CCD

The Solid State Imaging Technology

Fairchild CCD Imaging
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During the '70s, Fairchild led the development of CCD Technology. Since the beginning, the buried-channel concept has been utilized in all CCD products. The product line therefore exhibits all the advantages of buried-channel technology including low noise, high speed and high density.

Transferring this process from an R & D operation to a volume production environment required extensive efforts in research, design, development and production engineering. Our efforts paid off. Fairchild leads the way in CCD technology.

Fairchild CCD Imaging offers a broad product line. Specifically, we offer line scan sensors with 256 to 3,456 elements of resolution. We carry a full line of both line scan and area cameras. In addition we have a new line of vision interface processors. We also offer signal processing devices including video delay lines.

The '80s is the CCD Decade. And Fairchild is the CCD Leader.

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TABLE OF CONTENTS

INTRODUCTION

Line Scan Image Sensors

Basically, a line scan image sensor is composed of a row of image sensing elements (photosites), two analog transport registers, and an output amplifier. Light energy falls on the photosites and generates charge packets proportional to the light intensity. These charge packets are then transferred in parallel to two analog transport registers, which are clocked by 2-phase clocks. The packets are next delivered to an on-chip output amplifier where they are converted to proportional voltage levels. A series of pulses, amplitude modulated with the optical information, appear at the output.

Key advantages of Fairchild CCD line scan sensors, due to Fairchild's Isoplanar buried-channel structure, include high data rates, high charge transfer efficiencies, low noise, and relatively small die sizes.

Line scan sensors find applications ranging from optical character recognition (OCR) using the 256 × 1 device to facsimile sensing using the 1728 × 1 or 3456 × 1 device. The precise location of the photosites on the sensor allows the device to be used in high precision non-contact measurement applications such as dimensional measurements of objects, shape recognition and sorting, and defect detection.

The following tables summarize the features of Fairchild's Line Scan Imaging Products.

Line Scan Sensor

Order Code	Number of Elements	Element Size	Maximum Data Rate	Range (Typical)	Responsivity (Typical)
CD111ADC	256×1	13×17 microns	10 MHz	2500:1	1.3 V per μj/cm^2
CD111BDC	256×1	13×17 microns	10 MHz	2500:1	1.1 V per μj/cm^2
CCD112DC	256×1	13×13 microns	5 MHz	5000:1	3.0 V per μj/cm^2
CCD133DC	1024×1	13×13 microns	20 MHz	5000:1	3.0 V per μj/cm^2
CCD134DC	1024×1	13×13 microns	20 MHz	5000:1	3.0 V per μj/cm^2
CCD122DC	1728×1	13×13 microns	2 MHz	2500:1	3.5 V per μj/cm^2
CCD123DC	1728×1	10×13 microns	2 MHz	2500:1	3.5 V per μj/cm^2
CCD143DC	2048×1	13×13 microns	20 MHz	5000:1	3.0 V per μj/cm^2
CCD145DC	2048×1	13×13 microns	8 MHz	2500:1	4.0 V per μj/cm^2
CCD151DC	3456×1	7×7 microns	5 MHz	2500:1	4.0 V per μj/cm^2

Line Scan Design Aids (do not include sensors)

Order Code	Sensor Supported	Comments
I-SCAN*	CD111ADC	Fairchild offers a series of printed circuit boards for use as construction aids for experimental systems using CCD line scan image sensors. These design and development boards are fully assembled and tested, and require only power supplies and an oscilloscope to display the video information corresponding to the image positioned in front of the sensor.
CCD133DB	CCD133DC	
CCD122DB	CCD122DC	
CCD143DB	CCD143DC	
CCD151DB	CCD151DC	

* I-SCAN includes CD111ADC

Camera Subsystems

Fairchild CCD camera subsystems are fully assembled and calibrated electro-optical instruments useful in a wide variety of scientific and industrial applications.

Each subsystem is comprised of a camera, a line-powered control unit, and interconnecting cables. The camera, which may be ordered separately, may be equipped with a lens suitable for the application.

Line Scan Camera resolutions of 256, 512, 1024 and 2048 elements per line are available. Line scan subsystems are particularly useful for acquisition of optical data for objects in motion, i.e., facsimile scanning of documents transported past the camera's field of view or measurement of objects carried past a camera inspection station on a conveyor belt. Typical subsystem applications include microfiche and microfilm scanning, document scanning for mark sensing, facsimile transduction and OCR data acquisition; precision non-contact measurement and inspection, flaw detection, shape analysis, dimensional measurement, color sorting; and for a wide variety of laboratory uses.

