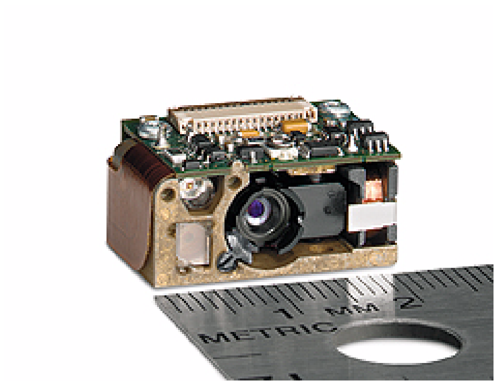
SE4400

Integration Guide



symbol®

The Enterprise Mobility Company™

SE4400
Integration Guide

72E-63399-04

Revision A

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The Enterprise Mobility Company ™

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Revision History

Changes to the original manual are listed below:

Change	Date	Description
72E-63399-01	6/2004	Initial release
72E-63399-02	8/2004	Updated mechanical drawing
72E-63399-03	4/2006	Update with engineering changes
72E-63399-04	1/2007	Added SE4400-E004E version decode ranges

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About This Guide

Introduction

The *SE4400 Integration Guide* discusses the theory of operation, installation, and specifications of the engine, and how to integrate the engine into data capture devices.

Note: *This guide provides general instructions for the installation of the engine into a customer's device. It is recommended that an opto-mechanical engineer perform an opto-mechanical analysis prior to integration.*

Chapter Descriptions

The manual includes the following chapters.

- *Chapter 1, Getting Started,* provides an overview of the engine and the theory of operation.
- *Chapter 2, Installation,* explains how to install the engine, including information on mounting, housing design, grounding, ESD, and environmental considerations.
- Chapter 3, *SE4400 Specifications*, provides technical specifications for the engine, including decode ranges.
- *Chapter 4, Electrical Interface,* includes signal information.
- *Chapter 5, Application Notes,* describes two modes the engine uses.
- *Appendix A, Register Settings,* provides register settings for the various engine modes.

Notational Conventions

The following conventions are used in this document:

- Bullets indicate:
  - action items
  - lists of alternatives
  - lists of required steps that are not necessarily sequential
- Sequential lists (e.g., those that describe step-by-step procedures) appear as numbered lists.

Referenced Documents

- *PL 4407 Decoder Integration Guide,* p/n 72E-68065-xx
- *The I^2C-Bus Specification, Version 2.1*, http://www.semiconductors.philips.com/acrobat/literature/9398/39340011.pdf
- *LC99704B-WK3 Sanyo DSP Specification*, *Version 1* (English)
- *LC99214 Sanyo B&W CCD Sensor Specification, Version 2* (English)
- *Molex connector specification*, 54809-3191, http://www.molex.com

Service Information

If you have a problem with your equipment, contact the *Symbol Global Customer Interactive Center* at: http://www.symbol.com/customersupport.

Call the Global Customer Interactive Center from a phone near the equipment so that the service representative can try to talk you through your problem. Have the model number and serial number of your product with you. If your problem cannot be solved over the phone, you may need to return your equipment for servicing. If that is necessary, you will be given specific directions.

Symbol Technologies is not responsible for any damages incurred during shipment if the approved shipping container is not used. Shipping the units improperly can possibly void the warranty. If the original shipping container was not kept, contact Symbol to have another sent to you.

If you purchased your Symbol product from a Symbol Business Partner, contact that Business Partner for service.

Chapter 1
Getting Started

Per FDA and IEC standards, the engine described in this guide is not given a laser classification. However, the following precautions should be observed:

Caution

> This laser component emits CDRH Class II/IEC Class I laser light. Do not stare into beam.

Overview

The SE4400 provides digital images which can be transmitted to a decoder to decode a bar code of any format supported by the decoding software. The SE4400 uses laser aiming and LED illumination, and can switch between two focus positions for extended working range or for more precise focusing in high-density bar code decoding or digital picture taking.

SE4400

The SE4400 contains:

- a monochrome VGA charge coupled device (CCD) imager system
- a laser-based aiming system
- an illumination system
- a motor drive for changing focus position
- ample signal processing to provide an 8-bit data output (grayscale) for each pixel of the CCD sensor array.

Figure 1-1 provides a block diagram of the imager system.

