K46-B60085
11/01

# DRIVER/AMPLIFIER CIRCUIT
# For CMOS Linear Image Sensors

# C10808 Series

## INSTRUCTION MANUAL

HAMAMATSU

**HAMAMATSU PHOTONICS K. K.**

**Solid State Division**

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# 1. Overview

The C10808 series is a driver/amplifier circuit specifically designed for the Hamamatsu S10111 to S10114 series current-output type CMOS linear image sensors.
The C10808 series driver/amplifier circuit supplies various timing signals necessary for image sensor operation and also processes analog video signals from an image sensor with low noise.
A linear image sensor can be mounted directly on the C10808 series driver/amplifier circuit board.
All that is needed to operate the C10808 series driver/amplifier circuit are two external control signals (MStart, MCLK) and a power supply (±15 V).

The table below shows the C10808 series driver/amplifier circuits and related products (pulse generator and cable).

| Product Name | Type No. | Features |
|---|---|---|
| Driver/amplifier Circuit | C10808 | High-speed readout<br>Excellent output linearity<br>Boxcar output waveform |
| | C10808-01 | Low noise<br>Excellent output linearity<br>Boxcar output waveform |
| Pulse Generator | C8225-01 | Integration time: 1 μs to 50 s<br>CLK frequency: 32 MHz to 62.5 kHz |
| Cable | A8226 | With BNC (male) connector<br>Cable length: 1 m |

# 2. Configuration

The C10808 driver/amplifier circuit basically consists of the following three sections.
1) Video signal processor
2) Timing signal generator
3) Voltage regulator

Figure 1 shows the block diagram of the C10808 driver/amplifier circuit.

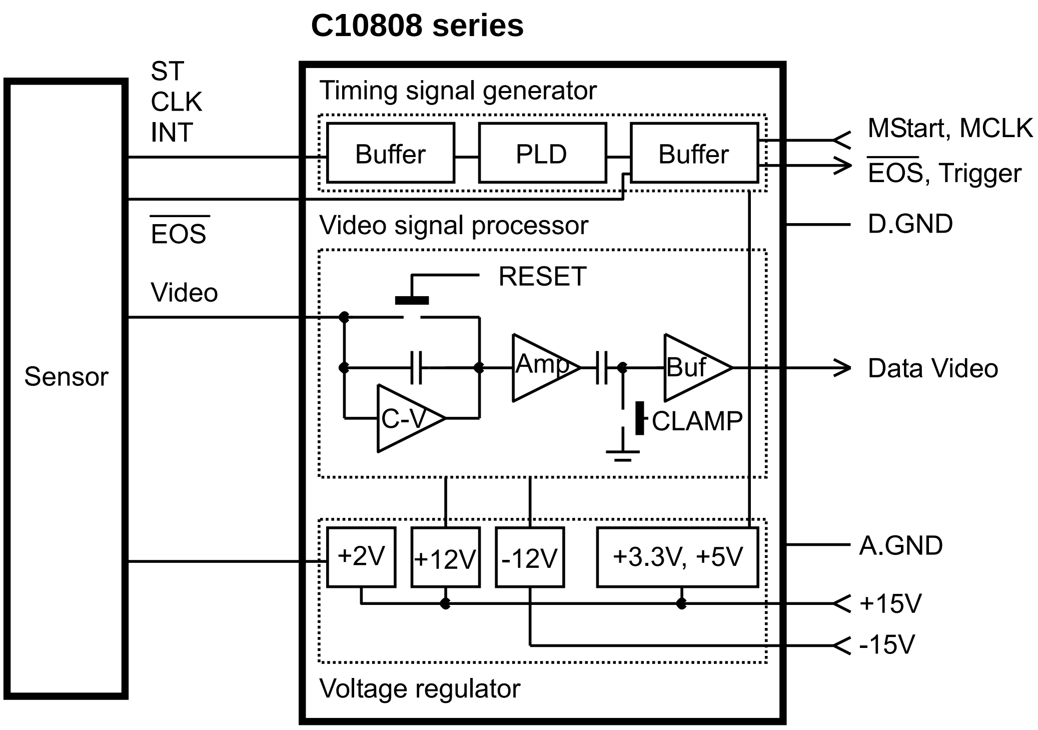



Figure 1: Block Diagram

## 1) Video signal processor

The video signal processor is comprised of 3 stages of amplifiers and processes analog signals from an image sensor with low noise.
The first stage is a charge storage amplifier that converts the signal charge accumulated in the image sensor into voltage signals by transferring the signal charge to the capacitor. The second stage is an amplifier with a gain of 2. The last stage is a buffer amplifier connected with a clamp circuit that keeps the signal at the ground potential. The output signal is extracted from this buffer amplifier with a gain of 2 as "Data Video".

***NOTE: The output impedance is not matched with a 50 or 75 ohm load.***

### 2) Timing signal generator

The timing signal generator is made up of buffers and a PLD (programmable logic device) to produce various timing signals for image sensor operation. It also supplies a trigger signal (Trigger) for external A/D conversion. These signals are synchronized with an external master clock pulse signal (MCLK) and initialized by a start pulse signal (MStart).

### 3) Voltage regulator

This regulator generates a voltage (+2 V) required for the image sensor and supply voltages for the digital circuit (+3.3 V, +5 V) and analog circuit (±12 V). Each voltage comes from this low noise regulator designed for high accuracy and high stability.

# 3. Setup

## [Standard operation (not using the integration time change function)]

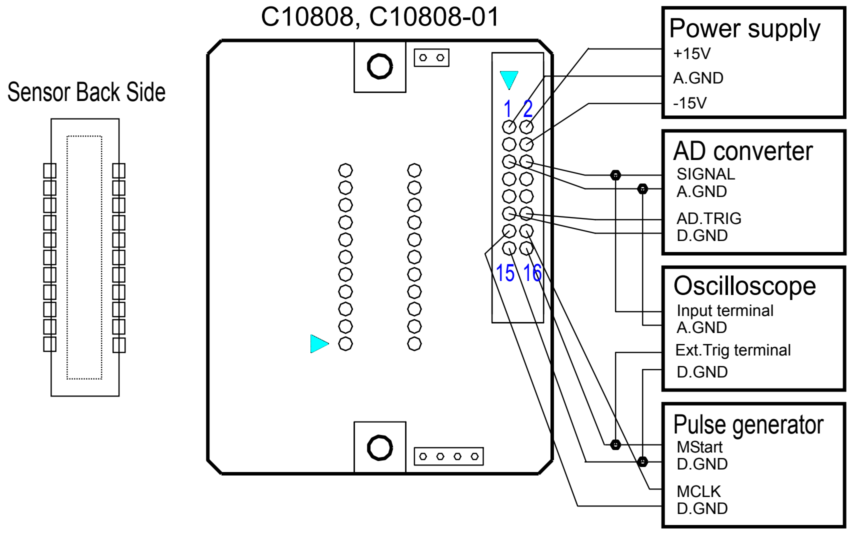



Figure 2: Wiring and Setup Diagram

Make necessary wiring and setups while referring to Figure 2.