Area Cameras are ideally suited for industrial environments. The CCD3000 Video Communications Camera provides standard television output signals for display of high-resolution images on low-cost monitors or for digital analysis using NTSC image processing equipment. The CCD3000 is also available with a fiber optic faceplate for interfacing to customer fiber optic image inputs as well as with an image intensifier for low light level applications. The CCD4001 Robotics Camera provides image data output in a non-interlaced 256 by 256 element square pixel pitch format which can be utilized by a CPU for automatic inspection, recognition and robot guidance. All Fairchild area cameras can be used as a relatively small single-component camera, or be separated into a camera control unit plus a cable-connected sense head which is robust enough to be mounted onto a robot arm.

Commercial Line Scan Camera System
Includes Camera Control Unit and Interconnect Cables
Camera only may be ordered as CAM1100C, CAM1200C, CAM1300C, CAM1400C or CAM1500C

Order Code	Number of Elements	Line Scan Rate	Exposure Time	Data Rate
CCD1100C	256×1	60 Hz - 35 KHz	30 µs - 16 ms	100 KHz - 10 MHz
CCD1200C	512×1	60 Hz - 20 KHz	51 µs - 16 ms	100 KHz - 10 MHz
CCD1300C	1024×1	60 Hz - 10 KHz	102 µs - 16 ms	100 KHz - 10 MHz
CCD1400C*	1728×1	60 Hz - 6 KHz	175 µs - 16 ms	100 KHz - 10 MHz
CCD1500C	2048×1	60 Hz - 5 KHz	204 µs - 16 ms	100 KHz - 10 MHz

* The CCD1400C and CAM1400C are being discontinued. Stock is currently available in small quantities.

Industrial Line Scan Camera System (camera only)

Order Code	Number of Elements	Max. Line Scan Rate	Min. Exposure Time	Data Rate
CCD1200R	512×1	38 K lines/sec	26 µs	100 KHz - 20 MHz
CCD1300R	1024×1	19 K lines/sec	52 µs	100 KHz - 20 MHz
CCD1500R	2048×1	9.7 K lines/sec	103 µs	100 KHz - 20 MHz

Area Camera Systems

Includes Camera, Power Supply and Remote Sense Head Cable
Camera only may be ordered as CAM3000, CAM3100, CAM3000F, CAM3100F or CAM4001

Order Code	Scanning format	Comment
CCD3000	Full 488×380 NTSC Resolution	
CCD3100	Full 488×380 NTSC Resolution	222A Sensor
CCD3000F	Full 488×380 NTSC Resolution	Fiber Optic Faceplate
CCD3100F	Full 488×380 NTSC Resolution	222A and Fiber Optic Faceplate
CCD4001	256×256 Non-Interlaced	

Camera Accessories

Order Code	For use with	Description
LENS13C	All (except CCD1500)	13 mm Lens, Standard C Mount
LENS25C	All (except CCD1500)	25 mm Lens, Standard C Mount
LENS50C	All (except CCD1500)	50 mm Lens, Standard C Mount
LENS28B	CCD1500C, CCD1500R	28 mm Lens, Bayonet Mount
LENS50B	CCD1500C, CCD1500R	50 mm Lens, Bayonet Mount
CNTRLINE	Comm. Line Scan Camera	Control Unit with Interconnect Cables
CABLE	Comm. Line Scan Camera	Interconnect Cables only
CABLAUTO	CCD3000, CCD3000F	Remote Sense Head Cable for CCD3000
CABL4001	CCD4001	Remote Sense Head Cable for CCD4001
PWRSPLY	CCD3000	Power Supply
PIX1100	CCD1100C	Pixel Locator
PIX1200	CCD1200C	Pixel Locator
PIX1300	CCD1300C	Pixel Locator
PIX1400	CCD1400C	Pixel Locator
PIX1500	CCD1500C	Pixel Locator
MONITOR	CCD3000, CCD4001	NTSC Monitor, Black and White

Vision Interface Processor

In many applications there is a need for decision-making based on the data from CCD cameras rather than just for a display of imagery. To yield a decision, the camera data must first be converted from analog to digital and subsequently interpreted. Fairchild's multibus* formatted VIP100 Vision Interface Processor accepts analog video from any Fairchild CCD camera. It converts the analog video to binary and then processes the converted data, which enables it to perform a host of industrial inspection and robotic vision system functions. Processing is accomplished using the on-board 16-bit 20MHz Fairchild F9445 microprocessor. Applications include Non-Contact Measurement, Defect, Surface Flaw and Edge Flaw Detection, Automated Parts sorting, OCR, Shape and Pattern Recognition, Object Recognition and Robot Guidance.

This versatile board is capable of being used as a stand alone processor or as part of a larger system using the link to the multibus, either of two RS-232 ports or separate user configurable 16-bit data input and output ports.

Computer Interface Systems

Order Code	For use with	Description
VIP100-20	All Fairchild cameras	Vision Interface Card with 20 MHz F9445

*Multibus is a trademark of Intel Corporation

Signal Processing

The capability to manipulate information in the form of discrete charge packets makes CCD technology ideal for analog signal processing. Fairchild signal processing components are monolithic silicon structures comprised of CCD analog shift registers, charge injection ports, and output charge-sensing amplifiers. They can be advantageously used for delay and temporary storage of analog video signals. The time delay for data transit through the CCD register is precisely controlled by the frequency of the externally supplied transport clock signal. Fairchild signal processing components include a sample-and-hold signal output stage for ease of application.

