M66332FP

FACSIMILE IMAGE DATA PROCESSOR

DESCRIPTION

The M66332 is a facsimile image processing controller that converts analog signals that are photoelectrically converted by an image sensor into bi-level signals.
It has image processing functions such as peak detection, uniformity correction, γ correction, MTF compensation, detector of background and object levels, dither control, separation of image data area, scale down, and area specification.
This controller has a built-in 5-bit flash type A-D converter and interface circuits to image sensor, analog signal processing circuit, and CODEC (Coder & Decoder) to simplify control of the readout mechanism.

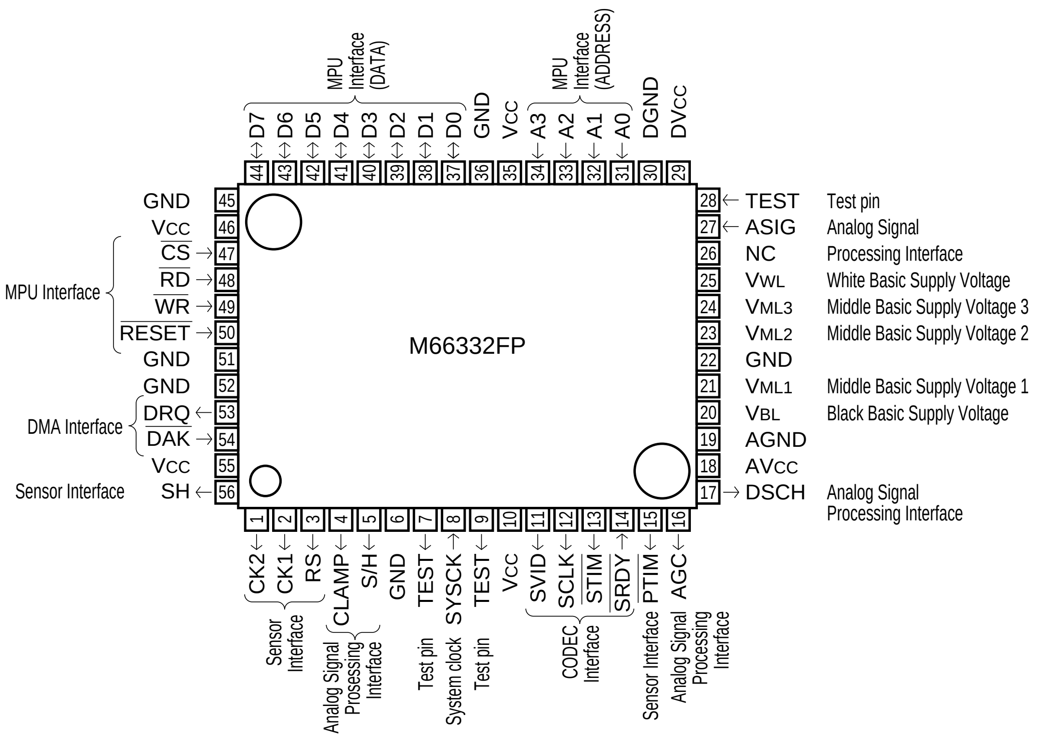
FEATURES

- High Speed Scan (MAX. 2 ms/line, TYP. 5 ms/line)
- A3 (8 pixels/mm) Line Sensor Attachment
- Image sensor (CCD,CIS) control signal generation
  CCD: SH, CK1, CK2, RS
  Contact sensor (CIS): SH, CK1 (or CK2)
- Analog signal processing circuit control signal generation
  CLAMP, S/H, AGC, DSCH
- Built-in 5-bit Flash Type A-D Converter
- Bi-level data external input/output interface Serial output (→M66330)
  8-bit MPU bus output with external DMA control signal
- Image data processing
  γ correction
  Uniformity correction (block correction in units of 8 pixels)
  MTF compensation (1 dimension)
  Detector of background and object level (programmable)
  Dithering control
  • Dither method (16 levels using 4 × 4 matrix)
  Separation of image data area (1 dimension)
  Scale down A3 → B4, A3 → A4, B4 → A4
- 5V Single Power Supply

APPLICATION

Facsimiles

PIN CONFIGURATION (TOP VIEW)



Outline 56P6N-A

BLOCK DIAGRAM

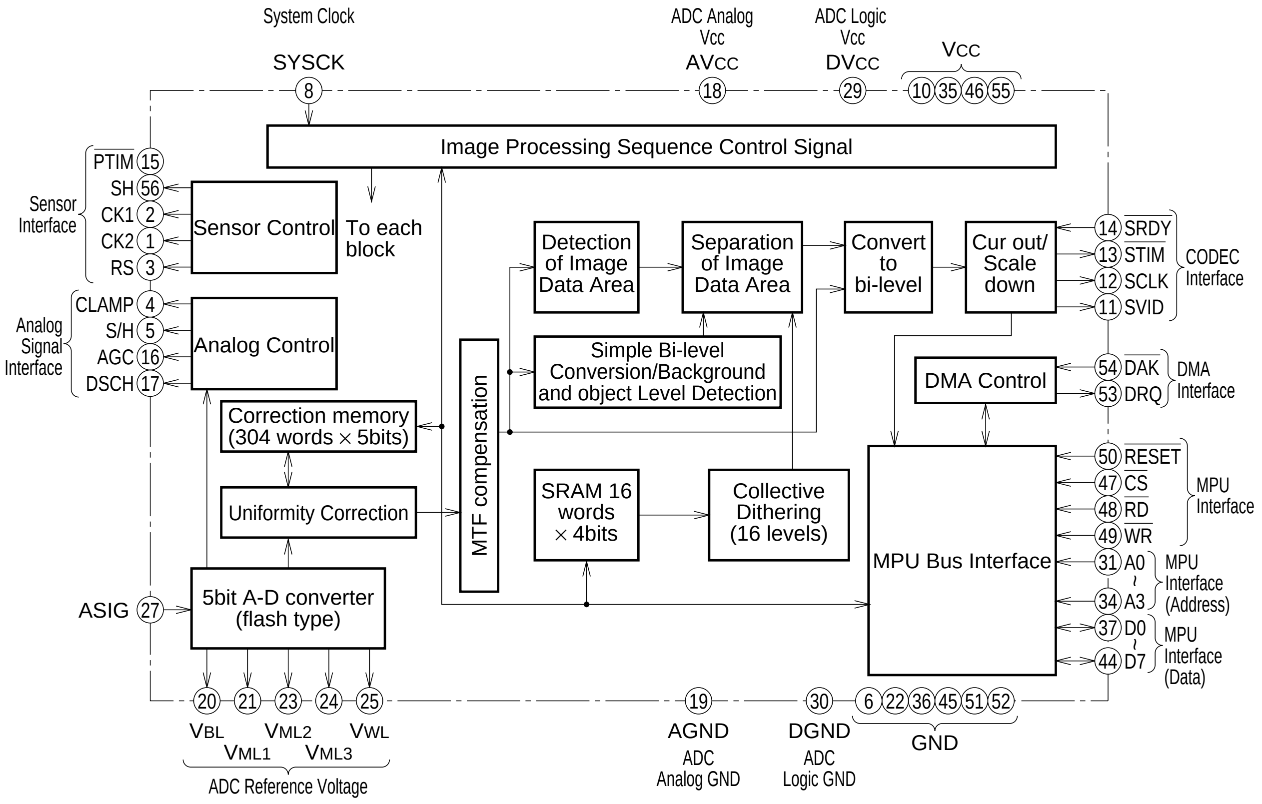


Table 1 Image Processing Functions

Image Processing Function	Specifications	Remarks
Read Width	• A4, B4, A3	
Resolution	• 8 pixels/mm (primary scanning direction)	
Read speed	• 5ms/line Typ. 2ms/line maximum	• Operated with system clock and PRE_DATA (registers 2, 3)
Uniformity Correction	• White correction only • Block correction in units of 8 pixels • 50% Correction range	• Built-in SRAM as correction memory (304 words × 5bits) (read/write allowed from MPU)
MTF Compensation	• Laplacian filter circuit for 3 × 1 pixels in current line (1 dimension)	• No need for compensation memory
Simple Bi-level Conversion	• Floating threshold method using background and object level detection circuit	
Pseudo half-tone	• Dither method: 16 levels (4 × 4matrix)	• Built-in SRAM as dither memory (16 words × 4bits) (read/write allowed from MPU)
Separation of Image Data Area	• Detection by brightness difference in 5 × 1 pixels area in current line	• No need for processing memory
Scale down	• Selection method • Scale down: A3 → B4 set to 13/15; B4 → A4, 9/11; A3 → A4, 12/17	
γ Correction	• Logarithmic correction	• Apply external voltage (resistor connection is also allowed) to A-D converter middle basic supply voltage pins.
Image Sensor Control Signal	• Control signal generation for contact sensor (CIS) and scale down CCD	
Analog Signal Processing	• Generate control signals for external CLAMP circuit, sample/hold circuit, and AGC circuit	• Built-in 5-bit flash A-D converter

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PIN DESCRIPTIONS

Block	Pin Names	I/O	Description
Sensor Interface	SH	O	CCD: Shift pulse signal to transmit photo charges from the sensor to the transfer unit. CIS: Start signal for the sensor read circuit.
	CK1	O	CCD: Clock pulse signal for sequentially transmitting the transfer unit signal charge of the sensor. CIS: Clock pulse signal for the sensor read circuit shift register.
	CK2	O	Reverse of CK1.
	RS	O	Pulse to reset the voltage of the CCD sensor floating capacitor to initial status.
	$\overline{\text{PTIM}}$	O	Read roller pulse motor control signal.
Analog Circuit Interface	CLAMP	O	CLAMP pulse to set the dark level of the sensor to reference voltage of the digital circuit.
	S/H	O	Sample-hold signal to smooth out sensor image signal waveform.
	ASIG	I	Analog signals.
	AGC	O	External AGC circuit gain down signal.
	DSCH	O	External AGC circuit gain up signal.
CODEC Interface	$\overline{\text{SRDY}}$	I	Data transmission ready signal from CODEC.
	$\overline{\text{STIM}}$	O	Data transmission bound signal for CODEC.
	SCLK	O	Clock signal for transmitting image data to CODEC.
	SVID	O	Serial output of image data to CODEC. “H”: Black; “L”: White.
DMA Interface	DRQ	O	DMA request signal to external DMA controller for parallel output of image data through MPU bus.
	$\overline{\text{DAK}}$	I	DMA acknowledge signal from external DMA controller for the above DRQ signal.
Clock	SYSCK	I	System clock input pin.
MPU Interface	$\overline{\text{RESET}}$	I	System reset signal. Resets counter, register, F/F, and latch, sets internal memory in standby mode, and halts clock generation circuit.
	$\overline{\text{CS}}$	I	Chip select signal used by MPU to access M66332. Set to “H” in operating mode (AGC, UNIF, SCAN).
	$\overline{\text{RD}}$	I	Control signal used by MPU to read data from M66332.
	$\overline{\text{WR}}$	I	Control signal used by MPU to write data to M66332.
	A0~A3	I	Address signals used to access M66332 internal registers.
	D0~D7	I/O	8-bit bidirectional buffer.

PIN DESCRIPTIONS (CONTINUED)

Block	Pin Names	I/O	Description
Others	V_{CC}	—	Plus supply voltage.
	AV_{CC}	—	Plus supply voltage for A-D converter analog units.
	DV_{CC}	—	Plus supply voltage for A-D converter logic units.
	GND	—	GND pin.
	AGND	—	Ground for A-D converter analog units.
	DGND	—	Ground for A-D converter digital units.
	V_{WL}	—	A-D converter white basic supply voltage pin.
	V_{BL}	—	A-D converter black basic supply voltage pin.
	V_{ML1}	—	Middle basic supply voltage pin. V_{ML1} =(V_{WL} – V_{BL}) /4
	V_{ML2}	—	Middle basic supply voltage pin. V_{ML2} =2 · (V_{WL} – V_{BL}) /4
	V_{ML3}	—	Middle basic supply voltage pin. V_{ML3} =3 · (V_{WL} – V_{BL}) /4
	TEST(IN)	—	Test input pin. Fix to “L”.
	TEST(OUT)	—	Test output pin. Keep open.

FUNCTIONAL DESCRIPTION

The following items which are necessary to use the image processing functions of the M66332 are described.

(1) Operating mode
(2) Line period and read sequence
(3) Image processing function
(4) Sensor unit/analog signal processing unit interface
(5) CODEC interface
(6) Read/write to dither memory and uniformity correction memory
(7) Reset
(8) Image quality control using registers

(1) Operating mode

The M66332 performs three basic operations.

- Peak value detection: The peak value of the analog signal output from the analog signal processing circuits is matched to the white reference voltage (V_{WL}) of the M66332 internal A-D converter. (See also Figs. 19 to 22 in the M66333FP document.)
- Uniformity correction data creation: White reference data is created for sensor unit uniformity correction and written to the correction memory (SRAM: 304 words × 5bits).
- Read operation: A document is read and the image is processed to output bi-level data as serial or parallel output.

These three basic operations are performed in the following sequence depending on whether the sensor is CCD or CIS. The sensor is selected with register 0 (SENS).

When the sensor is CCD:

UNIF mode ↓	Operation is started by setting the UNIF command in register 0 to “H”. If the sensor is CCD, peak detection (16 line periods) and white uniformity correction data creation (8 line periods) are performed consecutively. To exit this operating mode, wait 30 line periods (at least 24 lines) from the start and set the UNIF command to “L”.
SCAN mode	The read operation is started by setting the SCAN command in register 0 to “H”. Set the SCAN command to “L” to exit this operation mode.

When the sensor is CIS:

(Creation and transmission of uniformity correction data)

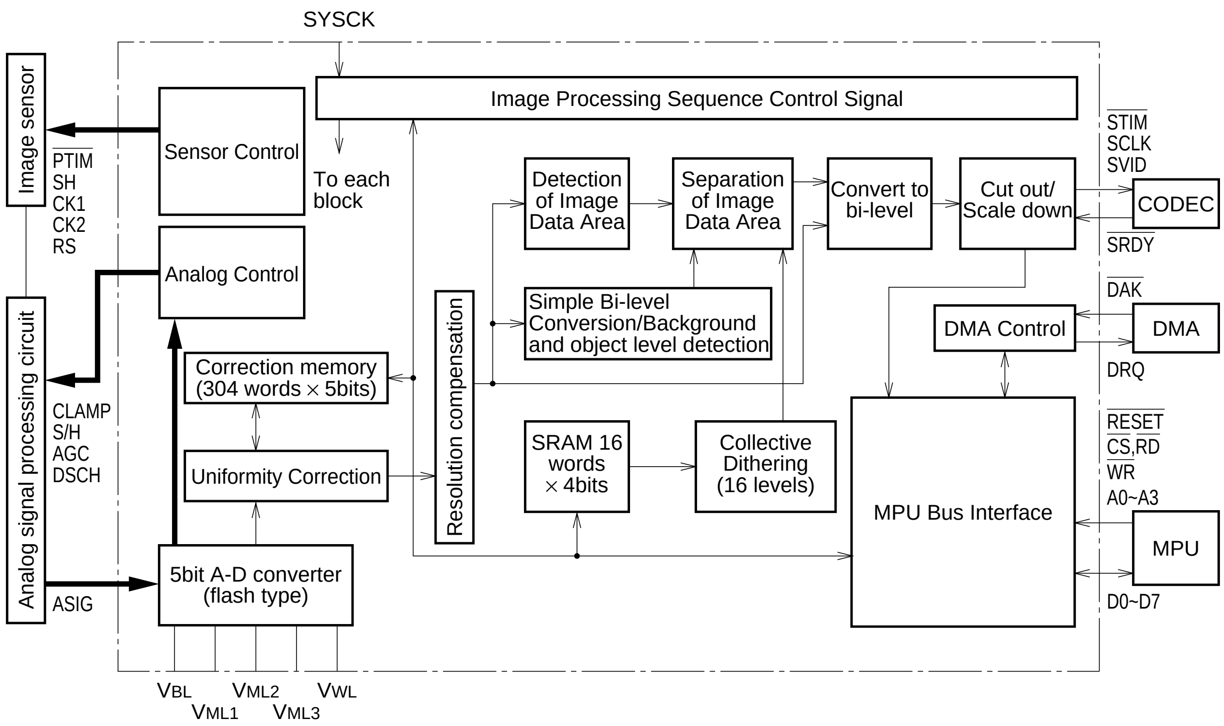
UNIF mode ↓	This mode is started when the UNIF command in register 0 is set to “H”. When the sensor is CIS, if white correction is started with the UNIF command, peak detection (16 line periods) and uniformity white correction data creation (8 line period) are started. To exit this operating mode, wait 30 line periods (at least 24 line periods) from the start and set the UNIF command to “L”.
Data transfer	The uniformity correction data pertaining to white correction created in UNIF mode are transferred to the backup memory.

