series switches' ON time and reset switch's OFF time define the integration time.

In another embodiment of this method, the difference of the said two currents is being integrated to create at least one output voltage. In this case, the input reference current can be applied to the integrator in smaller time. As a result, the total effect will be $K(I_{pixel}*t_{pixel} - I_{ref}*t_{ref})$ where K is the integrator gain, t_{pixel} is the integration time of the pixel, and t_{ref} is the integration time for the reference current. Similar technique can be used also if the pixel charge (voltage) is being sampled with a reference current. In this case, the output will be $K_q*Q_{pixel} - K_i* I_{ref}*t_{ref}$ where Q_{pixel} is pixel charge (or voltage), Kq is the gain of sampler for charge, and K_i is the charge of the integrator for the current. Based on the result, the input of the pixel is adjusted till the value of said equation becomes a given value (e.g. zero).

In case of embodiment in Figure 1, the pixel current and reference current are applied during the same integration operation to one integrator. However, the ON time of the switches in series with pixel and current source can define the integration ratio. For example, reset switch is OFF and so the integrator is in integration mode. During this time, the ON time of switch in series with pixel and the ON time of the switch in series with current source during integration time define the integration ratio. In case, a charge or voltage is sampled from the pixel, the ON time of the switch in series with current source defines the integration time of the reference current.

In both cases, the integration time for the reference current (or the pixel current) can be adjusted based on expected reference current. For example, for very small expected reference current, the integration time ratio can be larger so that the actual reference current value is larger. And for large reference current, the integration time ratio can be smaller so that the actual reference current is the not too large. For example, for 1nA expected reference current, the integration time ratio can be 10 and so the actual reference current is 10nA. In another example, for 1uA expected reference current, the integration time ratio can be 0.1 or (one). As a result, the actual reference current will be 100nA (1uA).

3. External Reference Value

In another case, instead of creating reference voltage with current, a predefined voltage (or charge is used. For example, in previous embodiment the effect of reference current can be calculated as V_{ref} (or Q_{ref})= $K_{ref}*I_{ref}*t_{ref}$.

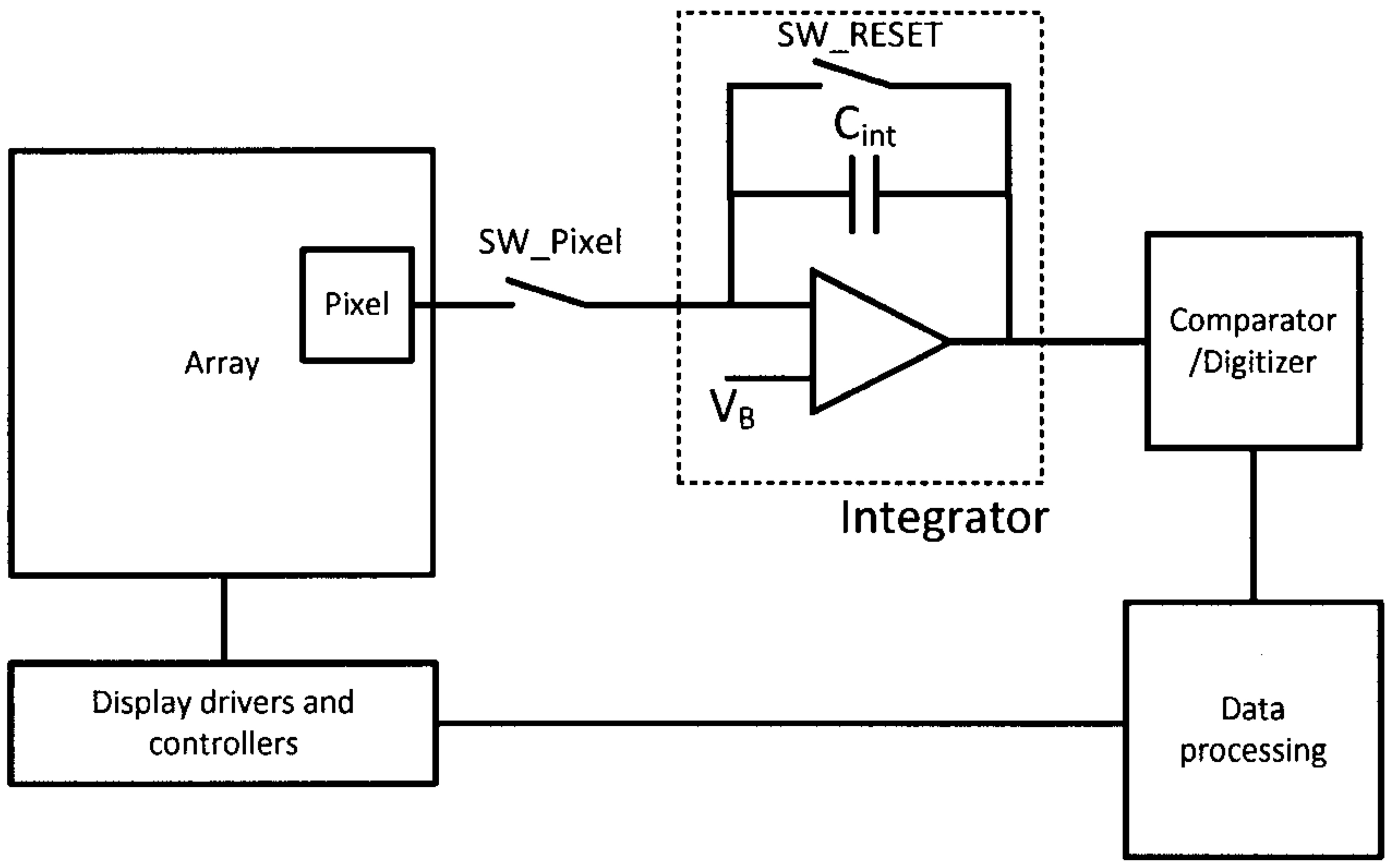


Figure 2: An embodiment for external reference.

