

# CCD area image sensor S8986, S10128

Front-illuminated FFT-CCDs for X-ray imaging



S8986 is an FFT-CCD image sensor ideal for intra-oral X-ray imaging in dental diagnosis. S8986 has about 2 mega (1700 × 1200) pixels each of which is 20 × 20 μm. S8986 delivers low dark current when operated in MPP (Multi Pinned-Phase) mode.

S10128 is an easy-to-use X-ray imaging module using S8986, with added functions such as a cable assembly and X-ray trigger circuit. S10128 is pin compatible with S10127 (number of pixels is increased). S10128 is low cost type for S8985-02 and adapted both AC and DC X-ray sources.

### Features

- Sensor has X-ray monitoring photodiode
- Compactness  
5.1 mm thickness excluding I/O connector part
- High dynamic range: 12 bit
- Long-term stability  
For use under 100,000 shots  
(60 kVp, 30 mR X-ray irradiation)
- Resolution: 10 Lp/mm
- 1700 (H) × 1200 (V) pixel format
- Pixel size: 20 × 20 μm
- Coupled with GOS for X-ray imaging
- 100 % fill factor
- Low dark signal
- Low readout noise
- MPP operation
- AC/DC X-ray source adapted

### Applications

- General X-ray imaging
- Non-destructive inspection
- Intra-oral X-ray imaging in dental diagnosis

### ■ Selection guide

| Type No. | Cooling    | Number of total pixels | Number of active pixels | Active area [mm (H) × mm (V)] |
|----------|------------|------------------------|-------------------------|-------------------------------|
| S8986    | Non-cooled | 1708 × 1202            | 1700 × 1200             | 34 × 24                       |
| S10128   |            |                        |                         |                               |

### ■ General ratings

| Parameter               | S8986  | S10128                 |
|-------------------------|--|------------------------|
| CCD structure           | Full frame transfer                                    |                        |
| Fill factor             | 100 %  |                        |
| Number of active pixels | 1700 (H) × 1200 (V)                                    |                        |
| Pixel size              | 20 (H) × 20 (V) μm                                     |                        |
| Active area             | 34 (H) × 24 (V) mm                                     |                        |
| Vertical clock phase    | 2 phase  |                        |
| Horizontal clock phase  | 2 phase  |                        |
| Output circuit          | Emitter follower without load resistance               |                        |
| Dimensional outline     | 39.5 (H) × 27.5 (V) mm                                 | 42.6 (H) × 30.6 (V) mm |
| Reliability             | 100,000 shots at 60 kVp, 30 m Roentgen                 |                        |
| Window                  | GOS film   |                        |
| Other                   | MPP mode (low dark current operation), module (S10128) |                        |

■ Absolute maximum ratings (Ta=25 °C)

| Parameter                | Symbol     | Min. | Typ. | Max. | Unit |
|--------------------------|------------|------|------|------|------|
| Storage temperature      | Tstg       | -20  | -    | +70  | °C   |
| Operating temperature    | Topr       | 0    | -    | +40  | °C   |
| OD voltage               | VOD        | -0.5 | -    | +20  | V    |
| RD voltage               | VRD        | -0.5 | -    | +18  | V    |
| SG voltage               | VSG        | -15  | -    | +15  | V    |
| OG voltage               | VOG        | -15  | -    | +15  | V    |
| RG voltage               | VRG        | -15  | -    | +15  | V    |
| TG voltage               | VTG        | -15  | -    | +15  | V    |
| Vertical clock voltage   | VP1V, VP2V | -15  | -    | +15  | V    |
| Horizontal clock voltage | VP1H, VP2H | -15  | -    | +15  | V    |
| Vcc voltage              | Vcc        | 0    | -    | +7   | V    |