(Read operation)

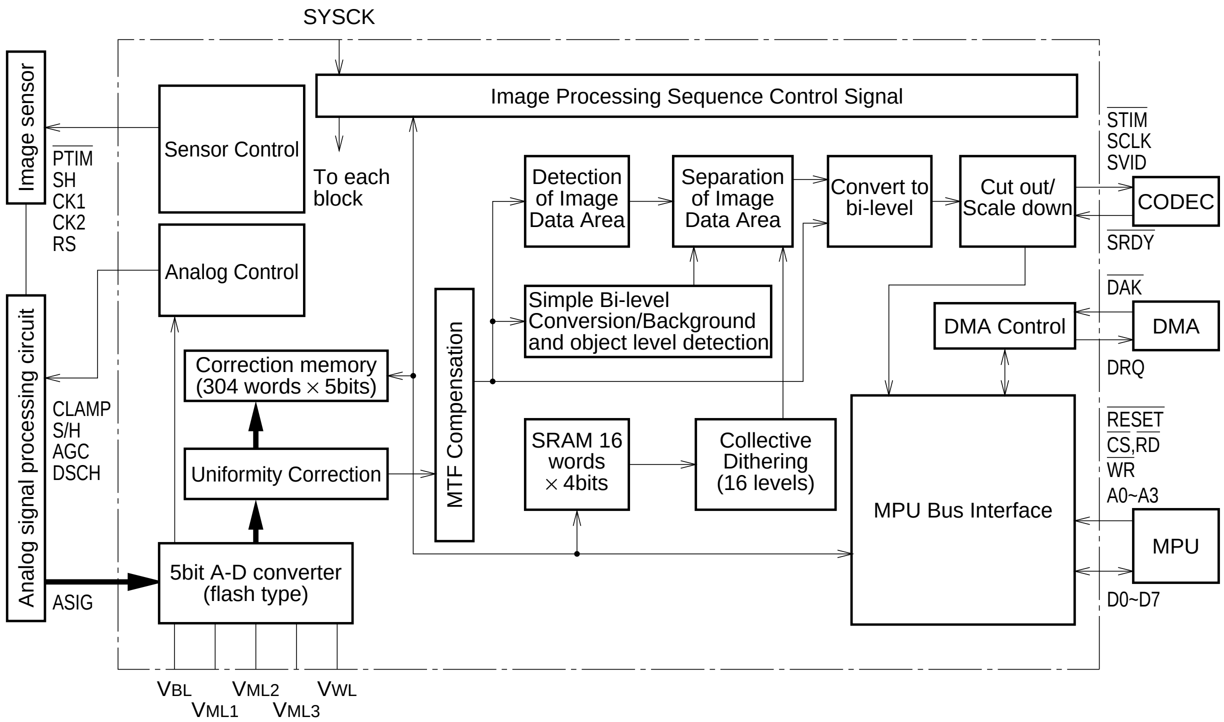
AGC mode ↓	Peak detection is performed for 16 line periods when the AGC command in register 0 is set to “H”. To exit this operating mode, wait 20 line periods (at least 16 lines) from the start and set the AGC command to “L”.
SCAN mode	The read operation is started by setting the SCAN command in register 0 to “H”. Set the SCAN command to “L” to exit this operating mode.

The signal functions and data flow in each mode are shown on pages 4–123 and 4–124. Flowcharts are shown on pages 4-158 to 4–160.

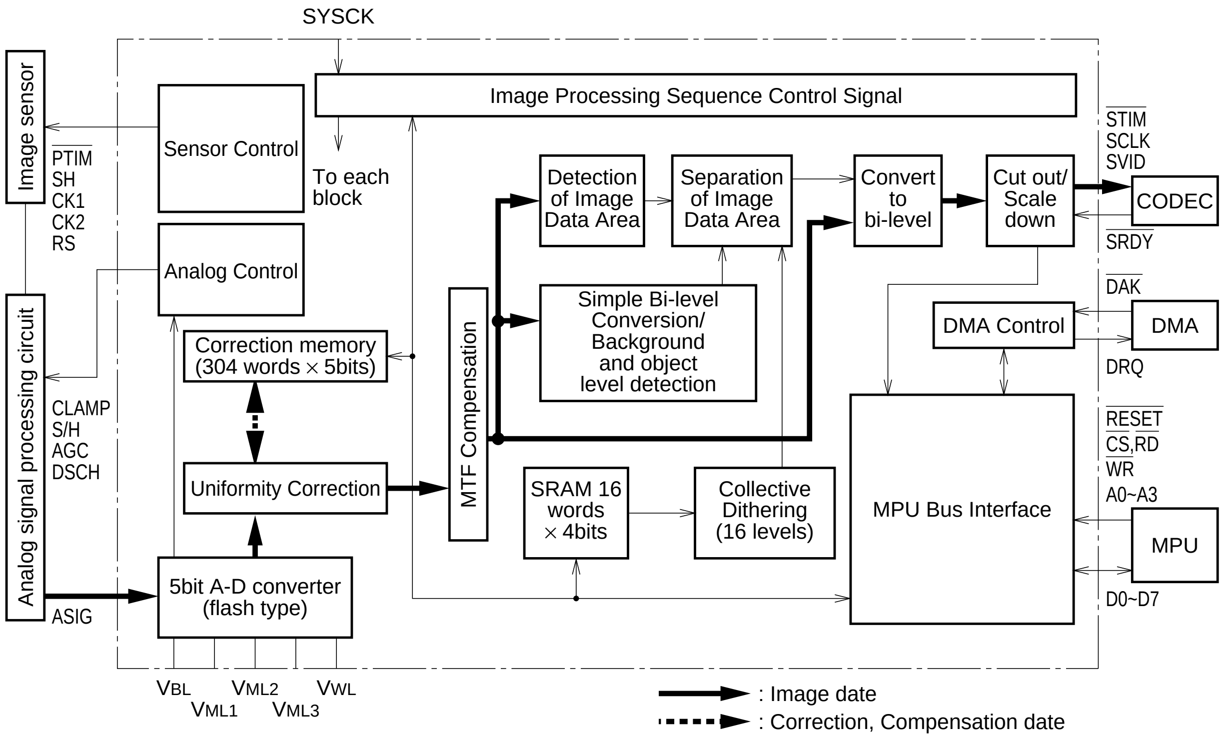
Operation During Peak Detection



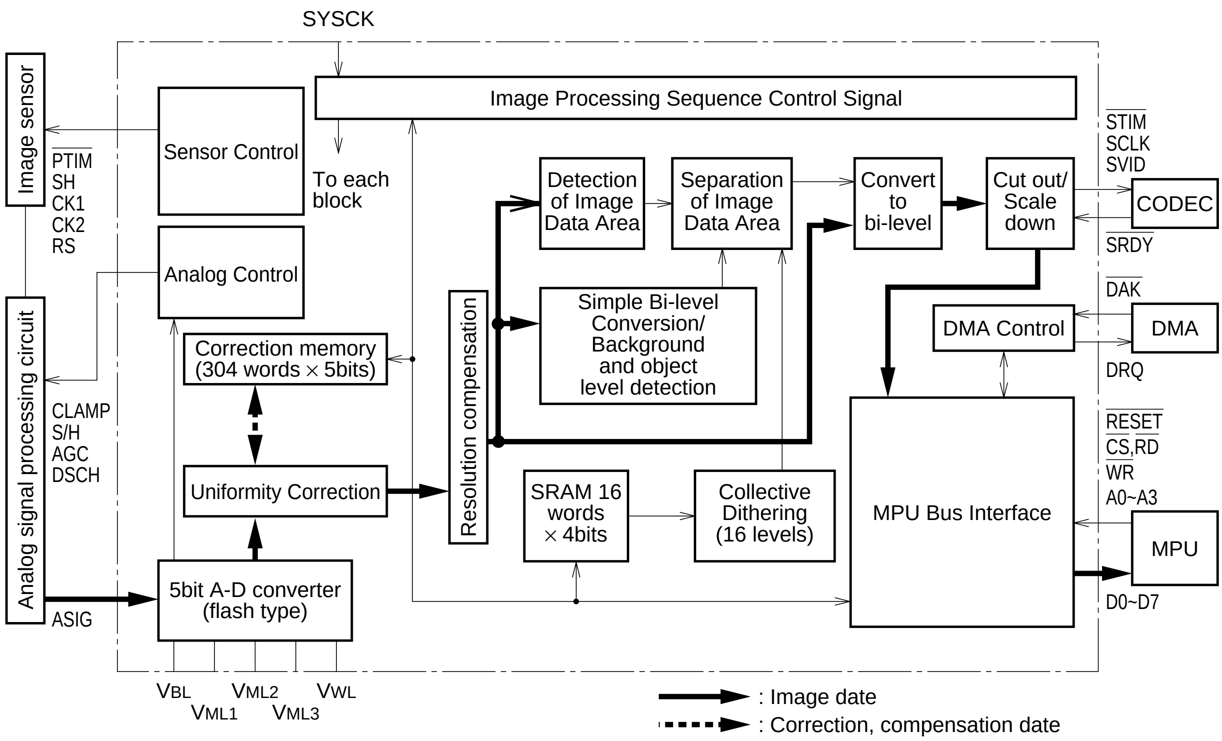
Data Flow in Creation of Uniformity Correction Data



Date Flow During Read Operation (for serial output)



Date Flow During Read Operation (for parallel output)



(2) Line period and read sequence

Figure 1 shows the relationship between the M66332 line period and the read sequence.

- 1 line period (1/ACCK): Defines the processing time per line for M66332. The line period is determined from the line period counter registers 2 and 3 (PRE_DATA) and pixel transmission clock (ADCK). ADCK is 1/16th of SYSCK.

  1 line period (1/ACCK) [NS]
  = line period counter × pixel transmission clock period [NS]
  = (PRE_DATA + 1) × 1/ADCK [NS]
  = (PRE_DATA + 1) × 16/SYSCK [NS]

  The line period counter is counted down with the pixel transmission clock after loading the PRE_DATA value and generates the following addresses.
- Sensor start pulse (SH): Image sensor start pulse. The position of the start pulse is determined by the value in register 4 (ST_PL) which is the offset from the uniformity correction range (UNIFG).
  Set ST_PL to the following values according to the type of image sensor.
  CCD: ST_PL = sensor dummy pixel + 2
  CIS: ST_PL =2
- Uniformity correction range (UNIFG): Defines the uniformity correction range. This range corresponds to the sensor width (A3 to A4).
  Refer to Table 2 for the relationship between sensor width and uniformity correction range.
- AGC range (AGCG): Defines the peak detection range. This range corresponds to the sensor width (A3 to A4).
  Auto gain control is performed for the entire width (solid line) of the sensor in AGC mode and for the range inside the sensor width (dotted line) in SCAN mode.
  Refer to Table 2 for the relationship between sensor width and AGC range.
- Source document read width: Defines the source document read width.
  If the document width is less than the sensor width, the document should be centered on the sensor because the read range is set from the center of the sensor.
  Refer to Table 3 for the relationship between sensor width and source document read width.
- Pulse motor control signal ($\overline{\text{PTIM}}$): Generates the pulse motor control signals for the read roller.

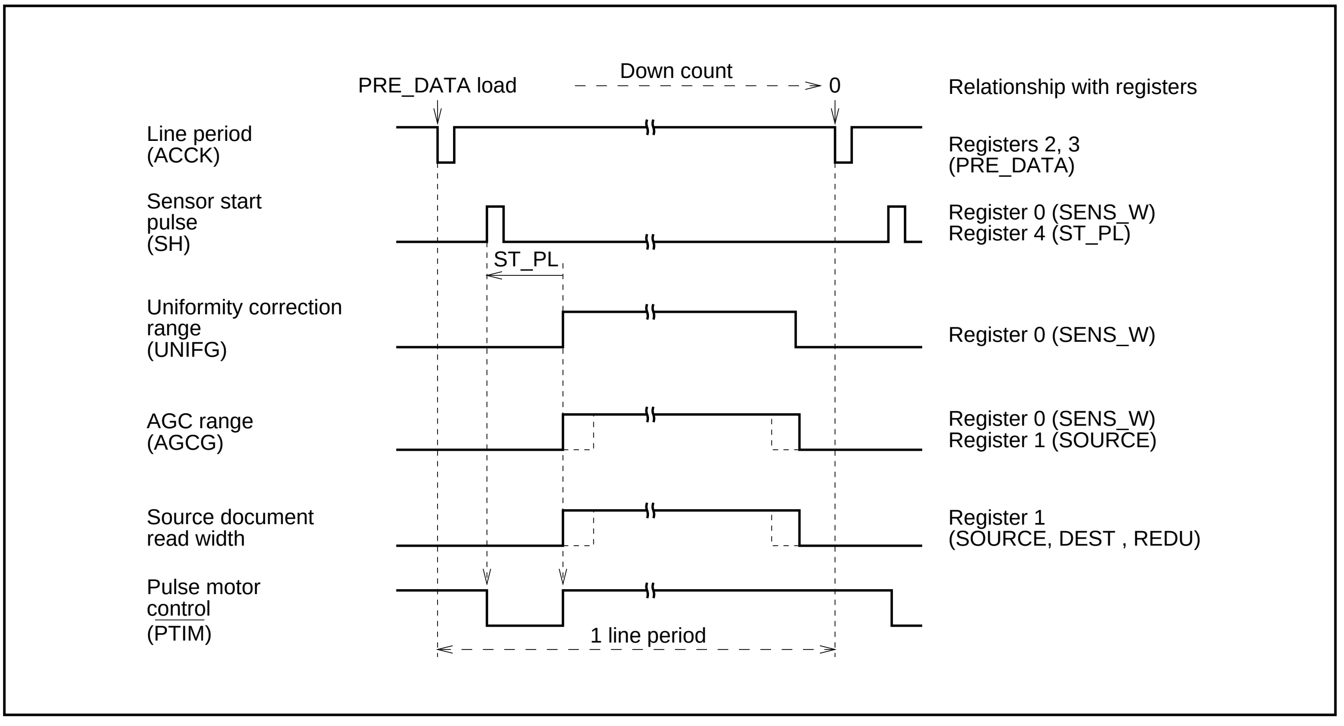


Fig. 1 Line period and read sequence

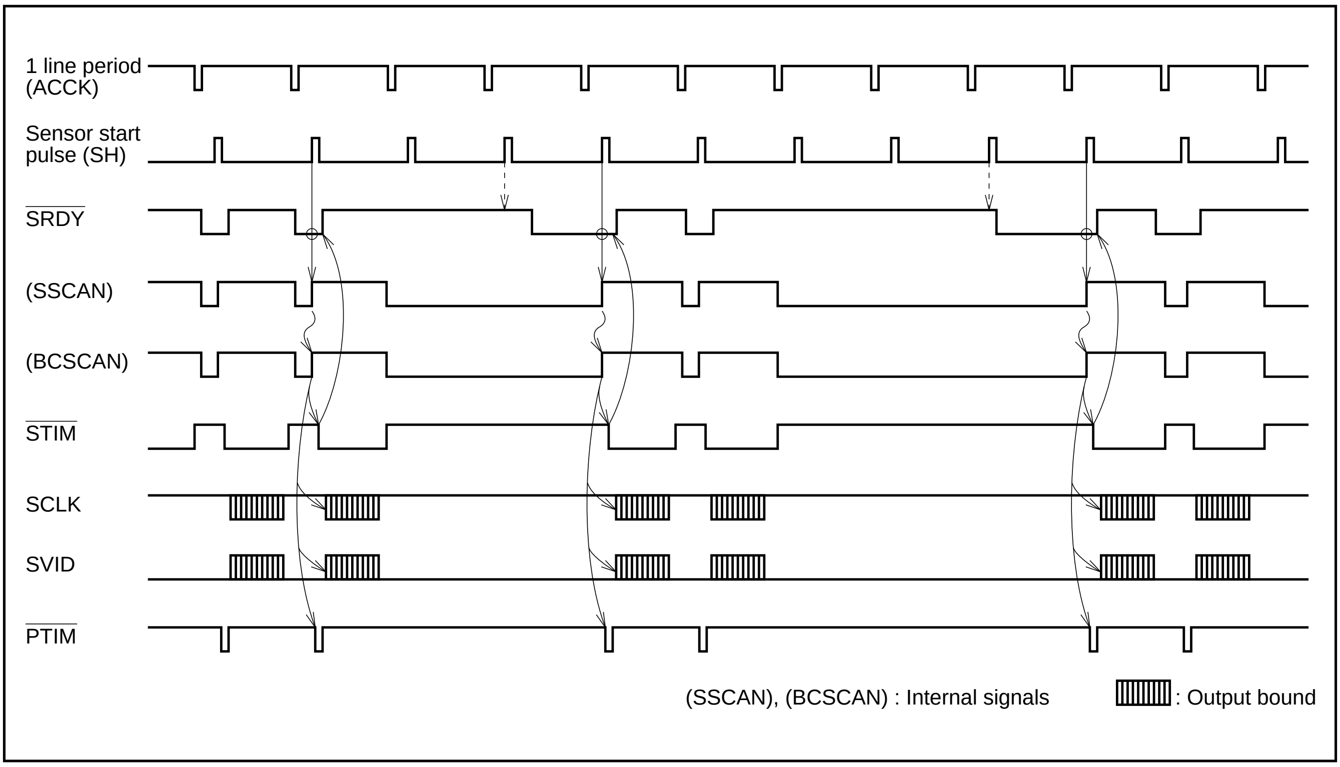


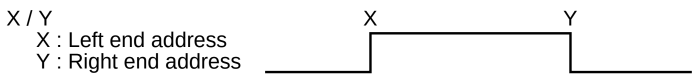
Fig. 2 CODEC Interface and read sequence

Table 2 Sensor width and gate signal range

Gate signal \ Sensor width		A3	B4	A4
Uniformity correction range (UNIFG)		2487/55	2279/231	2119/391
AGC range (AGCG)	AGC mode	2487/55	2279/231	2119/391
	SCAN mode	2370/162	2194/306	1760/740

Table 3 Source document read width according to sensor width and source document size

Source document size \ Sensor width	A3	B4	A4
A3	2487/55	—	—
B4	2278/230	2278/230	—
A4	2118/390	2118/390	2118/390



(3) Image processing function

The M66332 converts image signals from the image sensor to bi-level signals. Bi-level conversion can be either simple bi-level conversion or pseudo half-tone conversion which converts image shades into bi-levels.

The signal output from the image sensor must be corrected and compensated to reduce distortion and degradation before it can be converted to bi-level signals.

Furthermore, for reduction in transmission time, separation of image data area and optimum bi-level conversion must be performed.

The functions necessary for image processing are described below.

- Peak detection
- Uniformity correction
- MTF compensation
- Background and object level detection (simple bi-level conversion)
- Pseudo half-tone dither method
- Separation of image data area
- Image scale down/area specification

• Peak detection

The A-D converter of the M66332 is used with its reference voltages (V_{WL}, V_{BL}) fixed. Normallly, V_{WL} is set to V_{CC} and V_{BL}, is set to 0V to keep the dynamic range of the A-D converter wide. Peak detection must be performed for analog signals to match them with the full scale value of the A-D converter before they are input to the A-D converter.

Peak detection is performed by reading white data in AGC mode, one of the three M66332 operating modes (AGC, UNIF, SCAN).

In AGC mode, 8-line period worth of DSCH signal to raise gain—for gain control—and 16-line period worth of AGC signal to lower gain—for the overflowing of the A-D converter—are generated after AGC command start (register 0: AGC) as shown in Fig. 3.

This changes the gain as shown in Fig. 4.