***CAUTION: Use a coaxial cable (length: approximately 1 meter max.) for signal output and a shield cable for power supply.***

### 1) Installing the linear image sensor

Insert the linear image sensor pins into the socket on the driver/amplifier circuit board, while making sure that the pin orientation is correct. At this point, the linear image sensor should be installed on the reverse side of the component-mounted surface. Install the image sensor according to the mark printed on the component side.

**[Printed Side]** **[Image Sensor]**

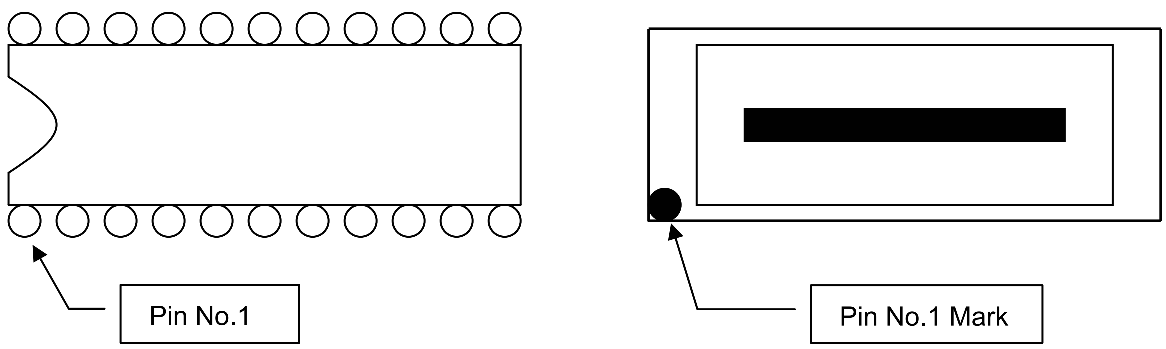



Figure 3: Installing the image sensor

## 2) Connecting the power supplies

Connect the power supply to the ±15 V terminals on this driver/amplifier circuit board. The digital ground and analog ground are connected to the optimum points in the internal circuit, so separate them from each other as much as possible when connecting the external wiring. As the power supply, use a highly stable series regulator with the lowest possible noise and ripple. Also use a thick, short cable for a low impedance power supply line.

***NOTE: When installing this driver/amplifier circuit into equipment, connect the ground line while taking into account the electrical potential of other connected devices.***

***NOTE: At our factory, this driver/amplifier circuit is tested by using a series regulator with noise/ripple within ±5 mVp-p. Avoid using a switching power supply since it may generate noise in the signal.***

***NOTE: Using a high-impedance cable may cause a voltage drop in the cable, causing the driver/amplifier circuit to malfunction.***

## 3) Connecting the pulse generator

Connect a pulse generator that produces a start pulse signal (MStart) and a clock pulse signal (MCLK). (For pulse generator electrical specifications, see section 5, “Specifications”.)
Hamamatsu also provides the C8225-01 pulse generator specially designed for this driver/amplifier circuit.

## 4) Connecting the oscilloscope

Connect the “Data Video” terminal of this amplifier/driver circuit to the input terminal of the oscilloscope. Input the start pulse signal from the pulse generator to the Ext. Trig. terminal of the oscilloscope to synchronize with the video signal. When making the video signal connection, be sure to use a shielded cable to prevent adverse effects from external noise. The shielded cable should be kept as short as possible with the lowest possible impedance.

***NOTE: An oscilloscope must be connected in order to check whether the image sensor and driver/amplifier are operating normally.***

## 5) Connecting the AD converter (option)

When connecting this amplifier/driver circuit to the AD converter, use the “Data Video” and “Trigger” signals, (For electrical specifications, see section 5, “Specifications”.)

***NOTE: Before connecting the AD converter, check the specifications carefully.***

# 4. Operating Procedure

## 4-1 Standard operation (not using the CMOS linear image sensor's integration time change function)

The INT signal for each pixel is output from the timing generator in the circuit.

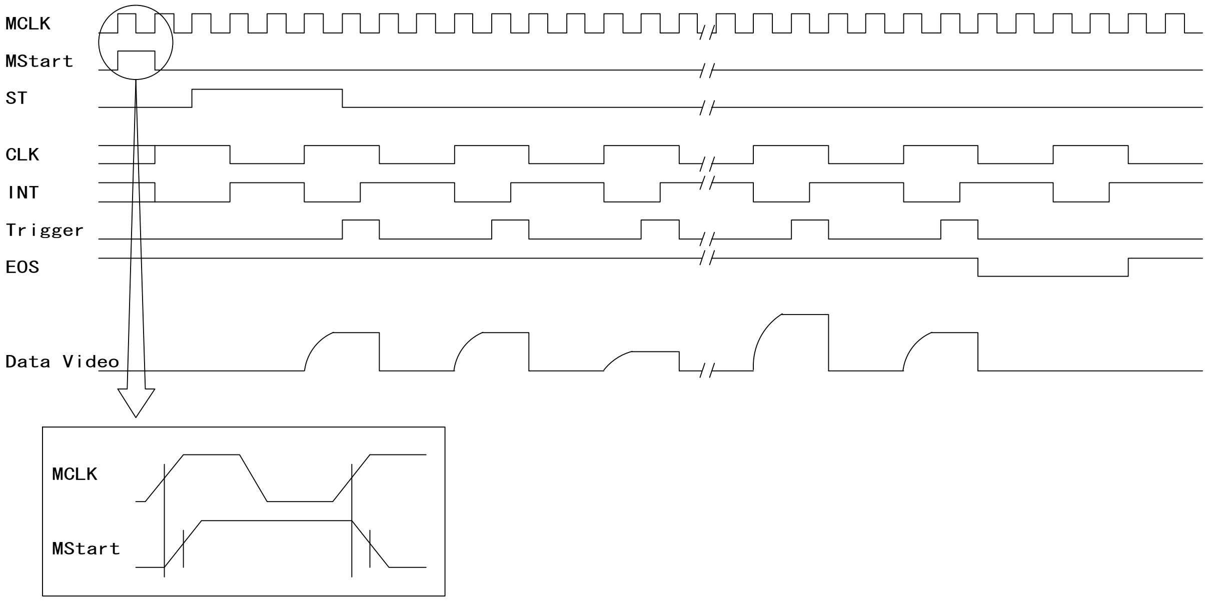



Figure 4: Timing Diagram

Use the following procedure to operate an image sensor while referring to Figure 4 "Timing Diagram" above. When checking the image sensor operation in a dark state, provide complete light-shielding so that no light enters the photosensitive area of the image sensor.

### 1) Turning the power on

After checking that the supply voltage is set to ±15 V, turn on the power supply. Check that the current level is normal when power is being supplied. If excessive current flows, the power supply line might have a short, so immediately turn off the power supply.

