

MN3611RE

Color CCD Linear Image Sensor
with 720 Pixels each for R, G, and B Colors

■ Overview

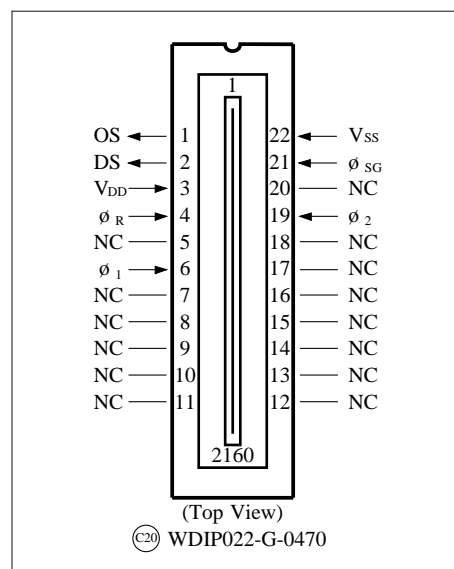
The MN3611RE is a high responsivity CCD color linear image sensor having low dark output floating photodiodes in the photodetector region, CCD analog shift registers for read out, and 720 pixels each for the primary colors R, G, and B.

It can read a B6 size color document with a high quality and a resolution of 170dpi.

■ Features

- 2160 (720 × R.G.B) floating photodiodes and an n-channel buried type CCD shift registers are built in a single chip.
- It is possible to read a B6 size color document with a high quality and a resolution of 170dpi.
- RGB primary colors type on chip color filters are used for color separation.
- Very high responsivity is obtained because voltage amplifier circuits are built in the chip.
- Use of photodiodes with a new structure has made the dark output voltage very low.
- Large signal output of typically 2V at saturation can be obtained.

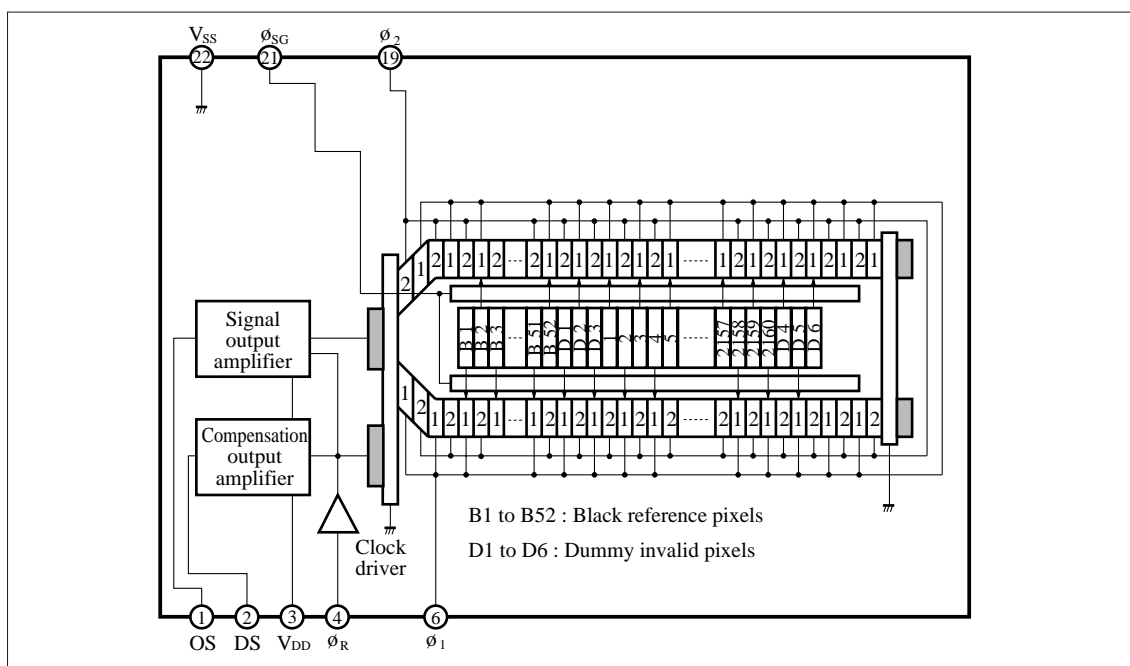
■ Pin Assignments



■ Application

- Reading out color images in a color scanner.