Fairchild video delay modules are printed circuit board structures which include the CCD321A3 device and are sold as fully assembled and calibrated units. The module is equipped for use as a variable delay circuit, using either an externally supplied or internal variable frequency clock, or for temporary analog data storage in a stopped-clock mode.

Typical applications for the CCD signal processing components and modules include time base correction for video tape recorders, fast input-slow output data expansion systems for A-D converter systems, comb filter realizations, drop-out compensators, and other analog applications up to frequencies of 30 MHz data rate.

Signal Processing Products

Order Code	Description
CCD321A1	NTSC Broadcast Quality Video Delay Line
CCD321A2	NTSC Industrial Quality Video Delay Line
CCD321A3	NTSC Time Base Correction Video Delay Line
CCD321VM	Video Delay Module (includes the CCD321A3)
CCD323A	PAL Video Delay Line

For further information on Fairchild CCD Imaging and Signal Processing products, call your nearest Fairchild Sales Office, representative, or distributor.

For technical or applications information and assistance, call (415) 493-8001, (TWX 910-373-2110) or write Fairchild CCD Imaging, 3440 Hillview Avenue, Palo Alto, California 94304.

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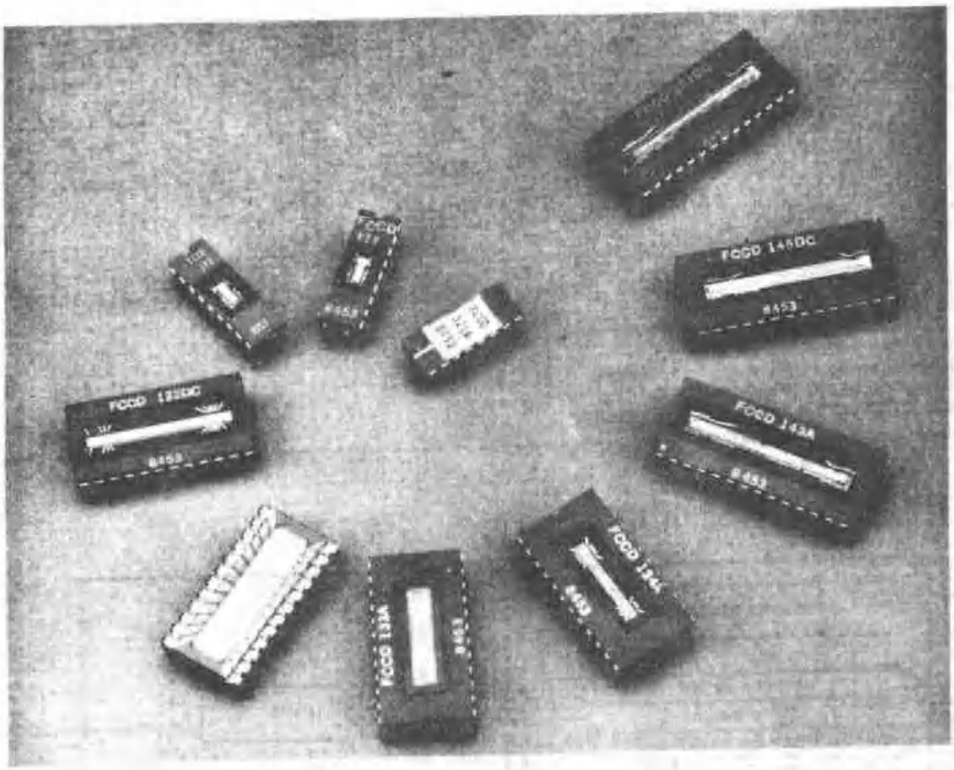

Sensors

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CCD 111
256-Element
Line Scan Image Sensor

CCD Imaging

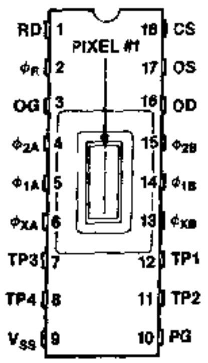
Description
The CCD111 is a monolithic 256-element line image sensor. The device is designed for optical character recognition and other imaging applications that require high sensitivity and high speed. The CCD111 is pin-for-pin compatible with and a functional replacement for the CCD110F.

In addition to a line of 256 sensing elements, the CCD111 chip includes: two charge transfer gates, two 2-phase analog transport shift registers, an output charge detector/amplifier, and a compensation amplifier. The transport registers both feed the input of the charge detector resulting in sequential reading of the 256 sensing elements.