### 2) Inputting the control signal from the pulse generator

Input two control signals (MStart and MCLK) to this driver /amplifier circuit from the pulse generator. Each signal input must be a TTL level.
The MStart signal pulse width should be at least one cycle of the MCLK signal and synchronized with the MCLK signal.
This amplifier/driver circuit detects the MStart signal level at the MCLK signal rising edge. When the High level of the MStart signal is detected, the drive signals (ST, CLK, INT, Trigger) are fixed to their standby levels and start operations in synchronization with the rising edge of the MCLK signal when the Low level of the MStart signal is detected. This means that the drive signals are kept fixed if the MStart signal pulse width is long (High level is long).
The MCLK signal frequency determines the Data Video signal readout frequency (MCLK signal frequency / 4), and the MStart signal pulse interval determines the integration time of the image sensor.

***CAUTION: The MStart and MCLK signals must be synchronized. If not synchronized, this driver/amplifier circuit may malfunction. The MStart signal rising and falling edges should not overlap the MCLK signal rising and falling edges.***

***CAUTION: Never input the Start and CLK signals while power to this driver/amplifier circuit is off. Doing so may cause malfunctions.***

## 3) Setting the integration time

When setting the integration time, refer to the following description.

<Example> When operating a CMOS linear image sensor S10111-512Q using the C10808-01 at a MCLK signal frequency of 250 KHz (data rate = 62.5 kHz).

The Data Video signal readout frequency is 1/4 of the MCLK signal frequency, so the readout time (t) per channel will be t = 16 μs/ch.
Thus, the time required for one scan, $t_{scan}$, becomes:

$$t_{scan} \fallingdotseq t \times N = 16\ \mu s/ch \times 512\ ch = 8.192\ ms$$

where
N: number of sensor channels

In this case, the integration time (ts) should be set to 8.2 ms or longer.

**(Note that the scan time will be slightly longer depending on the MStart signal pulse width and the synchronization conditions with the MCLK signal.**

## 4) Monitoring the "Data Video" signal

Use the oscilloscope to monitor the "Data Video" signal.

Ch.1: Data Video, Ch.2: Trigger, Ch.3: EOS

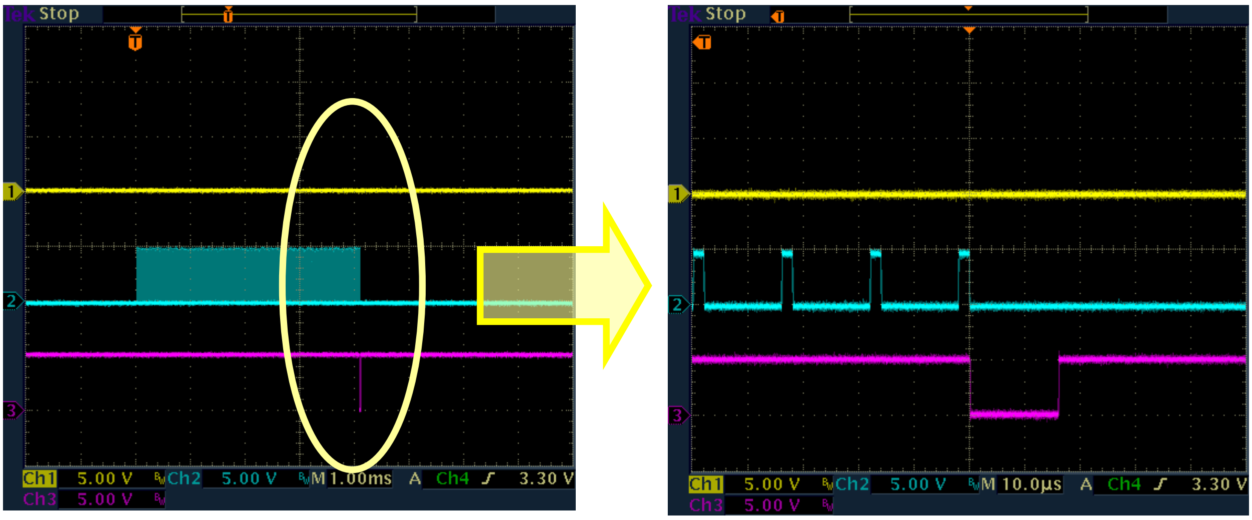



Photo 1-1: Dark output waveform

Photo 1-2: Enlarged view near EOS pulse

### [Dark state output]

When the image sensor is operated in a dark state, the output waveform monitored on the oscilloscope should appear like that shown in Photo 1, although the waveform profile may differ slightly according to the image sensor type and integration time. If such a waveform cannot be obtained, recheck the connections in the entire system.

After normal operation is verified in the dark state, allow light to enter the image sensor. At this point, we recommend using DC light as much as possible. Modulated light such as fluorescent lamp illumination causes fluctuations in the image sensor output and makes you think the image sensor is operating abnormally.

### [Output when irradiated with light]

Photos 2 and 3 show the output waveform when light is incident on the image sensor.

Photo 2: Output waveform when the image sensor is irradiated with light equal to about 50% of the saturation light level.

Photo 3: Output waveform when the image sensor is irradiated with light higher than the saturation light level