■ Block Diagram



■ Absolute Maximum Ratings (Ta=25°C, Vss=0V)

Parameter	Symbol	Rating	Unit
Power supply voltage	V _{DD}	− 0.3 to +15	V
Input voltage	V _I	− 0.3 to +15	V
Output voltage	V _O	− 0.3 to +15	V
Operating temperature range	T _{opr}	−25 to + 60	°C
Storage temperature range	T _{stg}	−40 to +100	°C

■ Operating Conditions

• Voltage conditions (Ta=−25 to +60°C, Vss=0V)

Parameter	Symbol	Condition	min	typ	max	Unit
Power supply voltage	V _{DD}		11.4	12.0	13.0	V
CCD shift register clock High level	V _{øH}		4.5	5.0	5.5	V
CCD shift register clock Low level	V _{øL}		0	0.2	0.5	V
Shift gate clock High level	V _{SH}		4.5	5.0	5.5	V
Shift gate clock Low level	V _{SL}		0	0.2	0.5	V
Reset gate clock High level	V _{RH}		4.5	5.0	5.5	V
Reset gate clock Low level	V _{RL}		0	0.2	0.5	V

• Timing conditions (Ta=−25 to +60°C)

Parameter	Symbol	Condition	min	typ	max	Unit
Shift register clock frequency	f _C	See drive timing diagram. f _C =1/2T	—	0.5	1.0	MHz
Reset clock frequency (=data rate)	f _R	See drive timing diagram. f _R =1/T	—	1.0	2.0	MHz
Shift register clock rise time	t _{Cr}	See input/output timing diagram.	0	60	100	ns
Shift regisster clock fall time	t _{Cf}	See drive timing diagram.	0	60	100	ns
Shift clock (ø _{SG}) rise time	t _{Sr}	See input/output timing diagram. See drive timing diagram.	0	50	100	ns
Shift clock (ø _{SG}) fall time	t _{Sf}		0	50	100	ns
Shift clock set up time	t _{Ss}		0	100	—	ns
Shift clock pulse width	t _{Sw}		200	1000	—	ns
Shift clock hold time	t _{Sh}		0	100	—	ns
Reset clock rise time	t _{Rr}	See input/output timing diagram. See drive timing diagram.	0	15	30	ns
Reset clock fall time	t _{Rf}		0	15	30	ns
Reset clock pulse width	t _{Rw}		60	250	—	ns
Reset clock hold time	t _{Rh}		100	125	—	ns

■ Electrical Characteristics

• Clock input capacitance (Ta=−25 to +60°C)

Parameter	Symbol	Condition	min	typ	max	Unit
Shift register clock input capacitance	C _{ø1} , C _{ø2}	f _{reg} = 1MHz	—	350	400	pF
Reset clock input capacitance	C _{øR}	f _{reg} = 1MHz	—	15	30	pF
Shift clock input capacitance	C _{øSG}	f _{reg} = 1MHz	—	130	200	pF

• DC characteristics

Parameter	Symbol	Condition	min	typ	max	Unit
Power supply current	I _{DD}	V _{DD} = +12V	—	8	15	mA

AC characteristics

Parameter	Symbol	Condition	min	typ	max	Unit
Signal output delay time	tos		—	100	—	ns

Optical Characteristics

<Inspection conditions>

- Ta=25°C, VDD=12V, VGH=VSH=VRH=5V (pulse), fC=0.5MHz, fR=1MHz, Tint (accumulation time)=10ms
- Light source: Daylight type fluorescent lamp with IR/UV cutting filter
- Optical system: A slit with an aperture dimensions of 20mm×20mm is used at a distance of 200mm from the sensor (equivalent to F=10).
- Load resistance = 100k Ohms
- These specifications apply to the 2160 valid pixels excluding the dummy pixels D1 to D6.