■ Operating conditions (MPP mode, Ta=25 °C)

| Parameter                               | Symbol | Min.         | Typ. | Max. | Unit |   |
|---|--------|--------------|------|------|------|---|
| Output transistor drain voltage         | VOD    | 12           | 15   | -    | V    |   |
| Reset drain voltage                     | VRD    | 12           | 13   | 14   | V    |   |
| Output gate voltage                     | VOG    | -0.5         | 2    | 5    | V    |   |
| Substrate voltage                       | Vss    | -            | 0    | -    | V    |   |
| Vertical shift register clock voltage   | High   | VP1VH, VP2VH | 0    | 3    | 6    | V |
|   | Low    | VP1VL, VP2VL | -9   | -8   | -7   | V |
| Horizontal shift register clock voltage | High   | VP1HH, VP2HH | 0    | 3    | 6    | V |
|   | Low    | VP1HL, VP2HL | -9   | -8   | -7   | V |
| Summing gate voltage                    | High   | VsGH         | 0    | 3    | 6    | V |
|   | Low    | VsGL         | -9   | -8   | -7   | V |
| Reset gate voltage                      | High   | VRGH         | 0    | 3    | 6    | V |
|   | Low    | VRGL         | -9   | -8   | -7   | V |
| Transfer gate voltage                   | High   | VTGH         | 0    | 3    | 6    | V |
|   | Low    | VTGL         | -9   | -8   | -7   | V |
| +5 V power supply voltage               | Vcc    | 4.75         | 5    | 5.25 | V    |   |

■ Electrical characteristics (Ta=25 °C)

| Parameter                             | Symbol     | Remark     | Min.    | Typ.    | Max. | Unit |
|---------------------------------------|------------|------------|---------|---------|------|------|
| Signal output frequency               | fc         | *1         | -       | 1       | 5    | MHz  |
| Vertical shift register capacitance   | CP1V, CP2V |            | -       | 70,000  | -    | pF   |
| Horizontal shift register capacitance | S8986      | CP1H, CP2H | -       | 400     | -    | pF   |
|                                       | S10128     |            | -       | 600     | -    |      |
| Summing gate capacitance              | S8986      | Csg        | -       | 20      | -    | pF   |
|                                       | S10128     |            | -       | 220     | -    |      |
| Reset gate capacitance                | S8986      | CRG        | -       | 20      | -    | pF   |
|                                       | S10128     |            | -       | 220     | -    |      |
| Transfer gate capacitance             | S8986      | CTG        | -       | 250     | -    | pF   |
|                                       | S10128     |            | -       | 450     | -    |      |
| Charge transfer efficiency            | CTE        | *2         | 0.99995 | 0.99998 | -    | -    |
| DC output level                       | Vout       | *3         | 5       | 8       | 11   | V    |
| Output impedance                      | Zo         | *3         | -       | 500     | -    | Ω    |
| Power dissipation                     | P          | *3 *4      | -       | 75      | -    | mW   |
| +5 V power supply current             | S8986      | Icc        | -       | 1       | -    | mA   |
|                                       | S10128     |            | -       | 2       | -    |      |

\*1: S8986 only. In case of S10128, maximum frequency is strongly depend on peripheral circuit and cable length.

\*2: Measured at half of the full well capacity. CTE is defined per pixel.

\*3: VOD=15 V

\*4: Power dissipation of the on-chip amplifier.

■ Electrical and optical characteristics (Ta=25 °C, unless otherwise noted, VOD=15 V)

| Parameter                     |                   | Symbol      | Remark  | Min. | Typ.  | Max.  | Unit                    |
|-------------------------------|-------------------|-------------|---------|------|-------|-------|-------------------------|
| Full well capacity            | Vertical          | Fw          |         | 100  | 200   | -     | ke <sup>-</sup>         |
|                               | Horizontal        |             |         | -    | 300   | -     |                         |
|                               | Summing           |             |         | -    | 600   | -     |                         |
| CCD node sensitivity          |                   | Sv          | *5      | 1.0  | 1.4   | -     | μV/e <sup>-</sup>       |
| Dark current (MPP mode)       |                   | DS          | *6      | -    | 250   | 2,500 | e <sup>-</sup> /pixel/s |
| Readout noise                 |                   | Nr          | *7      | -    | 60    | -     | e <sup>-</sup> rms      |
| Dynamic range                 |                   | DR          | *8      | -    | 3,333 | -     | -                       |
| X-ray response non-uniformity |                   | XRNU        | *9, *10 | -    | ±10   | ±30   | %                       |
| Blemish *11                   | Point defects *12 | White spots | -       | -    | -     | 20    | -                       |
|                               |                   | Black spots |         | -    | -     | 20    |                         |
|                               | Cluster defects   | *13         |         | -    | -     | 3     |                         |
|                               | Column defects    | *14         |         | -    | -     | 1     |                         |
| X-ray resolution              |                   | ΔR          | *9      | 8    | 10    | -     | Lp/mm                   |

\*5: VOD=15 V, RL(load resistance of emitter follower)=1 kΩ.