In one method, the integrator is directly charged (or set) with the effective charge (or effective voltage) of reference current as given by said equation. Then the pixel current (charge or voltage) is being integrated (or sampled). Here the output will be delta_V = $V_{pixel} - V_{ref}$ (or delta_Q = $Q_{pixel} - Q_{ref}$). Here, V_{pixel} is either sampled voltage from the pixel or the result of pixel integrated current (or the pixel charge).

In case of embodiment demonstrate in Figure 2, the effect of reference current can be applied directly to the integrator. For example, instead of reset switch (SW_RESET), C_{int} is charged to a voltage defined by the expected reference current. In another case, VB can be used to create the effective value during integration time. For example, VB changed from V1 to V2 during integration. The change in voltage and the line capacitance can create charge that will be transferred to the integrator. The value will be $Q_{ref} = C_{line}*(V1-V2)$ where C_{line} is the effective capacitance at input of the integrator. Also the effect can be created by a capacitor that is connected to the input of the integrator. A step voltage applied to the capacitor can create similar reference charge. Here, digitizer/comparator creates a digitized value for based on the output of the integrator. The data processing unit adjusts the input of the pixel according to the said digitized value till the output of the integrator (digitizer) get to a predefined value. In this case, the final input and/or the reference value created on the integrator can be used to the calibrate the pixel.

In another method, pixel output (Vpixel or Qpixel) is being sampled and digitalized. The digital output is used to compare to the digitalized reference value (digitalized Vref or Qref).

