CMOS Area Image Sensor

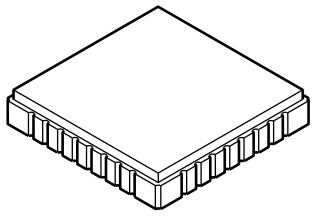
T C M 5 0 4 0 T

1/4-inch 330 k-Pixel CMOS Image Sensor
with Built-in ADC for VGA

The TCM5040T is a B/W CMOS image sensor with a built-in ADC for VGA. It outputs a signal for each pixel in sequence every 1/30 s. (This is known as progressive scanning.)

This element is equipped with 492 vertical and 660 horizontal signal pixels, and the image size conforms to the 1/4-inch optical format.

Use of the CMOS process enables low power-consumption using a single power supply voltage. The device is perfect for use as an image input device for machine vision, 2-D barcode use and surveillance camera.



WQFN32-C-S420-1.02

Weight: 0.54 g (typ.)

Features

- Optical size: 1/4-inch optical format
- Total number of pixels: 698 (H) × 502 (V)
- Number of signal pixels: 660 (H) × 492 (V)
- Pixel pitch: 5.4 μm (H) × 5.4 μm (V) (square pixel)
- Image size: 3.564 mm (H) × 2.657 mm (V)
- Package: 32-pin CLCC
- Color filter: N/A. Micro-lens is applicable
- Frame frequency: 30 Hz
- Power supply voltage: 2.8 V
- Additional functions: Variable speed electronic shutter (1/30 s~1/8000 s)
  Internal sync. mode (command setting)
  2H to 524H by 1H, 1 V to 16 V by 1H
  External sync. mode (ESR input)
  1H to 524H by 1H, 1 V to 16 V by 1H
  Gain control amplifier
  Internal feedback clamp circuit
  Built-in sync. signal generator

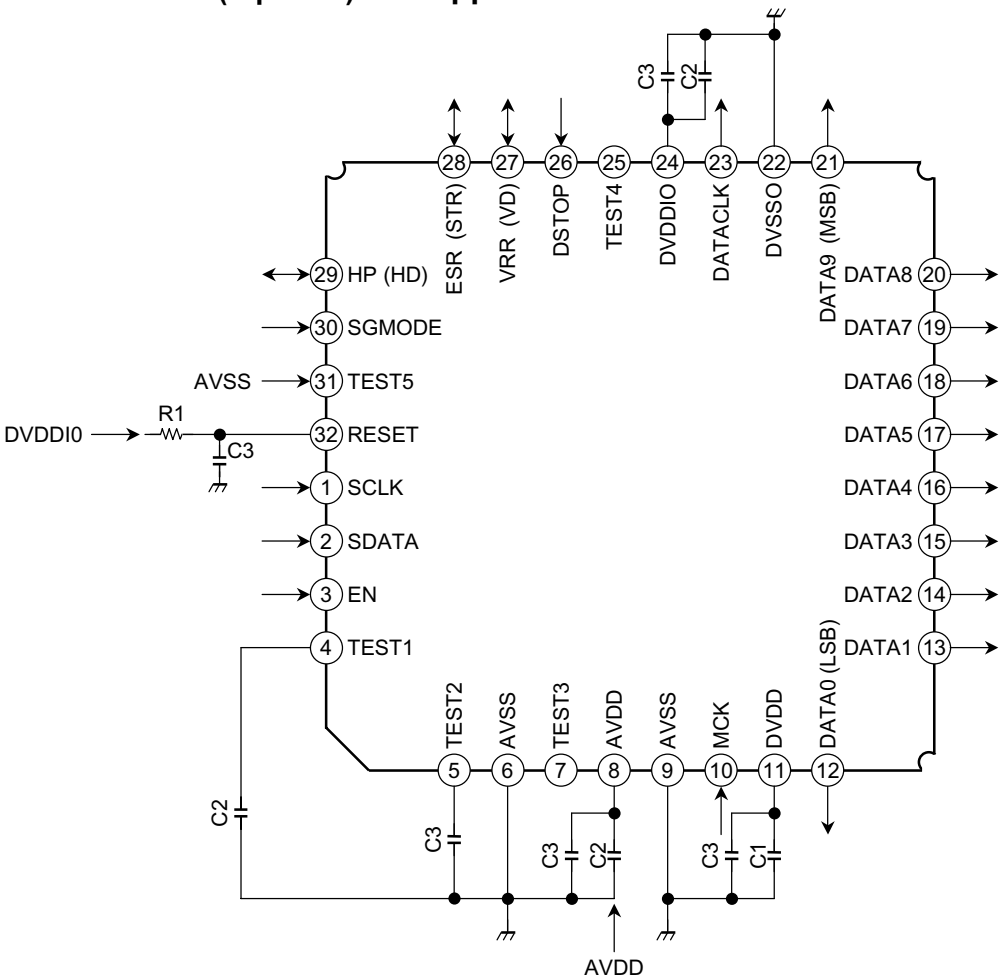
Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_{DVDDIO}	−0.5~4.4	V
	V_{AVDD}, V_{DVDD}	−0.5~3.7	
Input voltage	V_{IN}	−0.3~V_{DD} + 0.3	V
Storage temperature	T_{stg}	−30~85	°C

Recommended Operating Conditions

Characteristics	Symbol	Min	Typ.	Max	Unit
Power supply voltage	V_{AVDD}	2.6	2.8	3.0	V
	V_{DVDD}	2.6	2.8	3.0	
	V_{DVDDIO}	2.3	2.8	3.6	
Input voltage	V_{IN}	0~V_{DVDDIO}			V
Operating temperature	T_{opr}	−20~60			°C

Pin Connection (top view) and Application Circuit



C1: 4.7 μF (aluminum electrolytic capacitor or tantalum capacitor)
C2: 2.2 μF
C3: 0.1 μF
R1: 100 kΩ~1 MΩ