\*6: Dark signal doubles for every 5 to 7 °C.

\*7: -40 °C, operating frequency is 1 MHz.

\*8: Dynamic range = Full well capacity / Readout noise

\*9: X-ray irradiation of 60 kVp, measured at half of the full well capacity.

\*10: XRNU (%) = Noise / Signal × 100

Noise: Fixed pattern noise (peak to peak)

In the range that excludes 5 pixels from edges to the center at every position.

\*11: Refer to "Characteristics and use of FFT-CCD area image sensor" of technical information.

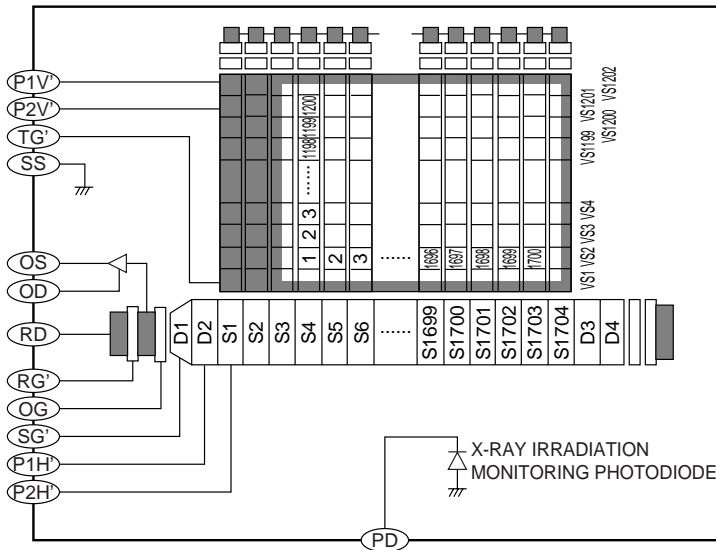
\*12: White spots > 10 times of Max. Dark signal (2500 e<sup>-</sup>/pixel/s).

Black spots > 50 % reduction in response relative to adjacent pixels, measured at half of the full well capacity.

\*13: continuous 2 to 9 point defects.

\*14: continuous > 10 point defects.