Ch.1: Data Video, Ch.2: Trigger, Ch.3: EOS

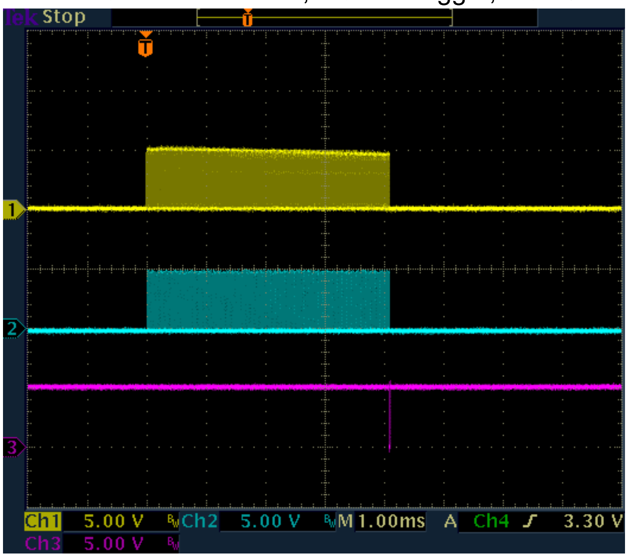



Photo 2-1: Output 1 when irradiated with light

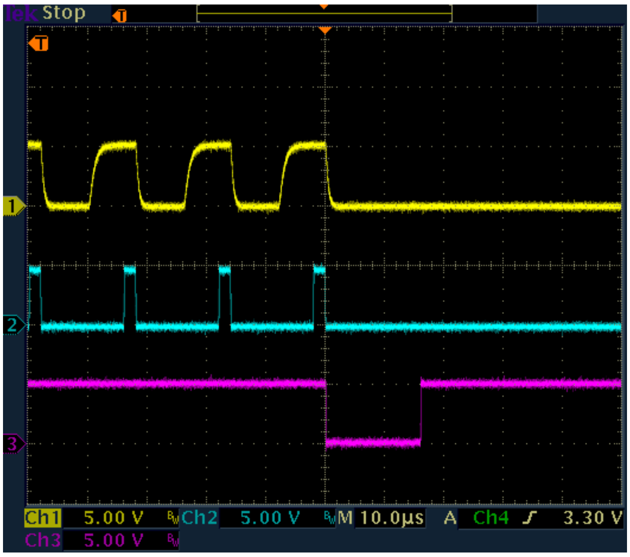



Photo 2-2: Enlarged view near EOS pulse

Ch.1: Data Video, Ch.2: Trigger, Ch.3: EOS

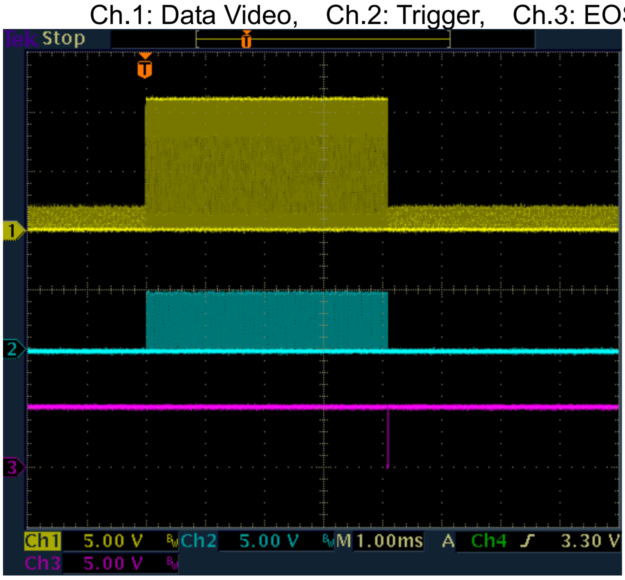



Photo 3-1: Output 2 when irradiated with light

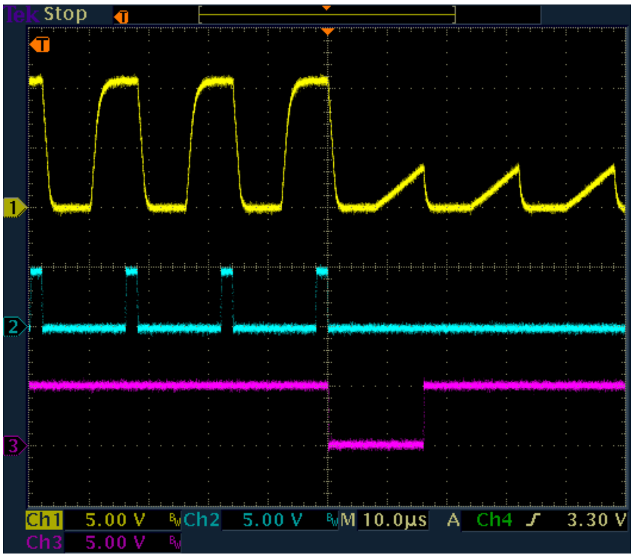



Photo 3-2: Enlarged view near EOS pulse

### [Saturated output voltage]

Saturated voltage Vsat is defined as follows.

$V_{sat} = G \times Q_{sat} = 0.067 \times Q_{sat}$ [V]

(G: Circuit gain, Qsat: Sensor saturation charge)

## 5) Offset voltage adjustment, switching noise cancellation and offset adjustment

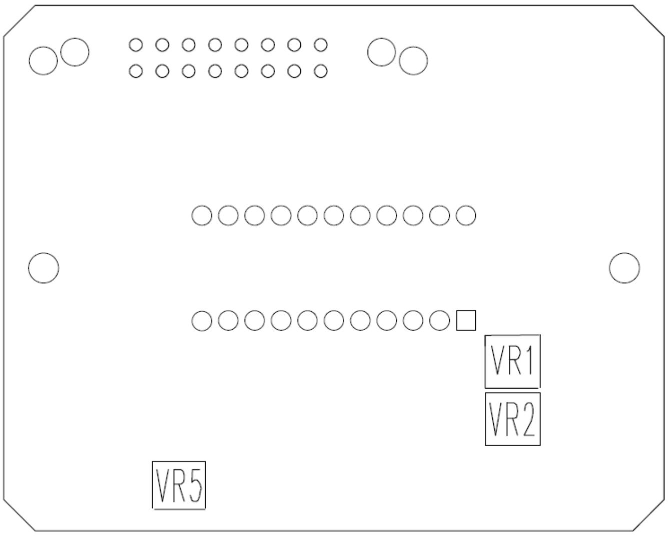



Figure 5: C10808, C10808-01 Trimmer Layout

### (1) Offset voltage adjustment

Turn VR2 to adjust the offset voltage.

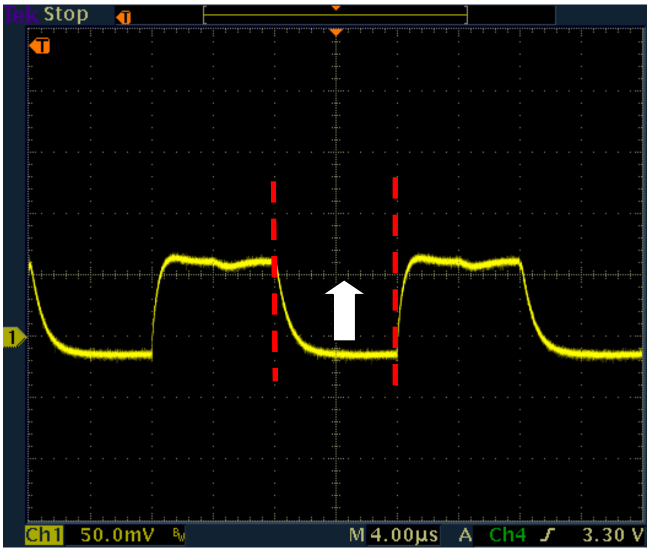



Photo 4-1: Before adjustment

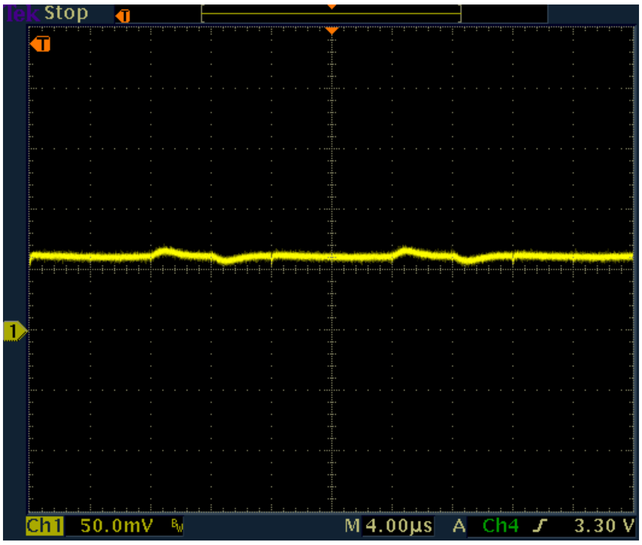



Photo 4-2: After adjustment

### (2) Switching noise cancellation

Turn VR1 to the left to reduce the switching noise (indicated by a red circle).