Recommended output impedance of DVDD supply circuit: less than 0.5 Ω at 10 kHz

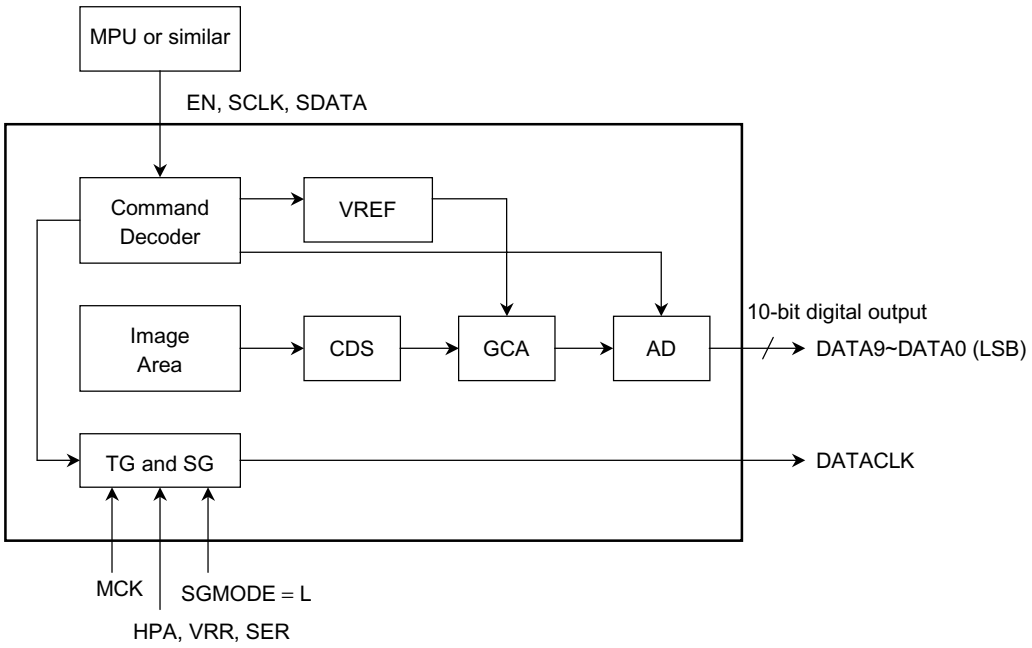
Block Diagram

The SGMODE pin can be used to select either internal or external synchronization.

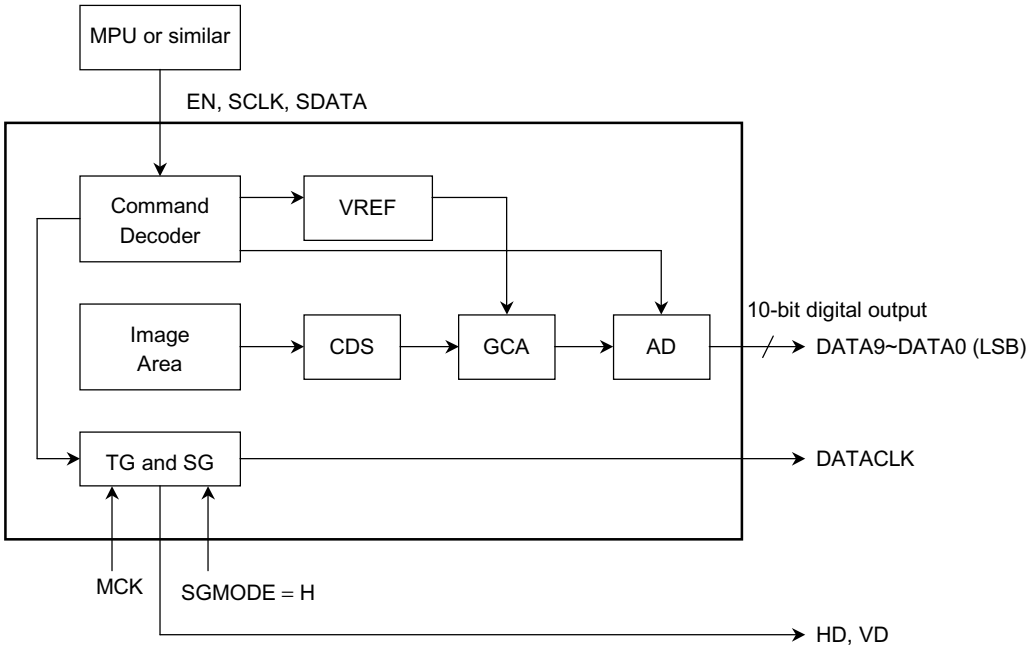
The SGMODE pin is pulled down. When the SGMODE pin is open, External Synchronization Mode is selected. When the SGMODE pin is High, Internal Synchronization Mode is selected.

In External Synchronization Mode, the HPA and VDD sync. signals and the electronic shutter signal are input from an external source. In Internal Synchronization Mode, HD and VD sync. signals are output and the value of the electronic shutter signal must be set using a command.

(i) External Synchronization Mode



(ii) Internal Synchronization Mode



Pin Configuration

Pin No.	Symbol	I/O	Function
1	SCLK	I	Serial clock input for commands
2	SDATA	I	Serial data input for commands
3	EN	I	Data enable input for commands
4	TEST1	—	TEST terminal 3 Normally this pin is connected to AVSS (2.2 μF) via a bypass capacitor.
5	TEST2	—	TEST terminal 4 Normally this pin is connected to AVSS (0.1 μF) via a bypass capacitor.
6	AVSS	—	Analog VSS
7	TEST3	—	TEST terminal 5
8	AVDD	—	Analog power supply. V_{DD} = 2.8 V ± 0.2 V
9	DVSS	—	Digital VSS
10	MCK	I	Master clock input
11	DVDD	—	Digital power supply. 2.8 V ± 0.2 V
12	DATA0	I/O	AD output (LSB)
13	DATA1	I/O	AD output
14	DATA2	I/O	AD output
15	DATA3	I/O	AD output
16	DATA4	I/O	AD output
17	DATA5	I/O	AD output
18	DATA6	I/O	AD output
19	DATA7	I/O	AD output
20	DATA8	I/O	AD output
21	DATA9	I/O	AD output (MSB)
22	DVSSIO	—	Digital I/O VSS
23	DATACLK	O	Data clock output (half of master clock)
24	DVDDIO	—	Digital I/O power supply
25	TEST4	—	TEST terminal 1
26	DSTOP	I	Read stop control input H: Active L: Read stop
27	VRR (VD)	I/O	Vertical timing start pulse input/VD pulse output
28	ESR (STR)	I	Electrical shutter start pulse input/STR pulse output
29	HPA (HD)	I/O	Horizontal timing start pulse input/HD pulse output
30	SGMODE	I	Internal/External sync select pin Pulled low (0 V) L: HPA, VRR, ESR input H: HD, VD, STR output
31	TEST5	—	TEST terminal 2 Must be connected to GND
32	RESET	I	Parameter Mode reset input Pulled up L: Level H: Active reset

Optical Characteristics (Note 1)

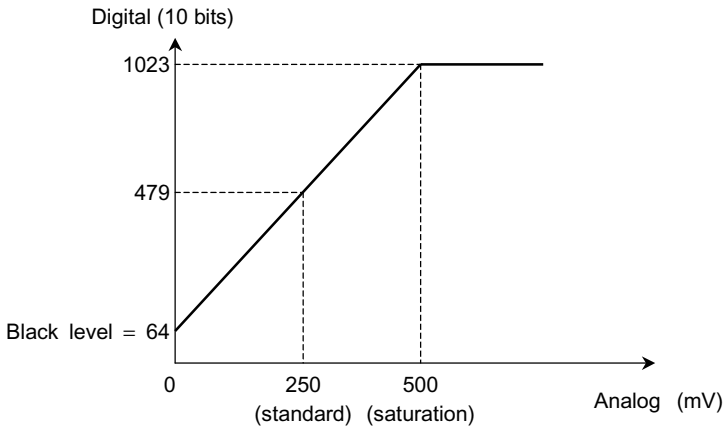
Characteristics	Symbol	Test Conditions	Min	Typ.	Max	Unit
Sensitivity	R	Standard conditions (Note 2)	250 (479 LSB)	300 (575 LSB)	—	mV
Saturation voltage	V_{SAT}	Saturation exposure Output	350 (671 LSB)	500 (959 LSB)	—	mV
Blooming margin	BLM	Light intensity is 500 times standard conditions (Note 3)	No blooming			—
S/N (dark)	S/N	Output	55	57	—	dB
Decay lag	LAG	Output = 20 mV	—	3 (5 LSB)	7 (13 LSB)	mV

Note 1: Amplifier gain setting: ×1 (0dB)
Actual digital output includes black level (64 LSB).