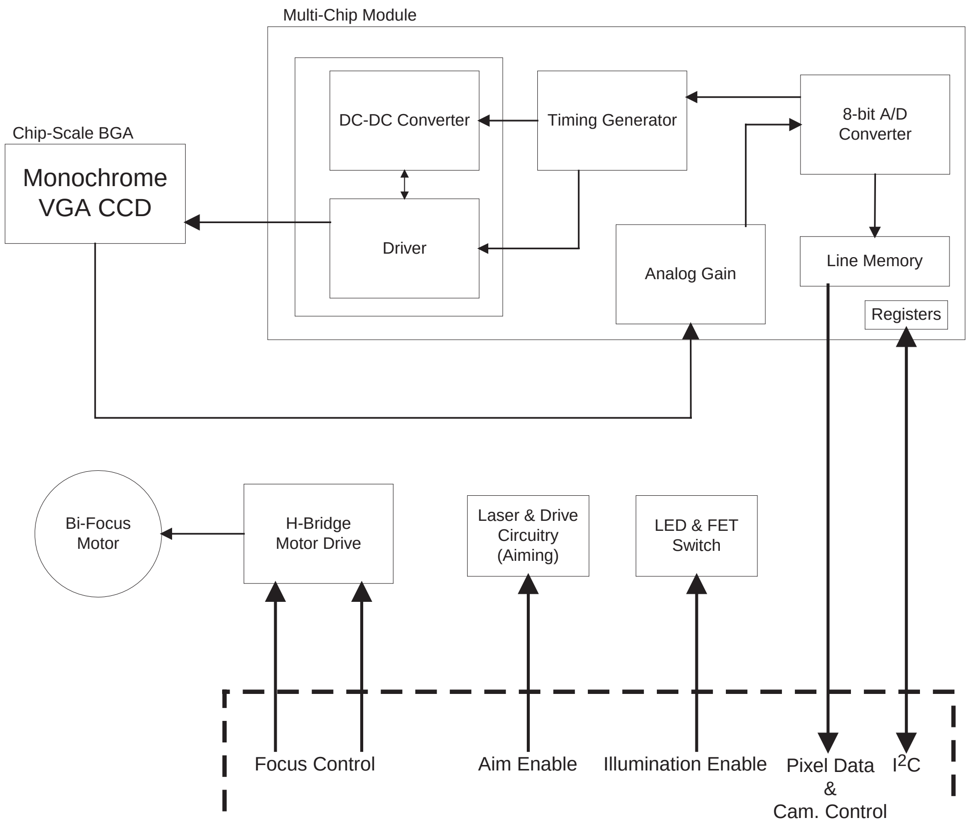


Figure 1-1. SE4400 Block Diagram

A 31-pin ZIF connector on the SE4400 connects the engine and the device via a 40 mm flex (available from Symbol, p/n 50-16000-650, via KT-SE4400-01). For information about this connector and flex, see Figure 4-1 on page 4-4 and Figure 4-3 on page 4-6.

The Visible Laser Diode (VLD) and a diffractive optical element (DOE) in the SE4400 generate an aiming pattern. The illumination LED allows image capture in any lighting condition.

The primary component of the imager system is a 1/5" format CCD monochrome VGA resolution sensor which consists of a 640 x 480 effective pixel array. The CCD sensor is a progressive scan type and converts the electrons depicting each pixel to a voltage, similar to a digital camera. An electronic shutter controls the exposure time of the sensor.

The CCD is accompanied by a signal processing companion multi-chip module (MCM), which contains the charge pumps and timing generator needed to drive the CCD. The MCM also contains a correlated double sampler (CDS) and A/D converter to convert the analog voltage output by the CCD into an 8-bit digital value representing one of 256 shades of gray.

Aiming System

A 650 nm laser and a DOE generate a laser-aiming pattern which represents the imager's field of view throughout its entire depth of field. The aiming subsystem uses a visible laser diode, a lens, and a diffractive optical element to generate the aiming pattern. The pattern's center cross hairs indicates the center of the field of view.

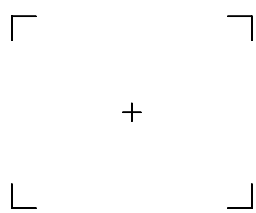


Figure 1-2. Aiming Pattern

Aiming Error

The aiming pattern is designed to eliminate divergence (parallax) between the aiming axis and the imaging axis. This method provides an aiming axis parallel to the imaging axis, while minimizing the offset between the two. See Table 3-1 on page 3-1 for Aiming Element specifications.

Aiming Control

The aiming subsystem is under dynamic software control and is independent of the illumination subsystem.

The SE4400 can capture images with both the aiming subsystem turned on (the image of the aiming pattern is captured in the digital image) and the aiming subsystem turned off.

