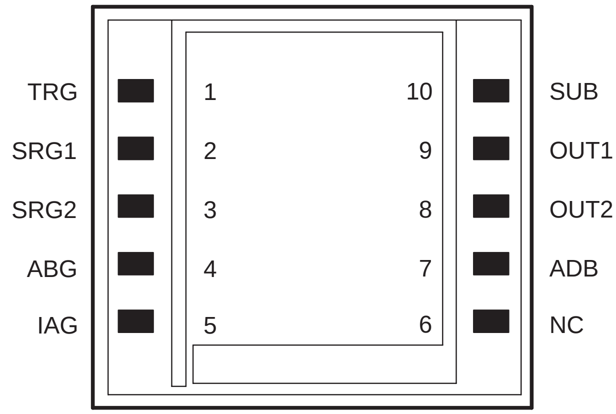
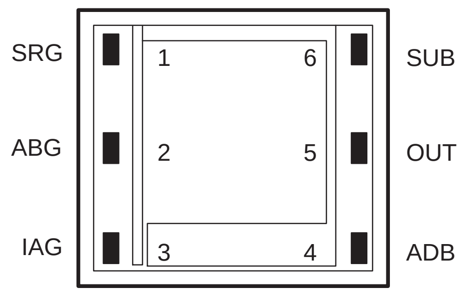
- **Full-Frame Operation**
  - **190 (H) × 190 (V) Active Elements for TC221**
  - **285 (H) × 285 (V) Active Elements for TC225**
  - **102 (H) × 102 (V) Active Elements for TC227**
- **Dark-Reference Pixels**
- **9-μm Square Pixels**
- **Single-Phase Clocking**
- **Low Dark Current**
- **Dynamic Range . . . More Than 60 dB**
- **High Photoresponse Uniformity**
- **High Sensitivity**
- **Low-Noise Operation**
- **Solid State Reliability With No Residual Imaging, Image Burn-In, Microphonics, or Image Distortion**