Parameter	Symbol	Condition	min	typ	max	Unit
Responsivity	red	RR	4.5	7.2	9.9	V/lx·s
	green	RG	10.0	13.5	17.0	
	blue	RB	6.5	9.6	12.7	
Photo response non-uniformity	PRNU	Note 1	—	—	15	%
Odd/even bit non-uniformity	O/E	Note 2	—	—	3	%
Saturation output voltage	VSAT	Note 3	1.5	2.0	—	V
Saturation exposure	SE	Note 3		0.13	—	lx·s
Dark signal output voltage	VDRK	Note 4	—	0.8	2.0	mV
Dark signal output non-uniformity	DSNU	Note 4	—	0.2	3.0	mV
Shift register total transfer efficiency	STTE		92	99	—	%
Output impedance	Zo		—	—	1	kΩ
Dynamic range	DR	Note 5	—	2,500	—	
Signal output pin DC level	VOS	Note 5	3.5	4.5	6.0	V
Compensation output pin DC level	VDS	Note 6	3.5	4.5	6.0	V
Signal and compensation output pin DC level difference	VOS – VDS	Note 6	—	50	100	mV

Note 1) The photo response non-uniformity (PRNU) for each color is defined by the following equation, where Xave is the average output voltage of the 720 valid pixels and Δx is the absolute value of the difference between Xave and the voltage of the maximum (or minimum) output pixel, when the surface of the photo-sites is illuminated with light having a uniform distribution over the entire surface.

$$PRNU = \frac{\Delta x}{X_{ave}} \times 100 (\%)$$

The incident light intensity shall be 50% of the standard saturation light intensity.

Note 2) The odd/even bit non-uniformity (O/E) for each color is defined by the following equation, where Xave is the average output voltage of the 720 valid pixels for each color and Xn is the output voltage of the 'n'th pixel for each color, when the surface of the photo-sites is illuminated with light having a uniform distribution over the entire surface.

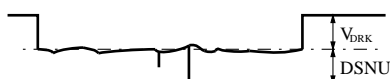
$$O/E = \frac{\sum_{n=1}^{719} |X_n - X_{n+1}|}{719 \times X_{ave}} \times 100 (\%)$$

The incident light intensity shall be 50% of the standard saturation light intensity.

Note 3) The Saturation output voltage (VSAT) is defined as the output voltage at the point when the linearity of the photoelectric characteristics cannot be maintained as the incident light intensity is increased. [The light intensity of exposure at this point is called the saturation exposure (SE).]

Note 4) The dark signal output voltage (VDRK) is defined as the average output voltage of the 2160 pixels in the dark condition at Ta=25°C and Tint=10ms. Normally, the dark output voltage doubles for every 8 to 10°C rise in Ta, and is proportional to Tint.

The dark signal output non-uniformity (DSNU) is defined as the difference between the maximum output voltage among all the valid pixels and VDRK in the dark condition at Ta=25°C and Tint=10ms.



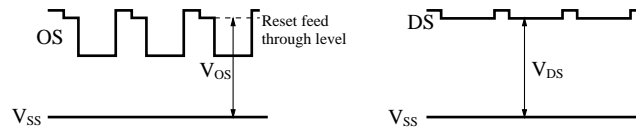
■ Optical Characteristics (continued)

Note 5) The dynamic range (DR) is defined by the following equation.

$$DR = \frac{V_{SAT}}{V_{DRK}}$$

Since the dark signal voltage is proportional to the accumulation time, the dynamic range becomes wider when the accumulation time is shorter.

Note 6) The signal output pin DC level (V_{OS}) and the compensation output pin DC level (V_{DS}) are the voltage values shown in the following figure.



■ Pin Descriptions

Pin No.	Symbol	Pin name	Condition
1	OS	Signal output	
2	DS	Compensation output	
3	V_{DD}	Power supply	
4	ϕ_R	Reset clock	
5	NC	Non connection	
6	ϕ_1	CCD Shift clock gate	
7	NC	Non connection	
8	NC	Non connection	
9	NC	Non connection	
10	NC	Non connection	
11	NC	Non connection	
12	NC	Non connection	
13	NC	Non connection	
14	NC	Non connection	
15	NC	Non connection	
16	NC	Non connection	
17	NC	Non connection	
18	NC	Non connection	
19	ϕ_2	CCD Shift clock gate	
20	NC	Non connection	
21	ϕ_{SG}	Shift clock gate	
22	V_{SS}	Ground	

Note) Connect all NC pins externally to V_{SS} .