Note 2: Standard conditions for measuring sensitivity
- 100 nt
- Other conditions are based on Note 3.

Note 3: Standard conditions (TC = 60°C centigrade) as follows
- Light source: 3200 K, halogen light box
- Optical filter: IR cut filter (cut in half at 650 nm)
- Optical lense: Fujinon f = 25 mm, F number 2.8
- Standard signal level: Output = 250 mV
- Driving conditions: frame rate = 30 fps, electronic shutter OFF

The analog output level can be estimated as follows when a ×1 gain DA converter (500 mVpp) is used.



Optical lens performance influences sensor characteristics.

(1) F number: Less than F2.8 is recommended to maintain a high level of sensitivity and an acceptable S/N ratio.

(2) Exit pupil may influence shading level.

Electrical Characteristics

DC Characteristics (Ta = 25°C, V_{DD} = 2.8 V)

Characteristics	Symbol	Test Circuit	Test Condition		Min	Typ.	Max	Unit
High level input voltage	V_{IH}	—	(Note 4)		2	—	—	V
Low level input voltage	V_{IL}	—	(Note 4)		—	—	0.8	V
High level input current	I_{IH}	—	$V_{IN} = V_{DD}$	(Note 7)	150		250	μA
				(Note 4 except DSTOP)	−10		10	
Low level input current	I_{IL}	—	$V_{IN} = V_{SS}$	(Note 4 except SGMODE)	−10		10	μA
			$V_{IN} = V_{SS}$	(Note 6)	−220		−80	
High level output voltage	V_{OH}	—	$I_{OH} = -4$ mA	(Note 5)	V_{DD} −0.4	—	—	V
Low level output voltage	V_{OL}	—	$I_{OL} = 4$ mA	(Note 5)	—	—	0.4	V
Power supply current	I_{DD}	—	30fps		—	21	—	mA

Note 4: DSTOP, VRR, ESR, HPA, SGMODE, RESET, SCLK, SDATA, EN, MCK

Note 5: VD, STR, HD, DATACLK, DATA0~DATA9

Note 6: DSTOP

Note 7: SGMODE

AC Characteristics (Ta = 25°C, V_{DD} = 2.8 V)

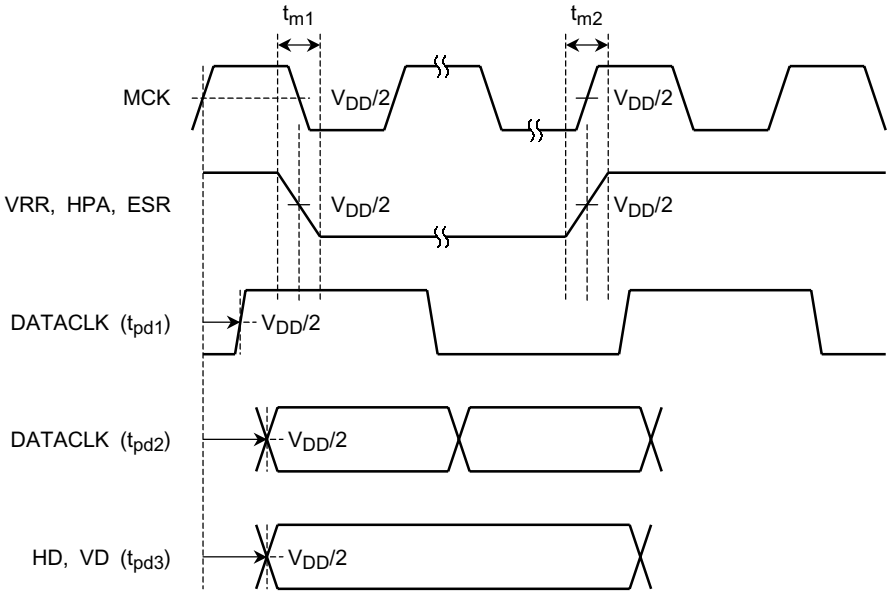
Characteristics	Symbol	Test Circuit	Test Condition	Min	Typ.	Max	Unit
Timing margin for input pulse	t_{m1}	—	Based on MCK (Note 8)	−10	—	10	ns
	t_{m2}	—		−1/4 SCLK	—	1/4 SCLK	
	t_{m3}	—		−1/4 SCLK	—	1/4 SCLK	
Output delay time	t_{pd1}	—	Based on MCK, C = 15 pF (Note 9)	—	—	20	ns
	t_{pd2}	—		—	—	30	
	t_{pd3}	—		—	12	30	
Command clock frequency	f_{sclk}	—	(Note 10)	—	—	6	MHz