TC225

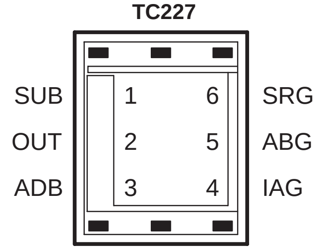


NC – No internal connection

TC221



TC227

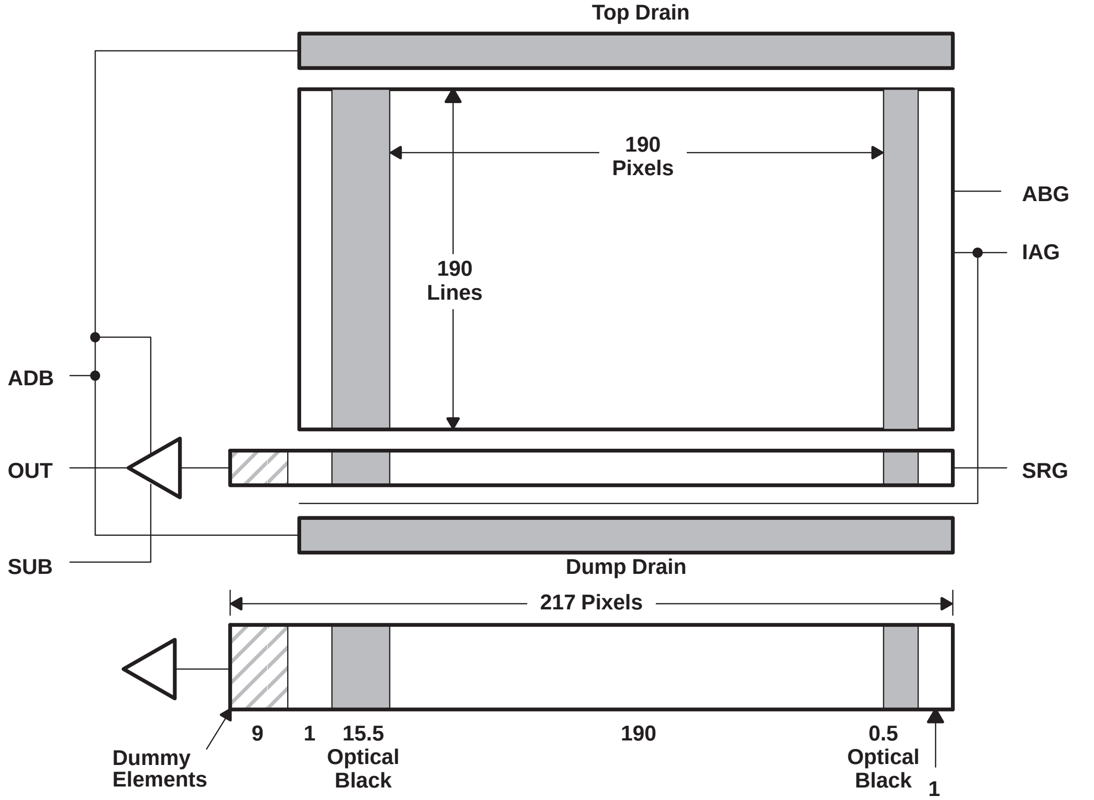


description

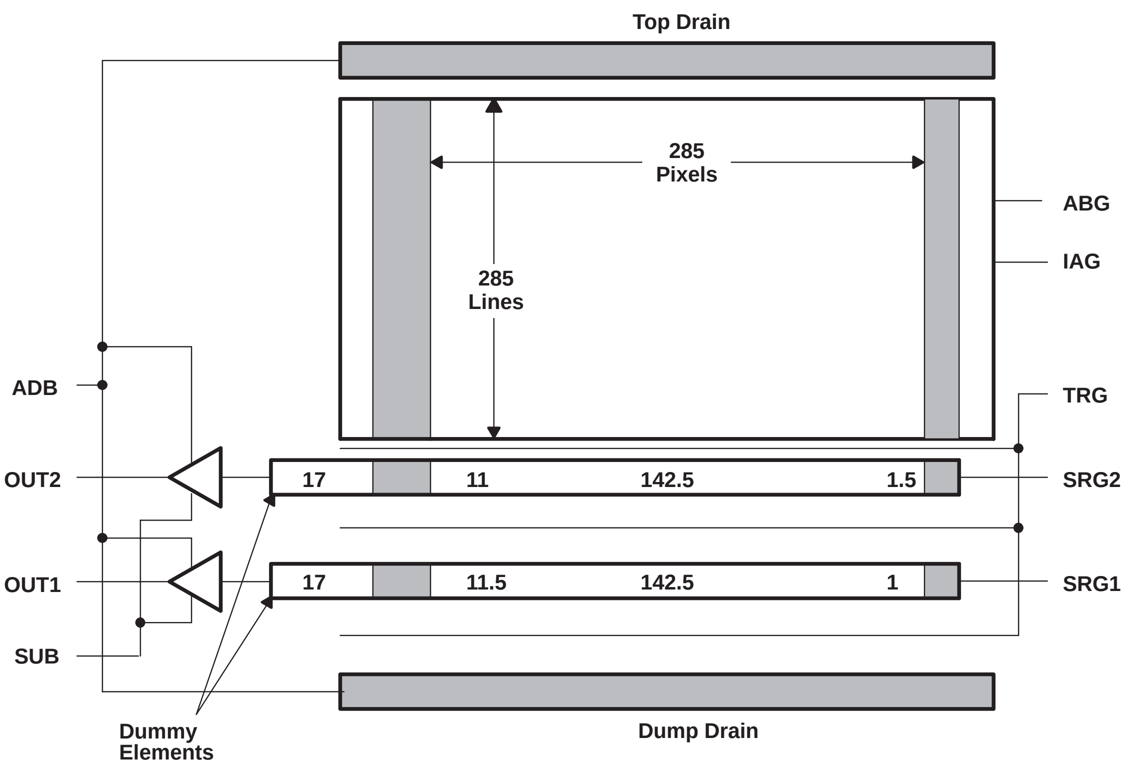
The TC221, TC225 and TC227 are full-frame charge-coupled device (CCD) image sensors designed specifically for medical and industrial applications where ruggedness and small size are required. The image-area diagonal measures 1.3 mm for the TC227, 2.4 mm for the TC221, and 3.63 mm for the TC225. The image sensors contain, in addition to dark reference pixels, 190, 285, and 102 active lines with 190, 285, and 102 active pixels per line, respectively. The antiblooming feature is activated by supplying clock pulses to the antiblooming gate, an integral part of each image-sensing element. The charge is converted to signal voltage at 9.5 μV per electron by a high-performance structure with built-in automatic reset and a voltage-reference generator. The signal is further buffered by a low-noise two-stage source-follower amplifier to provide high output-drive capability.

The TC221 and TC227 are supplied in 6-pin molded plastic packages; the TC225 is supplied in a 10-pin molded plastic package. The glass window can be cleaned using any standard method for cleaning optical assemblies or by wiping the surface with a cotton swab soaked in alcohol.