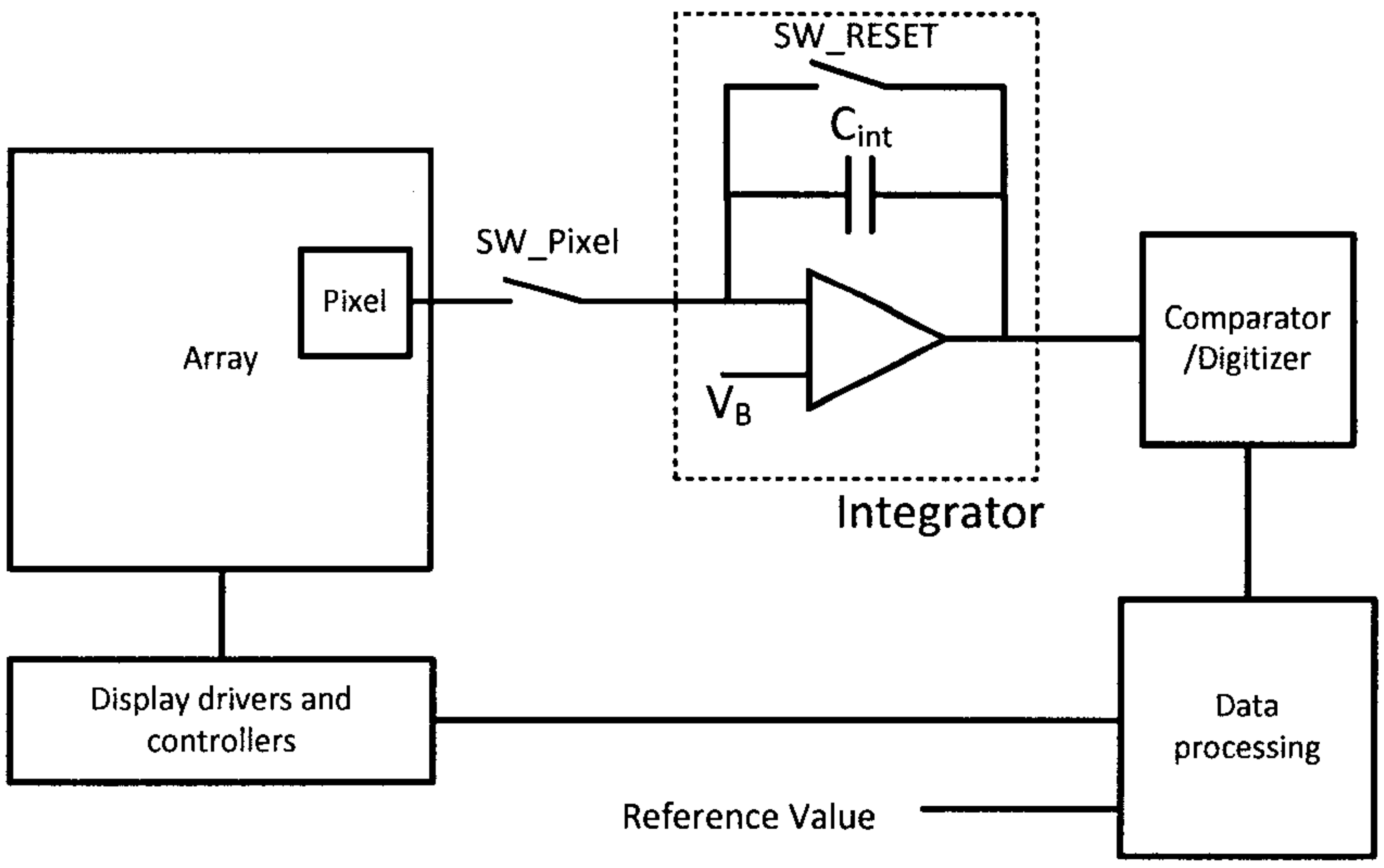


Figure 3: An embodiment for external digitized reference and integrated pixel current (or charge).

In the embodiment demonstrated in Figure 3, the reference values are generated digitally. The pixel current or charge is integrated and digitized. The output of the digitizer is compared with a given reference value and based on that the input of the pixel is adjusted. This process continues till the pixel difference between reference value and the digitized values is equal to a given threshold (e.g. zero). In this case, the final input of the pixel and/or the reference value is used to calibrate the input of the pixel circuit.

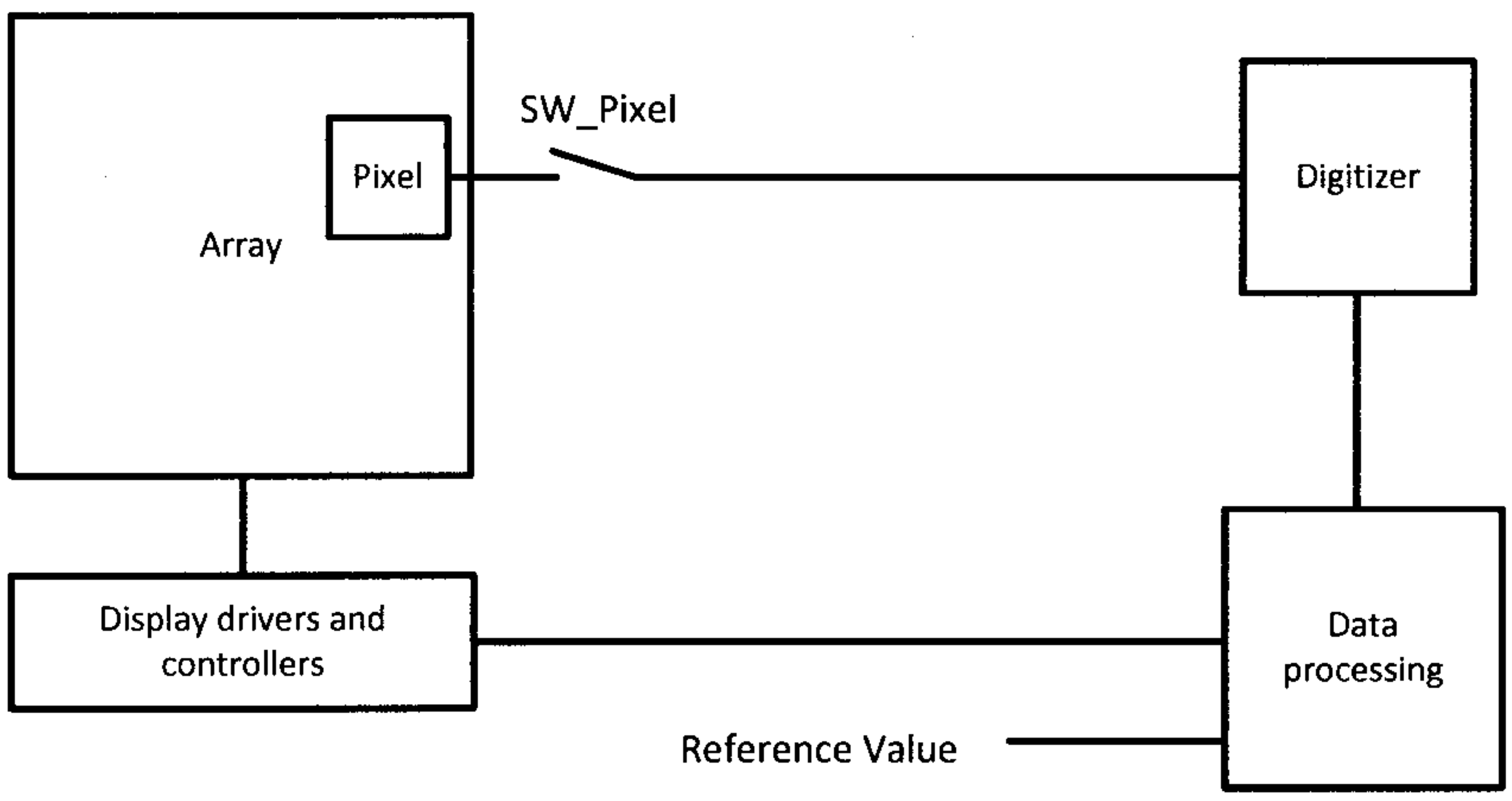


Figure 4: An embodiment for external digitized reference value and sampled pixel voltage (or charge).