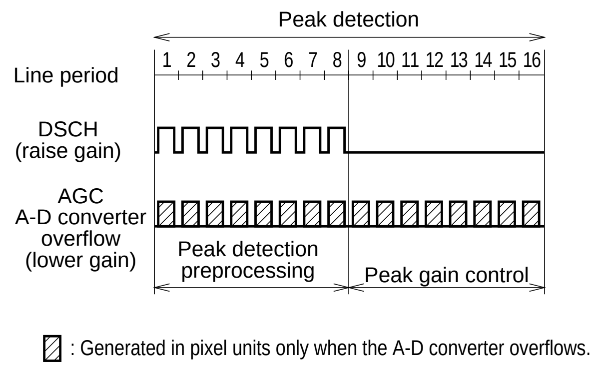


Fig. 3 Peak detection

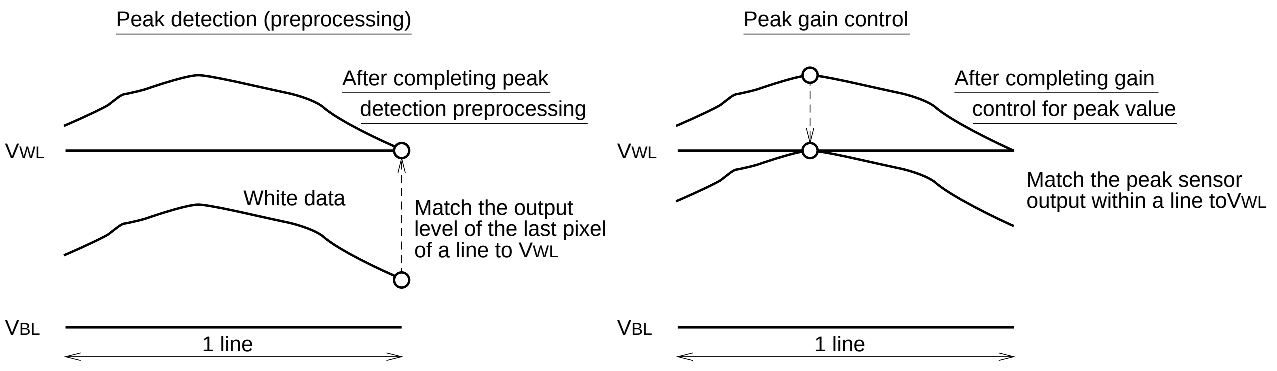


Fig. 4 Changes in gain during peak detection

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• Uniformity correction

Uniformity correction corrects the drop in lighting level at both ends of the light source, shading distortion due to drop in lighting level at the rim of the lens, and high frequency distortion caused by the scattering of pixel-unit image sensor characteristic (see Fig. 5).

The M66332 creates uniformity correction data in UNIF mode, one of the three operating modes (AGC, UNIF, SCAN), handling 8 pixels as a unit as shown in Fig. 6. The created data is written to the internal correction memory (SRAM: 304 words × 5 bits).

In SCAN mode, the correction data is read from the internal correction memory to successively correct the input image data in pixel units.

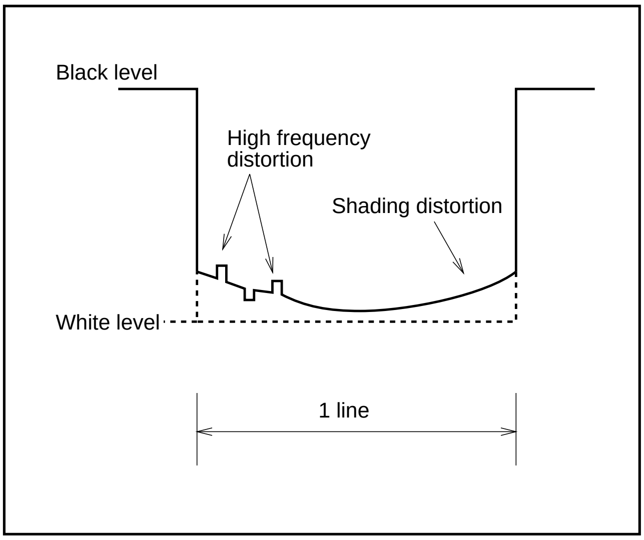


Fig. 5 Image sensor white data output waveform

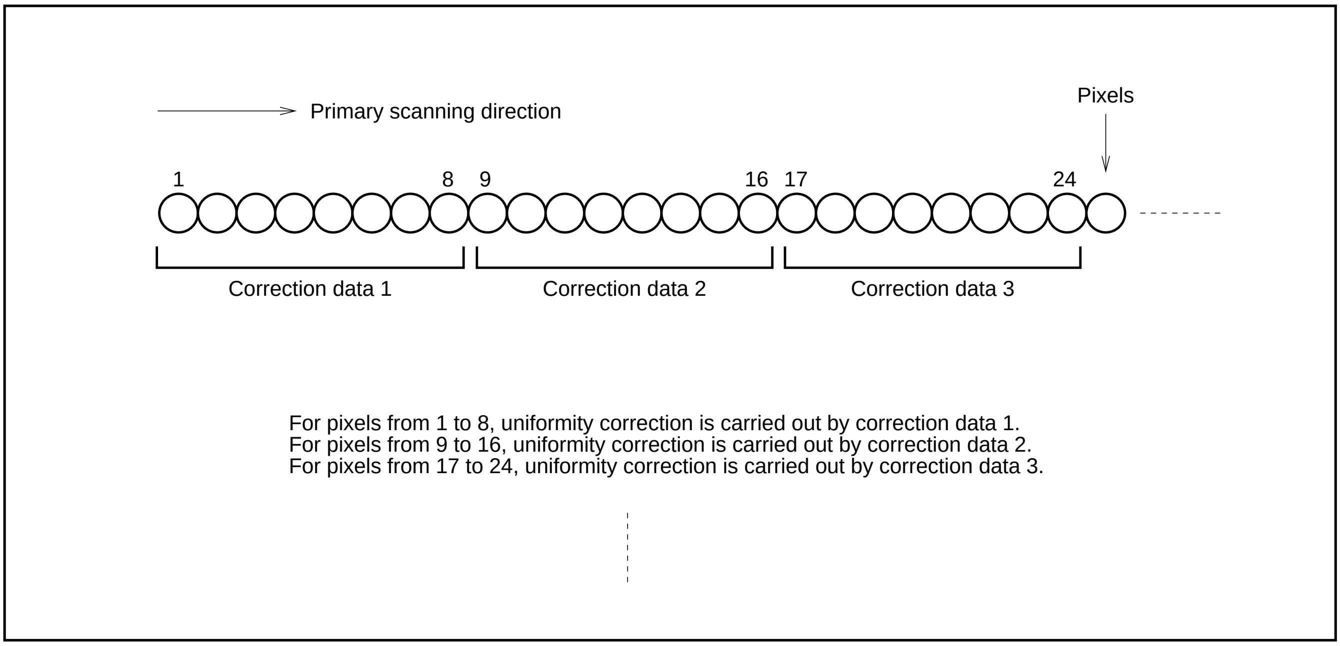


Fig. 6 Creation of uniformity correction data

• Correction

The M66332 performs entire pixel correction for 50% correction range as shown in Fig. 7.

Correction is not possible if the white correction data exceeds the 50% correction range as shown in Fig. 7. Therefore, be sure to keep the input signal within the correction range.

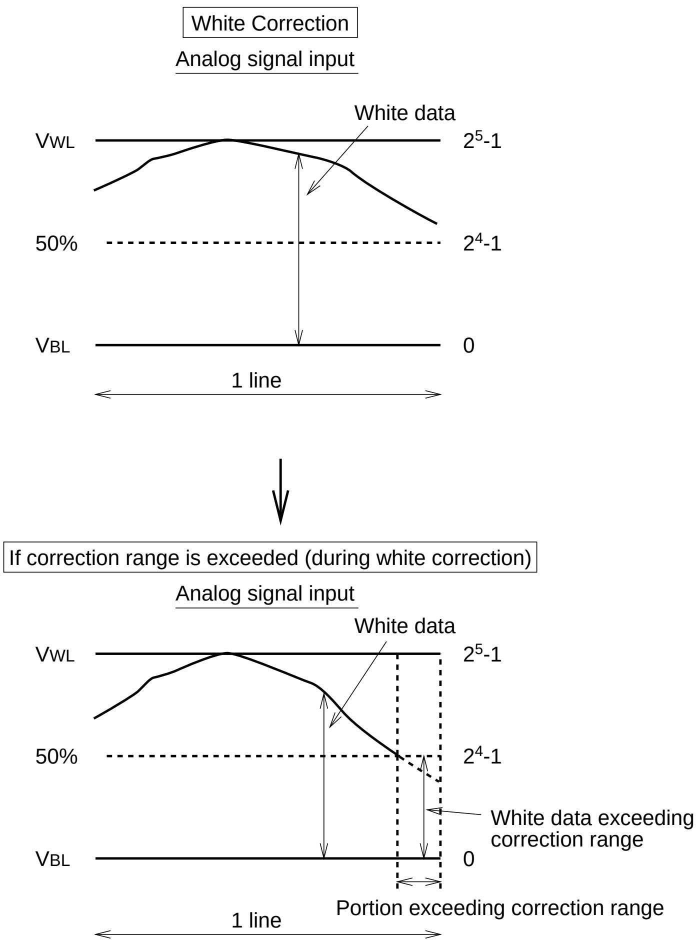


Fig. 7 Uniformity correction

• MTF compensation

As shown in Fig. 8, characters and photos that have been photoelectrically converted by the sensor unit are characterized by a drop in resolution. The MTF compensation performed by the M66332 enhances the high frequency components with a Laplacian filter to maintain the resolution of the image data and creates a perception of increased dynamic range.

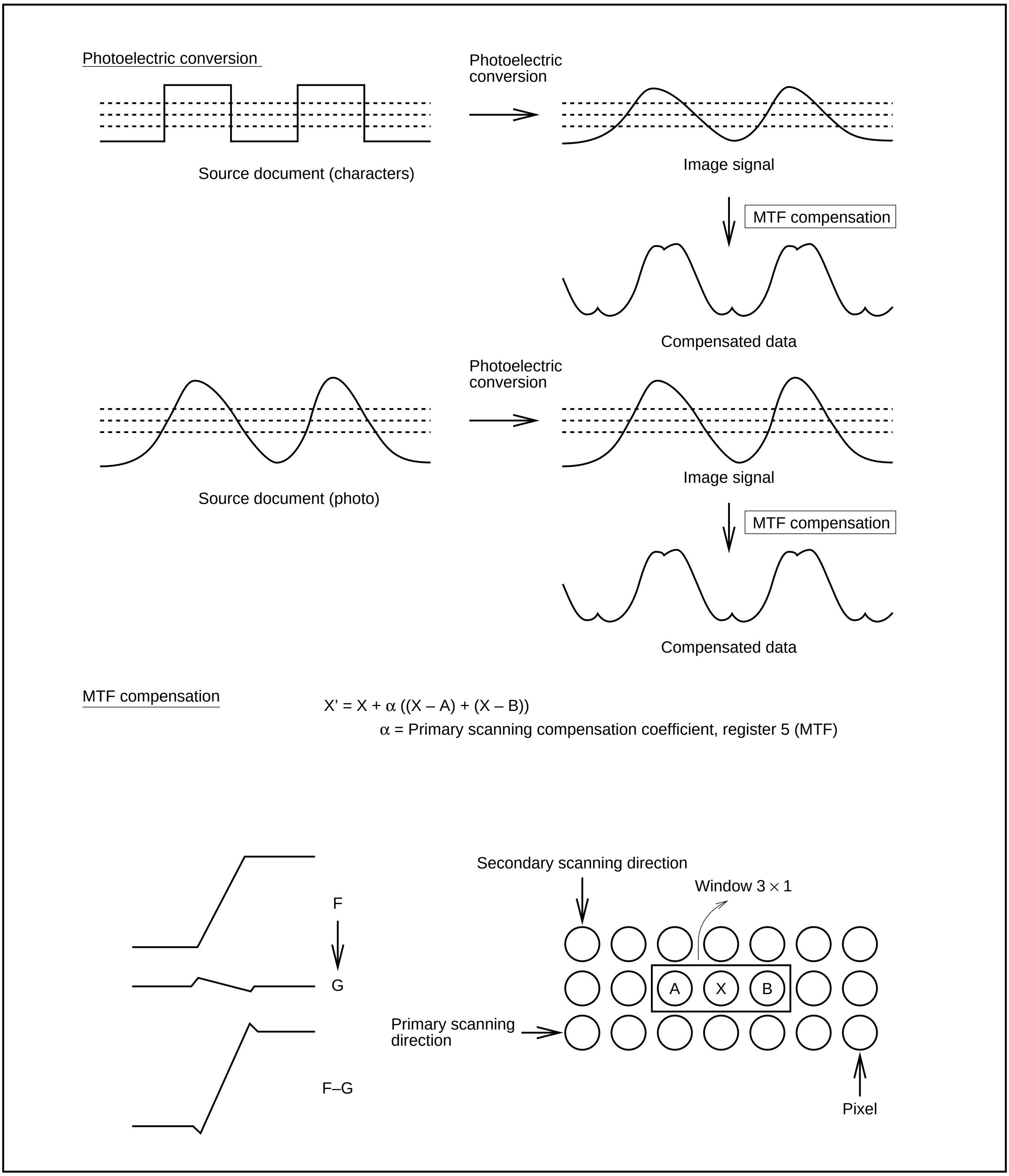


Fig. 8 MTF Compensation

• Background and object level detection

The M66332 uses the floating threshold method rather than the fixed threshold method. This method successively generates a threshold for optimum simple bi-level conversion of the target pixel.
Therefore, a threshold matching the picture data is generated without modifying the image data.
This value is used as the threshold of the bi-level area when simple bi-level conversion or image separation is selected as bi-level conversion mode.
: register 5 (MODE)

Background level counter

If an image data greater (brighter) than the current counter value is input, this counter is incremented to approach the image data.
If an image data less (darker) than the current counter value is input, this counter is decremented to approach the image data.
The count up/down speed can be set with the following register.
: register 9 (MAX_UP, MAX_DOWN)
The lower limit of the background level can be set with the following register.
: register B (LL_MAX)

Object level counter

If an image data greater (brighter) than the current counter value is input, this counter is incremented to approach the image data.
It an image data less (darker) than the current counter value is input, the image data is set to this counter.
The count down speed can be set with the following register.
: register 9 (MIN_UP)
The upper limit of the character level can be set with the following register.
: register A (UL_MIN)

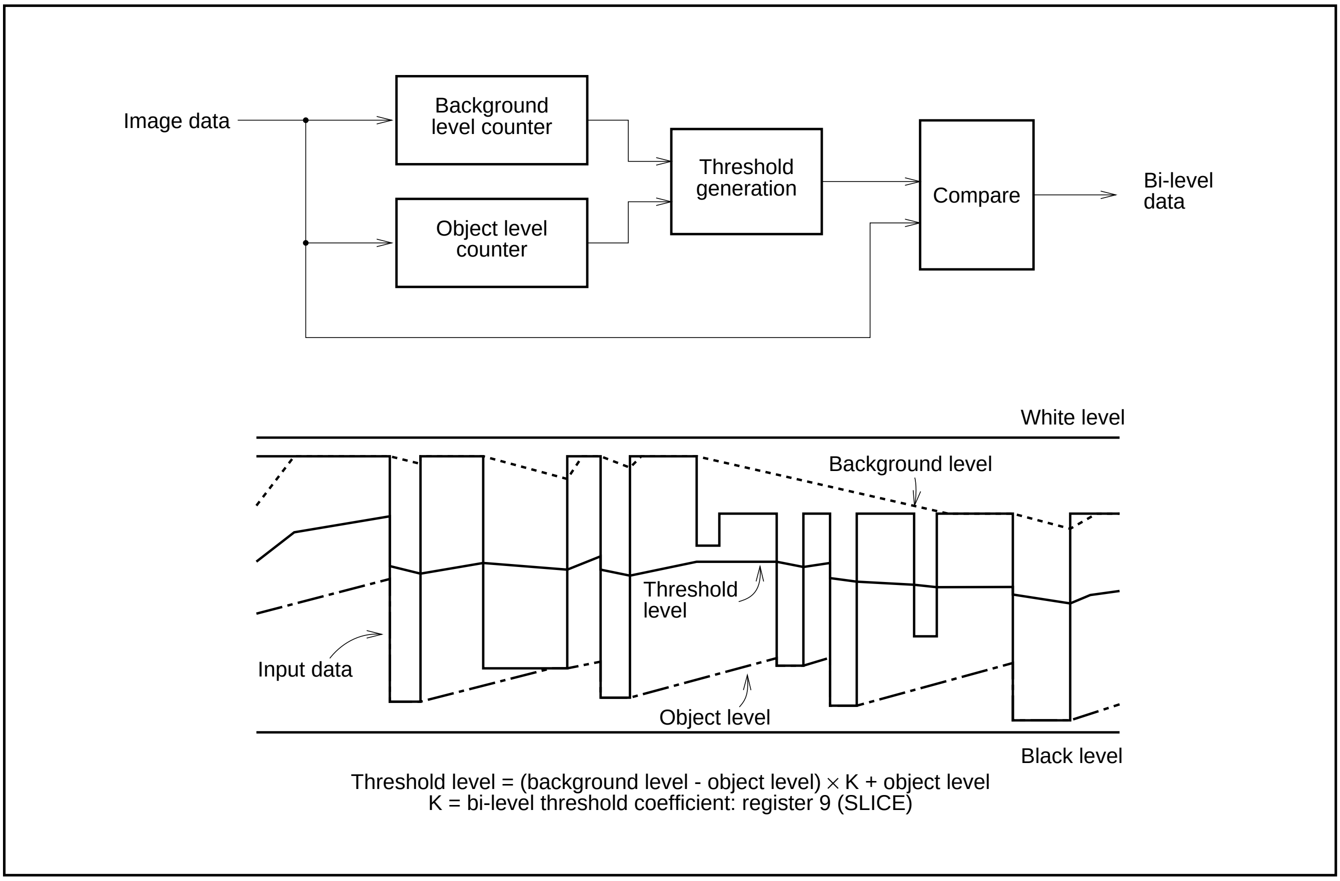


Fig. 9 Background-object level

• Dither method

The M66332 has a built-in 16 words × 4 bits SRAM which is used as a collective dithering memory.
During initialization, threshold values are written in the dither memory, matching the desired dither pattern into 4 × 4 dither matrix.
: register E (DITH_D)

Fig. 10 shows some examples of dither patterns.
Refer to the section on dither memory and uniformity correction memory read/write for details on how to read/write the dither memory.
This is used when dither method and image data area separation are selected for bi-level conversion mode during read.
: register 5 (MODE)

4 × 4 matrix sequence

a) Diffused type

0	8	2	10
12	4	14	6
3	11	1	9
15	7	13	5

b) Concentrated type

4	10	5	11
15	0	2	6
9	3	1	12
14	8	13	7

c) Mesh type

11	4	6	9
12	0	2	14
7	8	10	5
3	15	13	1

Fig. 10 Collective dither pattern

Table 4 Scanning line density and dither matrix size

Scanning Line Density	Primary/Secondary Scanning Line (line/mm)	Level	Matrix Size
Normal	8 × 3.85	—	—
Fine	8 × 7.7	16	4 × 4

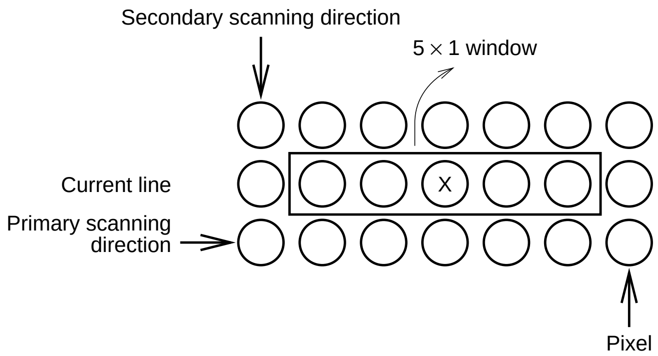
• Separation of image data area

In order to perform bi-level conversion appropriate for the image, a black and white image is separated into bi-level conversion area and gradation conversion area. Simple bi-level conversion is applied to the bi-level conversion area and dither method is applied to the gradation area.