■ Construction of the Image Sensor

The MN3611RE can be made up of the three sections of—a) photo detector region, b) CCD transfer region (shift register), and c) output region.

a) Photo detector region

- The photoelectric conversion device consists of an $11\mu\text{m}$ floating photodiode and a $3\mu\text{m}$ channel stopper for each pixel, and 2160 of these devices are linearly arranged side by side at a pitch of $14\mu\text{m}$.
- The photo detector's windows are $14\mu\text{m} \times 14\mu\text{m}$ squares and light incident on areas other than these windows is optically shut out.
- The photo detector is provided with 52 optically shielded pixels (black dummy pixels) which serve as the black reference.

b) CCD Transfer region (shift register)

- The light output that has been photoelectrically converted is

transferred to the CCD transfer for each odd and even pixel at the timing of the shift clock (ϕ_{SG}). The optical signal electric charge transferred to this analog shift register is successively transferred out and guided to the output region.

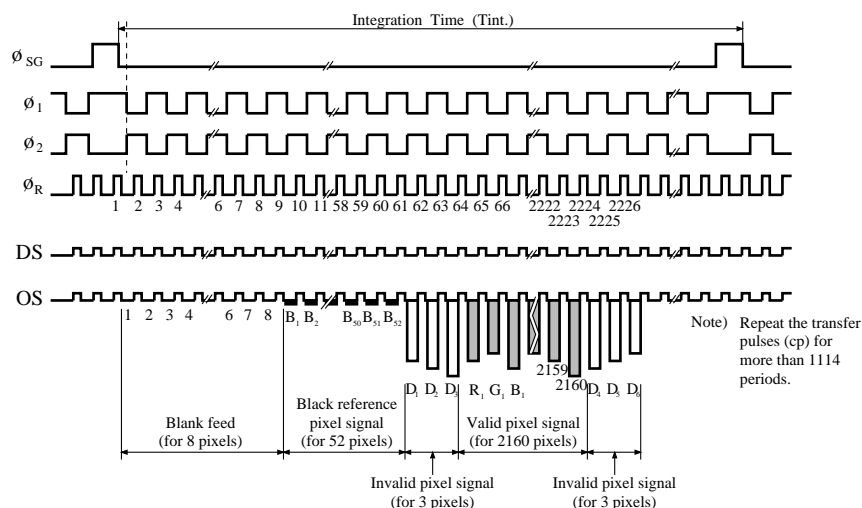
- A buried type CCD that can be driven by a two phase clock (ϕ_1, ϕ_2) is used for the analog shift register.

c) Output region

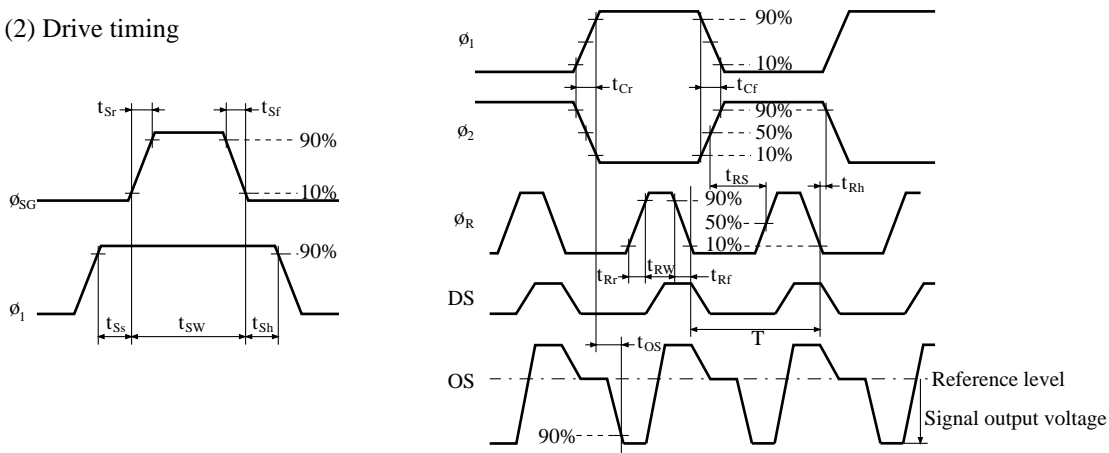
- The signal charge that is transferred to the output region is sent to the detector where impedance transformation is done using two source follower stages.
- The DC level component and the clock noise component not containing optical signals are output from the DS pin.
- By carrying out differential amplification of the two outputs OS and DS externally, it is possible to obtain an output signal with a high S/N ratio by reducing the clock noise, etc.

■ Timing Diagram

(1) I/O timing



(2) Drive timing



■ Graphs and Characteristics

Spectral Response Characteristics