In the embodiment demonstrated in Figure 4, the reference values are generated digitally. The pixel charge or voltage is sampled and digitized. The output of the digitizer is compared with a given reference value and based on that the input of the pixel is adjusted. This process continues till the pixel difference between reference value and the digitized values is equal to a given threshold (e.g. zero). In this case, the final input of the pixel and/or the reference value is used to calibrate the input of the pixel circuit.

WHAT IS CLAIMED IS:

1. A method for compensating an image produced by an emissive display system having pixels, each pixel having a light-emitting device, the method comprising:

integrating a pixel current output from the pixel for a pixel integration time generating an integrated pixel current value;

comparing the integrated pixel current value with a reference signal, generating at least one comparison value; and

adjusting an input for the pixel with use of the comparison value.

2. The method of claim 1, wherein the reference signal is a reference current, and wherein comparing the integrated pixel current value with the reference signal comprises integrating the reference current for a reference integration time generating an integrated reference current value and comparing the integrated reference current value with the integrated pixel current value, generating the at least one comparison value.

3. The method of claim 2, wherein a ratio of the pixel integration time to the reference integration time is controlled with use of an expected ratio of an expected magnitude of the pixel current to a magnitude of the reference current.

4. The method of claim 3, wherein the pixel integration time and the reference integration time comprise non-overlapping time periods.

5. The method of claim 3, wherein the pixel integration time and the reference integration time comprise overlapping time periods.

6. The method of claim 1, wherein the reference signal is an analog reference value, and wherein comparing the integrated pixel current value with the reference signal comprises storing the stored analog reference value in a capacitor of at least one integrator and comparing the stored analog reference value with the integrated pixel current value, generating the at least one comparison value.

7. The method of claim 6, wherein storing the analog reference value comprises one of directly charging the capacitor up to the analog reference value and controlling an input of the at least one integrator to charge the capacitor up to the analog reference value.

8. The method of claim 7, wherein the analog reference value is controlled with use of an expected magnitude of the pixel output.

9. A method for compensating an image produced by an emissive display system having pixels, each pixel having a light-emitting device, the method comprising:

sampling a pixel output from the pixel generating a sampled pixel value;

integrating a reference current for a reference integration time generating an integrated reference current value;

comparing the sampled pixel value with the integrated reference current value, generating at least one comparison value; and

adjusting an input for the pixel with use of the comparison value.

10. The method of claim 9, wherein the reference integration time is controlled with use of an expected magnitude of the pixel output.

11. A method for compensating an image produced by an emissive display system having pixels, each pixel having a light-emitting device, the method comprising:

sampling a pixel output from the pixel with use of at least one integrator generating a sampled pixel value;

comparing the sampled pixel value with a digital reference value, generating at least one comparison value; and

adjusting an input for the pixel with use of the comparison value.

12. A system for compensating an image produced by an emissive display system having pixels, each pixel having a light-emitting device, the system comprising:

at least one integrator coupled via a pixel switch to a pixel of said emissive display system for measuring an electrical output of the pixel;

a comparator digitizer coupled to the at least one integrator for comparing the electrical output of the pixel with a reference signal, generating at least one comparison value; and

a data processing unit for adjusting an input for the pixel with use of the comparison value.

13. The system of claim 12, further comprising:

a reference current source coupled via a reference switch to the at least one integrator,

wherein the reference signal is a reference current produced by the reference current source, wherein the at least one integrator measures the electrical output of the pixel by integrating a pixel current output from the pixel for a pixel integration time generating an integrated pixel current value, the at least one integrator for integrating the reference current for a reference integration time generating an integrated reference current value, and wherein the comparator digitizer compares the electrical output of the pixel with the reference signal by comparing the integrated reference current value with the integrated pixel current value, generating the at least one comparison value.

14. The system of claim 13, wherein the pixel switch is for controlling the pixel integration time and the reference switch is for controlling the reference integration time, and wherein a ratio of the pixel integration time to the reference integration time is controlled with use of an expected ratio of an expected magnitude of the pixel current to a magnitude of the reference current.

15. The system of claim 14, wherein the pixel integration time and the reference integration time comprise non-overlapping time periods.

16. The system of claim 14, wherein the pixel integration time and the reference integration time comprise overlapping time periods.

17. The system of claim 12, further comprising:

a reference current source coupled via a reference switch to the at least one integrator,

wherein the reference signal is a reference current produced by the reference current source, wherein the at least one integrator measures the electrical output of the pixel by sampling a pixel output from the pixel generating a sampled pixel value, the at least one integrator for integrating the reference current for a reference integration time generating an integrated reference current value, and wherein the comparator digitizer compares the electrical output of the pixel with a reference signal by comparing the integrated reference current value with the sampled pixel value, generating the at least one comparison value.