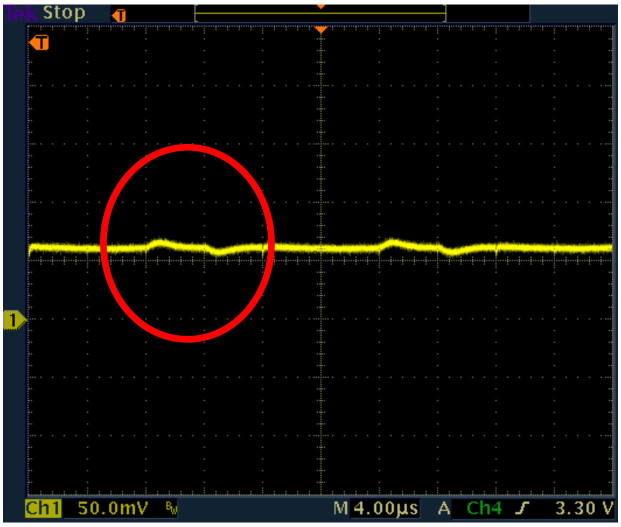



Photo 5-1: Before adjustment

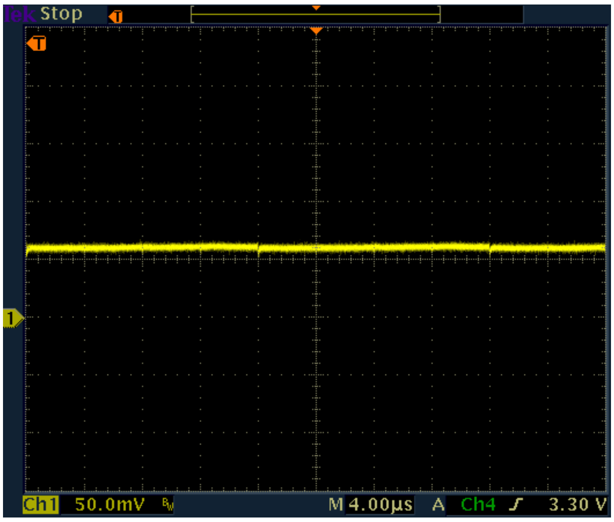
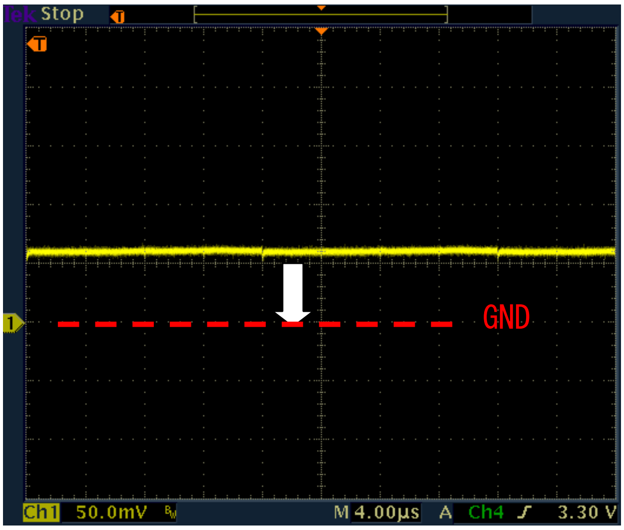


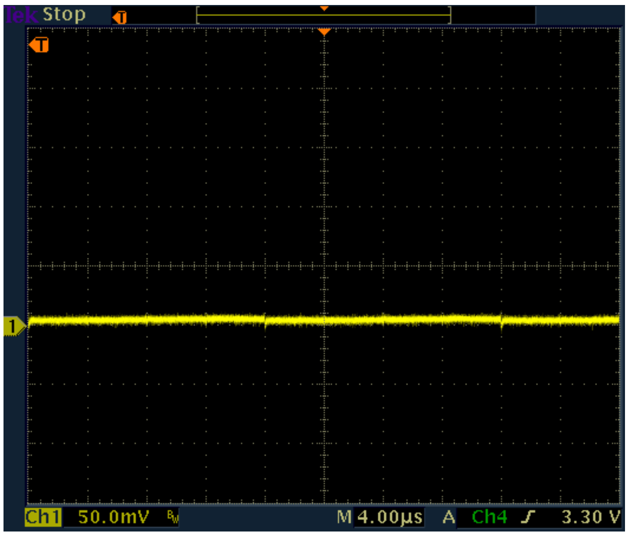

Photo 5-2: After adjustment

### (3) Data Video DC offset adjustment

Turn VR5 to adjust the DC offset of the Data Video signal.




Before adjustment




After adjustment

***NOTE: Signal output waveforms slightly differ depending on sensor type.***

## 4-2 Changing the integration time

The integration time of the CMOS linear image sensor can be changed by controlling the INT signal timing from an external circuit.

### Integration time change function

The integration time for each pixel can be changed to an integral multiple of the readout period by controlling the INT signal. When the INT signal is set to High level at a timing that a particular pixel is read out, the signal of that pixel is not output. In this case, the signal integration continues since no signal is output. Using this function lengthens the signal integration time of any particular pixel and so allows detecting low-level light signal components with high efficiency.

### Timing diagram for changing integration time

In the diagram below, the integration times at channels 2, 3 and 4 are respectively set to 2, 3 and 4 times the integration time at channel 1.

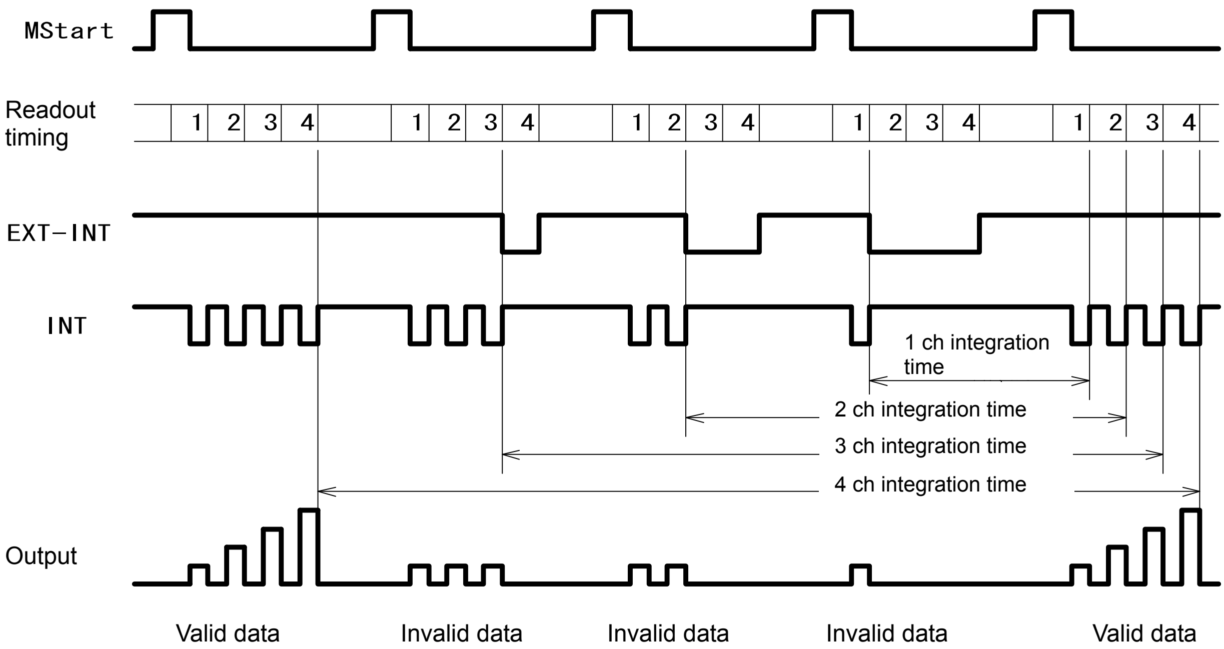



Figure 6: Timing diagram for changing integration time

## Circuit configuration

To use the integration time change function, the EXT_IN and INT_SEL signals must be input to the CN3 connector from the external circuit.