functional block diagrams

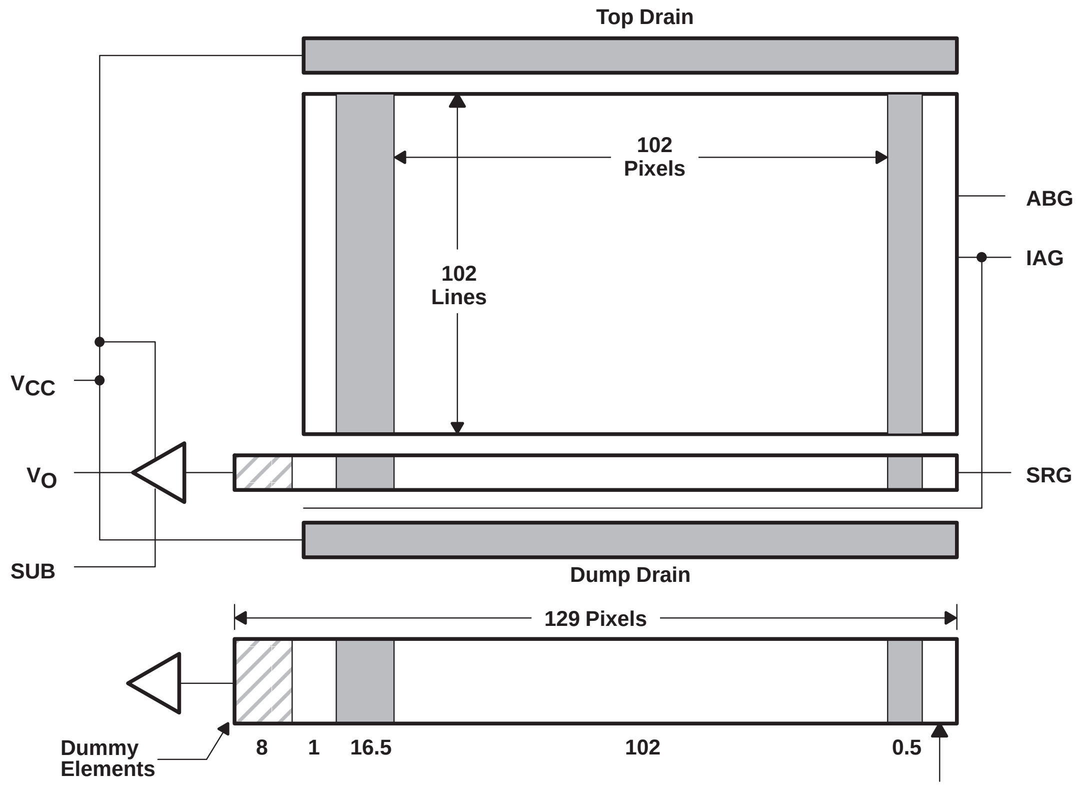


TC221



TC225

functional block diagram



TC227

detailed description

The TC221, TC225, and TC227 consist of four basic functional blocks: (1) the image-sensing area, (2) the serial registers, (3) the sensor node, and (4) the low-noise source-follower amplifier. The location of each of these blocks is identified in the functional block diagrams.

image-sensing area

As light enters the silicon in the image-sensing area, free electrons are generated and collected in the potential wells of the sensing elements. During this time, blooming protection is activated by applying a burst of pulses to the antiblooming gate. This prevents blooming by the spilling of charge from overexposed elements into neighboring elements. After integration and under dark conditions, the charge is transferred line by line into the serial register(s). The required timing is shown in Figure 1 through Figure 3. During transfer, the antiblooming gate is held at a low level. Each imager contains a specified number of dark pixels on the left side of the image-sensing area. These elements provide the dark reference used in subsequent video-processing circuits to restore the video black-level.

serial register(s)

Once an image line is transferred into the serial register, the serial-register gate can be clocked until all of the charge packets are moved out onto the sense node. A drain is also included to provide the capability to clear the image-sensing area of unwanted charge. Such charge can accumulate in the imager during the start-up of operation or under special conditions when nonstandard TV operation is desired.

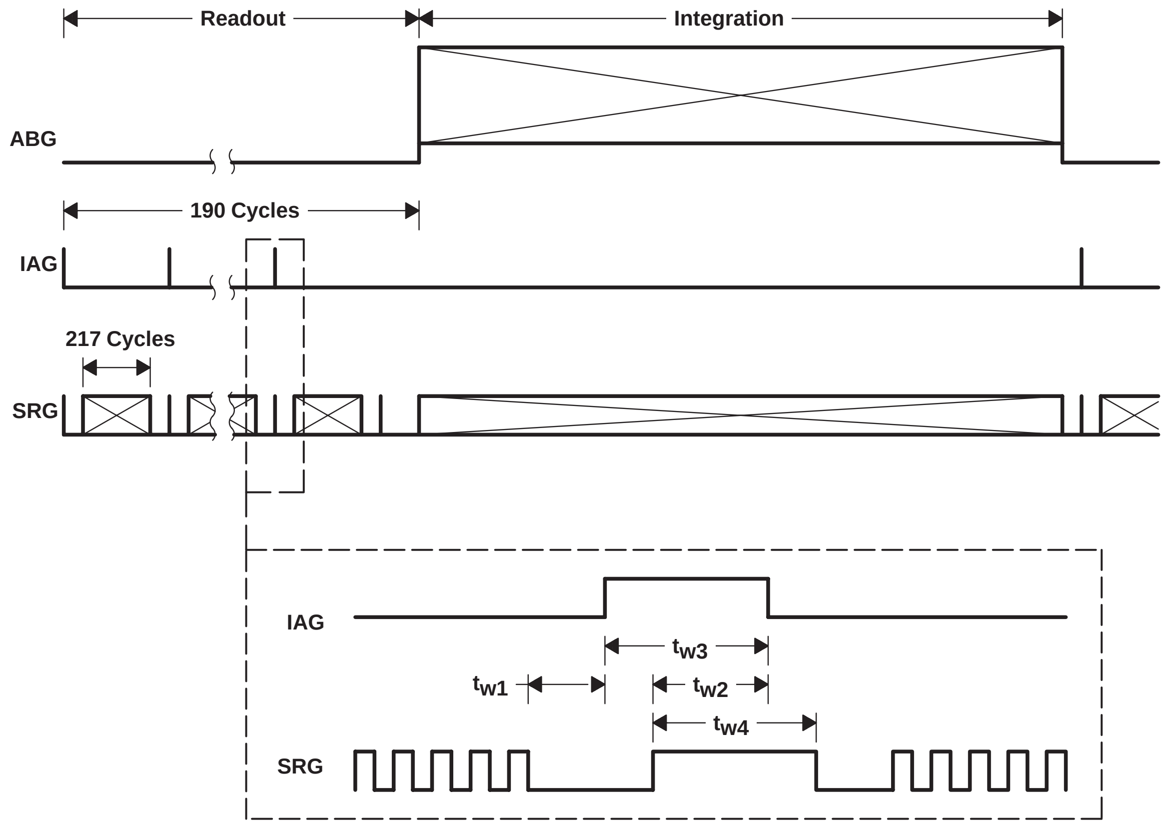
sense node(s) and source-follower amplifier(s)

After the charge packet is placed on the sense node, the potential of this node changes in proportion to the amount of signal received. It is then buffered by a dual-stage source-follower amplifier. The sense node and amplifier are located some distance from the serial register; a specified number of dummy elements is used to span the distance. The location and number of the dummy elements are shown in the functional block diagrams.