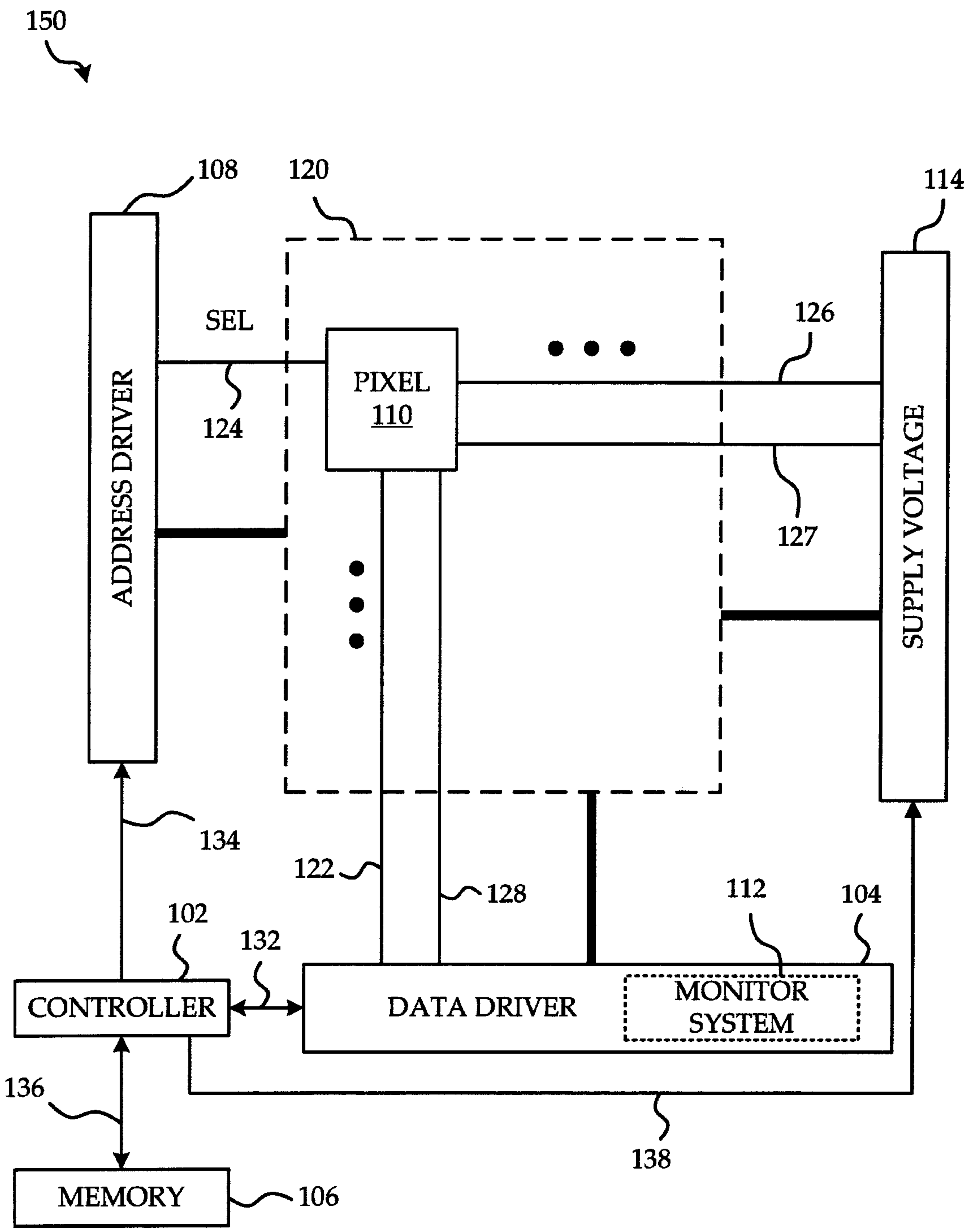
18. The system of claim 17, wherein the reference switch is for controlling the reference integration time, and wherein the reference integration time is controlled with use of an expected magnitude of the pixel output.

19. The system of claim 12, wherein the reference signal is an analog reference value, wherein the at least one integrator comprises a capacitor, the at least one integrator for storing the analog reference value in said capacitor, wherein the at least one integrator measures the electrical output of the pixel by integrating a pixel current output from the pixel for a pixel integration time generating an integrated pixel current value, and wherein the comparator digitizer compares the electrical output of the pixel with the reference signal by comparing the stored analog reference value with the integrated pixel current value, generating the at least one comparison value.

20. The system of claim 19, wherein the at least one integrator stores the analog reference value in said capacitor by one of directly charging the capacitor up to the analog reference value and having an input of the at least one integrator controlled to charge the capacitor up to the analog reference value.

21. The system of claim 20, wherein the analog reference value is controlled with use of an expected magnitude of the pixel output.