Note 8: DSTOP, VRR, ESR, HPA,

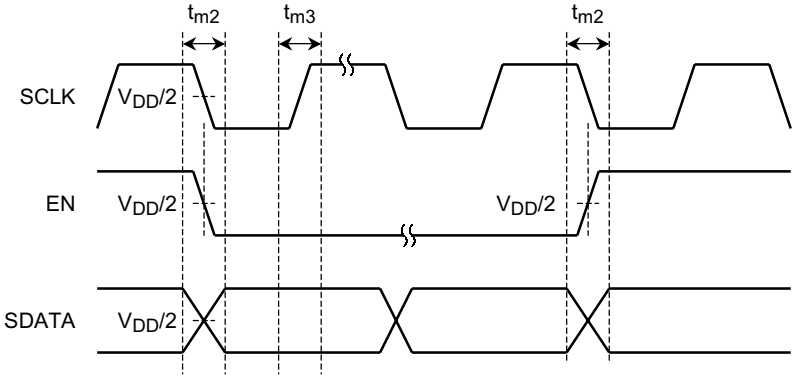
Note 9: DATACLK, DATA0~DATA9

Note 10: SCLK

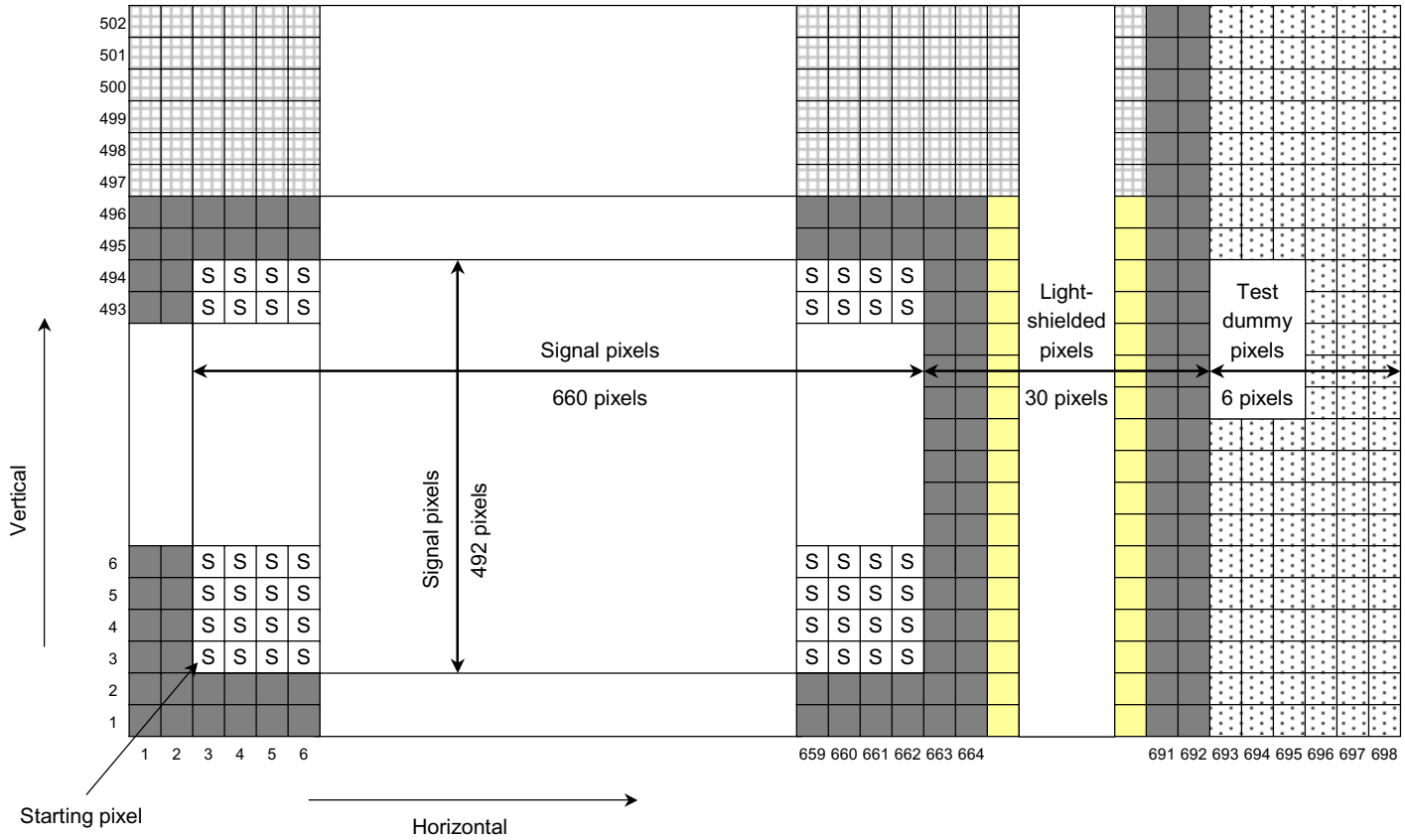
Inputs/Outputs Other than Commands



Command Inputs



Pixel Configuration



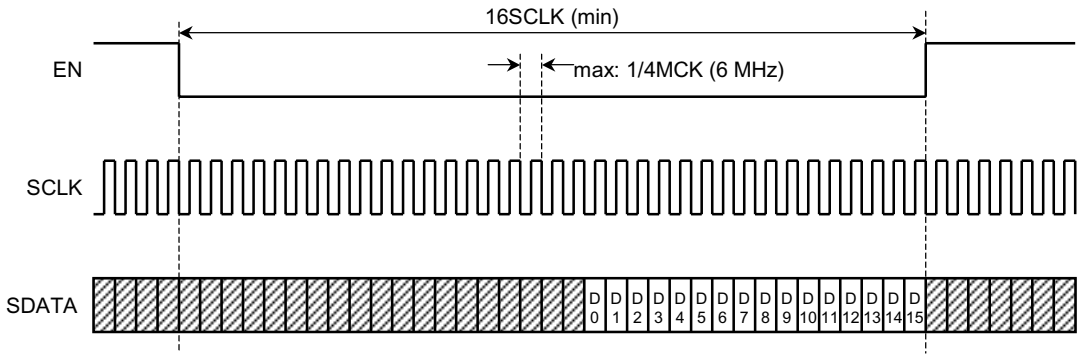
Definition of pixels S: Signal pixel

Light-shielded dummy pixels | Light-shielded pixels | Test dummy pixels | Dummy pixels

Light-shielded pixels are used as optical black reference.

Command Input

Timing Diagram



Settings

Item	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	Remarks
Gain	0	0	0	0	MSB			Data (10 bit)						LSB			
Electronic shutter speed	1	0	1	0	MSB			Data (10 bit)						LSB			2H to 16 V
Monitoring mode	1	1	1	1		*											0: 30fps (default) 1: 60fps
Feed back clamp	1	1	1	1				*									0: Auto (default) 1: Manual (OFF)