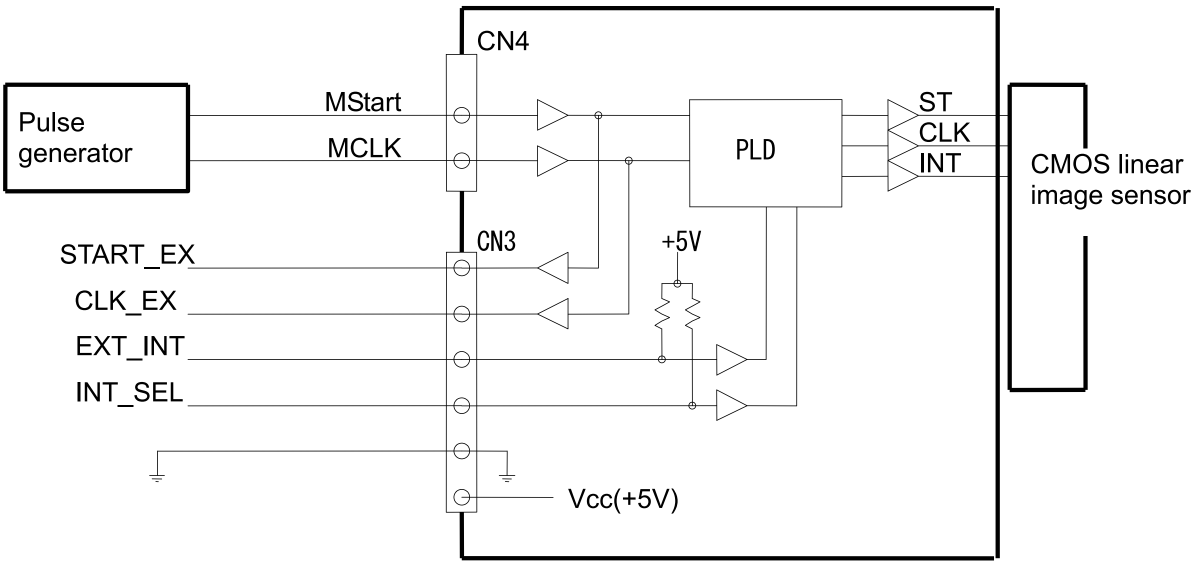



Figure 7: Connection when using integration time change function

### CN3 connector signal description

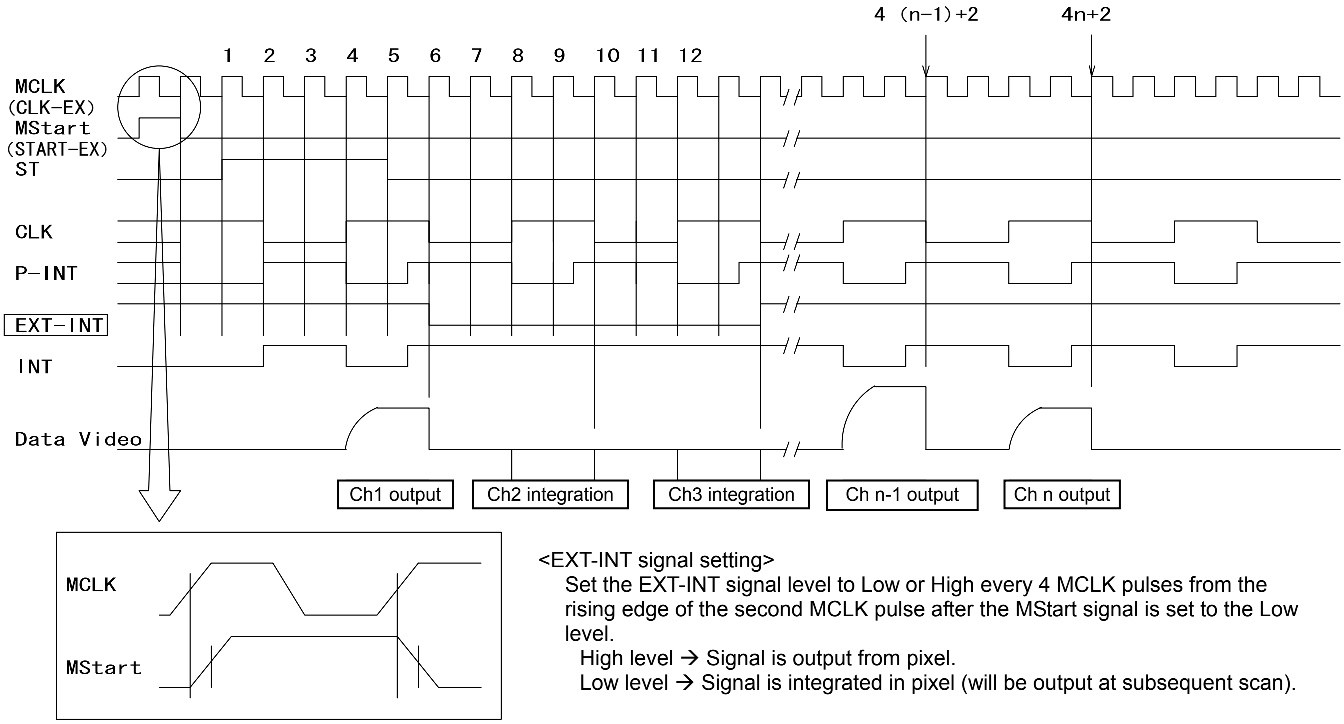
| Pin No. | Signal name | I/O | Function |
|---|---|---|---|
| 1 | START_EX | OUT | Signal for timing synchronization. Same as MStart that is input from the pulse generator. |
| 2 | CLK_EX | OUT | Signal for timing start. Same as MCLK that is input from the pulse generator. |
| 3 | EXT_INT | IN | Used to mask the INT signal generated by the internal circuit.<br>High level period → Outputs the internal INT signal without masking so that pixel signals are continuously output.<br>Low level period → Masks the internal INT signal so pixel signals are integrated. |
| 4 | INT_SEL | IN | Not used (Should be no connection or High level input.) |
| 5 | D.GND | | Digital ground |
| 6 | Vcc | | +5V output (Supply current: 100mA max.) |

Input signals should be TTL level and output signals should be HCMOS level except for Vcc. The supply capacity of Vcc (+5 V) from pin No. 6 is 100 mA maximum. If the supply current from the driver circuit to an external device exceeds 100 mA, leave pin No. 6 unconnected and use a separate power source to supply power to the external circuit. When not using the integration time change function (when using constant readout from all pixels), keep the EXT_INT signal set at the High level or leave the CN3 connector unconnected. (When in an open state, the EXT-INT is pulled up and set to the H level input.)