23. The system of claim 12, wherein the at least one integrator measures the electrical output of the pixel by sampling a pixel output from the pixel generating a sampled pixel value, wherein the reference signal is a digital reference value, and wherein the comparator digitizer compares the electrical output of the pixel with the reference signal by comparing the digital reference value with the sampled pixel value, generating the at least one comparison value.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SYSTEM
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MEMORY
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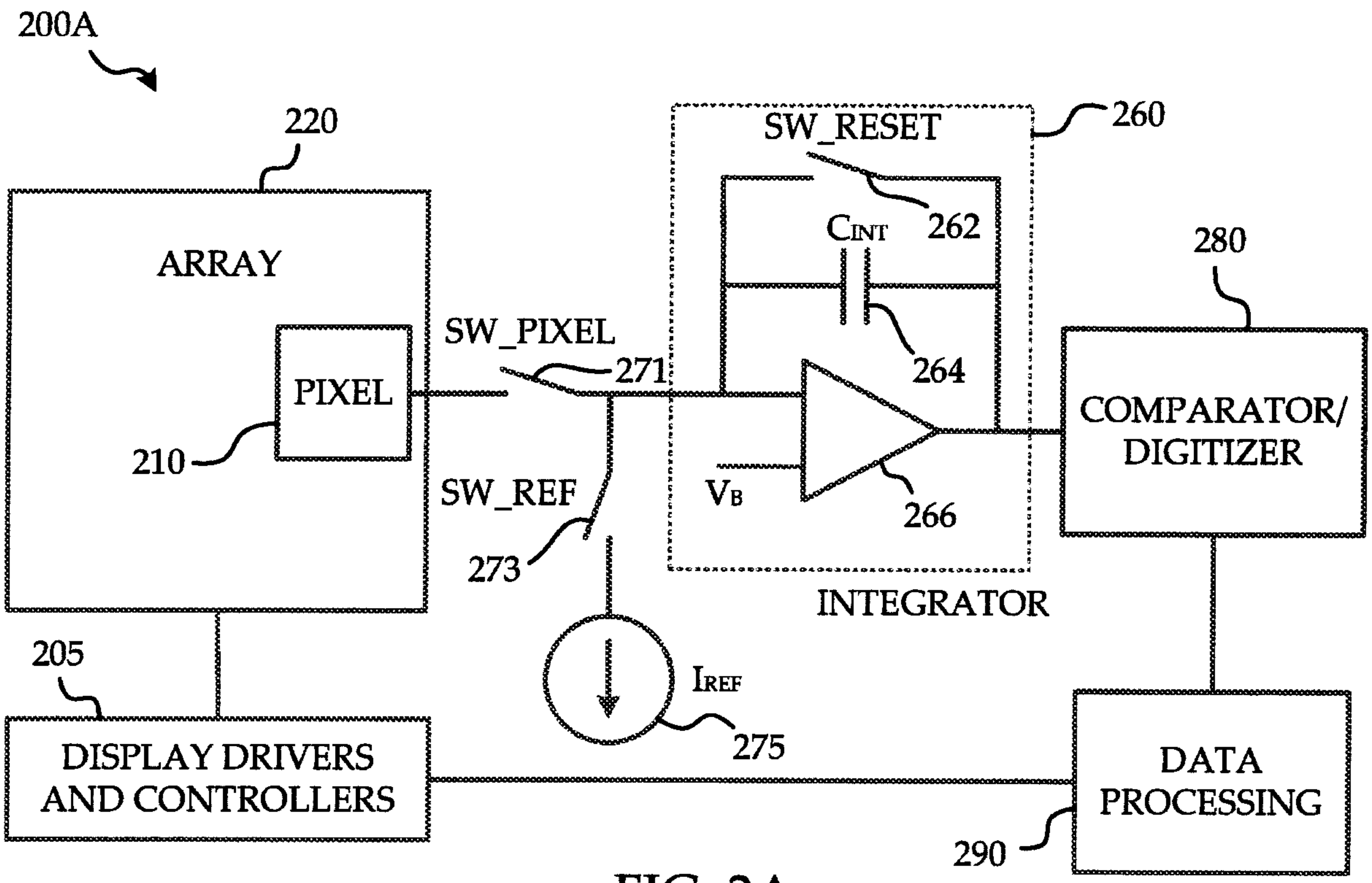
FIG. 1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PROCESSING
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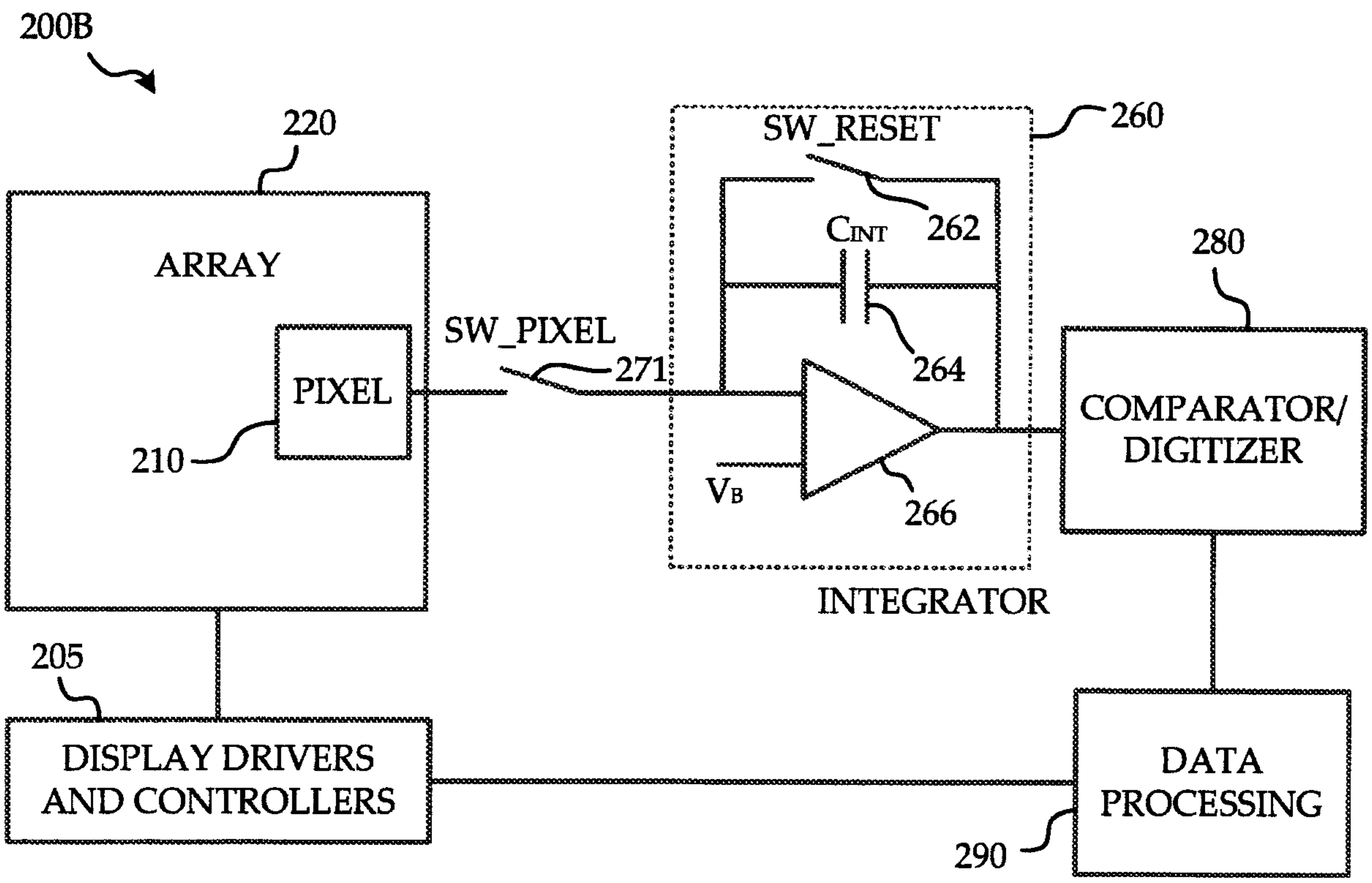
FIG. 2A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DIGITIZER
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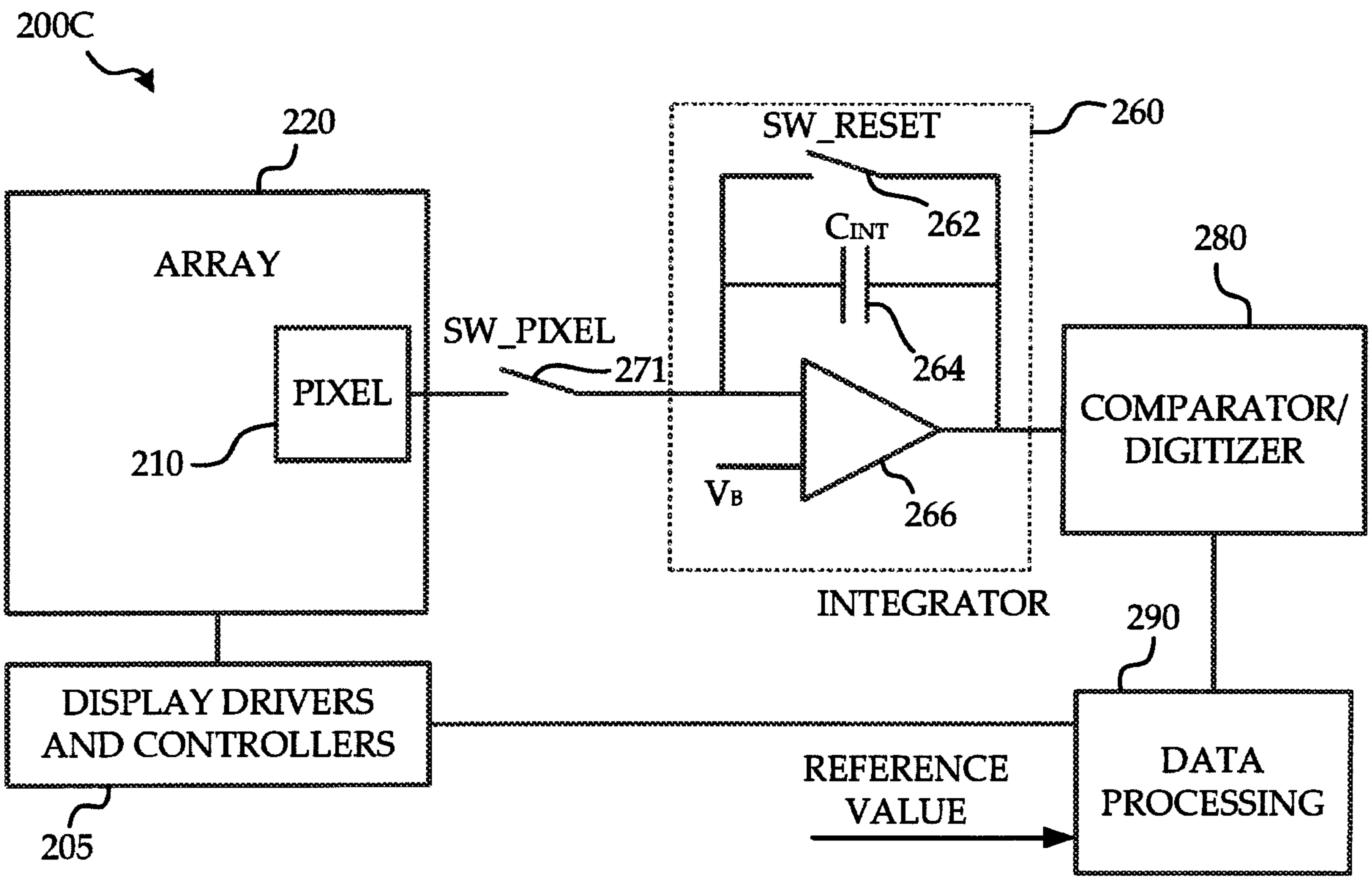
AND CONTROLLERS
DATA
PROCESSING
290