The cell size is 13 μm (0.51 mils) by 17 μm (0.67 mils) on 13 μm (0.51 mils) centers. The device is manufactured using Fairchild advanced charge-coupled device n-channel Isoplanar buried-channel technology.

- DYNAMIC RANGE TYPICAL: 2500:1
- ON-CHIP VIDEO AND COMPENSATION AMPLIFIERS
- LOW POWER REQUIREMENTS
- ALL OPERATING VOLTAGES 15V AND UNDER
- LOW NOISE EQUIVALENT EXPOSURE
- DIMENSIONALLY PRECISE PHOTOSITE SPACING

Connection Diagram

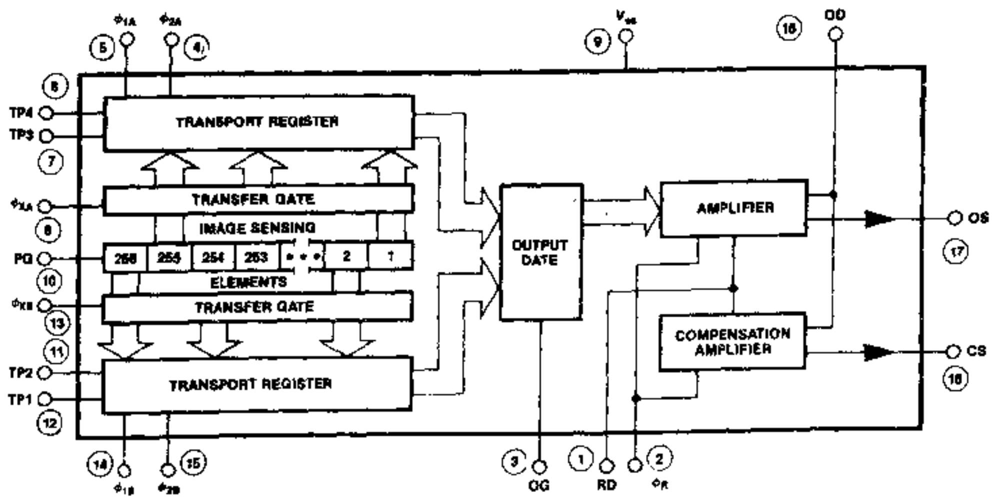


DIP (TOP VIEW)

Pin Names:

PG	Photogate
ϕ_{XA}, ϕ_{XB}	Transfer Clock
ϕ_{1A}, ϕ_{2A}, ϕ_{1B}, ϕ_{2B}	Transport Clocks
OG	Output Gate
OS	Output Source
OD	Output Drain
CS	Compensation Source
ϕ_R	Reset Clock
RD	Reset Drain
TP	Test Point
V_{ss}	Substrate (ground)

Block Diagram



Functional Description
The CCD111 consists of the following functional elements illustrated in the Block Diagram:

Image Sensor Elements — A row of 256 image sensor elements separated by a diffused channel stop and covered by a silicon photogate. Image photons pass through the transparent polycrystalline silicon photogate and are absorbed in the single crystal silicon creating hole-electron pairs. The photon generated electrons are accumulated in the photosites. The amount of charge accumulated in each photosite is a linear function of the incident illumination intensity and the integration period. The output signal will vary in an analog manner from a thermally generated background level at zero illumination to a maximum at saturation under bright illumination.

Two Transfer Gates — Gate structures adjacent to the row of image sensor elements. The charge packets accumulated in the image sensor elements are transferred out via the transfer gates to the transport registers whenever the transfer gate voltages go HIGH. Alternate charge packets are transferred to the left and right transport registers. The transfer gates also control the integration time for the sensing elements.

Two 130-Bit Analog Transport Shift Registers — One on each side of the line of image sensor elements and are separated from it by a transfer gate. The two registers, called the transport registers, are used to move the light generated charge packets delivered by the transfer gates serially to the charge detector/amplifier. The complementary phase relationship of the last elements of the two transport registers provides for alternate delivery of charge packets to establish the original serial sequence of the line of video in the output circuit.

A Gated Charge Detector/Amplifier — Charge packets are transported to a precharged diode whose potential changes linearly in response to the quantity of the signal charge delivered. This potential is applied to the gate of the output n-channel MOS transistor producing a signal at the output OS. A reset transistor is driven by the reset clock (ϕ_R) and recharges the charge detector diode capacitance before the arrival of each new signal charge packet from the transport registers.

Definition of Terms

Charge-Coupled Device — A charge-coupled device is a semiconductor device in which finite isolated charge packets are transported from one position in the semiconductor to an adjacent position by sequential clocking of an array of gates. The charge packets are minority carriers with respect to the semiconductor substrate.

Transfer Clocks ϕ_{XA}, ϕ_{XB} — The voltage waveforms applied to the transfer gates to move the accumulated charge from the image sensor elements to the CCD transport registers.