### EXT-INT signal generation timing

Synchronize the external EXT-INT signal with the CLK_EX(MCLK) and START-EX(MStart) from the driver circuit. Then set the EXT-IN signal to either of the pixel output level (High level) or pixel integration level (Low level) for every output period (every 4 MCLK pulses) of each pixel, and input it to the driver circuit.
The integration time of each pixel can be changed by setting the EXT-INT signal level every 4 MCLK pulses in the interval from the second MCLK pulse after the START-EX(MStart) signal is set to the Low level to the 4n+2MCLK (n: number of pixels of CMOS linear image sensor to be used). (See the timing chart below.)
The P_INT signal is generated inside the circuit and is used to output the INT signal by OR (logical addition) on the inverted EXT_INT signal. Therefore, the sensor operates in normal mode when the EXT_INT signal is fixed at the High level or CN3 is not connected.

EXT_INT: High level → Signals of specified pixels are output without integration.
EXT_INT: Low level → Signals of specified pixels are integrated.




<EXT-INT signal setting>
Set the EXT-INT signal level to Low or High every 4 MCLK pulses from the rising edge of the second MCLK pulse after the MStart signal is set to the Low level.
High level → Signal is output from pixel.
Low level → Signal is integrated in pixel (will be output at subsequent scan).

Figure 8: Timing diagram for changing integration time

# 5. Specifications

## 5-1 Absolute maximum ratings (Ta=25 °C)

| Parameters | Symbol | Rated Value | Unit | Remarks |
|---|---|---|---|---|
| Positive supply voltage | +Vs Max | +20 | V | |
| Negative supply voltage | -Vs Max | -20 | V | |
| Operating temperature | Topr | 0 to +50 | °C | No condensation |
| Storage temperature | Tstg | -10 to +70 | °C | No condensation |

## 5-2 Characteristics (Ta=25°C, ±Vs=±12 V, unless otherwise specified)

### (1) Analog circuit

| Parameter | Symbol | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Circuit mode | | Charge integration mode | | | | | |
| Circuit gain | G | Applies to all series | | | 0.067 | | V/pC |
| Data rate (=MCLK/4) | fvo | C10808 | S10111, S10114 series | | | 250 | kHz |
| | | | S10112, S10113 series | | | 500 | MHz |
| | | C10808-01 | Applies to all series | | | 62.5 | kHz |

### (2) Digital circuit

| Parameter | | | | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| Input | Master start pulse MStart (Positive logic) | Input voltage | | Vms(H) | 2.0 | 5.0 | 5.5 | V |
| | | | | Vms(L) | 0 | - | 0.8 | V |
| | | Pulse width | | tpwΦms | 1/fΦmc | - | - | ns |
| | | Rise time | | trΦms | - | - | 50 | ns |
| | | Fall time | | tfΦms | - | - | 50 | ns |
| | Master clock pulse MCLK (Positive logic) | Input voltage | | Vmc(H) | 2.0 | 5.0 | 5.5 | V |
| | | | | Vmc(L) | 0 | - | 0.8 | V |
| | | Pulse width | | tpwΦmc | 30 | - | - | ns |
| | | Rise time | | trΦmc | - | - | 20 | ns |
| | | Fall time | | tfΦmc | – | - | 20 | ns |
| | | Frequency | C10808 | fΦmc | – | – | 1 (2) * | MHz |
| | | | C10808-01 | | - | - | 250 | kHz |

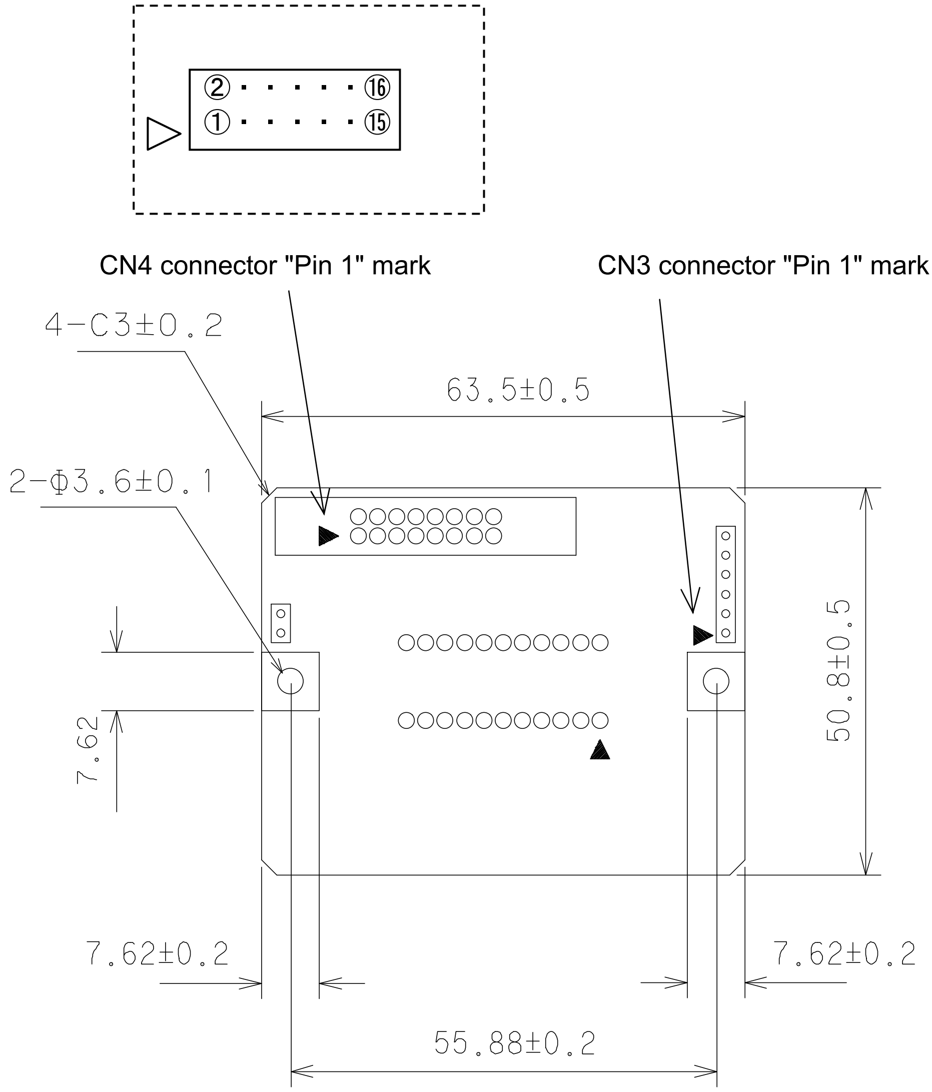
* Maximum clock frequency. The value in ( ) is for the S10112 and S10113 series.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Output | Trigger pulse Trig (Positive logic) | Output voltage | Vtrig(H) | 3.8 | - | - | V |
| | | | Vtrig(L) | 0 | - | 0.44 | V |
| | | Pulse width | tpwtrig | - | 1/fΦmc | - | ns |
| | | Rise time | trtrig | - | - | 100 | ns |
| | | Fall time | tftrig | - | - | 100 | ns |
| | End-of-scan pulse EOS (Negative logic) | Output voltage | Veos(H) | 3.8 | - | - | V |
| | | | Veos(L) | 0 | - | 0.44 | V |
| | | Pulse width | tpweos | - | 2/fΦmc | - | ns |
| | | Rise time | treos | - | - | 100 | ns |
| | | Fall time | tfeos | - | - | 100 | ns |