FIG. 2B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AND CONTROLLERS
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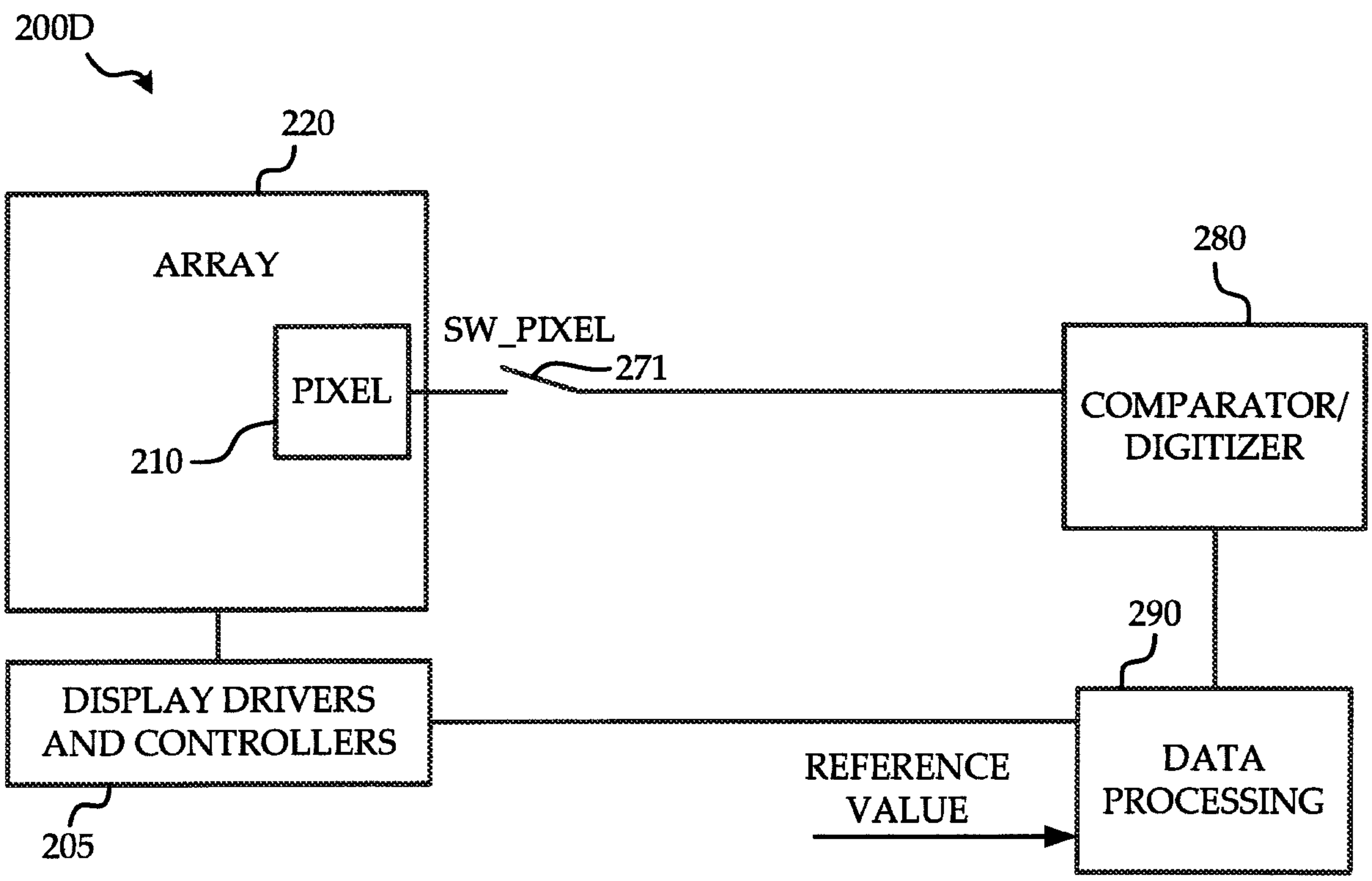
VALUE
DATA
PROCESSING

FIG. 2C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PROCESSING

FIG. 2D