: register 5 (MODE)

	Area	Process	Example
Black and white image	Bi-level conversion area →	Simple bi-level conversion →	Character
	Gradation conversion area →	Pseudo half-tone conversion →	Photo

There is no significant change in illumination of the gradation conversion area (photo) when a black and white image is viewed through a 5 × 1 window.
This characteristic is used to distinguish between gradation conversion area and bi-level conversion area.



Lmax: maximum illumination in window
Lmin : minimum illumination in window

Identification equation 1 Lmax - Lmin > A (illumination difference in bi-level conversion area) : register 6 difference (SEPA_A)
Identification equation 2 Lmin > B (area is entirely white) : register 7 minimum (SEPA_B)
Identification equation 3 Lmax < C (area is entirely black) : register 8 maximum (SEPA_C)

Simple bi-level conversion if identification equation 1, 2, or 3 is satisfied.
Pseudo half-tone conversion when none of the identification equations is satisfied.

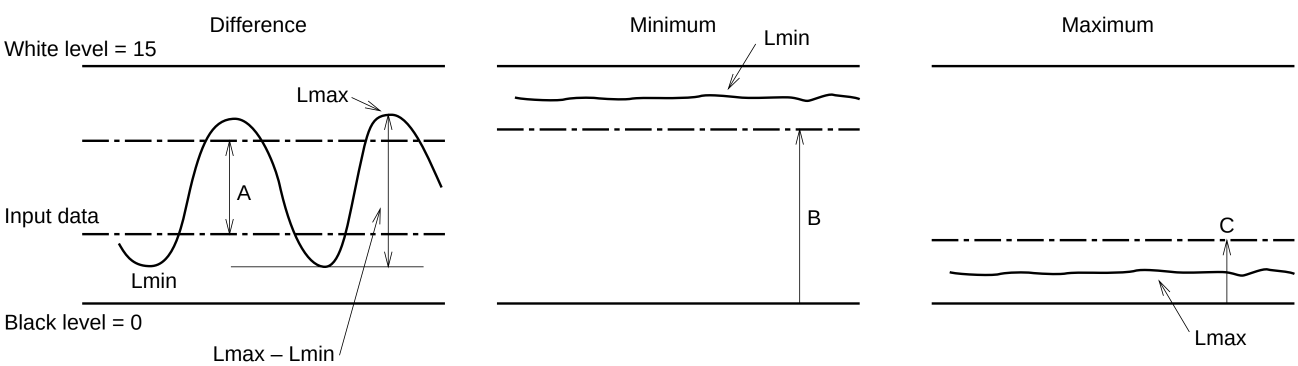


Fig. 11 Separation of image data area

• **Image scale down/area specification**

Scale down function

The image data input from the analog signal processing circuit can be scaled down (A3 → B4, A3 → A4, B4 → A4) by leaving out pixels in the primary scanning direction for bi-level conversion.

: register 1 (SOURCE, DEST, REDU)

Scale down in secondary scanning direction can be performed in the same rate by MPU program.

Table 5 Scaling rate

OUT \ IN	A3	B4	A4
B4	13/15	1	—
A4	12/17	9/11	1

Area specification function

When area specification is selected, bi-level conversion is performed only in the specified area from the center of the source document as shown Fig. 12.

: register 1 (SOURCE, DEST, REDU)

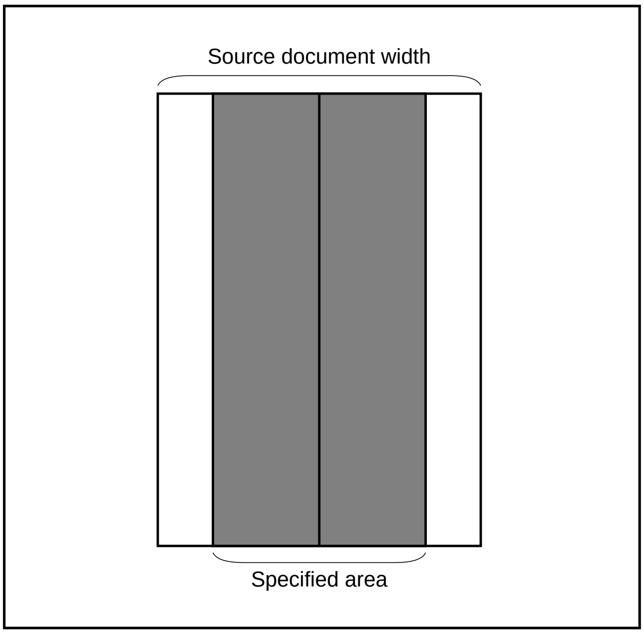
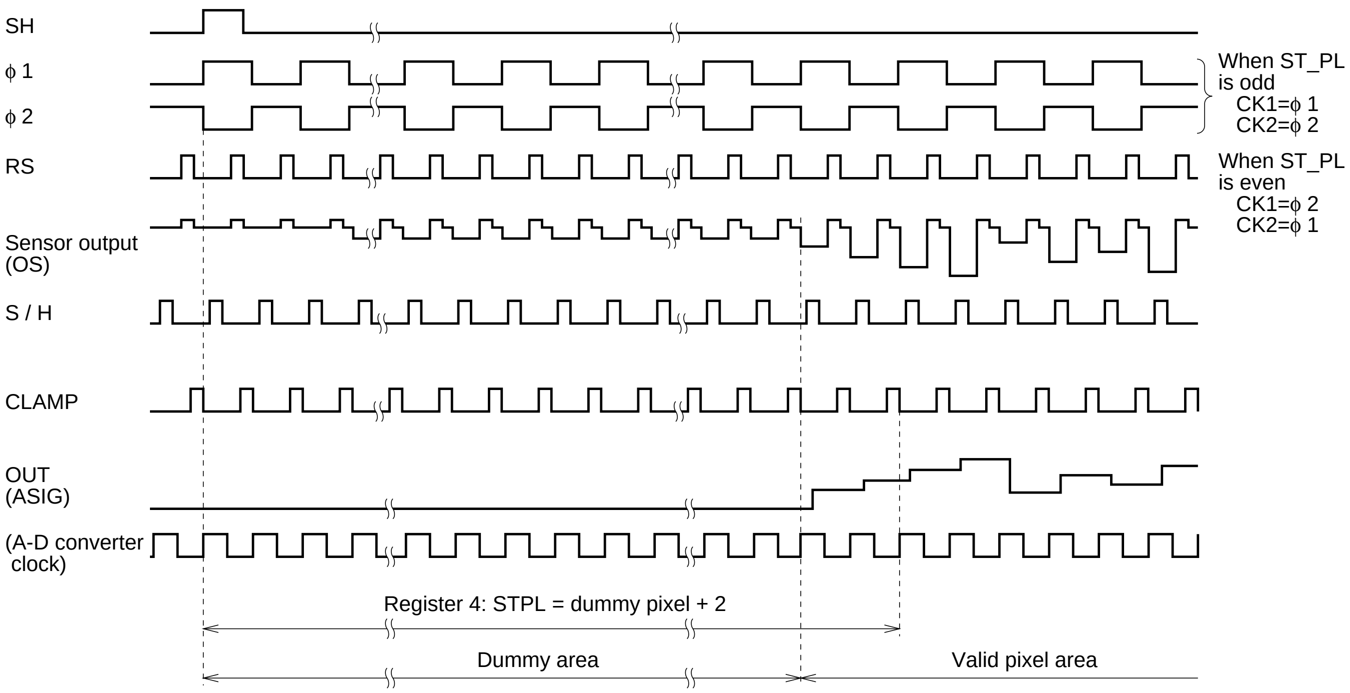
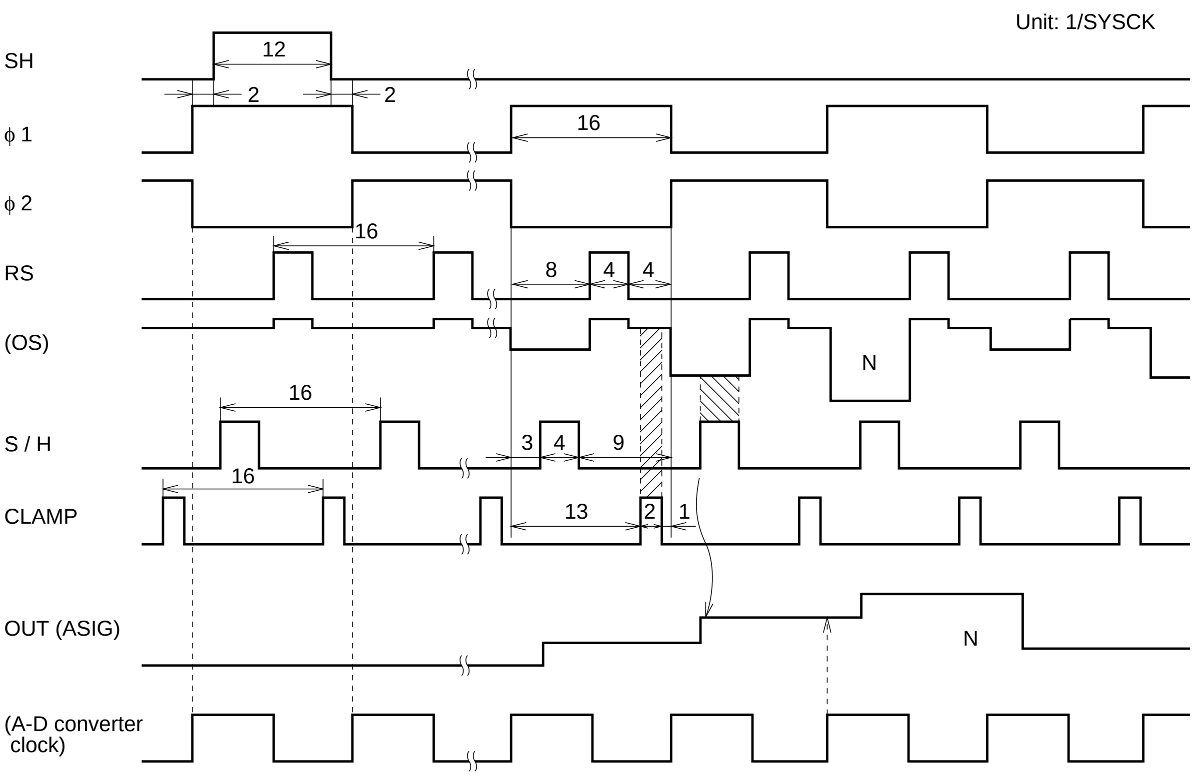