Transport Clocks ϕ_{1A}, ϕ_{2A}, ϕ_{1B}, ϕ_{2A} — The two sets of 2-phase waveforms applied to the gates of the transport registers to move the charge packets received from the image sensor elements to the gated charge detector/amplifier.

Gated Charge Detector/Amplifier — The output circuit of the CCD111 that receives the charge packets from the transport registers and provides a signal voltage proportional to the size of each charge packet received. Before each new charge packet is sensed, a reset clock returns the charge detector voltage to a fixed level.

Reset Clock ϕ_R — The voltage waveform required to reset the voltage on the charge detector.

Dynamic Range — The saturation exposure divided by the rms noise equivalent exposure. (This does not take into account dark signal components.) Dynamic range is sometimes defined in terms of peak-to-peak noise. To compare the two definitions a factor of four to six is generally appropriate in that peak-to-peak noise is approximately equal to four to six times rms noise.

RMS Noise Equivalent Exposure — The exposure level that gives an output signal equal to the rms noise level at the output in the dark.

Saturation Exposure — The minimum exposure level that will produce a saturation output signal. Exposure is equal to the light intensity times the photosite integration time.

Charge Transfer Efficiency — Percentage of valid charge information that is transferred between each successive stage of the transport registers

Spectral Response Range — The spectral band in which the response per unit of radiant power is more than 10% of the peak response.

Responsivity — The output signal voltage per unit exposure for a specified spectral type of radiation. Responsivity equals output voltage divided by exposure.

Total Photoresponse Non-uniformity — The difference of the response levels of the most and the least sensitive

CCD111

element under uniform illumination. Measurement of PRNU excludes first and last elements. (See accompanying photos for details of definition.)

Dark Signal — The output signal in the dark caused by thermally generated electrons that is a linear function of the integration time and highly sensitive to temperature. (See accompanying photos for details of definition.)

Saturation Output Voltage — The maximum useable signal output voltage. Charge transfer efficiency decreases sharply when the saturation ouput voltage is exceeded.

Integration Time — The time interval between the falling edges of any two transfer pulses ϕ_{XA} or ϕ_{XB} as shown in the timing diagram. The integration time is the time allowed for the photosites to collect charge.

Pixel — A picture element (photosite).

Peripheral Response — The output signal caused by light-generated charge that is collected by the transport registers (instead of the photosites). The device is covered, except over the photosites, by a gapped metal layer, which functions both as an array of interconnections and as a reflective light shield. The major component of Peripheral Response for visible light ($\lambda \leq 700$nm) is generated in the transport registers by light transmitted through these gaps in the metal above the registers. For near-infrared light ($\lambda \geq 700$nm), especially on CCD111A devices, a portion of the charge generated by light absorbed under the photosites and one transport register is collected in the opposite transport register.

Major Differences Between the CCD111A and CCD111B
Both the CCD111A and the CCD111B have the same responsivity to visible light (400-700nm). The principal differences are as follows:

The CCD111A is intended for use in applications where very low dark signal and high responsivity to very near-infrared (700-900nm) light are needed, and where peripheral response is not critical.

The CCD111B is selected for use in applications where standard responsivity to very near-infrared (700-900nm) light and standard dark signal are acceptable and where peripheral response needs to be minimized.

It is not recommended that either part be used with illumination containing wavelengths greater than 900nm (near-infrared). If use of such a light source (unfiltered tungsten, for example) is unavoidable, the CCD111B will generally provide the user with more satisfactory results. The table on performance characteristics provides more information.

Absolute Maximum Ratings

Storage Temperature	−25°C to 100°C
Operating Temperature	−25°C to 55°C
Pins 2, 3, 4, 5, 6, 7, 10, 12, 13, 14, 15	−0.3V to 15V
Pins 1, 8, 11, 16	−0.3V to 18V
Pins 17, 18	output, no voltage applied
Pin 9	0V

Caution Note
This device has limited built-in gate protection. It is recommended that static discharge be controlled and minimized. Care must be taken to avoid shorting pins OS and CS to V_{SS} or V_{OD} during operation of the device. Shorting these pins temporarily to V_{SS} or V_{OD} may destroy the output amplifiers.

DC Characteristics: T_c = 25°C (Note 1)

Symbol	Characteristic	Limits Min	Typ	Max	Unit	Condition
V_{OD}	Output Transistor Drain Voltage	14.5	15.0	15.5	V	
V_{RD}	Reset Transistor Drain Voltage	11.5	12.0	12.5	V	
V_{OG}	Output Gate Voltage		5.0		V	
V_{PG}	Photogate Voltage	9.5	10.0	12.5	V	
TP1, TP3	Test Points		0.0		V	
TP2, TP4	Test Points	14.5	15.0	15.5	V	

Clock Characteristics: $T_c = 25°C$ (Note 1)