Examples of Gain Settings

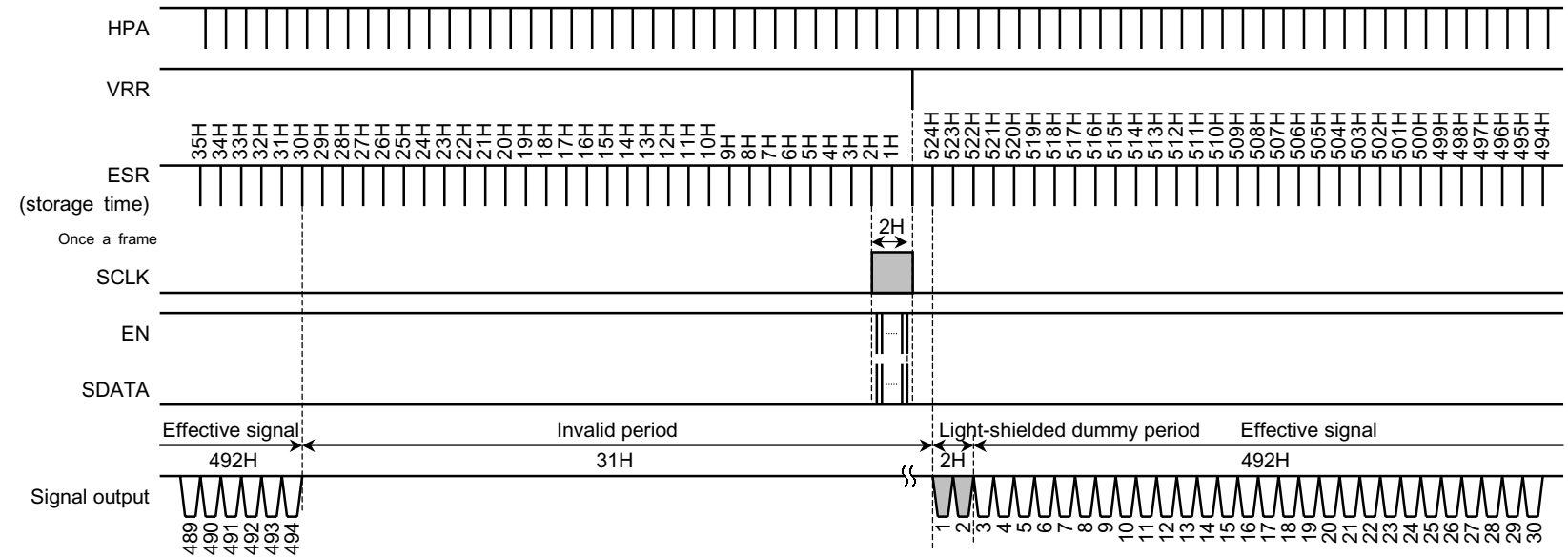
Gain Factor (dB)	Settings									
	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2
−2.4 (min)	1	1	1	1	1	1	1	1	1	1
0 (default)	1	1	0	0	0	0	0	0	0	0
3	1	0	0	0	1	0	0	0	0	0
6	0	1	1	0	0	0	0	0	0	1
9	0	1	0	0	0	1	0	0	0	0
12	0	0	1	1	0	0	0	0	0	1
18	0	0	0	1	1	0	0	0	0	1
20 (recommended max)	0	0	0	1	0	0	1	1	0	1

Examples of Electronic Shutter Speed Settings on Internal Sync. Mode

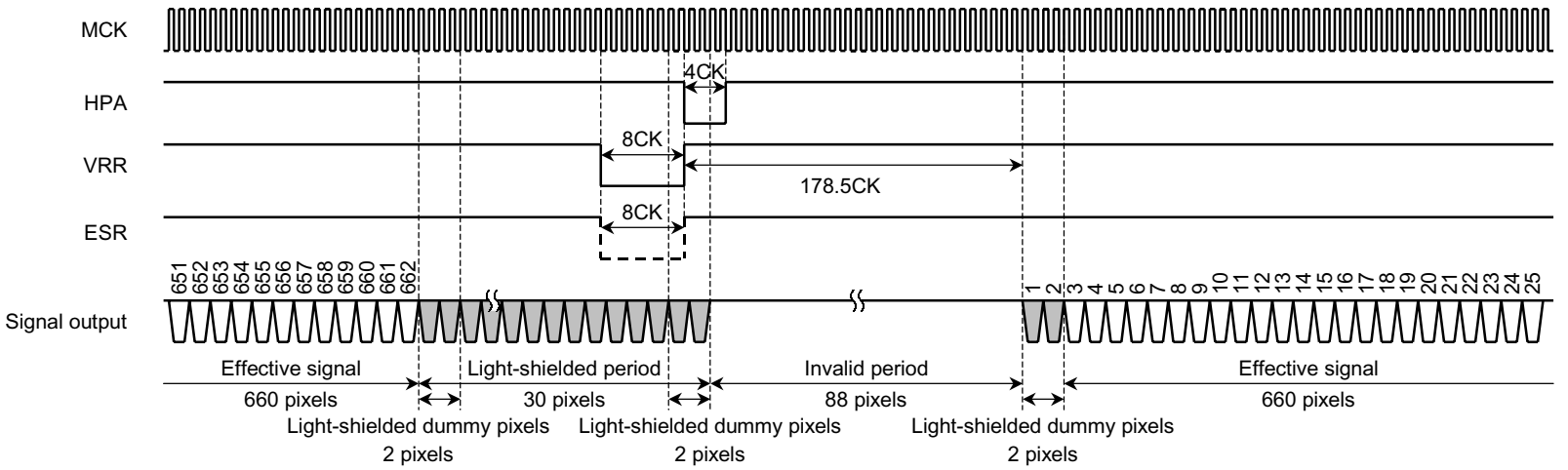
Electronic Shutter Speed (exposure time)	Settings									
	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2
OFF (525H)	0	0	0	0	0	0	0	0	0	0
2 (H)	0	0	0	0	0	0	0	0	0	1
3 (H)	0	0	0	0	0	0	0	0	1	0
׀	׀	׀	׀	׀	׀	׀	׀	׀	׀	׀
523 (H)	1	0	0	0	0	0	1	0	1	0
524 (H)	1	0	0	0	0	0	1	0	1	1

External Synchronization Mode (1 V = 525H)