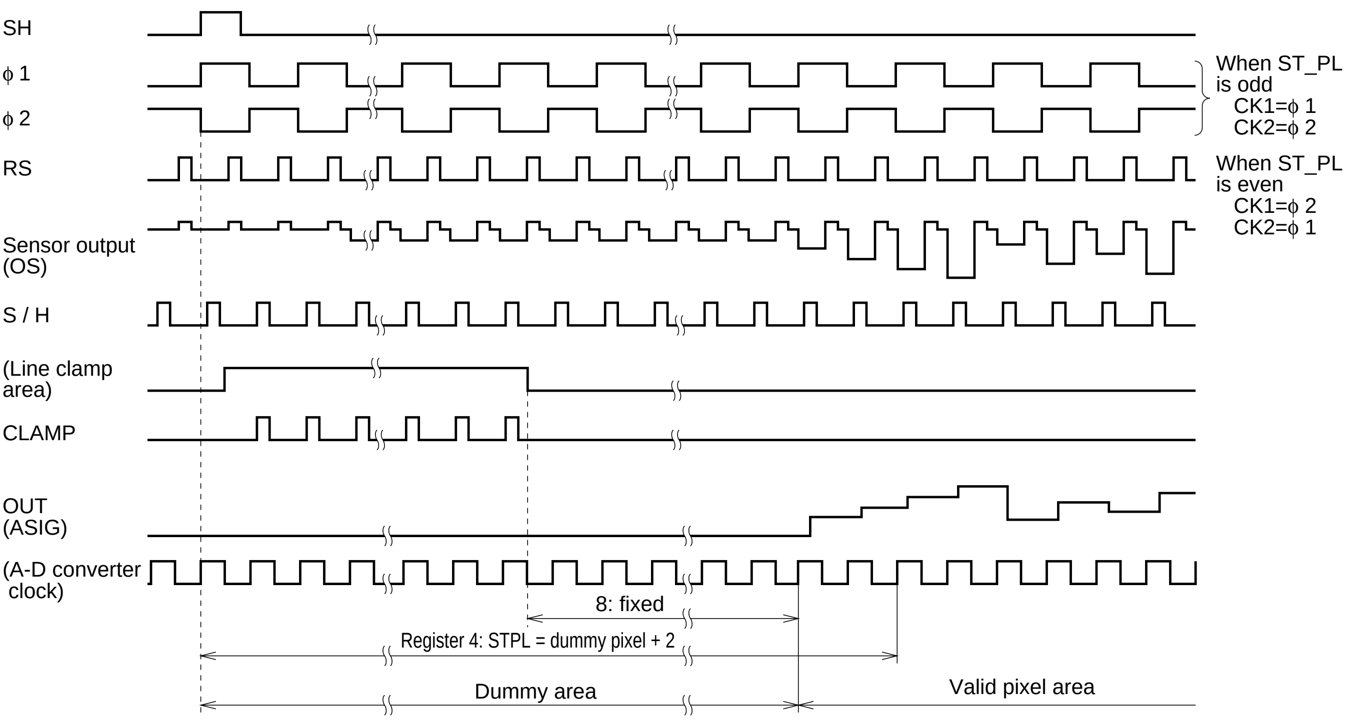
Fig. 12 Cut out function

(4) Sensor unit/analog signal processing unit interface
CCD-bit clamp type



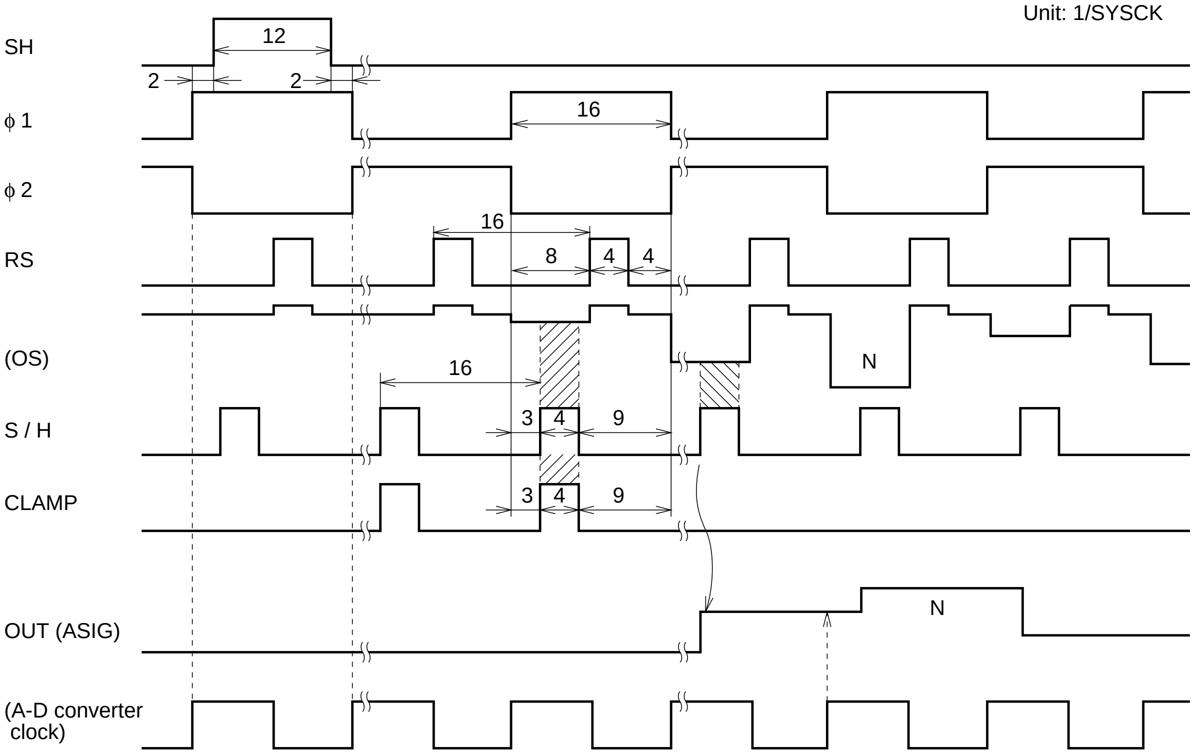


CCD-line clamp type

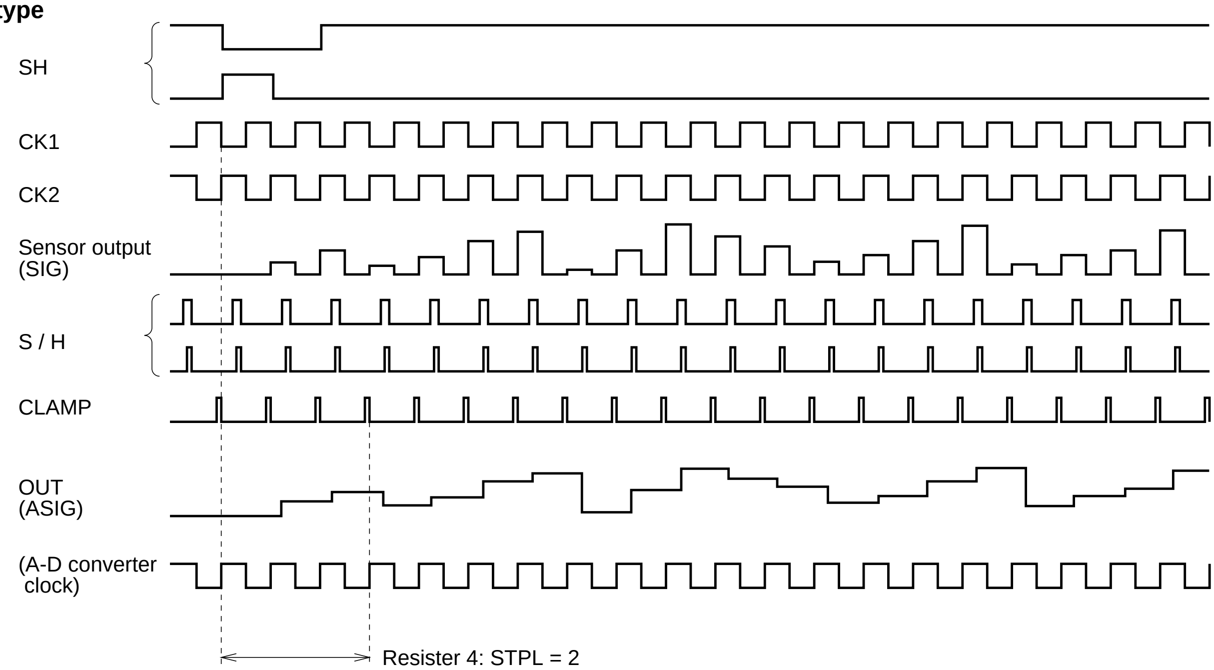


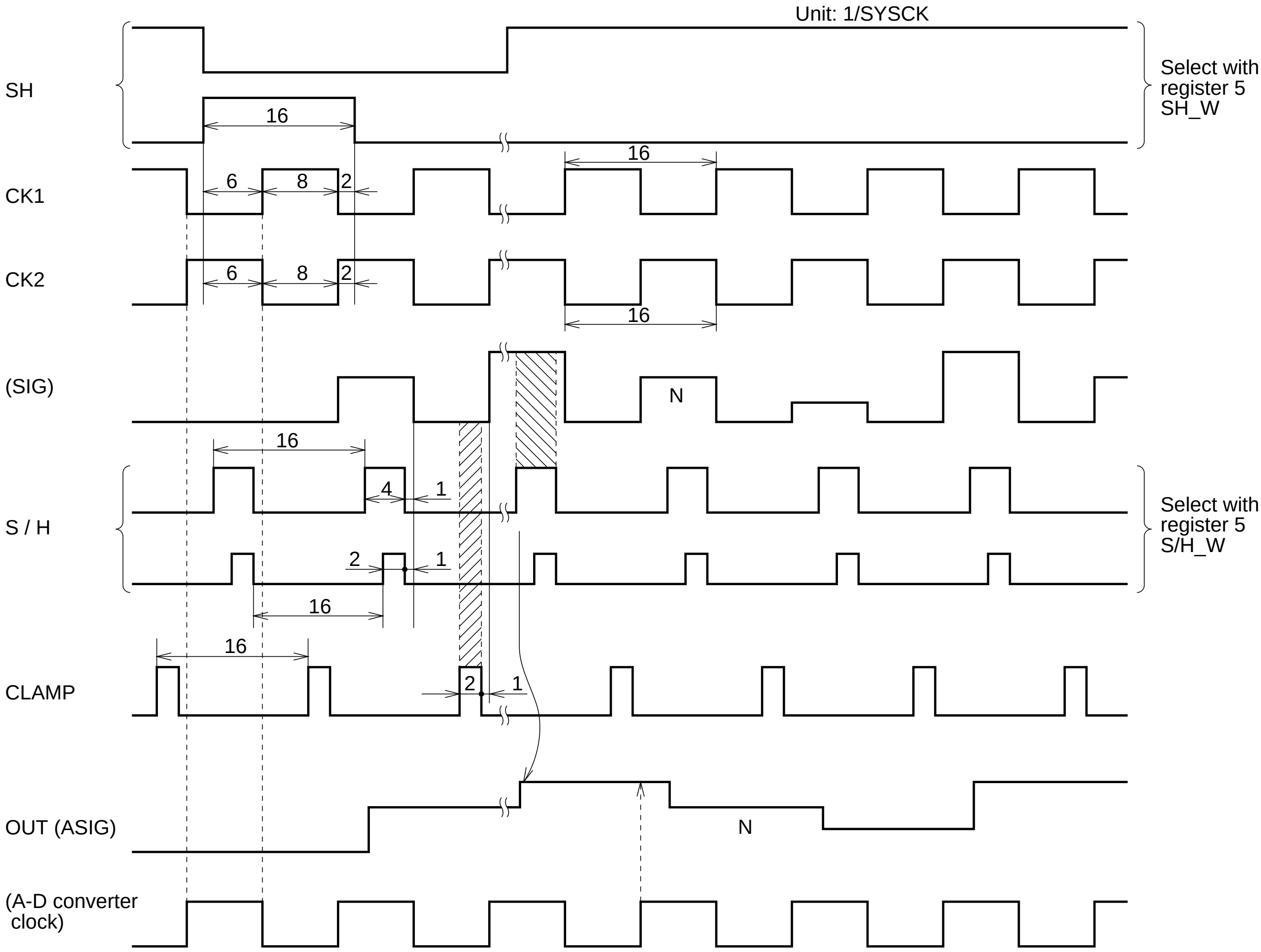
Note: Line clamp uses sensor output equivalent to (dummy area –8) pixels from the first pixel after SH.

Unit: 1/SYSCK



CIS type





Note: CLAMP: In case of CIS, check with the sensor manufacturer for the use of CLAMP.
SH and CK1, CK2: SH can be selected with register 5 and CK can be selected with CK1 and CK2 (2 choices each) to provide interface with various types of CIS.

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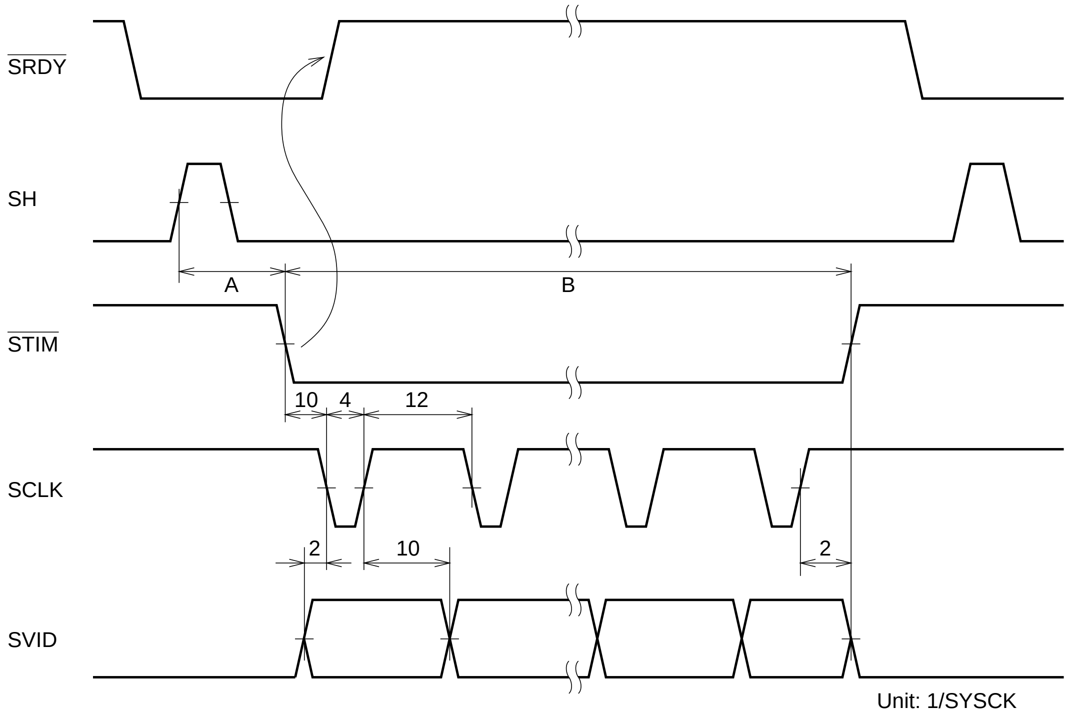
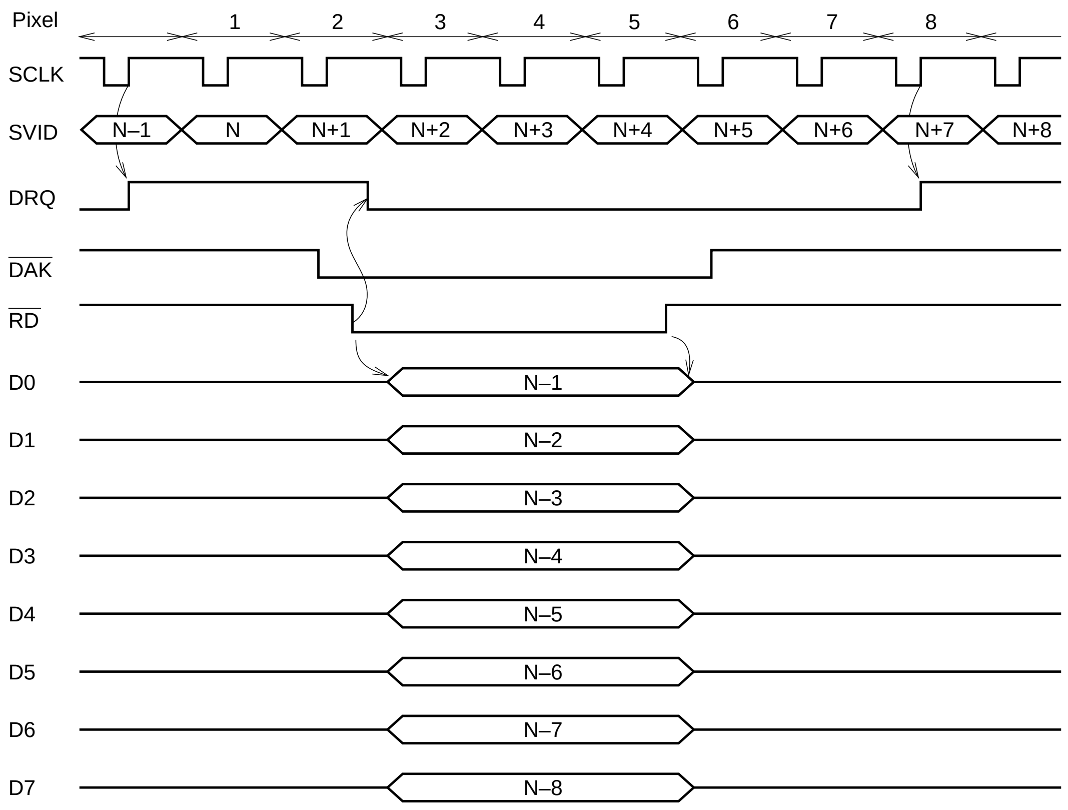
(5) CODEC interface
Serial output



Note: A is determined by register 4 (ST_PL), and B is determined by register 1 (SOURCE, DEST, REDU).

Parallel output

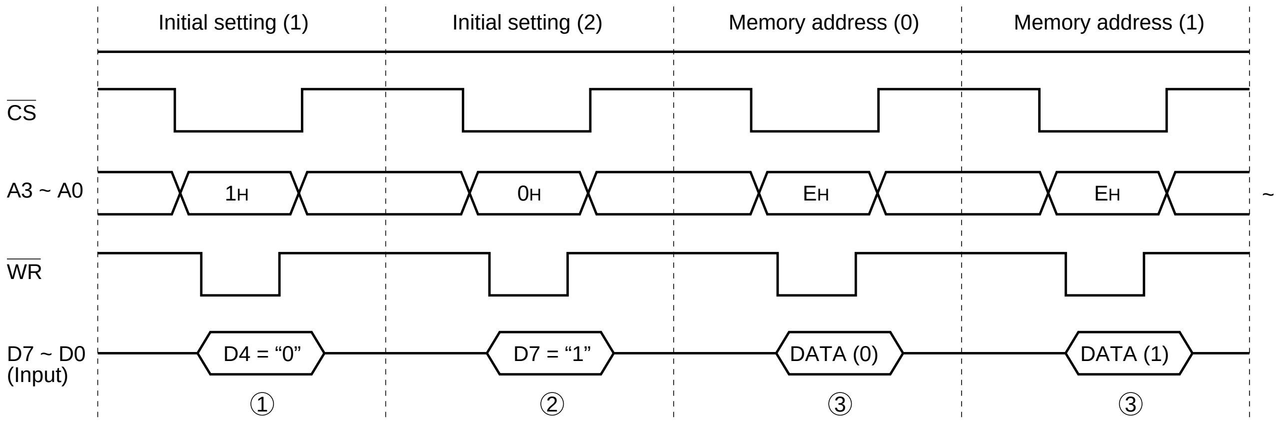


Note: Handshaking of three lines SRDY, SH, and STIM, which are interface to the CODEC, is the same as serial output.

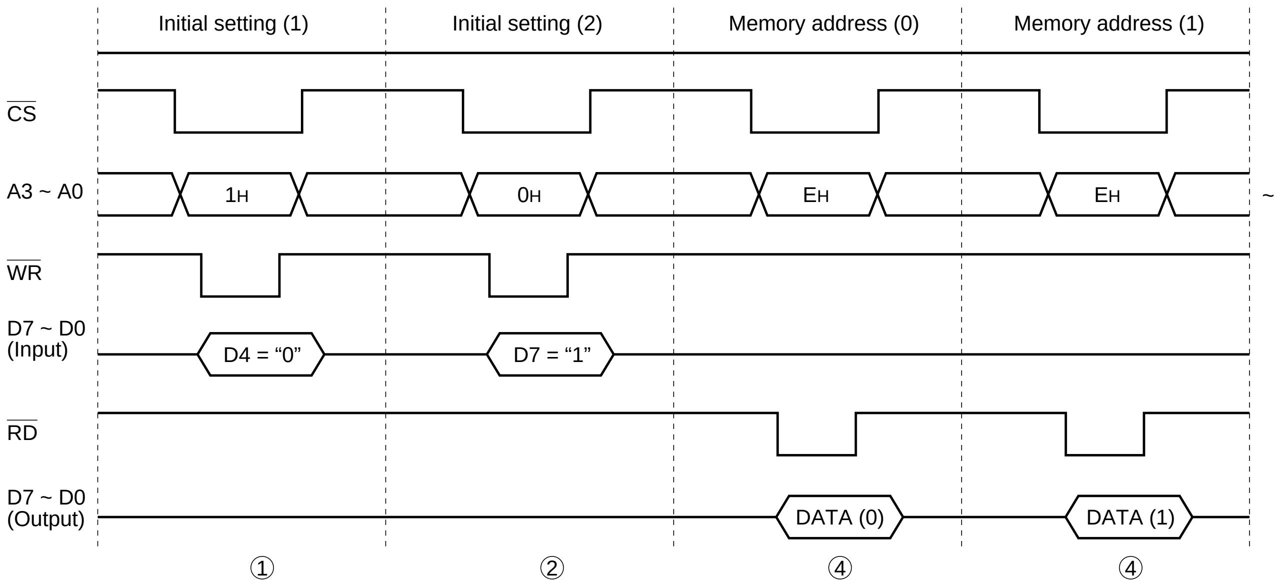
(6) Read/write to dither memory, uniformity correction memory

The following figures show the sequence for writing and reading dither patterns in the 16 words × 4 bits collective dithering SRAM built in the M66332.