Illumination System

An illumination subsystem, consisting of one red 635 nm LED, is provided to meet the image capture and decoding requirements throughout the full range of ambient lighting (total darkness to full sunlight).

Illumination Control

The SE4400 can capture images with the illumination subsystem turned on or off, accommodating images that are close to the wavelength of the illumination. For example, since red LED illumination is used, it may be desirable to shut off the illumination when capturing a printed image in red ink.

Focus Control

The SE4400 has two focus positions controlled by an electromagnetic motor, which is under dynamic software control and is independent of the illumination and aiming systems. The operating modes of the motor are:

- Disabled (off)
- Near Focus
- Far Focus
- Toggle (automatic switching between near and far focus positions).

Chapter 2
Installation

Overview

This chapter provides information for mounting and installing the SE4400, including physical and electrical considerations, and recommended window properties for the SE4400.

General Information

Grounding

The chassis is at ground. Isolate the SE4400 and host if installing the engine to a host that is not at ground, or has ground with the potential to inject noise.

Electrostatic Discharge (ESD)

The SE4400 is protected from ESD events that may occur in an ESD-controlled environment. Use care when handling this component and apply standard ESD handling procedures such as using grounding wrist straps and handling in a properly grounded work area.

Environment

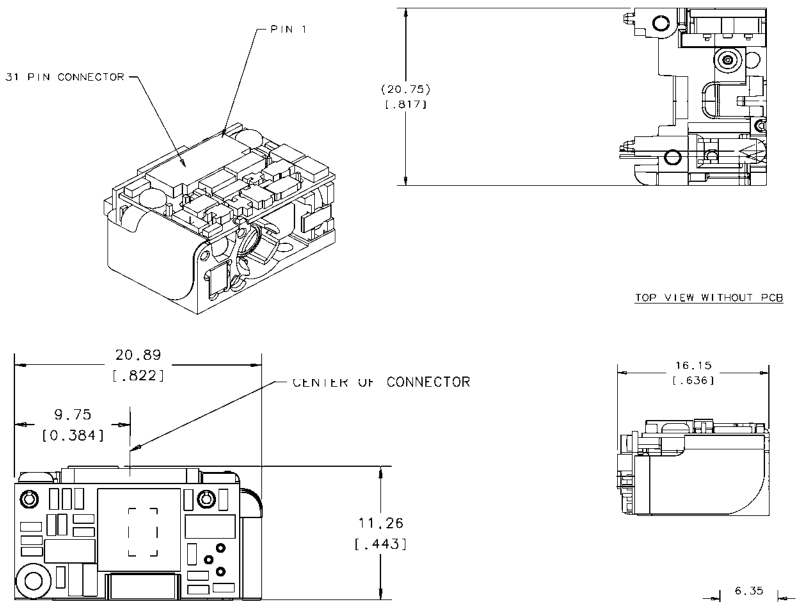
The engine and decoder must be sufficiently enclosed to prevent dust from gathering on the laser lens, optical lens, illumination system LEDs, and especially the CCD. Dust and other external contaminants eventually degrade unit performance. Symbol does not guarantee performance of the SE4400 when used in an exposed application.

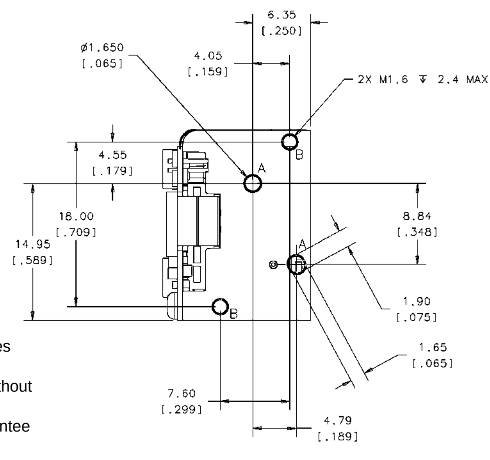
Mounting

There are two mounting holes (M1.6x0.35) and two locator holes on the bottom of the chassis (see Figure 2-1). The SE4400 can be mounted in any orientation without degradation in performance.

Note: *Mounting the SE4400 in a non-upright position results in images rotated accordingly in snapshot or video mode.*

When installing the mounting screws, ensure they do not protrude past the mounting hole threads in the chassis; use 2.4 mm maximum mounting screw thread engagement. Recommended mounting screw torque is 1.25 ±0.25 in-lb.