■ Device structure



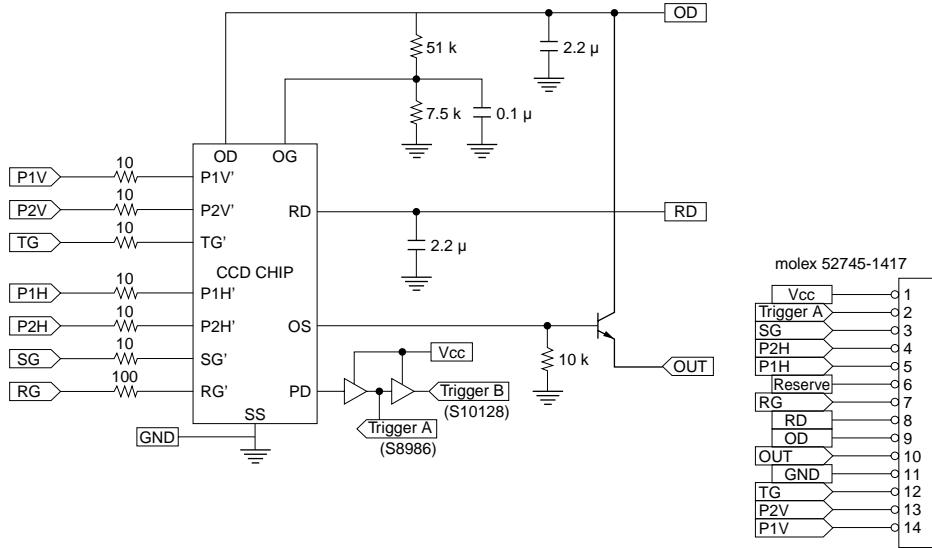
KMPDC0220EA

■ Pixel format

| ← Left Horizontal Direction → Right |               |           |           |           |               |       |
|-------------------------------------|---------------|-----------|-----------|-----------|---------------|-------|
| Blank                               | Optical black | Isolation | Effective | Isolation | Optical black | Blank |
| 2                                   | 2             | 1         | 1700      | 1         | 0             | 2     |

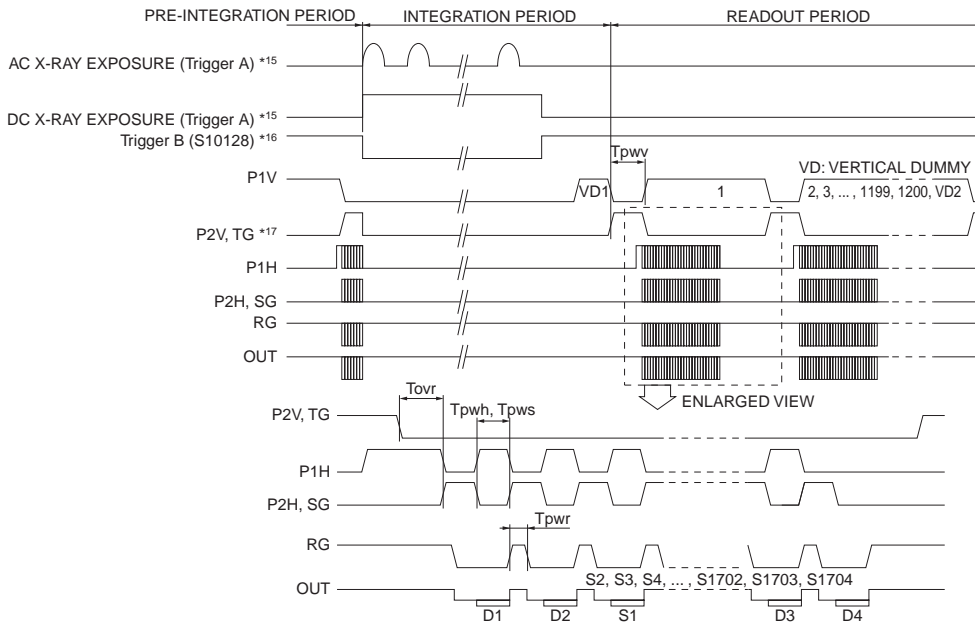
| Top ← Vertical direction → Bottom |           |           |
|-----------------------------------|-----------|-----------|
| Isolation                         | Effective | Isolation |
| 1                                 | 1200      | 1         |

## On-board circuit



KMPDC0218EC

## Timing chart



\*15: Trigger A (S8986) is the same as AC/DC X-ray exposure form.