Dither memory write (MPU → M66332)



Dither memory read (M66332 → MPU)



① Clear D4 (PO) in register 1 to "0" in order to set the MPU bus (D7 – D0) to dither matrix memory data output mode.
② Set D7 (RESET) in register 0 to "1" in order to reset the dither memory address counter.
③ Select DITH_D with register E and write DATA (0) on the MPU bus (D5 – D0). Increment the address counter of the dither memory at the rising edge of WR. (during write)
④ Select DITH_D with register E and read DATA (0) in dither memory to the MPU bus (D5 – D0). Increment the address counter of the dither memory at the rising edge of RD. (during read)

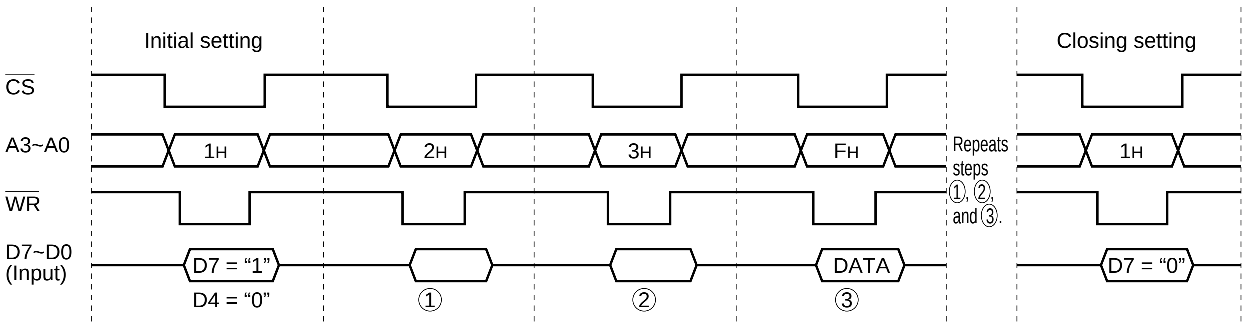
Dither matrix address

A0	A1	A2	A3
A4	A5	A6	A7
A8	A9	A10	A11
A12	A13	A14	A15

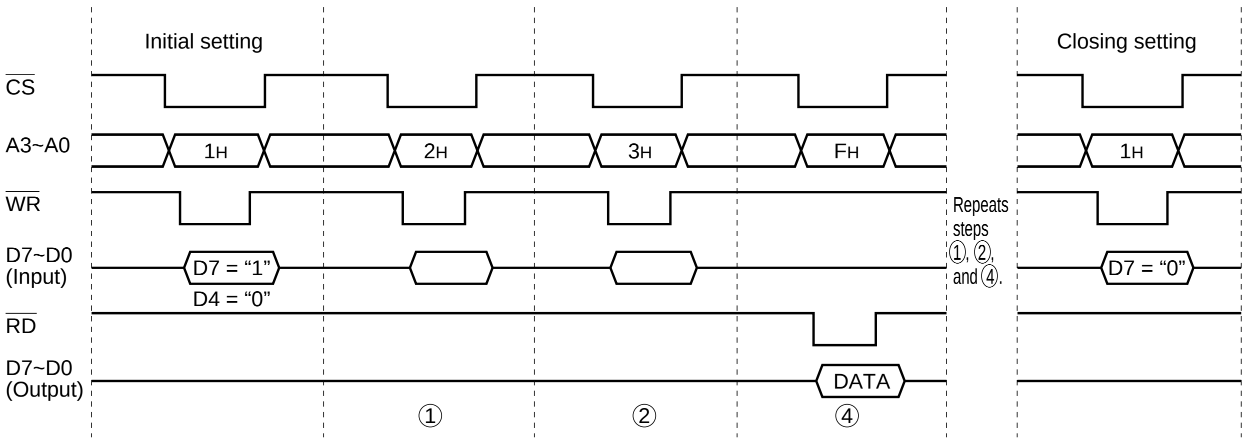
4 × 4 matrix

The M66332 can read/write uniformity correction data in the external correction SRAM through the MPU bus. This enables the uniformity correction data to be temporarily saved in backup memory during power off. The following figures show the uniformity correction data read/write sequence.

Uniformity correction memory write (MPU → M66332)



Uniformity correction memory read (M66332 → MPU)



	D7	D6	D5	D4	D3	D2	D1	D0
R2	A4	A3	A2	A1	A0	0	0	0
R3	0	*	0	0	A8	A7	A6	A5

D_LOAD : 0 for normal
1 for data load
A8~A0 : UNIF memory address

① The last 5 digits (A4 – A0) of an address in the UNIF memory are written in register 2.
② The initial 4 digits (A8 – A5) of the address in the UNIF memory and D_LOAD = "1" (D6) are written in register 3.
Steps ① and ② identifies the address in the UNIF memory.
③ The UNIF memory is selected with register F, and DATA on the MPU bus (D4 – D0) is written at the identified address.
④ The UNIF memory is selected with register F, and DATA stored at the identified address is read to the MPU bus (D4 – D0).

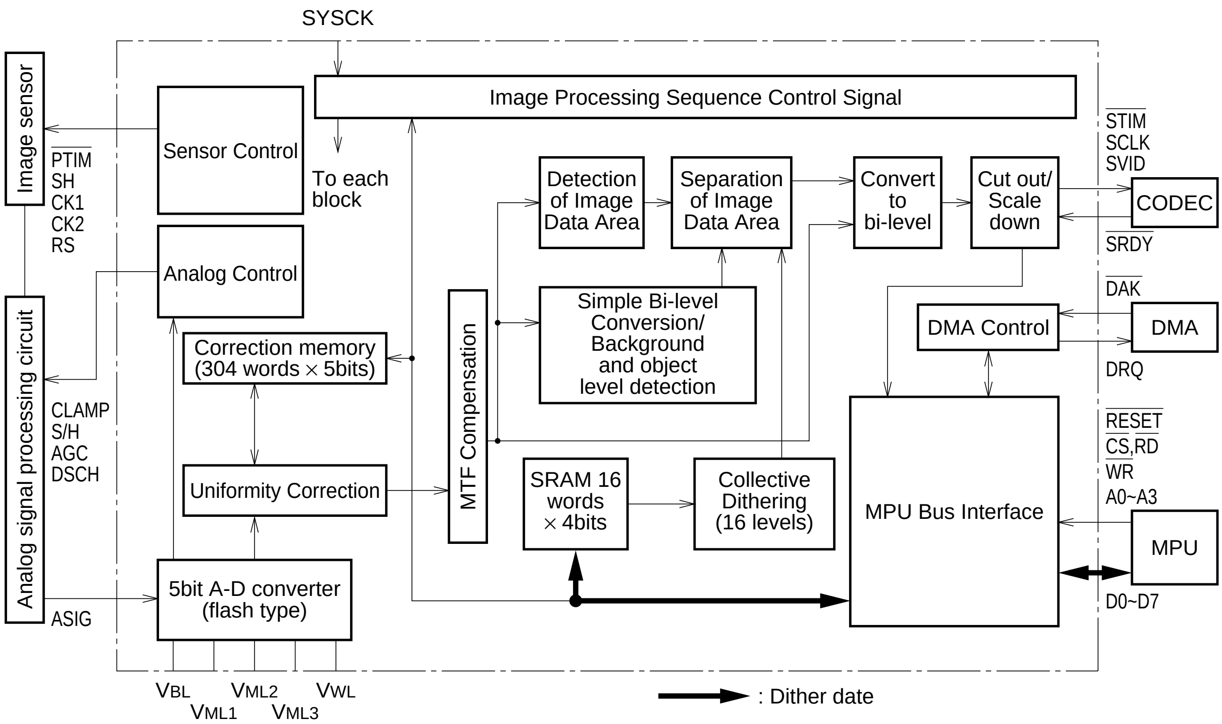
Initial setting: D7 (UM_R/W) and D4 (P0) of register 1 are set to "1" and "0", respectively, to select read/write mode of uniformity correction memory.

Closing setting : D7 (UM_R/W) of register 1 is set to "0" while D4 (P0) is set to that taken in operation, to cancel read/write mode of uniformity correction memory.

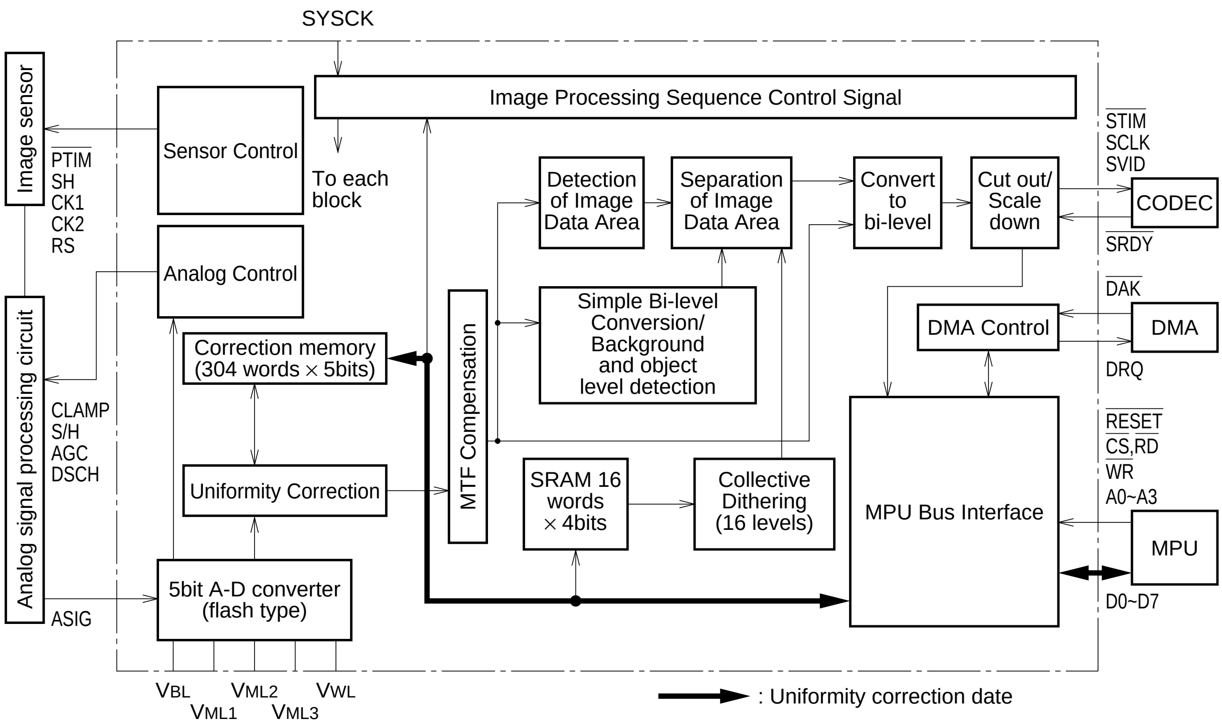
Address Space

Sensor width	Left end address	Right end address
A3	310	7
B4	284	29
A4	264	49

Dither memory write/read



Uniformity correction memory write/read



(7) Reset
The M66332 has three types of reset. Each reset function is described below.

Hard reset: Initializes the circuit. Hard reset also performs the following soft reset and standby reset.

Soft reset: Used when cancelling a line read operation in the middle during SCAN mode. Read operation is resumed starting from the next line.

Standby : Used as standby mode. The internal clock is stopped by stopping the clock generator which generates the internal clock from the system clock. Therefore, the internal circuit is stopped and power is saved.
The period counter and register statuses are saved and the internal memory is placed in standby mode.

Table 6 Reset function

Function / Reset Type	Initialize Register	Initialize Internal F/F	Reset Period Counter	Stop Clock Generator Operation	Stop Line Read
Hard Reset RESET	○	○	○	○	
Soft Reset Register 0 (RESET)					○
Standby Register1 (STNBY)		○		○	

(8) Image quality control using registers

• **MTF compensation**
If the sensor has high resolution, resolution compensation need not be performed for half-tone area.
MTF compensation should be performed for bi-level area regardless of the sensor resolution in order to achieve good object reproduction.

• **Simple bi-level conversion, background and object level detection**
Set the background level detection and object level detection counters as follows in order to obtain clear output of objects that do not have completely white background and that are not entirely black.
⟵——— fast
MAX_UP > MAX_DOWN > MIN_UP
The output becomes darker as bi-level conversion threshold coefficient (SLICE) is increased.
Select a large SLICE value for light source document.

• **Pseudo half-tone conversion, dither method**
Select collective dithering (16 gradations using 4 × 4 dither matrix) for fine mode. Refer to the section on image processing function for details on providing dither pattern threshold.

• **Separation of image data area**
The optimum parameter is selected to perform the best bi-level conversion for each area: simple bi-level conversion for the object and pseudo half-tone conversion for half-tone.

Table 7 shows the recommended values for parameters related to picture quality. Use these values as reference to determine the optimum parameter.

Table 7 Recommended parameter values

Image	Uniformity Correction	Resolution Compensation MTF	Background and Object Level						γ Correction	Dither Pattern	Separation of Image Data Area		
			SLICE	MAX UP	MAX DOWN	MIN UP	UL MIN	LL MAX			SEPA A	SEPA B	SEPA C
Simple Bi-Level Conversion	Yes	1/2	5/8	Normal	Normal	Normal	04_H	$0A_H$	No	—	—	—	—
Dithering	Yes	MON	—	—	—	—	—	—	γ=0.9 V_{ML1}=1.1V V_{ML2}=2.2V V_{ML3}=3.5V	4 × 4 diffusion pattern, γ = 0.8	—	—	—
Separation of Image Data Area	Yes	MON	5/8	Normal	Normal	Normal	04_H	$0A_H$	γ=0.9 V_{ML1}=1.1V V_{ML2}=2.2V V_{ML3}=3.5V	4 × 4 diffusion pattern, γ = 0.8	06_H	$0D_H$	01_H

0 1	8 6	2 2	10 8
12 A	4 3	14 C	6 4
3 2	11 9	1 2	9 7
15 D	7 5	13 B	5 3

Dither pattern (γ = 0.8)

USAGE PRECAUTIONS

- Peak detection in SCAN mode

  In SCAN mode, successive peak detection is performed for the image data being read as shown for the AGC range (dotted line) in Fig. 1.

  This enables better picture reproduction when picture data brighter than the white reference used during peak detection is input in SCAN mode.

  This is especially effective for sensor units such as CIS that do not have a built-in white reference.
- Read operation with CIS sensor

  If the sensor is CIS, it is possible to select whether or not to use white correction in SCAN mode.

  Do not select white correction for the input of analog signals already processed by entire pixel correction.
- Collective dithering

  Thresholds written in dither matrix should be between 1 and 15 excluding 0 as shown in Fig. 13.

  As the M66332 carries out block correction in 8-bit units for uniformity correction, a CIS sensor may generate background noises due to irregularity of pixels.

  It is possible to remove noises and gain a fine image quality by reducing the maximum threshold value as shown in Fig. 14.
- γ correction

  γ correction is performed to simulate the sensitivity characteristics (exponential nature) of the human eye in order to make the image data more similar to natural image.

  $\gamma = 0.45$ is said to be the optimum correction when using a thermal head printer.

  The M66332, due to its capacity to handle 4-bit internal data, performs γ correction by means of both collective dithering and the middle reference voltage pins (V_{ML1}, V_{ML2}, and V_{ML3}) of the A-D converter.

  (γ Correction by Collective Dithering)

  γ correction is realized applying a γ characteristic to the threshold value to be written in the dither matrix as shown in Fig. 15. The example given in Fig. 15 is an approximation of γ characteristic, γ, to 0.8.

  (γ Correction by the Middle Reference Voltage Pins of the A-D converter)

  The example shown in Fig. 16 is an approximation of γ characteristic, γ, to 0.9 , which is carried out by applying V_{ML1} = 1.1V, V_{ML2} = 2.2V, and V_{ML3} = 3.5V to the middle reference pins of the A-D converter.

  Fig. 23 in the M66332FP leaflet shows an example of circuits for applying voltages to middle reference voltage pins.

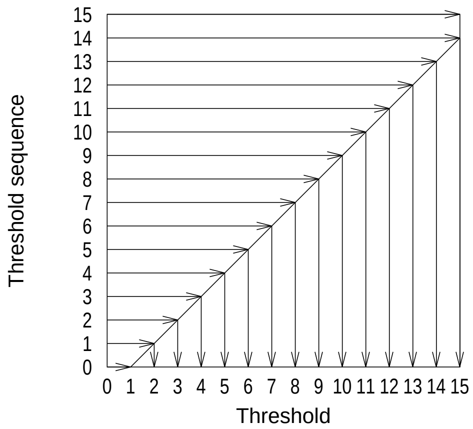


Fig. 13 Thresholds for collective dithering : Example 1

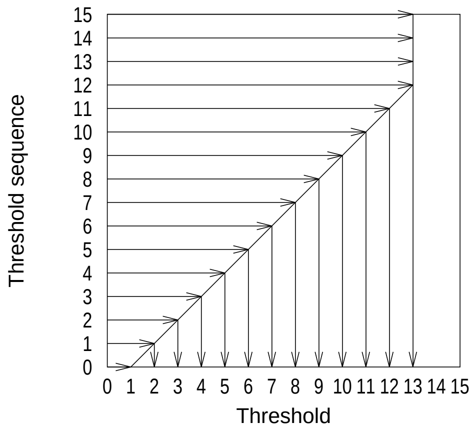


Fig. 14 Thresholds for collective dithering : Example 2

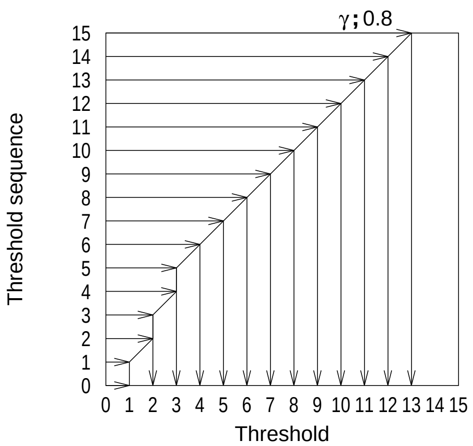


Fig. 15 An example of γ correction by dither matrix

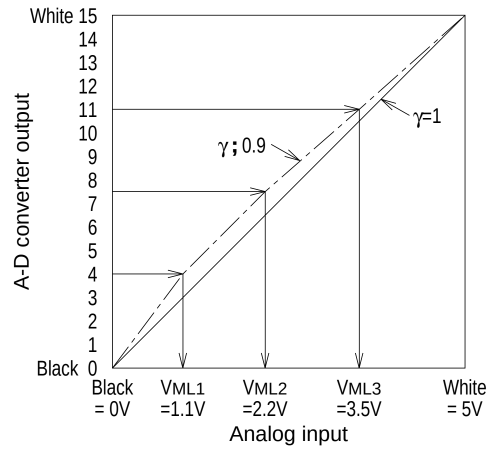


Fig. 16 An example of γ correction by middle reference pins

• TIME function

When TIME = “1” is set in register 1, the processing time per line is doubled to 2 line periods,
Data is read once every two line periods and processed.

When the read and write motors operate simultaneously during copy operation, this command can be used to reduce the processing speed to 1/2 in order to reduce the power load.