Vertical period

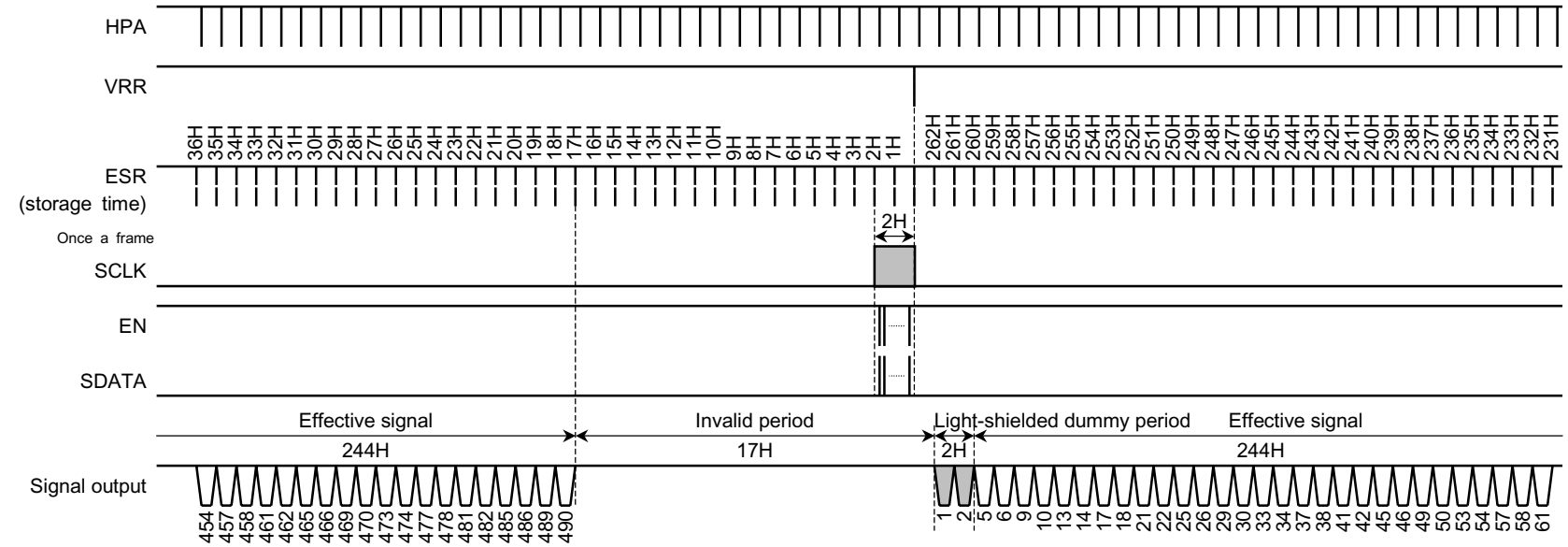


Horizontal period

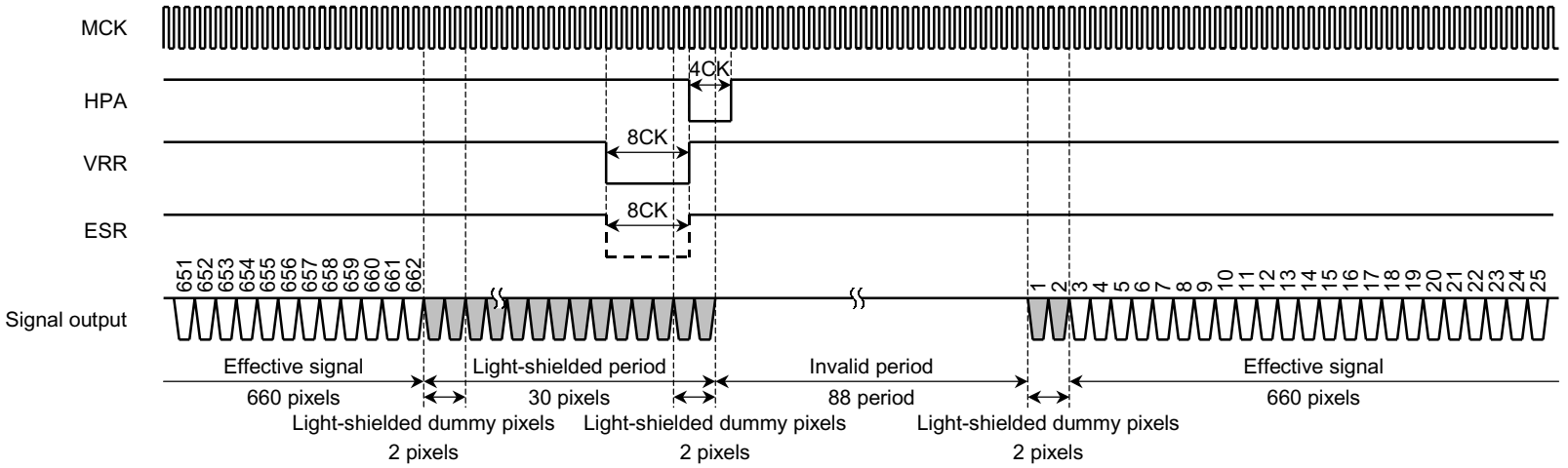


External Synchronization and Monitoring Mode (1 V = 263H)