Terminal Functions

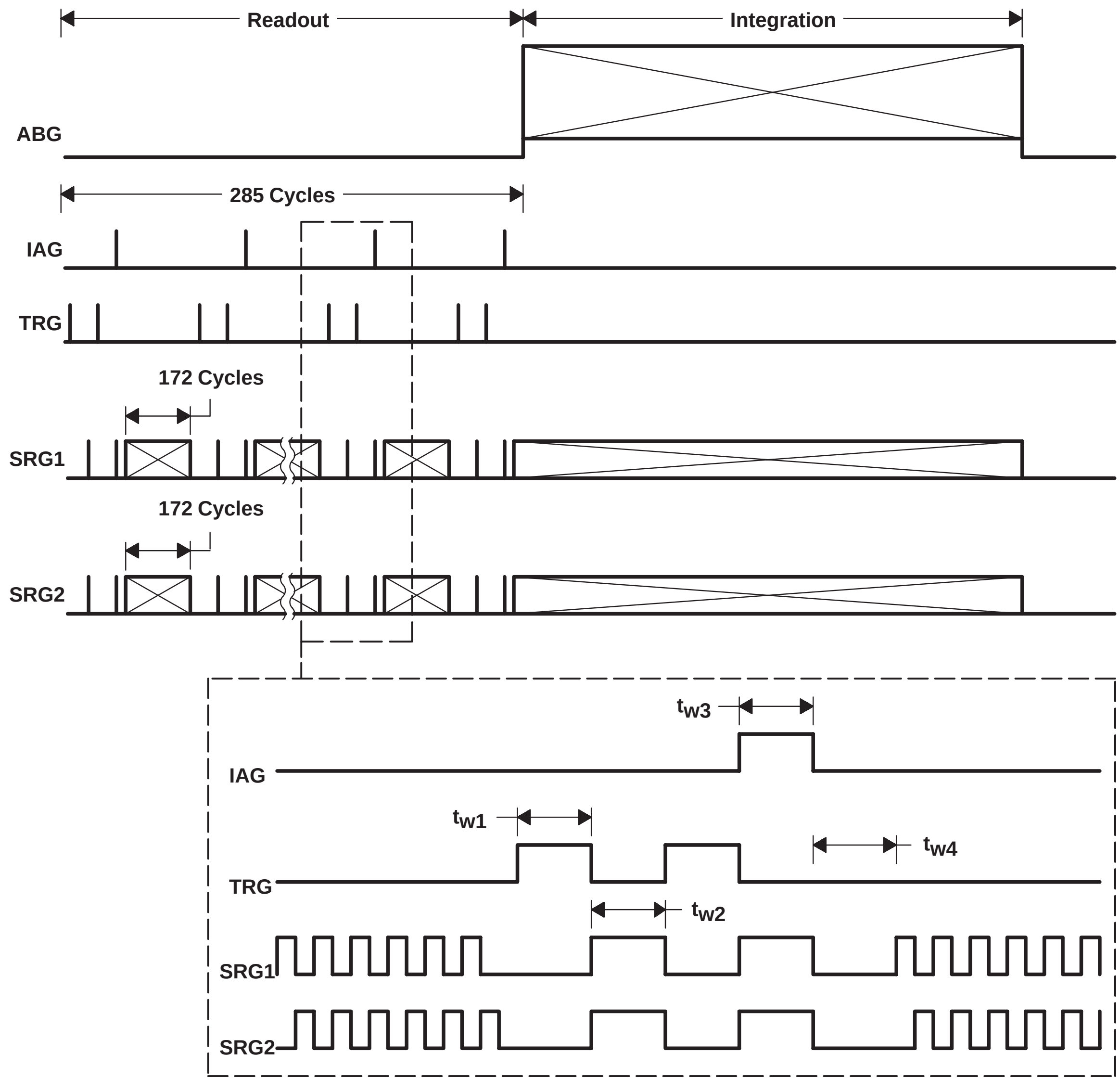
TERMINAL				I/O	DESCRIPTION
NAME	NUMBER				
	TC221	TC225	TC227		
ABG	2	4	5	I	Antiblooming gate
ADB	4	7	3		Amplifier-drain bias
IAG	3	5	4	I	Image-area gate
NC	N/A	6	N/A		No internal connection
OUT1	5	9	2	O	Output signal 1
OUT2	N/A	8	N/A	O	Output signal 2
SRG1	1	2	6	I	Serial-register gate 1
SRG2	N/A	3	N/A	I	Serial-register gate 2
SUB	6	10	1		Substrate
TRG	N/A	1	N/A	I	Transfer gate