\*16: Low active trigger pulse

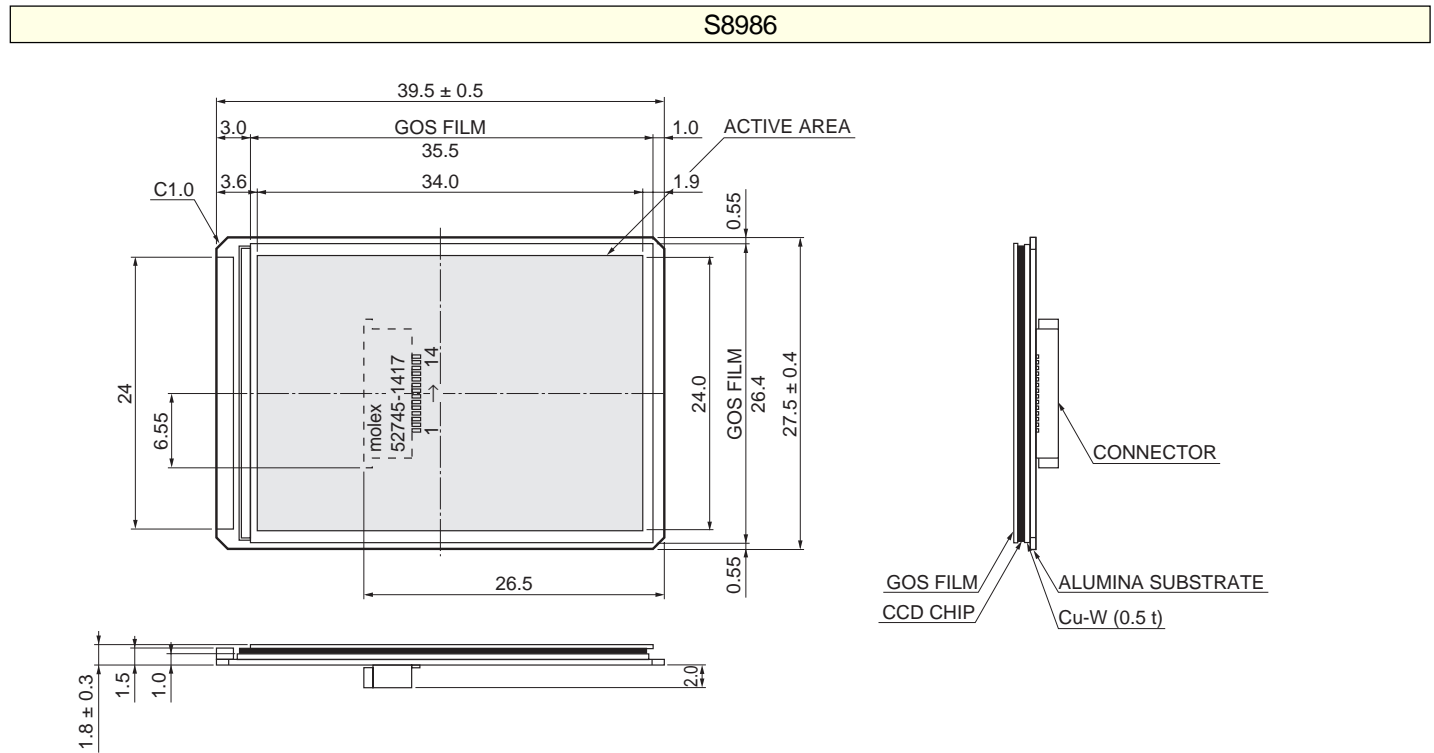
\*17: TG terminal can be short-circuited to P2V terminal.

KMPDC0219EB

| Parameter    |                    | Symbol     | Remark | Min. | Typ. | Max. | Unit |
|--------------|--------------------|------------|--------|------|------|------|------|
| P1V, P2V, TG | Pulse width        | tpwv       | *18    | 30   | 60   | -    | μs   |
|              | Rise and fall time | tprv, tpfv |        | 200  | -    | -    | ns   |
| P1H, P2H     | Pulse width        | tpwh       | *18    | 100  | 500  | -    | ns   |
|              | Rise and fall time | tprh, tprf |        | 5    | -    | -    | ns   |
|              | Duty ratio         |            |        | -    | 50   | -    | %    |
| SG           | Pulse width        | tpws       |        | 100  | 500  | -    | ns   |
|              | Rise and fall time | tprs, tprf |        | 3    | -    | -    | ns   |
|              | Duty ratio         |            |        | -    | 50   | -    | %    |
| RG           | Pulse width        | tpwr       |        | 10   | 50   | -    | ns   |
|              | Rise and fall time | tpr, tprf  |        | 3    | -    | -    | ns   |
| TG-P1H       | Overlap time       | tovr       |        | 18   | 36   | -    | μs   |

\*18: Symmetrical pulses should be overlapped at 50 % of maximum amplitude.