Symbol	Characteristic	Limits			Unit	Condition
		Min	Typ	Max		
$V_{\phi 1AL}, V_{\phi 1BL}$ $V_{\phi 2AL}, V_{\phi 2BL}$	Transport Clocks LOW	0.0	0.5	0.8	V	Note 2
$V_{\phi 1AH}, V_{\phi 1BH}$ $V_{\phi 2AH}, V_{\phi 2BH}$	Transport Clocks HIGH	7.5	8.0	8.5	V	Note 5
$V_{\phi XAL}, V_{\phi XBL}$	Transfer Clock LOW	0.0	0.5	0.8	V	Notes 2, 5
$V_{\phi XAH}, V_{\phi XBH}$	Transfer Clock HIGH	7.5	8.0	8.5	V	Note 5
$V_{\phi RL}$	Reset Clock LOW	0.0	0.5	0.8	V	Notes 2, 5
$V_{\phi RH}$	Reset Clock HIGH	7.5	8.0	8.5	V	Notes 3, 5
$f_{\phi 1A}, f_{\phi 1B}$ $f_{\phi 2A}, f_{\phi 2B}$	Maximum Transport Clock Frequency		5.0		MHz	Note 5
$f_{\phi R}$	Maximum Reset Clock Frequency (Output Data Rate)		10.0		MHz	Note 6

AC Characteristics: $T_c = 25°C$, $f_{\phi R} = 1.0$ MHz, $t_{int} = 320\ \mu s$, $t_{transport} = 259\ \mu s$, Light Source = 2854°K + filters as specified. All operating voltages nominal specified values. (Note 1)

Symbol	Parameter	Range			Unit	Condition
		Min	Typ	Max		
DR	Dynamic Range (relative to rms noise) (relative to peak-to-peak noise)	 1250:1 250:1	 2500:1 500:1			Note 7
NEE	RMS Noise Equivalent Exposure		2×10^{-4}		$\mu J/cm^2$	
SE	Saturation Exposure		0.5		$\mu J/cm^2$	
CTE	Charge Transfer Efficiency		99.995		%	Note 8
SR	Spectral Response Range Limits		0.45 – 1.05		µm	
P	Power Dissipation		100		mW	$V_{OD} = 15V$
Z	Output Impedance		1000		Ω	
N	RMS Noise Peak-to-Peak Noise		80 400		µV	

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Performance Characteristics: T_c = 25°C, $f_{\phi R}$ = 1.0 MHz, t_{int} = 320μs, $t_{transport}$ = 259μs, Light Source = 2854°K + filters as specified. All operating voltages nominal specified values. (Note 1)

Symbol	Characteristic	Range CCD111A Min	CCD111A Typ	CCD111A Max	CCD111B Min	CCD111B Typ	CCD111B Max	Unit	Condition
PRNU	Photoresponse Non-uniformity Peak-to-Peak								
	2854°K + 700 nm cutoff filter		35	70		25	70	mV	14, 15, 16
	2854°K + 900 nm cutoff filter		45	110		45	110	mV	14, 15, 16
	2854°K unfiltered		70			60		mV	14, 15, 16
	Single-pixel Positive Pulses		<10			<10		mV	15, 16
	Single-pixel Negative Pulses		20	60		20	60	mV	15, 16
RI	Register Imbalance ('Odd'/'Even')		<5			<5		mV	15, 16
DS	Dark Signal DC Component	0	<1	3	0	2	15	mV	2, 9, 10
	Low Frequency Component	0	<1	2	0	2	10	mV	2, 9, 11
SPDSNU	Single-pixel DS Non-uniformity	0	<1	2	0	1	2	mV	9, 11, 12
PR	Peripheral Response								
	2854°K + 700 nm cutoff filter		10	17		<2	5	% of V_{OUT}	14
	2854°K + 900 nm cutoff filter		12	20		3	7	% of V_{OUT}	14
	2854°K unfiltered		25			4		% of V_{OUT}	14
R	Responsivity								
	2854°K + 700 nm cutoff filter	0.7	1.3	2.1	0.5	1.1	2.0	V/μJ/cm²	13, 14
	2854°K + 900 nm cutoff filter	1.3	2.4	3.8	0.8	1.6	2.4	V/μJ/cm²	13, 14
	2854°K unfiltered		2.0			0.9		V/μJ/cm²	13, 14
V_{SAT}	Saturation Output Voltage	500	900		500	900		mV	17