N/A – not applicable



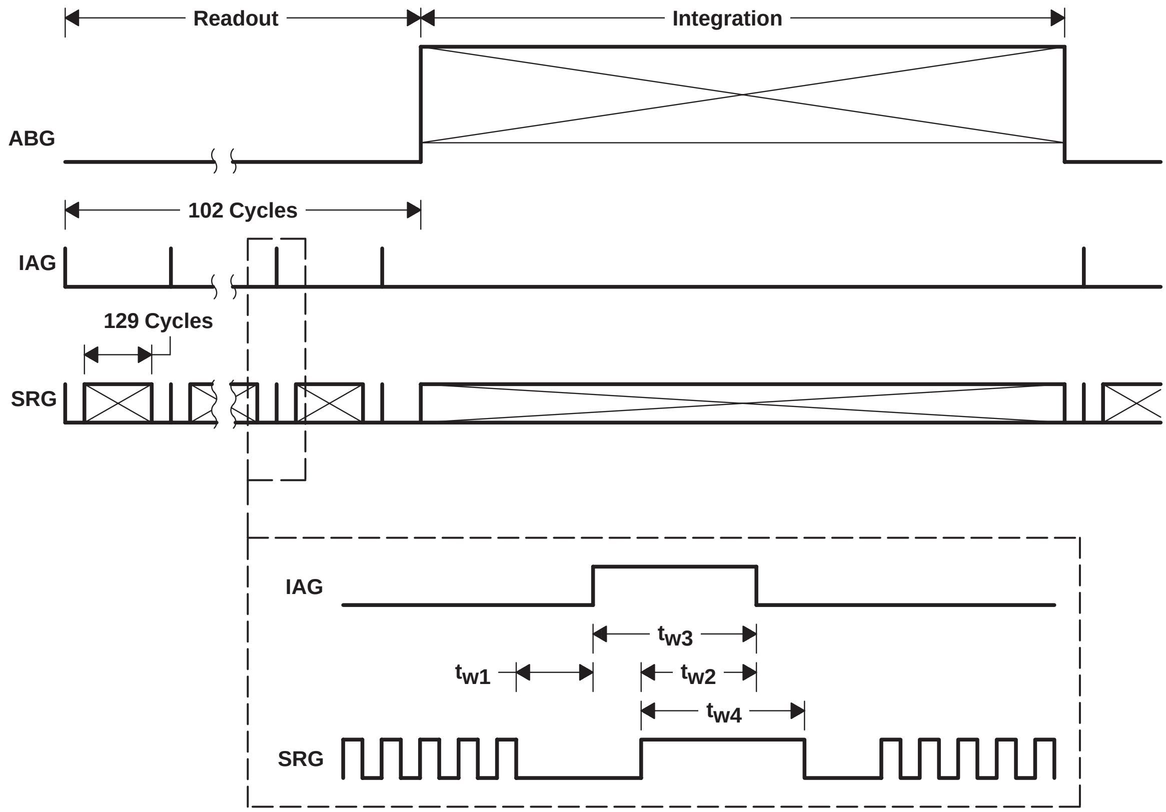
$t_{w1} \geq 125$ ns
50 ns $\leq$ t2 $\leq$ 250 ns
$t_{w3} \geq 600$ ns
$t_{w4} \geq 600$ ns

Figure 1. TC221 Timing Diagram



$t_{w1} \geq 600$ ns
$t_{w2} \geq 600$ ns
$t_{w3} \geq 600$ ns
$t_{w4} \geq 125$ ns

Figure 2. TC225 Timing Diagram



$t_{w1} \geq 125$ ns
$50 \text{ ns} \leq t2 \leq 250$ ns
$t_{w3} \geq 600$ ns
$t_{w4} \geq 600$ ns

Figure 3. TC227 Timing Diagram

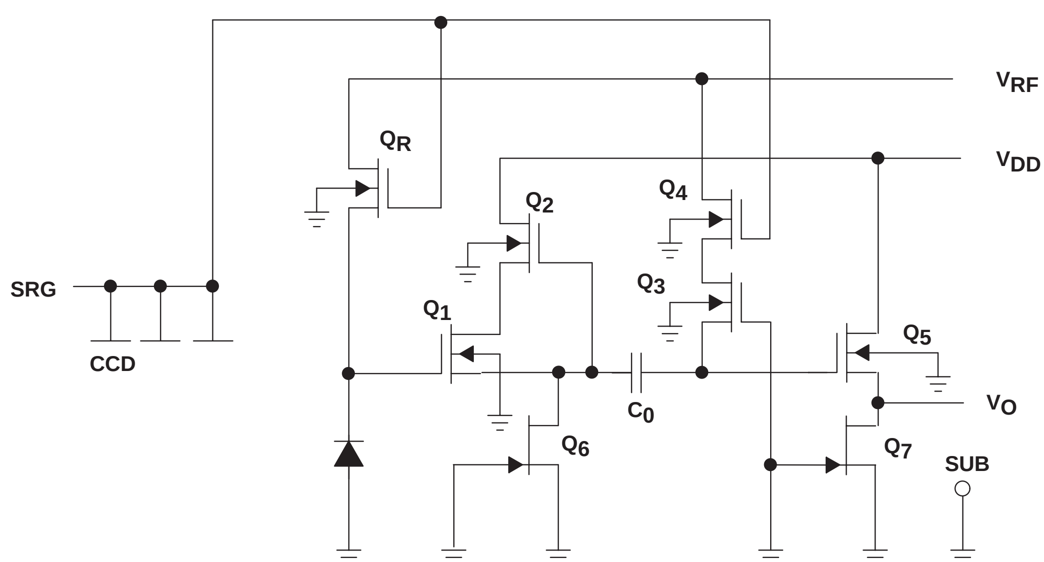


Figure 4. Charge-Detection Schematic

spurious-nonuniformity specification

The spurious-nonuniformity specification of the TC221, TC225 and TC227 grades –30 and –40 is based on several sensor characteristics:

- Amplitude of the nonuniform pixel
- Polarity of the nonuniform pixel
  - Black
  - White
- Location of the nonuniformity (see Figure 5)
- Nonuniform pixel count

The CCD sensors are characterized in both an illuminated condition and a dark condition. In the dark condition, the nonuniformity is specified in terms of absolute amplitude as shown in Figure 6. In the illuminated condition, the nonuniformity is specified as a percentage of the total illumination as shown in Figure 7.