Vertical period

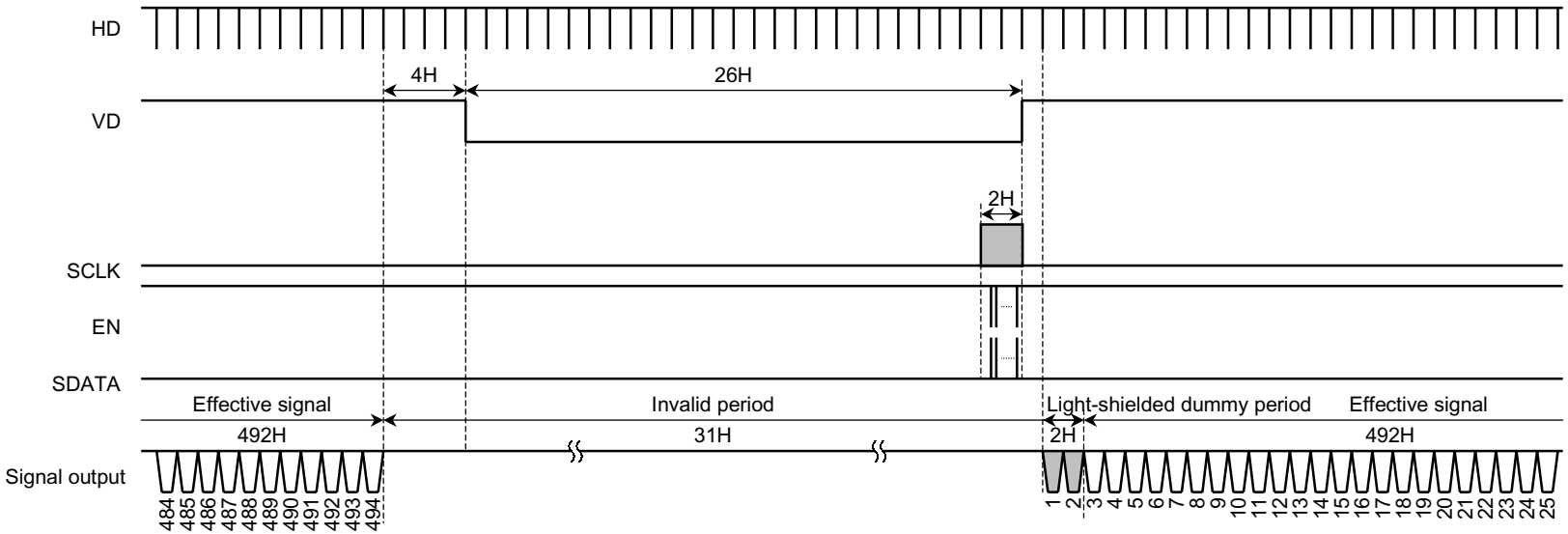


Horizontal period

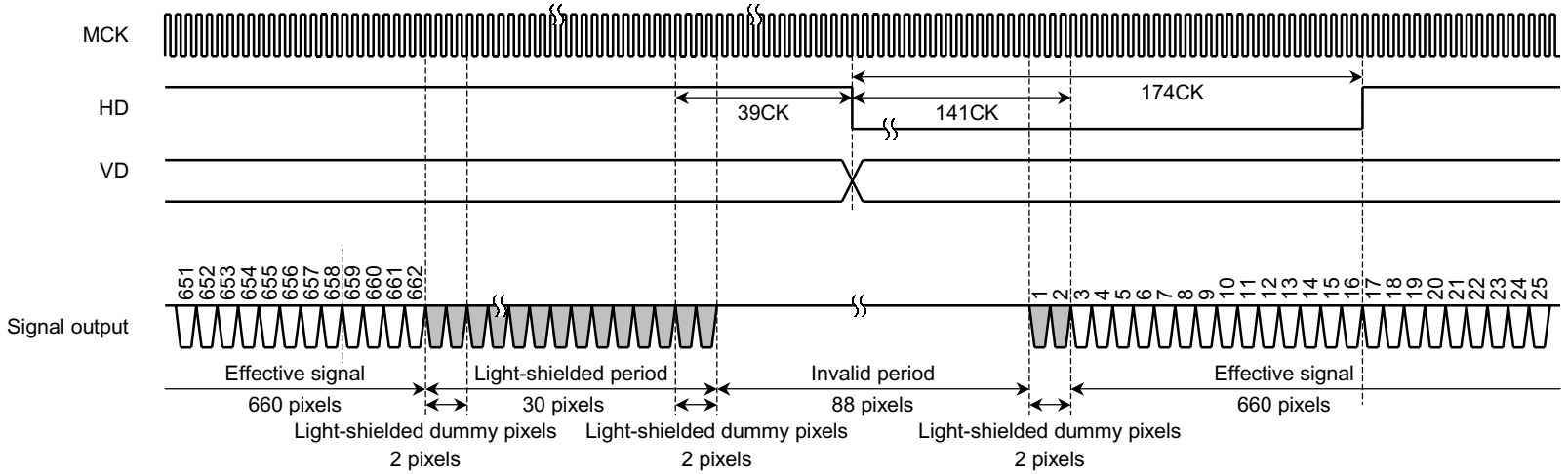


Internal Synchronization Mode (1 V = 525H)

Vertical period

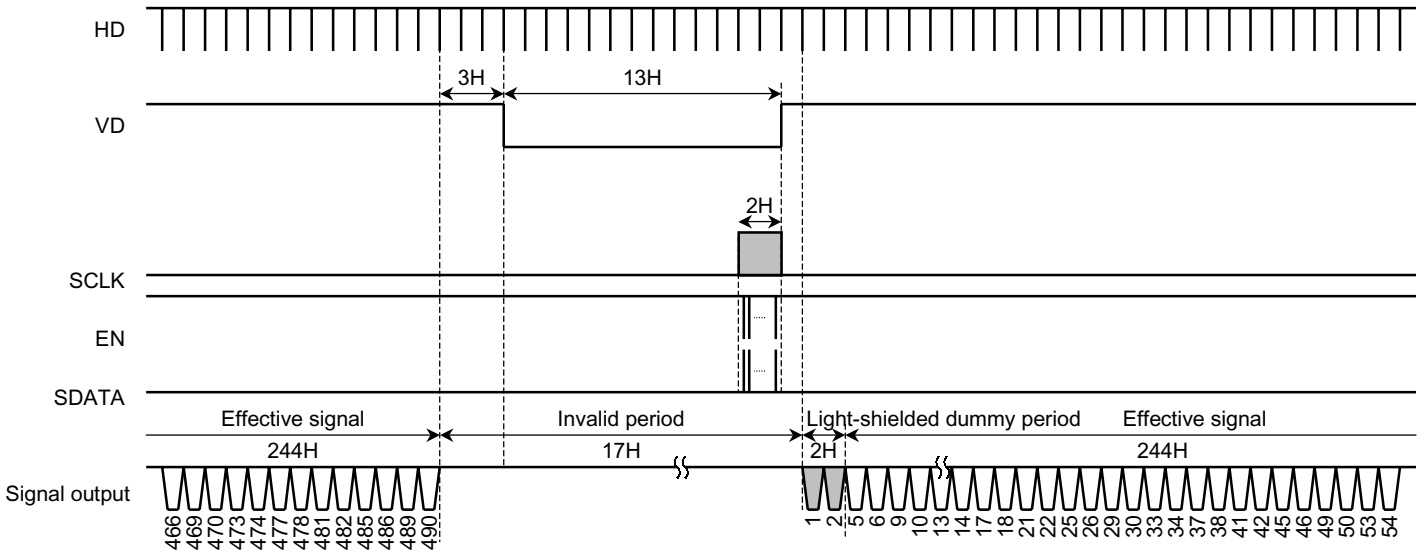


Horizontal period

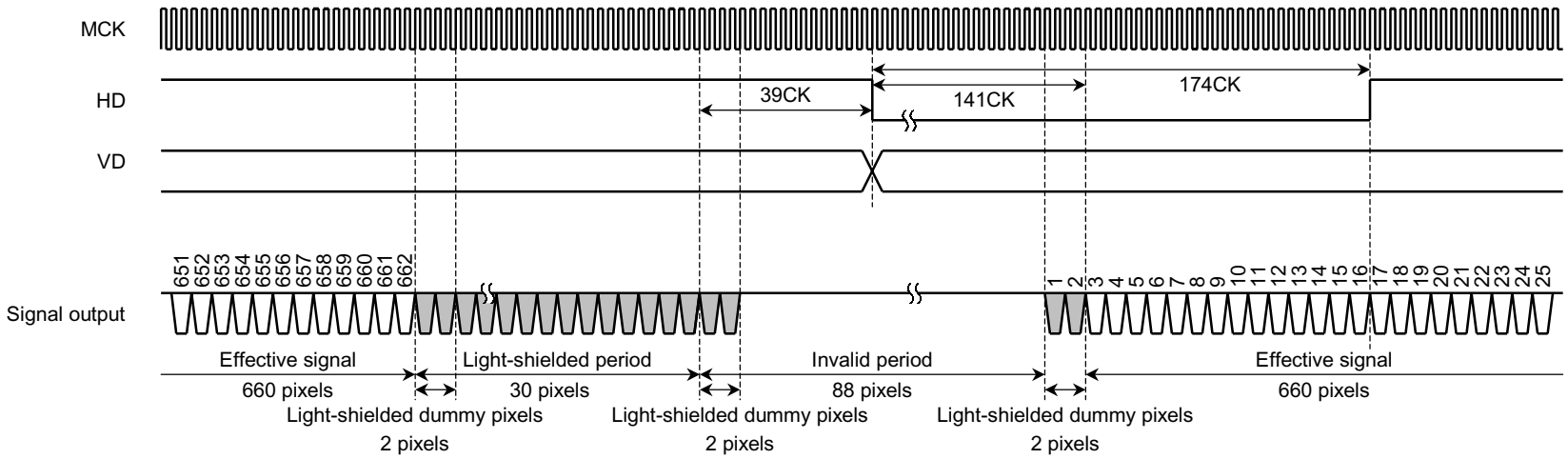


Internal Synchronization and Monitoring Mode (1 V = 263H)

Vertical period



Horizontal period



Long Storage Mode

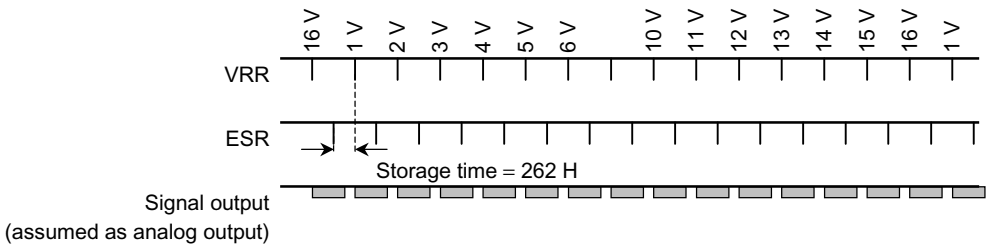
a) External synchronization mode
Intermittent of VRR pulse realize long storage mode.

b) Internal synchronization mode
Command setting can control long storage mode.