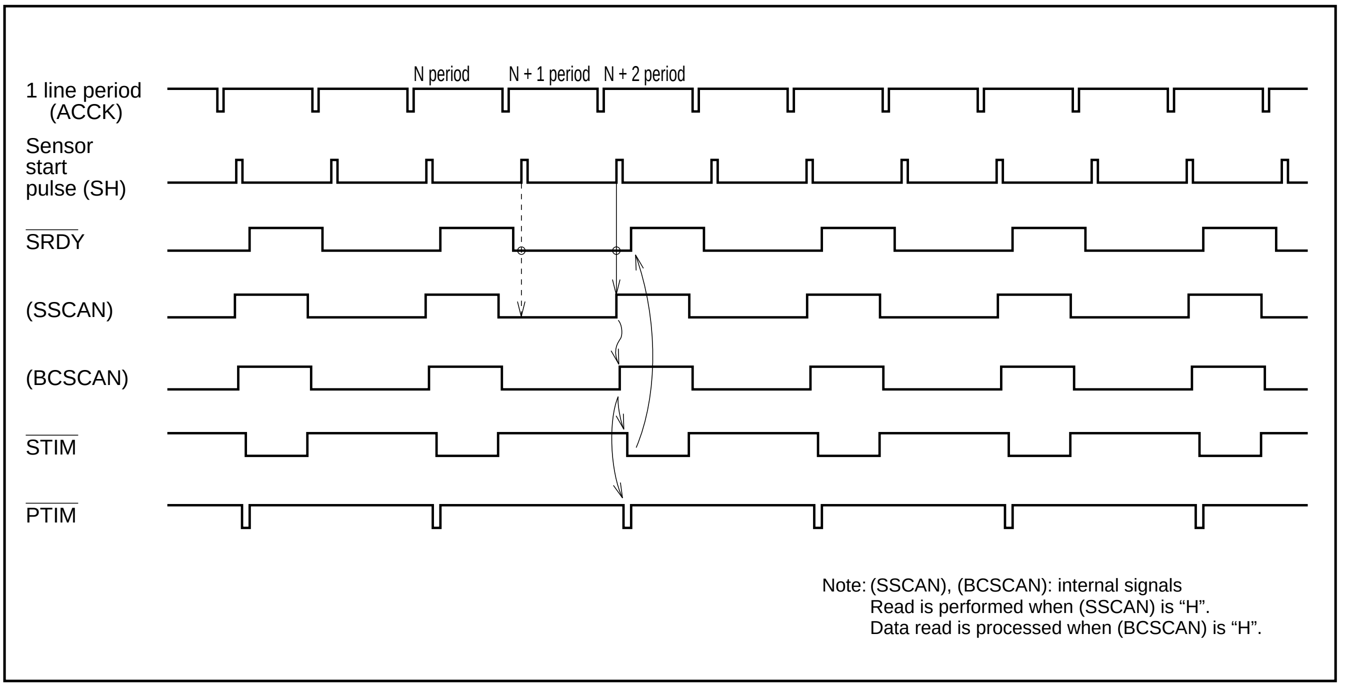


Fig. 17 When processing speed is 1/2

Register Structure

Address	R/W	Explanation
0H	W	See bit layout and tables below

D7	D6	D5	D4	D3	D2	D1	D0
RESET	SENS	SENS_W		UMODE	AGC	UNIF	SCAN

(Default is 00H)

D7	RESET System Reset
0	Normal Mode
1	Reset Mode

Reset while write pulse is “L” when D7 = “1”

D6	SENS Sensor Type
0	CCD
1	CIS

D5	D4	SENS_W Sensor Width
0	0	A4
0	1	B4
1	0	A3
1	1	—

D3	UMODE CIS Uniformity Correction Mode
0	With White Correction
1	No White Correction

• For selecting with or without correction in SCANning (with CIS only)

D2	AGC AGC mode
0	Stop
1	Start

• Controls AGC mode start/stop.

D1	UNIF UNIF Mode
0	Stop
1	Start

• Controls UNIF mode start/stop.

D0	SCAN SCAN Mode
0	Stop
1	Start

• Controls SCAN mode start/stop.

Address	R/W	Explanation
1H	W	D7 UM_R/W, D6 STNBY, D5 TIME, D4 P_0, D3–D2 SOURCE, D1 DEST, D0 REDU (Default is 00H)

D7	D6	D5	D4	D3	D2	D1	D0
UM_R/W	STNBY	TIME	P_0	SOURCE		DEST	REDU

(Default is 00H)

D7	UM_R/W Uniformity Correction Memory Read/Write
0	Normal
1	UNIF Memory Read/Write

D6	STNBY Standby Mode
0	Normal
1	Standby Mode

• Standby mode stops the clock generation circuit. The period counter and register status are saved and the internal memory is placed in standby mode.

D5	TIME Line Time
0	1 Line Period
1	2 Line Period

• When read and write operations are performed together as in copy operation, the power load can be reduced by selecting 2 line period. The processing speed drops to 1/2 when 2 line period is selected.

D4	P_O Parallel Output
0	Without Parallel Output
1	Parallel Output

• D0 is output in LSB format and D7, in MSB format. When SCAN data is output in SCAN mode, D7 is output in LSB (left) format and D0, is output in MSB (right) format.

D3	D2	SOURCE Source Width
0	0	A4
0	1	B4
1	0	A3
1	1	—

D1	DEST Destination Width
0	A4
1	B4

D0	REDU Scale down/Cut out
0	Cut out
1	Scale down

Scaling Rate	
A3 → B4	13/15
B4 → A4	9/11
A3 → A4	12/17

• Refer to image scale down/area specification for scale down/cut out.

<table>
<tr><th>Address</th><th>R/W</th><th>Explanation</th></tr>
<tr><td>2H</td><td>W</td><td>
<table>
<tr><th>D7</th><th>D6</th><th>D5</th><th>D4</th><th>D3</th><th>D2</th><th>D1</th><th>D0</th><th></th></tr>
<tr><td colspan="8">PRE_DATA <7:0></td><td>(Default is 00H)</td></tr>
</table>
D7~D0: PRE_DATA <7:0> Pre Data of Line period Counter (Lower part)

D7~D4: If register 3 D_LOAD = “1” these bits will be the address denoted by lower 5 digits (A4~A0) used for read/write operations on the uniformity correction memory.
</td></tr>
<tr><td>3H</td><td>W</td><td>
<table>
<tr><th>D7</th><th>D6</th><th>D5</th><th>D4</th><th>D3</th><th>D2</th><th>D1</th><th>D0</th><th></th></tr>
<tr><td>0</td><td>D_LOAD</td><td>\</td><td colspan="5">PRE_DATA <12:8></td><td>(Default is 00H)</td></tr>
</table>
<table>
<tr><th>D6</th><th>Uniformity correction memory address setting mode.</th></tr>
<tr><td>0</td><td>Normal</td></tr>
<tr><td>1</td><td>Data load</td></tr>
</table>
• This bit is for address setting for the access form MPU to the uniformity correction memory. Set this bit to normal during access operation.

D4~D0: PRE_DATA <12:8> Pre Data of Line period Counter (Upper part)
• 1 line period is determined from PRE_DATA and pixel transmission clock frequency (ADCK). ADCK is 1/16 of system clock.
Refer to line period and read sequence section.

D3~D0: If register 3 D_LOAD = “1” these bits will be the address denoted by upper 4 digits (A8~A5) used for read/write operations on the uniformity correction memory.
</td></tr>
<tr><td>4H</td><td>W</td><td>
<table>
<tr><th>D7</th><th>D6</th><th>D5</th><th>D4</th><th>D3</th><th>D2</th><th>D1</th><th>D0</th><th></th></tr>
<tr><td>\</td><td colspan="7">ST_PL <6:0></td><td>(Default is 00H)</td></tr>
</table>
D6~D0: ST_PL <6:0> Start Pulse of Line sensor
ST_PL = (sensor dummy pixel + 2)
Refer to line period and read sequence Section.
</td></tr>
</table>

Address	R/W	Explanation
5H	W	D7–D0: (D7 unused), D6 S/H_W, D5 SH_W, D4 CLAMP, D3–D2 MODE, D1–D0 MTF (Default is 00H)

D6	S/H_W Pulse Width of S/H
0	Normal (Sysclk period × 4)
1	Normal × 0.5

D5	SH_W SH pulse width for CIS
0	Normal
1	Reverse of (normal × 2)

• In case of CCD, there is only one SH pulse width and this register is ignored.

D4	CLAMP Clamp Method of Analog Circuit
0	Bit Clamp
1	Line Clamp

• Line clamp does not apply to CIS.

D3	D2	MODE Bi-level Mode
0	0	Simple Bi-level
0	1	Dither
1	0	Separation (Simple Bi-level + Dither)
1	1	—

D1	D0	MTF Main Coefficient of MTF Compensation
0	0	NON(0)
0	1	A little less (1/4)
1	0	Middle (1/2)
1	1	A little over (1)

Address	R/W	Explanation
6H	W	D7–D4: (unused), D3–D0: SEPA_A (Default is 00H) D3~D0: SEPA_A Separation of Image Data Area (Difference)
7H	W	D7–D4: (unused), D3–D0: SEPA_B (Default is 00H) D3~D0: SEPA_B Separation of Image Data Area (MIN.)

Address	R/W	Explanation
8H	W	See below
9H	W	See below

Address 8H, W

D7	D6	D5	D4	D3	D2	D1	D0	
				SEPA_C				(Default is 00H)

D3~D0: SEPA_C Separation of Image Data Area (MAX.)

Address 9H, W

D7	D6	D5	D4	D3	D2	D1	D0	
SLICE		MAX_UP		MAX_DOWN		MIN_UP		(Default is 00H)

D7	D6	SLICE Detector of Background and Object levels (SLICE)
0	0	Normal (4/8)
0	1	Light (3/8)
1	0	Dark (5/8)
1	1	Darker (6/8)

D5	D4	MAX_UP Detector of Background level (Up Counter CLK)
0	0	Normal (T = (1 pixel period) × 32)
0	1	Slow (T = (1 pixel period) × 64)
1	0	Fast (T = (1 pixel period) × 16)
1	1	Faster (T = (1 pixel period) × 8)

D3	D2	MAX_DOWN Detector of Background level (Down Counter CLK)
0	0	Normal (T = (1 pixel period) × 128)
0	1	Slow (T = (1 pixel period) × 256)
1	0	Fast (T = (1 pixel period) × 64)
1	1	Faster (T = (1 pixel period) × 32)

D1	D0	MIN_UP Detector of Object level (Up Counter CLK)
0	0	Normal (T = (1 pixel period) × 512)
0	1	Slow (T = (1 pixel period) × 1024)
1	0	Fast (T = (1 pixel period) × 256)
1	1	Faster (T = (1 pixel period) × 128)

T: Counter clock period

Address	R/W	Explanation
A_H	W	D7 D6 D5 D4 D3 D2 D1 D0 D3–D0: UL_MIN (Default is 06H) D3~D0: UL_MIN Detector of background and object levels (upper limit of object level)
B_H	W	D7 D6 D5 D4 D3 D2 D1 D0 D3–D0: LL_MAX (Default is 07H) D3~D0: LL_MAX Detector of background and object levels (lower limit of background level)
E_H	R/W	D7 D6 D5 D4 D3 D2 D1 D0 D3–D0: DITH_D D3~D0: DITH_D Internal dither memory data • Refer to the section on dither memory and uniformity correction memory read/write for information concerning read/write method.
F_H	R/W	D7 D6 D5 D4 D3 D2 D1 D0 D4–D0: UNIF_D D4~D0: UNIF_D Internal uniformity correction data • Refer to the section on dither memory and uniformity correction memory read/write for information concerning read/write method.

ABSOLUTE MAXIMUM RATING (Ta = –20 ~ 75˚C, unless otherwise noted)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Supply voltage		–0.3 ~ +7.0	V
V_I	Input voltage		–0.3 ~ V_{CC} + 0.3	V
V_O	Output voltage		0 ~ V_{CC}	V
AV_{CC}	Analog supply voltage		V_{CC}–0.3 ~ V_{CC}+0.3	V
V_{WL}	Reference voltage (White)		–0.3 ~ AV_{CC}+0.3	V
V_{BL}	Reference voltage (Black)		–0.3 ~ AV_{CC}+0.3	V
V_{ML}	Reference voltage (Middle)		–0.3 ~ AV_{CC}+0.3	V
V_{AIN}	Analog Input voltage		–0.3 ~ AV_{CC}+0.3	V
T_{stg}	Storage temperature range		–65 ~ 150	˚C

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter		Limits			Unit
			Min.	Typ.	Max.	
V_{CC}	Supply voltage		4.5	5.0	5.5	V
GND	GND voltage			0.0		V
V_I	Input voltage		0.0		V_{CC}	V
AV_{CC}	Analog supply voltage		4.5	5.0	5.5	V
A_{GND}	Analog GND voltage (Note)			0.0		V
V_{WL}	Reference voltage (White)		3		AV_{CC}	V
V_{BL}	Reference voltage (Black)		0.0	0.0	1.0	V
V_{AIN}	Analog input voltage	ASIG	V_{BL}		V_{WL}	V
T_{opr}	Operating temperature range		–20		75	˚C

Note: Connect AGND with GND externally.

ELECTRICAL CHARACTERISTICS (Ta = –20 ~ 75˚C, VCC = 5 V ± 10%, unless otherwise noted)

Symbol	Parameter		Test conditions	Limits			Unit
				Min.	Typ.	Max.	
VIH	"H" Input voltage	SYSCK, SRDY, DAK, CS, RD, WR, A0~A3, D0~D7		2.0			V
VIL	"L" Input voltage					0.8	V
VT+	Positive-going threshold voltage	RESET				2.4	V
VT–	Negative-going threshold voltage			0.6			V
VH	Hysteresis voltage				0.2		V
VOH	"H" output voltage	D0~D7	IOH=–12mA	VCC–0.8			V
VOL	"L" output voltage		IOL=12mA			0.55	V
VOH	"H" output voltage	DRQ, SH, CK1, CK2, RS, PTIM, CLAMP, S/H, AGC, DSCH, STIM, SCLK, SVID	IOH=–4mA	VCC–0.8			V
VOL	"L" output voltage		IOL=4mA			0.55	V
IIH	"H" input current	SYSCK, SRDY, DAK, RESET, CS, RD, WR, A0~A3	VCC=5.5V VI=5.5V			1.0	µA
IIL	"L" input current		VCC=5.5V VI=0V			–1.0	µA
IOZH	Off-state "H" output current	D0~D7	VCC=5.5V VI=5.5V			5.0	µA
IOZL	Off-state "L" output current		VCC=5.5V VI=0V			–5.0	µA
IAIN	Analog input current	ASIG (Standby)				±10	µA
RL	Reference resistance				1.0		kΩ
SINL	A-D converter Non-linear error (Note 1)		VCC=5.0V		±0.5	±1.0	LSB
ICCS	Quiescent supply current (Standby) (Note 2)		VCC=5.5V VI=VCC, GND		10	20	mA
ICCA	Quiescent supply current (Active state) (Note 2)		VCC=5.5V VI=VCC, GND		15	40	mA
ICC	Dynamic supply current	SYSCK=8MHz	VCC=5.5V VI=VCC,GND		40		mA

Note 1: The A-D converter has a 5-bit resolution.
2: Current flowing in the reference resistor in the A-D converter is not included.

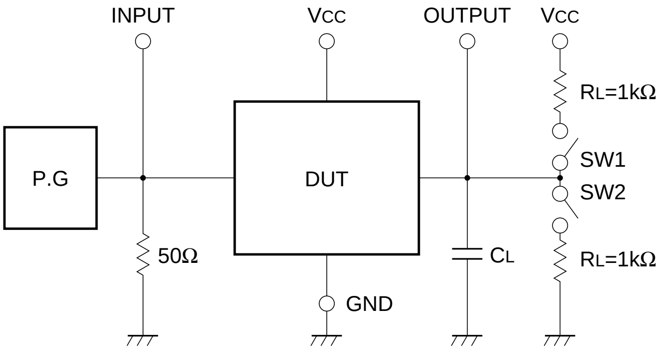
TIMING REQUIREMENTS (Ta = –20 ~ 75˚C, VCC = 5 V ± 10%, unless otherwise noted)

Symbol	Parameter			Test conditions	Limits			Unit
					Min.	Typ.	Max.	
$t_{c(SYS)}$	System clock	Period				125		ns
$t_{w+(SYS)}$		High-level pulse width				62.5		ns
$t_{w-(SYS)}$		Low-level pulse width				62.5		ns
$t_{r(SYS)}$		Rise time					20	ns
$t_{f(SYS)}$		Fall time					20	ns
$t_{w(\overline{RD})}$	Read pulse	Pulse width			100			ns
$t_{su(\overline{CS}-\overline{RD})}$		Setup time	$\overline{CS}$		20			ns
$t_{su(A-\overline{RD})}$		Setup time	A0~A3		20			ns
$t_{su(\overline{DAK}-\overline{RD})}$		Setup time	$\overline{DAK}$		20			ns
$t_{h(\overline{RD}-\overline{CS})}$		Hold time	$\overline{CS}$		10			ns
$t_{h(\overline{RD}-A)}$		Hold time	A0~A3		10			ns
$t_{h(\overline{RD}-\overline{DAK})}$		Hold time	$\overline{DAK}$		10			ns
$t_{w(\overline{WR})}$	Write pulse	Pulse width			100			ns
$t_{su(\overline{CS}-\overline{WR})}$		Setup time	$\overline{CS}$		20			ns
$t_{su(A-\overline{WR})}$		Setup time	A0~A3		20			ns
$t_{su(D-\overline{WR})}$		Setup time	D0~D7		50			ns
$t_{h(\overline{WR}-\overline{CS})}$		Hold time	$\overline{CS}$		20			ns
$t_{h(\overline{WR}-A)}$		Hold time	A0~A3		10			ns
$t_{h(\overline{WR}-D)}$		Hold time	D0~D7		0			ns
$t_{h(\overline{STIM}-\overline{SRDY})}$	$\overline{STIM}$	Hold time	$\overline{SRDY}$		0			ns

SWITCHING CHARACTERISTICS (Ta = –20 ~ 75˚C, V_{CC} = 5 V ± 10%, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits Min.	Limits Typ.	Limits Max.	Unit
$t_{PZL}(\overline{RD}\text{-}D)$ $t_{PZH}(\overline{RD}\text{-}D)$	Output enable time to low-level and high-level (RD-D)	C_L=150pF			75	ns
$t_{PLZ}(\overline{RD}\text{-}D)$ $t_{PHZ}(\overline{RD}\text{-}D)$	Output disable time from low-level and high-level (RD-D)	C_L=150pF	10		50	ns
$t_{PHL}(\overline{RD}\text{-}DRQ)$	High-level to low-level output propagation time (RD-DRQ)	C_L=50pF			50	ns