TC221 nonuniformity table

PART NUMBER	DARK CONDITION			ILLUMINATED CONDITION		
	PIXEL AMPLITUDE	PIXEL COUNT		% OF TOTAL ILLUMINATION	PIXEL COUNT	
		AREA A	AREA B		AREA A	AREA B
TC221-30	8–12 mV	4	6	30–40	4	6
TC221-40		8	12		8	12
TC221-30	12–16 mV	2	4	40–50	2	4
TC221-40		4	8		4	8
TC221-30	> 16 mV	0	0	>50	0	0
TC221-40		0	0		0	0

TC225 nonuniformity table

PART NUMBER	DARK CONDITION			ILLUMINATED CONDITION		
	PIXEL AMPLITUDE	PIXEL COUNT		% OF TOTAL ILLUMINATION	PIXEL COUNT	
		AREA A	AREA B		AREA A	AREA B
TC225-30	8–12 mV	6	9	30–40	6	9
TC225-40		12	15		12	15
TC225-30	12–16mV	3	6	40–50	3	6
TC225-40		6	10		6	10
TC225-30	> 16 mV	0	0	>50	0	0
TC225-40		0	0		0	0

TC227 nonuniformity table

PART NUMBER	DARK CONDITION			ILLUMINATED CONDITION		
	PIXEL AMPLITUDE	PIXEL COUNT		% OF TOTAL ILLUMINATION	PIXEL COUNT	
		AREA A	AREA B		AREA A	AREA B
TC227-30	8–12 mV	4	6	30–40	4	6
TC227-40		8	12		12	12
TC227-30	12–16 mV	2	4	40–50	2	4
TC227-40		4	8		4	8
TC227-30	> 16 mV	0	0	>50	0	0
TC227-40		0	0		0	0

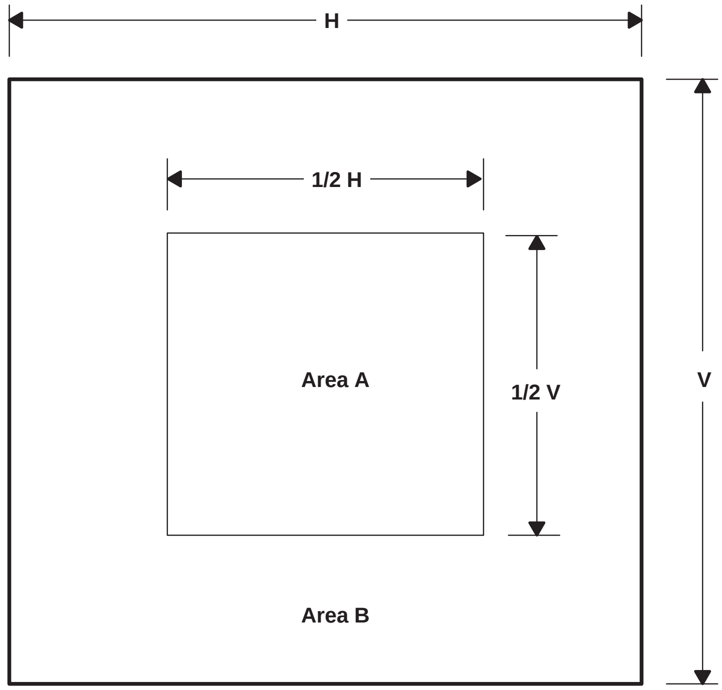


Figure 5. Area Location Map

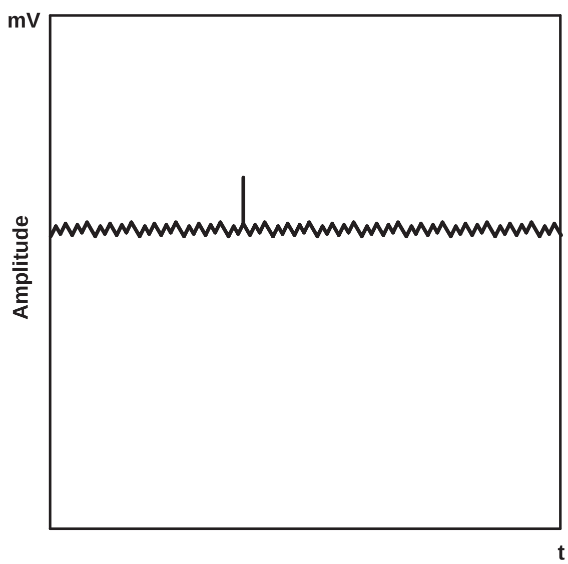


Figure 6. Pixel Nonuniformity, Dark Condition

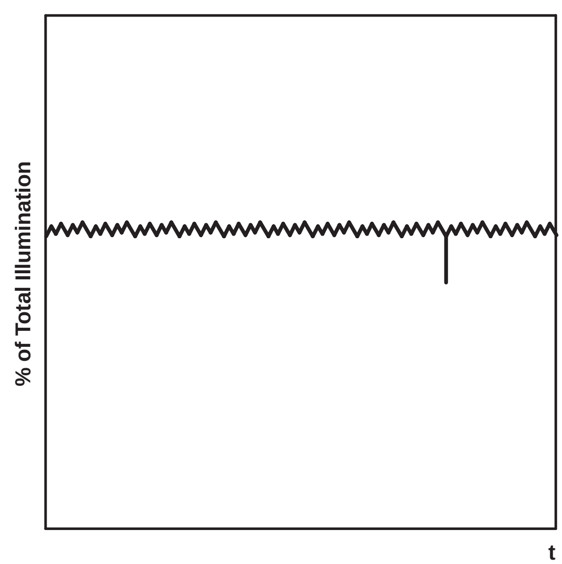


Figure 7. Pixel Nonuniformity, Illuminated Condition

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range V_{CC} for ADB (see Note 1) . . . . 0 V to 15 V
Input voltage range V_I for ABG, IAG, SRG, TRG . . . . –15 V to 15 V
Operating free-air temperature range, T_A . . . . –10°C to 60°C
Storage temperature range . . . . –30°C to 85°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values are with respect to the substrate.