■ Dimensional outlines (unit: mm)



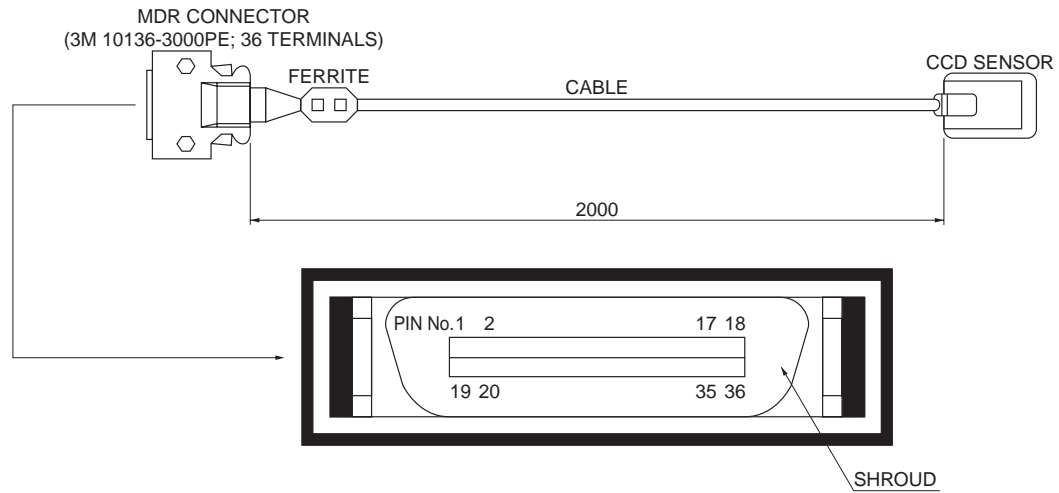
■ Pin connections (Connector on CCD package)

| Pin No. | Symbol    | Description                     | Remark           |
|---------|-----------|---------------------------------|------------------|
| 1       | Vcc       | Analog power +5 V               |                  |
| 2       | Trigger A | Trigger A output                |                  |
| 3       | SG        | Summing gate                    |                  |
| 4       | P2H       | CCD horizontal register clock-2 |                  |
| 5       | P1H       | CCD horizontal register clock-1 |                  |
| 6       | Reserve   |                                 | Should be opened |
| 7       | RG        | Reset gate                      |                  |
| 8       | RD        | Reset drain                     |                  |
| 9       | OD        | Output transistor drain         |                  |
| 10      | OUT       | Signal output                   |                  |
| 11      | GND       | Ground                          |                  |
| 12      | TG        | Transfer gate                   |                  |
| 13      | P2V       | CCD vertical register clock-2   |                  |
| 14      | P1V       | CCD vertical register clock-1   |                  |