Storage Time	Settings									
	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2
2 V	1	1	0	0	0	0	0	0	0	1
3 V	1	1	0	0	0	0	0	0	1	0
~	~	~	~	~	~	~	~	~	~	~
15 V	1	1	0	0	0	0	1	1	1	0
16 V	1	1	0	0	0	0	1	1	1	1

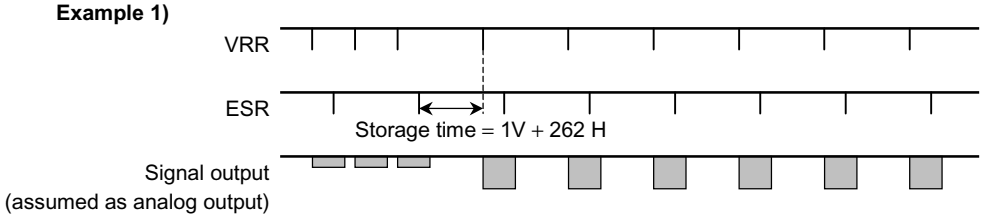
Timing Diagram

Normal mode

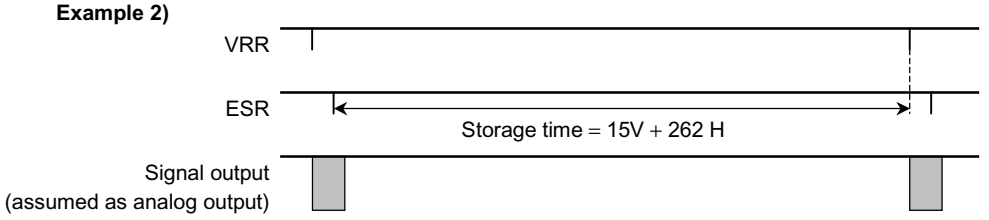


Long storage mode (1 V~16 V: by 1H)

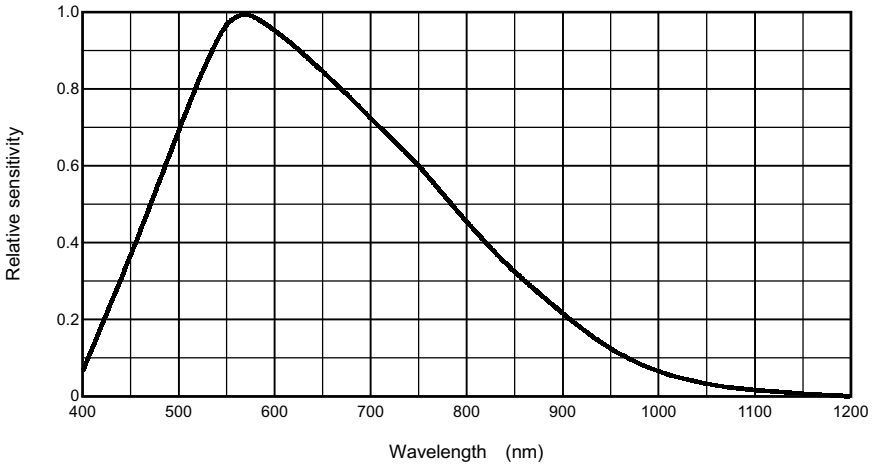
Example 1)



Example 2)

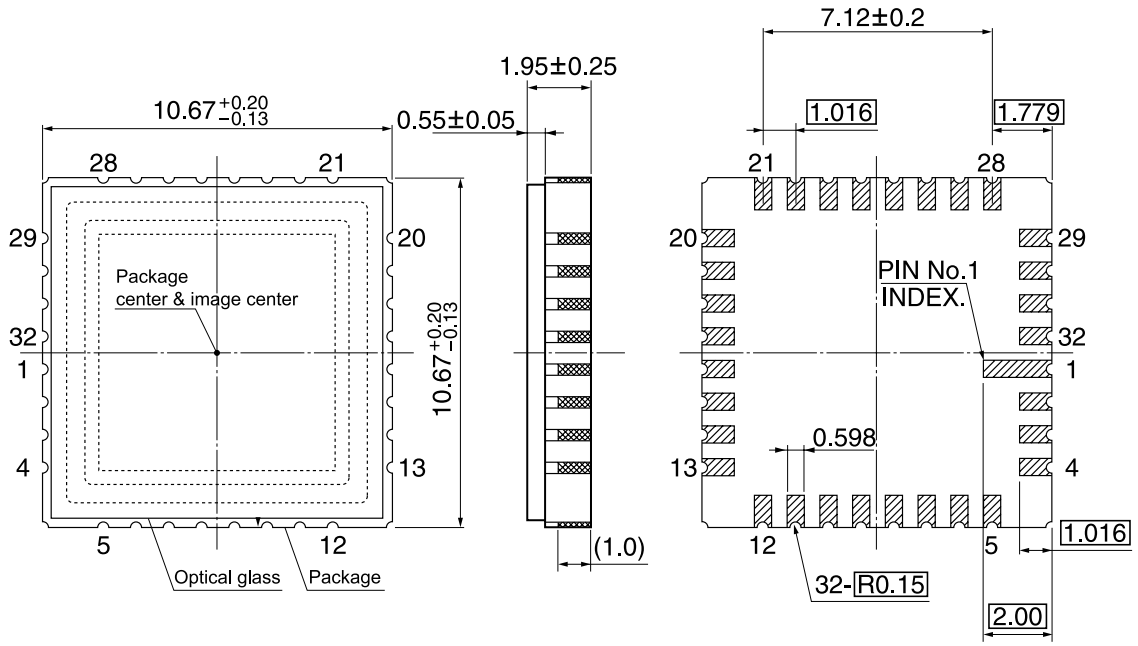


Spectral response



Package Dimensions

WQFN32-C-S420-1.02(B) Unit: mm



Note) ・Glass size: 10.10 ± 0.05 mm, t = 0.55 ± 0.05 mm
・Glass refractive index: n = 1.52 mm
・Sensor chip direction of rotation accuracy: θ = 1.0° (max)
・The distance from sensor photosensitive face to package rear face: 1.06 ± 0.08 mm
・Package center coincide with image center with torelance of ± 0.15 mm

Weight: 0.54 g (typ.)