## 5-3 General ratings

| Parameter | | | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| Supply voltage | Positive supply voltage | | +Vs | - | +14.5 | +15.0 | +15.5 | V |
| | Negative supply voltage | | -Vs | - | -14.5 | -15.0 | -15.5 | V |
| Current consumption | C10808 | Positive supply current | +Is | +15 V | 30 | 35 | 50 | mA |
| | | Negative supply current | -Is | -15 V | -15 | -20 | -25 | mA |
| | C10808-01 | Positive supply current | +Is | +15 V | 25 | 30 | 40 | mA |
| | | Negative supply current | -Is | -15 V | -10 | -15 | -20 | mA |

# 6. Dimensional outline




[Unit: mm]

Figure 9: Dimensional outline of C10808 and C10808-01 (component side)

# 7. Input/Output Connector Pin Arrangement

### Connector for external input /output (CN. 4)

| Pin No. | I/O | Terminal Name | Description |
|---|---|---|---|
| 1 | - | A.GND | Analog ground |
| 2 | IN | +15V | Positive power supply |
| 3 | - | A.GND | Analog ground |
| 4 | IN | -15V | Negative power supply |
| 5 | - | A.GND | Analog ground |
| 6 | OUT | Data Video | Analog video output signal; positive polarity |
| 7 | - | A.GND | Analog ground |
| 8 | - | A.GND | Analog ground |
| 9 | - | D.GND | Digital ground |
| 10 | OUT | EOS | Digital output signal for indicating end-of scan of image sensor; Negative logic |
| 11 | - | D.GND | Digital ground |
| 12 | OUT | Trigger | Digital output signal for A/D conversion; positive logic |
| 13 | - | D.GND | Digital ground |
| 14 | IN | MCLK | Digital input signal for circuit operation; The circuit operates at rising edge of MCLK pulse. |
| 15 | - | D.GND | Digital ground |
| 16 | IN | MStart | Digital input signal for resetting the circuit; positive logic Interval of these pulses equals the integration time. |

See the dimensional outline for the "Pin 1" mark on the board.

Connector: FAP-16-07#2 (Yamaichi Electronics) or equivalent

### Connector for changing integration time (CN. 3)

| Pin No. | I/O | Terminal name | Description |
|---|---|---|---|
| 1 | OUT | START-EX | Signal for starting EXT-INT signal output |
| 2 | OUT | CLK-EX | Signal for synchronizing EXT-INT signal |
| 3 | IN | EXT-INT | External signal for changing integration time |
| 4 | IN | INT-SEL | Not used |
| 5 | - | D.GND | Digital ground |
| 6 | - | Vcc | +5 V output (Supply current: 100 mA max.) |

See the dimensional outline for the "Pin 1" mark on the board.

Connector: XR2P series (OMRON) or equivalent

# 8. CMOS Linear Image Sensor Selection Guide

The list below shows major specs of the Hamamatsu NMOS linear image sensors that can be used with the C10808 series.

| Type No. | Number of Photodiodes | Active Area per Element (Pitch×Height) | Entire Active Area | Spectral Response | Features |
|---|---|---|---|---|---|
| S10111-128Q | 128 | 50 μm×2.5 mm | 6.4×2.5 mm | 200 to 1000 nm | · Low power consumption<br>· Excellent linearity<br>· Wide dynamic range |
| S10111-256Q | 256 | | 12.8×2.5 mm | | |
| S10111-512Q | 512 | | 25.6×2.5 mm | | |
| S10114-256Q | 256 | 25 μm×2.5 mm | 6.4×2.5 mm | 200 to 1000 nm | |
| S10114-512Q | 512 | | 12.8×2.5 mm | | |
| S10114-1024Q | 1024 | | 25.6×2.5 mm | | |
| S10112-128Q | 128 | 50 μm×0.5 mm | 6.4×0.5mm | 200 to 1000 nm | |
| S10112-256Q | 256 | | 12.8×0.5 mm | | |
| S10112-512Q | 512 | | 25.6×0.5 mm | | |
| S10113-256Q | 256 | 25 μm×0.5 mm | 6.4×0.5 mm | 200 to 1000 nm | |
| S10113-512Q | 512 | | 12.8×0.5 mm | | |
| S10113-1024Q | 1024 | | 25.6×0.5 mm | | |

***NOTE: The C10808 series does not include a CMOS linear image sensor. Please order the image sensor separately.***

# 9. Handling Precautions

Observe the following instructions when handling this product.

- Use sufficient caution to protect this product from electrostatic charges.
- Never disassemble or modify any part of this product. This will cause equipment problems or malfunctions.
- Handle carefully so as not to drop this product and protect it from bumps or impacts. These may cause damage to the circuit.
- Do not leave this product in locations with high temperatures or high humidity.
- Use caution when connecting to another unit.
- Always use this product within the maximum ratings.

To extract the fullest performance from this product, follow the instructions below.

- Provide adequate shielding as needed to protect this product against external electromagnetic induction. We recommend using shielded wire to make cable connection.
- Using a power supply with low ripple and noise is recommended.
- To ensure accurate measurement, use caution not to allow any extraneous light to enter the image sensor.

## To customers

### Important - Be sure to read!

- To ensure correct and safe use of this product, always use it within the maximum ratings and observe the precautions in this manual.
  We are making every effort to constantly improve product quality and reliability. However, this will not guarantee the complete safety of this product. In particular, when this product is used in equipment or facilities which might cause personal injury, fatal accidents or damage to property if handled improperly, be sure to provide appropriate safety measures while taking into account possible trouble or danger.

- When giving instructions to the end user about how to use this product or equipment using this product, please explain detailed functions, performance and correct handling of the product or equipment, as well as safety information including warning labels.

- This product is warranted for a period of one year from the date of delivery. If any failure is found in the workmanship or materials within this warranty period, Hamamatsu will repair or replace the defective parts without charge. Even within the warranty period, we are not liable for failure or trouble which was caused by accidents (such as natural or man-made disasters) or incorrect use (such as modification, operation in unsuitable environment or application, misoperation, mishandling, improper storage and disposal not complying with the instructions and precautions described in this manual).

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