recommended operating conditions

			MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}	ADB		11	12	13	V
Substrate bias voltage				0		V
Input voltage, V_I‡	IAG	High level	1.5	2	2.5	V
		Low level	–11	–10	–9	
	SRG	High level	1.5	2	2.5	
		Low level	–11	–10	–9	
	ABG	High level		11		
		Intermediate level§		–3		
		Low level		–6		
	TRG	High level	1.5	2	2.5	
		Low level	–11	–10	–9	
Pulse duration	IAG		0.7	1.0	1.3	µs
Clock frequency, f_{clock}	SRG, TRG				10	MHz
	ABG				4	
Load capacitance					6	pF
Operating free-air temperature, T_A			–10		45	°C

‡ The algebraic convention, in which the least positive (most negative) value is designated minimum, is used in this data sheet for clock voltage levels.

§ The antiblooming gate clocks from high level to intermediate level during exposure time and is held at low level during readout time.

electrical characteristics over recommended operating ranges of supply voltage and operating free-air temperature (unless otherwise noted)

PARAMETER		MIN	TYP†	MAX	UNIT
Dynamic range (see Note 2)			60		dB
Charge-conversion factor			9.5		µV/e
Charge-transfer efficiency (see Note 3)		0.99990		1.00000	
Signal-response delay (see Note 4)			30		ns
Gamma (see Note 5)		0.90		1.0	
Noise-equivalent signal (KTC noise without CDS circuit)			36		e
Output resistance				600	Ω
Rejection ratio	ADB (see Note 6)		–20		dB
	SRG (see Note 7)		–40		
	ABG (see Note 8)		–50		
Supply current				5	mA
Input capacitance, C_i (TC221)	IAG		600		pF
	SRG		20		
	ABG		240		
Input capacitance, C_i (TC225)	IAG		1320		pF
	SRG1, SRG2		40		
	TRG		60		
	ABG		520		
Input capacitance, C_i (TC227)	IAG		200		pF
	SRG		10		
	ABG		100		

† All typical values are at T_A = 25°C.

NOTES: 2. Dynamic range is –20 times the logarithm of the mean-noise signal divided by the saturation-output signal.
3. Charge-transfer efficiency is 1 minus the charge loss per transfer in the output register. The test is performed in the dark using an electrical-input signal.
4. Signal-response delay time is the time between the falling edge of the SRG clock pulse and the output-signal valid state.
5. Gamma (γ) is the value of the exponent in the equation below for two points on the linear portion of the transfer-function curve (this value represents points near saturation):

$$\left(\frac{\text{Exposure (2)}}{\text{Exposure (1)}}\right)^{\gamma} = \left(\frac{\text{Output signal (2)}}{\text{Output signal (1)}}\right)$$

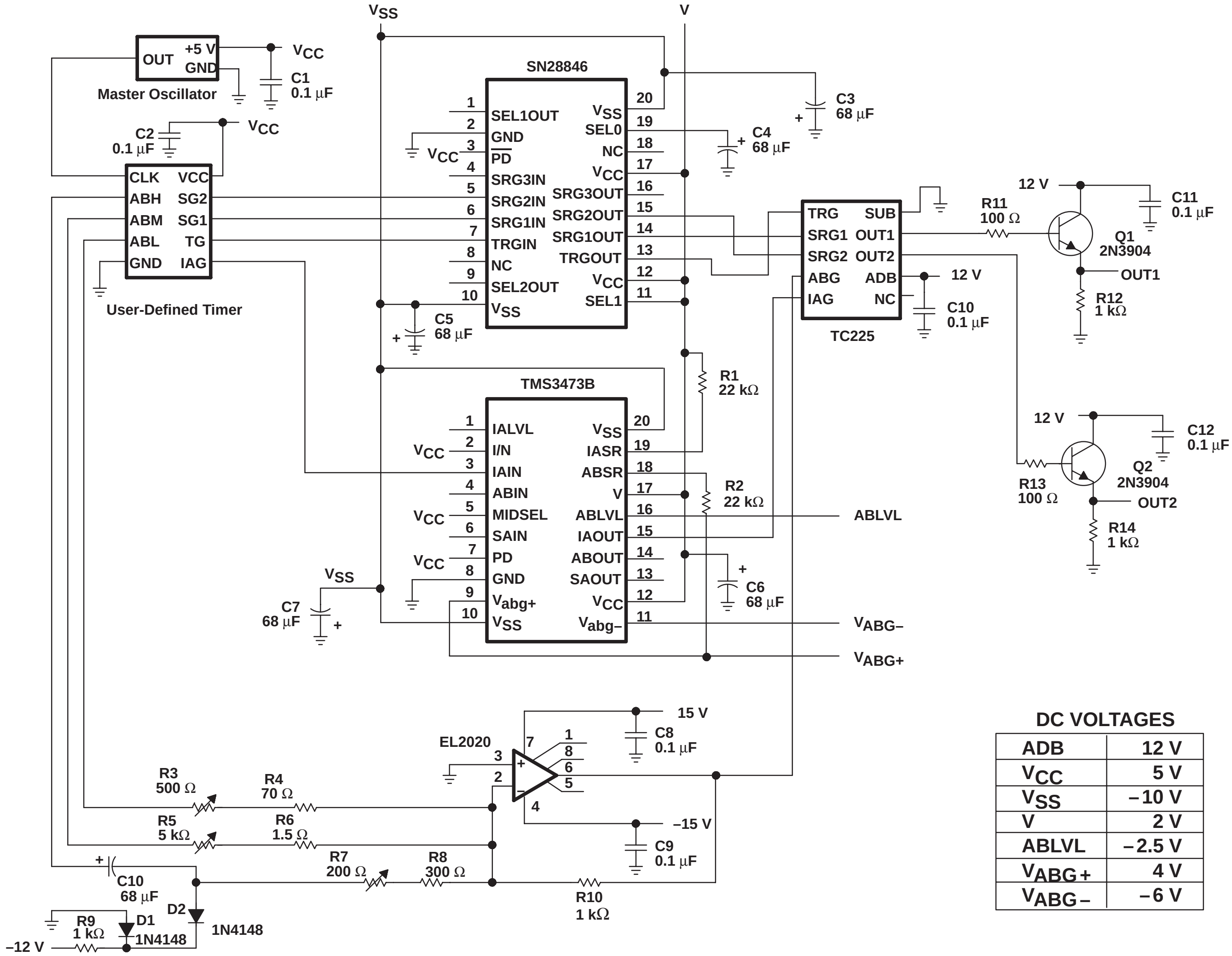
6. ADB rejection ratio is –20 times the logarithm of the ac amplitude at the output divided by the ac amplitude at ADB.
7. SRG rejection ratio is –20 times the logarithm of the ac amplitude at the output divided by the ac amplitude at SRG.
8. ABG rejection ratio is –20 times the logarithm of the ac amplitude at the output divided by the ac amplitude at ABG.