## Dimensional outlines (unit: mm)

### S10128

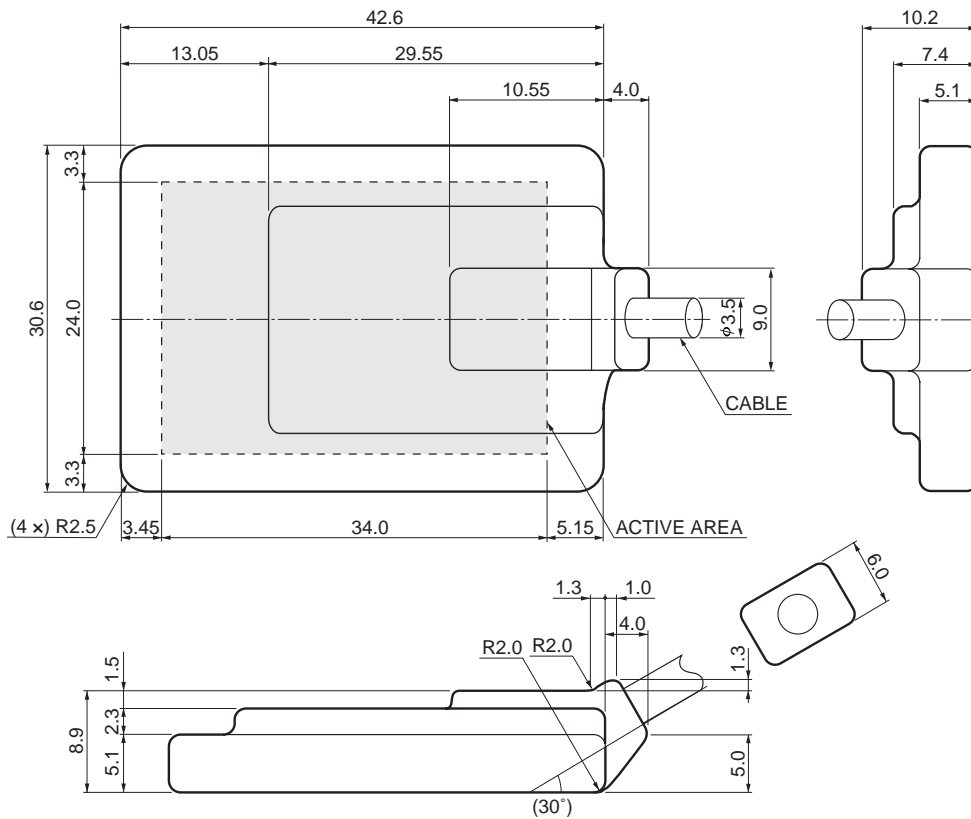
#### Entire view



KMPDA0189EA

\* The shield of cable and the shroud of MDR connector are electrically connected each other. They are short-circuited, so there is no electrical contact to any other positions.

#### CCD sensor



KMPDA0192EA

■ Pin connections

| Pin No. | Symbol    | Description                     | Remark             |
|---------|-----------|---------------------------------|--------------------|
| 1       | GND       | Ground                          |                    |
| 2       | Vcc       | +5 V power supply               |                    |
| 3       | SG        | Summing gate                    | Same timing as P2H |
| 4       | Trigger B | Trigger B output                |                    |
| 5       | RG        | Reset gate                      |                    |
| 6       | NC        |                                 |                    |
| 7       | Reserve   |                                 | Should be opened   |
| 8       | NC        |                                 |                    |
| 9       | RD        | Reset drain                     |                    |
| 10      | NC        |                                 |                    |
| 11      | OD        | Output transistor drain         |                    |
| 12      | NC        |                                 |                    |
| 13      | OUT       | Sensor output                   |                    |
| 14      | NC        |                                 |                    |
| 15      | GND       | Ground                          |                    |
| 16      | NC        |                                 |                    |
| 17      | P1V       | CCD vertical register clock-1   |                    |
| 18      | Reserve   |                                 | Should be opened   |
| 19      | Reserve   |                                 | Should be opened   |
| 20      | P2H       | CCD horizontal register clock-2 |                    |
| 21      | NC        |                                 |                    |
| 22      | P1H       | CCD horizontal register clock-1 |                    |
| 23      | NC        |                                 |                    |
| 24      | GND       | Ground                          |                    |
| 25      | NC        |                                 |                    |
| 26      | RD        | Reset drain                     |                    |
| 27      | NC        |                                 |                    |
| 28      | OD        | Output transistor drain         |                    |
| 29      | NC        |                                 |                    |
| 30      | GND       | Ground                          |                    |
| 31      | NC        |                                 |                    |
| 32      | OUT       | Sensor output                   |                    |
| 33      | NC        |                                 |                    |
| 34      | P2V       | CCD vertical register clock-2   |                    |
| 35      | NC        |                                 |                    |
| 36      | TG        | Transfer gate                   | Same timing as P2V |

■ Precautions for use (Electrostatic countermeasures)

- \*Handle these sensors with bare hands or wearing cotton gloves. In addition, wear anti-static clothing or use a wrist band with an earth ring, in order to prevent electrostatic damage due to electrical charges from friction.
- \*Avoid directly placing these sensors on a work-desk or work-bench that may carry an electrostatic charge.
- \*Provide ground lines or ground connection with the work-floor, work-desk and work-bench to allow static electricity to discharge.
- \*Ground the tools used to handle these sensors, such as tweezers and soldering irons.

It is not always necessary to provide all the electrostatic measures stated above. Implement these measures according to the amount of damage that occurs.