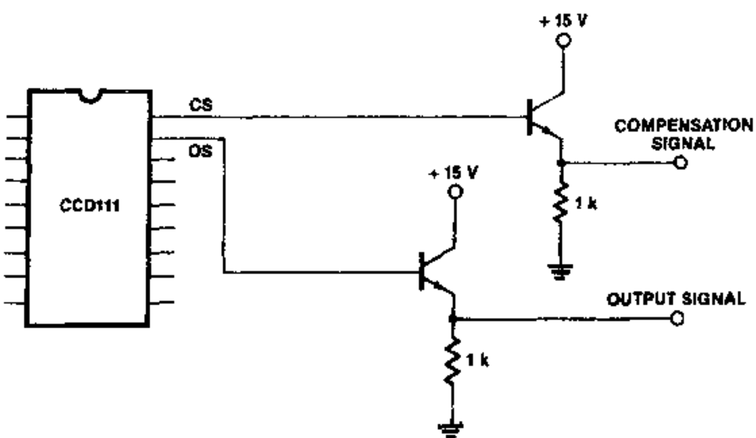
Notes

1. T_C is defined as the package temperature, measured on the back surface of the ceramic body.
2. Negative transients on any clock pin going below 0.0V may cause charge injection that results in an increase in the apparent Dark Signal.
3. $V_{\phi RH}$ should track V_{RD}.
4. The data output frequency $f_{\phi R}$ is twice that of each transport clock ($f_{\phi 1A}$, $f_{\phi 1B}$, $f_{\phi 2A}$, $f_{\phi 2B}$)
5. $C_{\phi XA} = C_{\phi XB}$ = 20pF, $C_{\phi 1A} = C_{\phi 2A} = C_{\phi 1B} = C_{\phi 2B}$ = 32pF, $C_{\phi R}$ = 5pF
6. Minimum reset clock frequency is limited by the increase in Dark Signal
7. Dynamic Range is defined as "V_{SAT}/rms (temporal) Noise" or "V_{SAT}/Peak-to-Peak (temporal) Noise."
8. CTE is measured for a one-stage transfer.
9. See photographs for Dark Signal definitions
10. DC and low-frequency Dark Signal components approximately double for every 5°C increase in T_C. The shift register component is also inversely proportional to $f_{\phi R}$
11. Single-pixel Dark Signal non-uniformity (SPDSNU) approximately doubles for every 8°C increase in T_C. They are also directly proportional to the integration time t_{int}
12. Each SPDSNU is measured from the DS level adjacent to the base of the SPDSNU
13. RESPONSIVITY is defined as the "volts of video output" per "Incident Radiant Energy measured over the 350 nm–1200 nm band." The device will not respond to infrared wavelengths longer than ≈ 1200 nm. However, 2/3 of the radiant energy from a 2854°K source is at λ > 1200 nm. For the unfiltered 2854°K source, the responsivity values for light measured over $0 < \lambda < \infty$ will be ~0.3X of the responsivity values for light measured over 350 nm < λ < 1200 nm

Notes (cont'd)

14. OPTICAL FILTERS. a "700 nm cutoff" filter is realized by using one "Wide Band Hot Mirror" (Optical Coating Labs, Inc., Santa Rosa, California) and one 2.0 mm thick "BG-38" blue glass (Schott Optical Glass, Duryea, Pennsylvania) filter in series. The "900 nm cutoff" filter is available on special order; consult Fairchild CCD Applications Engineering for details. Transmittance curves for the two cutoff filters and Spectral Energy Distribution curves for these filters with a 2854°K light source are given in the "Typical Performance Curves" section of this data sheet. It should be noted that the "2854°K + 700 nm cutoff" source is a good approximation to a Daylight Fluorescent bulb.
15. All PRNU measurements taken at a 350mV output level using a F/5.0 lens; all PRNU measurements exclude the outputs from the first and last photoelements of the array. The "f" number is defined as the distance from the lens to the array divided by the diameter of the lens aperture. As f number increases, the resulting more highly collimated light causes package window aberrations to dominate and increase the PRNU. A lower f number (f ≤ 5) results in less collimated light, causing photosite blemishes to dominate PRNU.
16. See photographs for PRNU definitions.
17. See test load configuration.

Test Load Configuration



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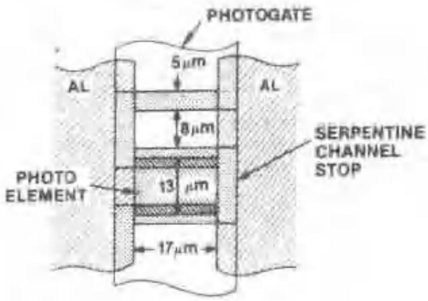
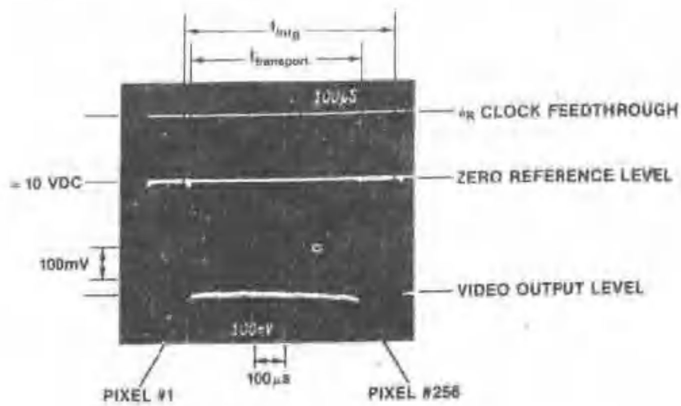
Photoelement Dimensions



ALL DIMENSIONS ARE TYPICAL VALUES.