optical characteristics, T_A = 25°C, integration time = 16.67 ms (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
Sensitivity (see Note 9)	No IR Filter		210		mV/lx
	With IR Filter		30		
Saturation signal (see Note 10)		350	380	400	mV
Maximum usable signal		170	190	200	mV
Blooming overload ratio (see Note 11)		5			
Image-area well capacity			40		ke
Dark current	T_A = 21°C		0.27		nA/cm^2
Dark signal uniformity	T_A = 45°C			10	mV
Shading	Output signal = 100 mV			20%	

NOTES: 9. Sensitivity is measured at a source temperature of 2856 K. A 1-mm CM-500 filter is used.
10. Saturation is the condition in which further increase in exposure does not lead to further increase in output signal.
11. Blooming-overload ratio is the ratio of blooming exposure to saturation exposure.

APPLICATION INFORMATION



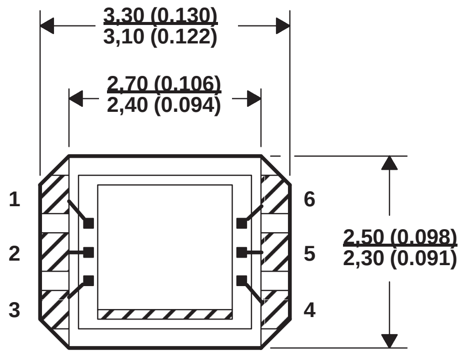
DC VOLTAGES	
ADB	12 V
V_{CC}	5 V
V_{SS}	−10 V
V	2 V
ABLVL	−2.5 V
V_{ABG+}	4 V
V_{ABG-}	−6 V

SUPPORT CIRCUITS			
DEVICE	PACKAGE	APPLICATION	FUNCTION
SN28846DW	20 pin small outline	Serial driver	Driver for SRG
TMS3473BDW	20 pin small outline	Parallel driver	Driver for IAG

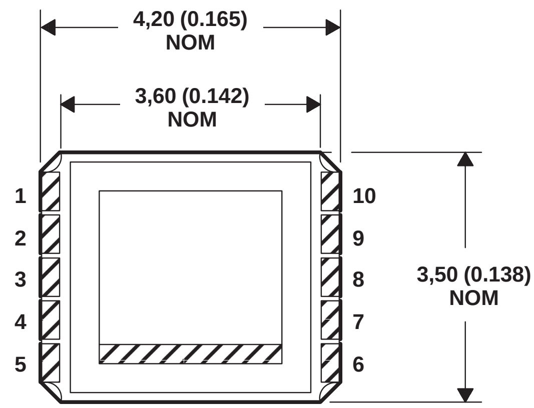
Figure 8. Typical Application Circuit Diagram

MECHANICAL DATA

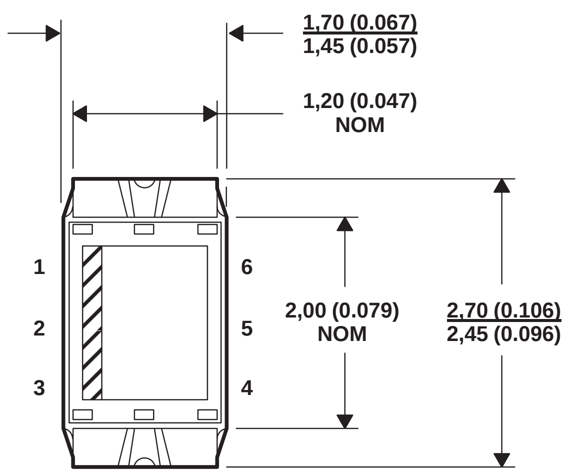
TC221



TC225



TC227



ALL LINEAR DIMENSIONS ARE IN MILLIMETERS AND PARENTHETICALLY IN INCHES

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