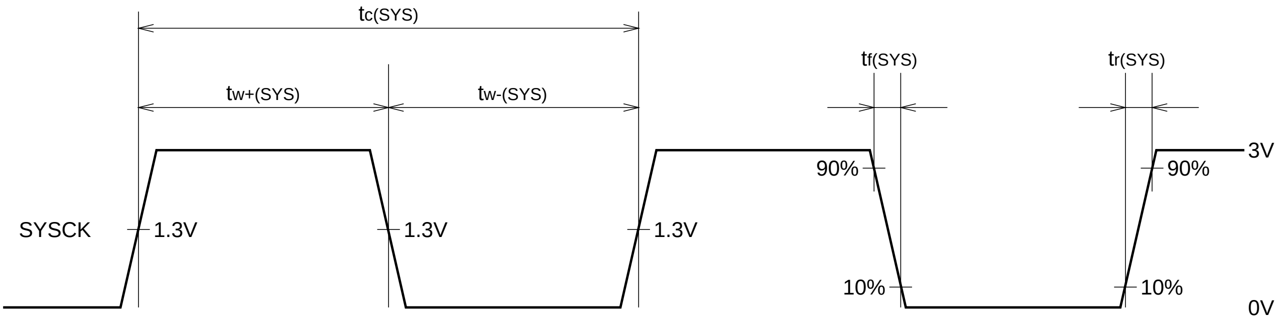
Test Circuit



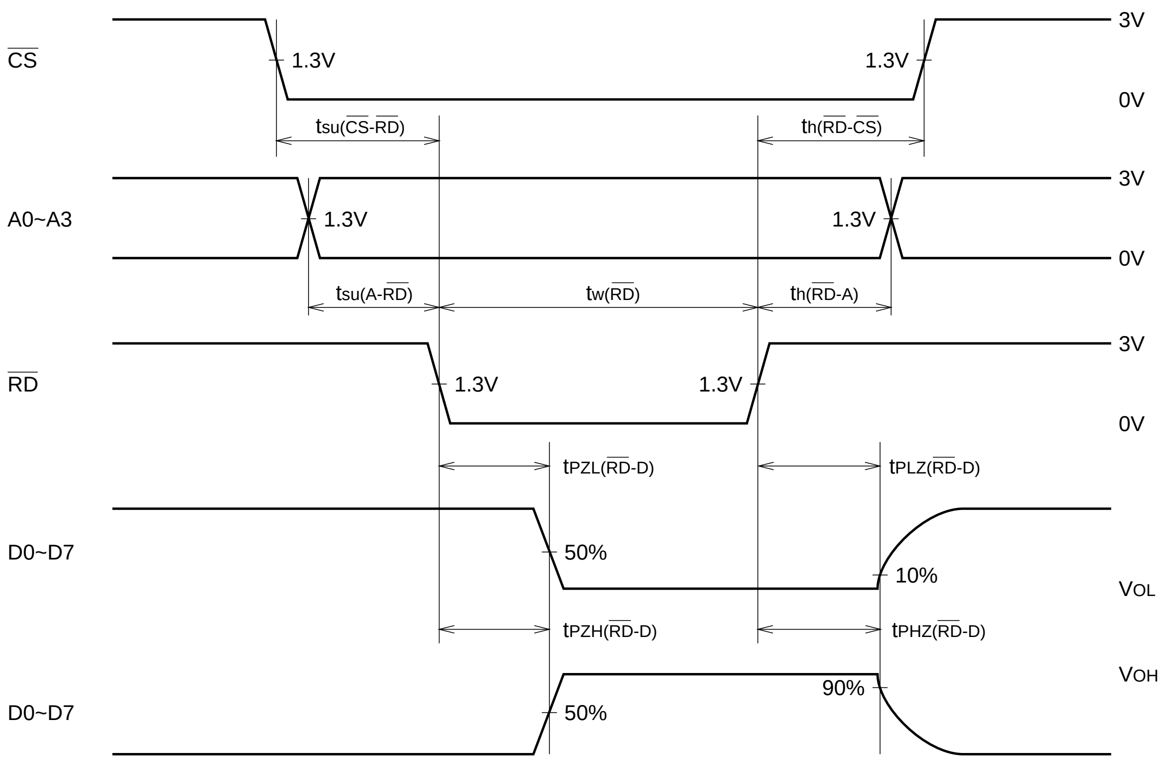
Parameter	SW1	SW2
t_{PLH}, t_{PHL}	Open	Open
t_{PLZ}	Closed	Open
t_{PHZ}	Open	Closed
t_{PZL}	Closed	Open
t_{PZH}	Open	Closed

(1) The pulse generator (PG) has the following characteristics (10%~90%) : t_r = 3 ns, t_f = 3 ns
(2) The capacitance C_L = 150pF includes stray wiring capacitance and the probe input capacitance.

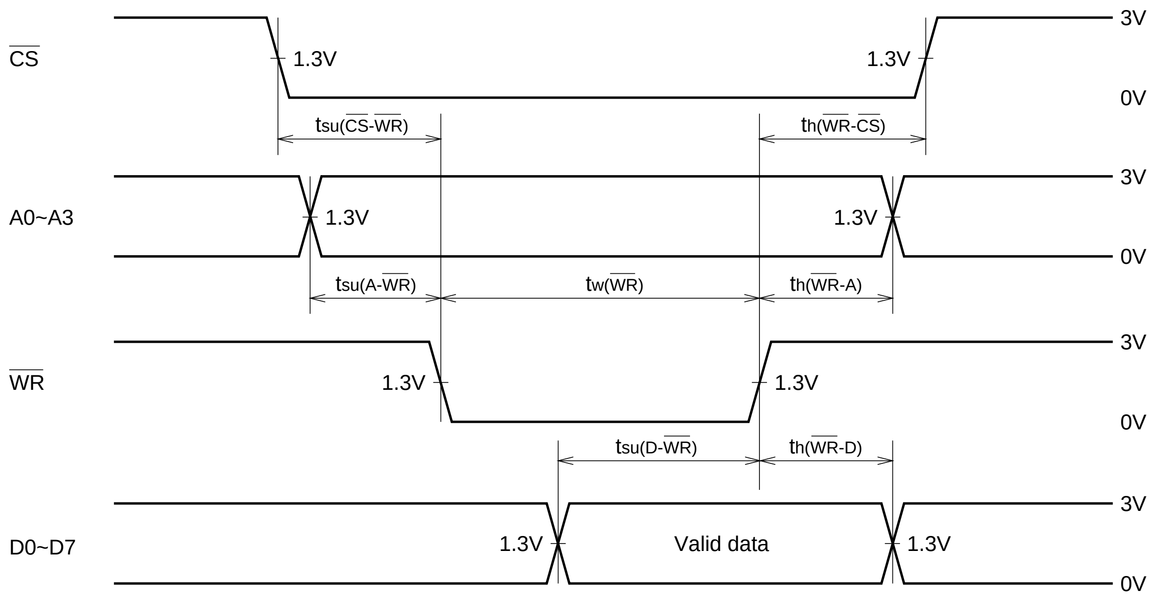
System Clock



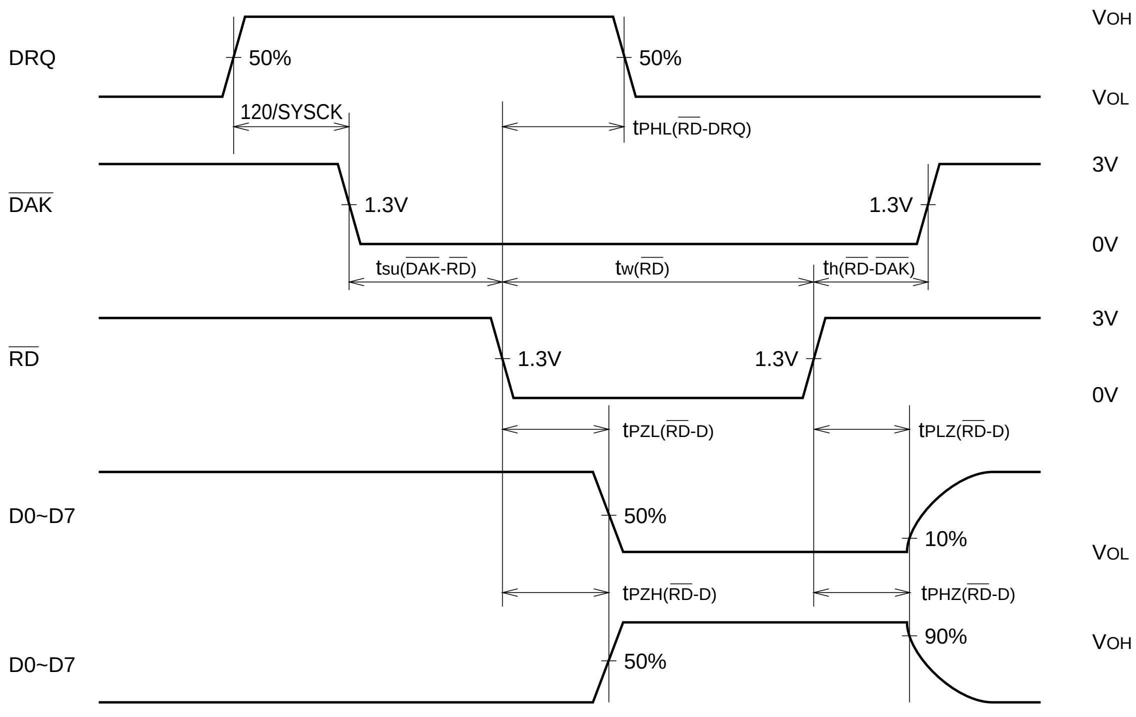
MPU Interface
(1) Read timing (M66332 → MPU)



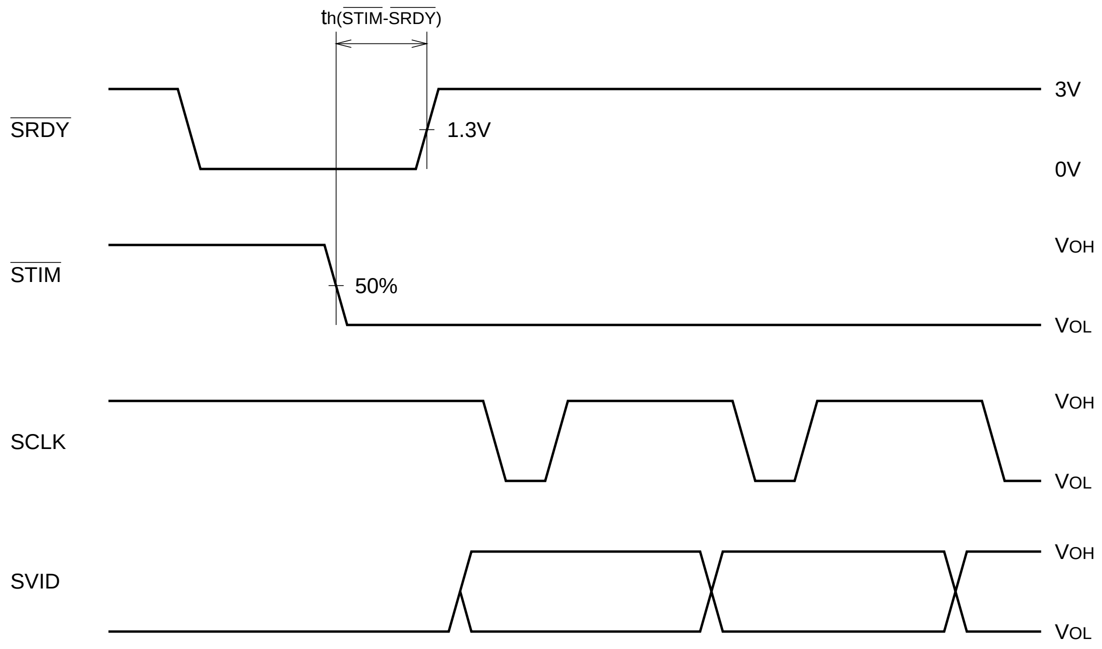
(2) Write timing (MPU → M66332)



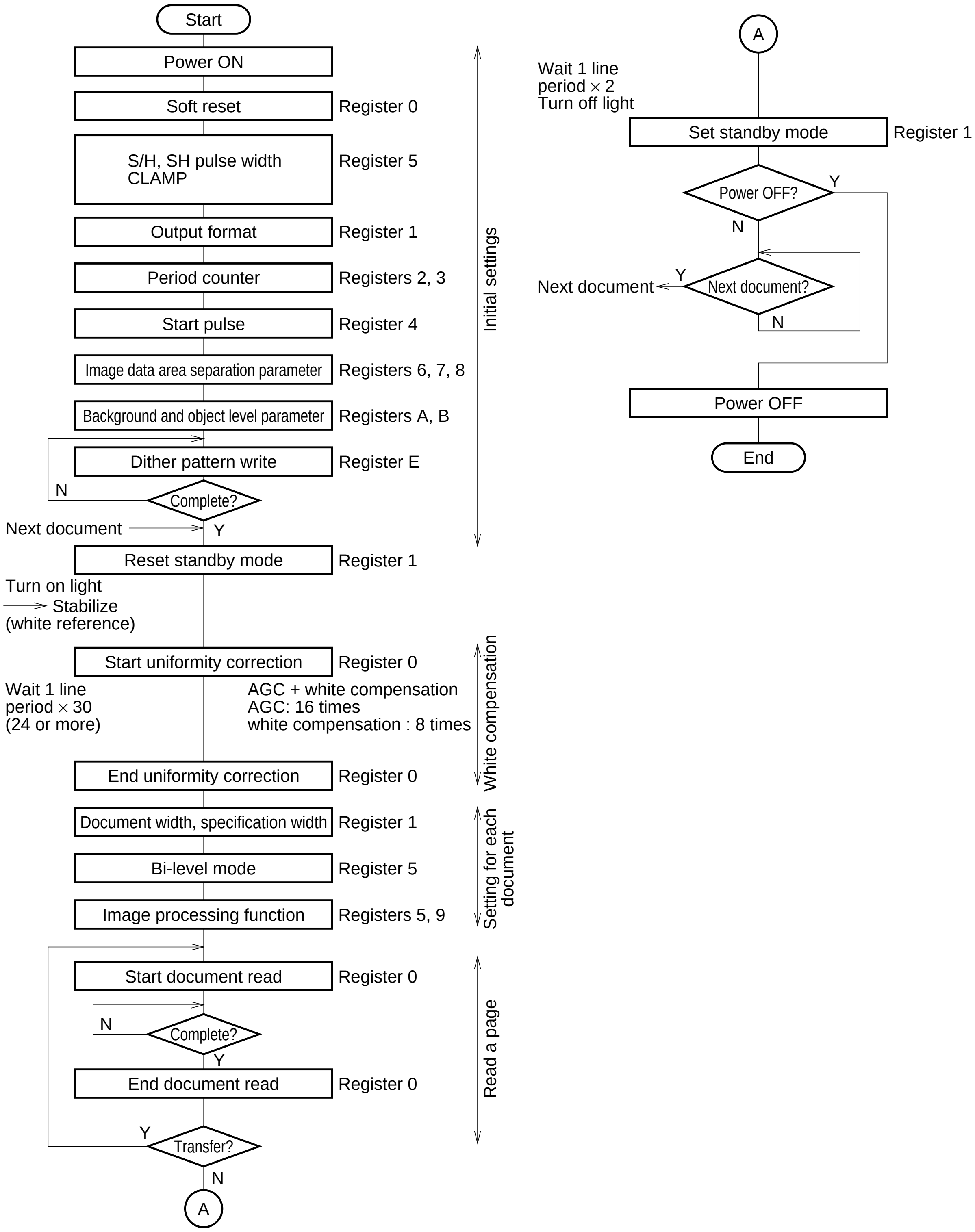
DMA Timing
Read timing (M66332 → System bus)



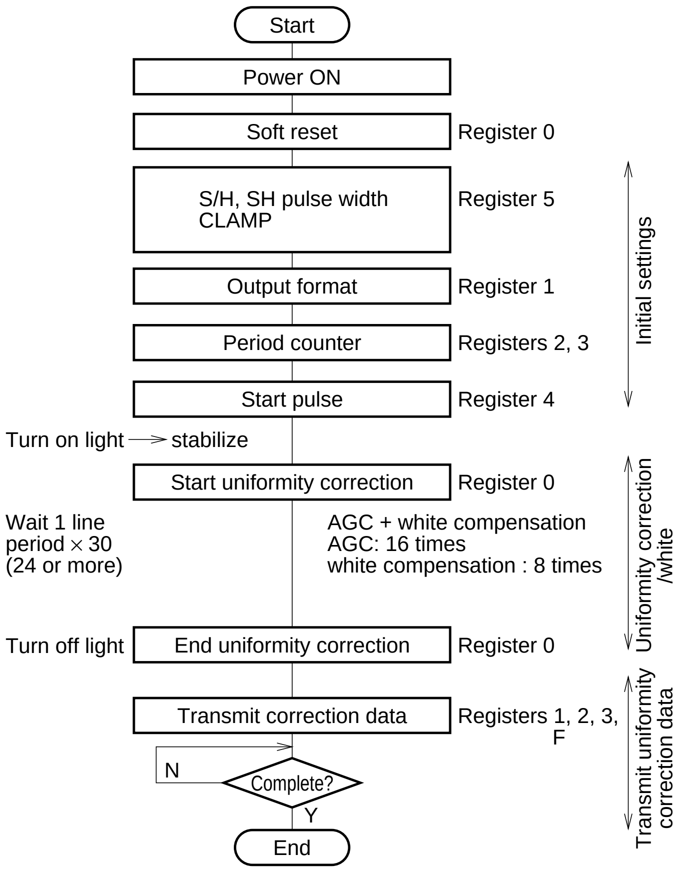
CODEC Interface



FLOWCHART
Read Operation (Sensor: CCD)



Uniformity correction data creation, transmission (sensor: CIS)



Read operation (sensor: CIS)