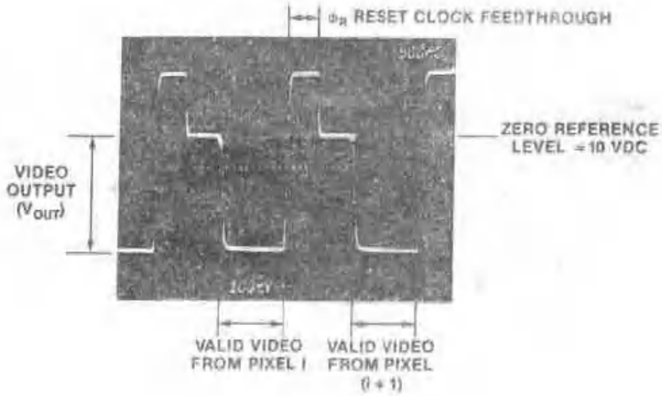
Output with Uniform Illumination



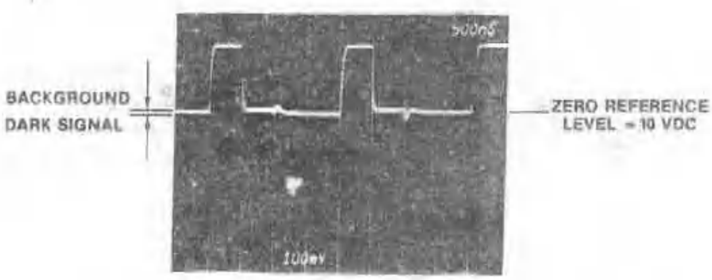
TEST CONDITIONS: T_C = +25°C, t_{int} = 640 µs, $f_{\phi R}$ = 512 kHz, "typ" voltage inputs, 2854°K + 700 nm cutoff filter set. (Half standard test speeds for clearer photos.)

Output of Two Pixels

DEVICE ILLUMINATED



DEVICE IN DARK

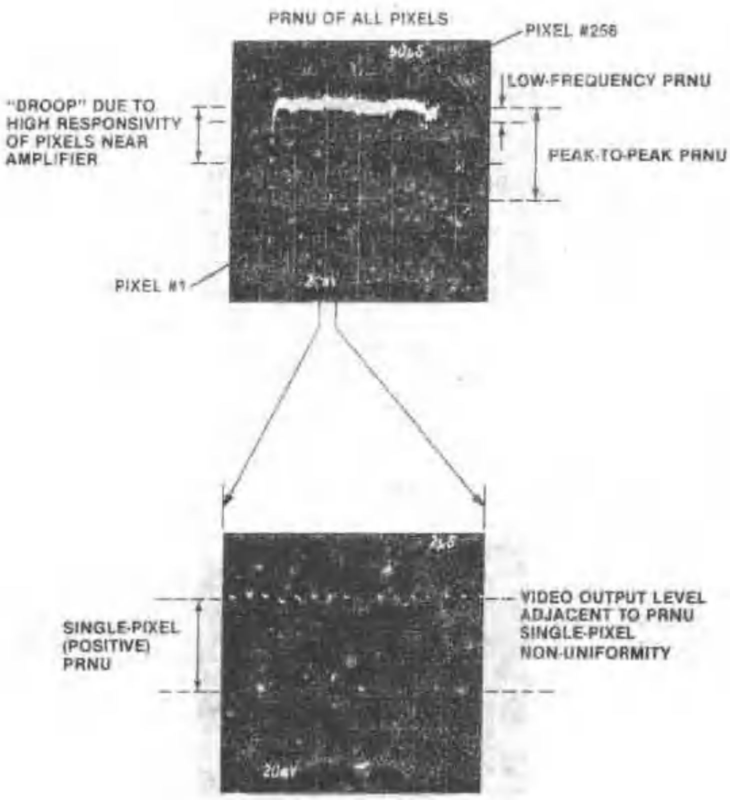


TEST CONDITIONS: T_C = +25°C, t_{int} = 640 μs, $f_{\phi R}$ = 512 kHz, "typ" voltage inputs, 2854°K + 700 nm cutoff filter set. (Half standard test speeds for clearer photos.)

CCD111

Photoresponse Non-uniformity

MEASURED AT V_{OUT} = 350 mV; ALL PRNU COMPONENTS EXCLUDE PIXELS #1 AND #256.



TEST CONDITIONS: T_C + 25°C, t_{int} = 320 μs, $f_{\phi R}$ = 1.0 MHz, "typ" voltage inputs, 2854°K + 700 nm cutoff filter set.