Notes: Unless otherwise specified:

- Chassis is at ground.
- Nominal aiming pattern envelope is 30^{o} x 22.5^{o}.
- Nominal imaging FOV envelope is 32^{o} x 24^{o}.
- Nominal illumination envelope is 40^{o} cone.
- Maximum envelopes do not include integration tolerances.
- SE4400 may be located with 1.2mm maximum long pins in 2 places marked “A”.
- Do not place any magnetic material within 1 inch of the chassis without testing performance.
- This is a reference drawing and is not intended to specify or guarantee all possible integration requirements for this engine.

Figure 2-1. SE4400 Mounting Diagram

Housing Design

Note: *Opto-mechanical analysis is recommended for housing design to ensure optimal scanning or imaging performance.*

Design the housing so that internal reflections from the illumination system are not directed back toward the engine. The reflections from the window can cause problems, and for particular window tilt angles, these reflections can bounce off the top or bottom of the housing and reach the engine.

The Exit Window Information (Table 2-4 on page 2-9) provides minimum exit window dimensions and tilt angles. These dimensional requirements can vary. Consider using baffles or matte-finished dark internal housing colors.

Optical

The SE4400 uses a sophisticated optical system that provides imaging performance that matches or exceeds the performance of much larger imagers. However, the performance of the SE4400 can be affected by an improperly designed enclosure, or improper selection of window material.

Positioning the Exit Window

Position the window so that illumination system light reflected off the inside of the window is not reflected back into the engine (see Table 2-4 on page 2-9). The specified angles are minimums; allow for manufacturing tolerances. If the designed enclosure cannot accommodate the recommended window angle, contact Symbol Technologies to discuss positioning requirements. An improperly positioned window can significantly decrease performance.

Avoiding Scratched Windows

Scratches on the window can greatly reduce the performance of the imaging system. We recommend recessing the window into the housing or applying a scratch resistance coating.

Window Material

Many window materials that look clear can contain stresses and distortions that reduce performance. For this reason, only cell-cast plastics or optical glass is recommended (with or without an anti reflection coating, depending on the application). Following are descriptions of three popular window materials: PMMA, ADC (CR-39™), and chemically tempered float glass. Table 2-1 outlines the suggested window properties.

Table 2-1. Suggested Window Properties

Material	Clear cell-cast acrylic
Thickness	0.06 in. (1.5 mm)
Wavefront Distortion (transmission)	0.2 wavelengths peak-to-valley maximum and 0.04 λ maximum rms over any 0.08 in. diameter within the clear aperture
Clear Aperture	To extend to within 0.04 in. of the edges all around
Surface Quality	60-20 scratch/dig

Cell Cast Acrylic (ASTM: PMMA)

Cell Cast Acrylic, or Poly-methyl Methacrylic (PMMA) is fabricated by casting acrylic between two precision sheets of glass. This material has very good optical quality, reasonably good impact resistance and low initial cost, but is relatively soft and susceptible to attack by chemicals, mechanical stresses, and UV light. Therefore polysiloxane coating is strongly recommended. Acrylic can be laser cut into odd shapes and ultrasonically welded.

Cell Cast ADC (ASTM: ADC)

Also known as CR-39™, Allyl Diglycol Carbonate (ADC) is a thermal-setting plastic produced by cell-casting. Most plastic eyeglasses sold today are uncoated, cell-cast CR-39. This material has excellent chemical and environmental resistance, and reasonably good impact resistance. It also has quite good surface hardness, and therefore does not have to be hard-coated, but may be coated for severe environments. This material cannot be ultrasonically welded.

Chemically Tempered Float Glass

Glass is a hard material that provides excellent scratch and abrasion resistance. However, unannealed glass is brittle. Increasing flexibility strength with minimal optical distortion requires chemical tempering. Glass cannot be ultrasonically welded and is difficult to cut into odd shapes.

Commercially Available Coatings

Anti-Reflection Coatings

Anti-reflection coatings can be used for stray light control or to achieve maximum working range, and can be applied to the inside and/or outside of the window to reduce the amount of light reflected off the window back into the engine. However, they are expensive and have very poor abrasion and scratch resistance.

Polysiloxane Coating

Polysiloxane type coatings are applied to plastic surfaces to improve the surface resistance to both scratch and abrasion. To apply, dip and air dry in an oven with filtered hot air.

To gauge a window's durability, use ASTM standard D1044, Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion (the Taber Test), which quantifies abrasion resistance as a percent increase in haze after a specified number of cycles and load. Lower values of the increase in haze correspond to better abrasion and scratch resistance. See Table 2-2.

Table 2-2. Taber Test Results on Common Exit Window Materials

Sample	Haze 100 cycles	Haze 500 cycles	Abrasion Resistance
Chemically Tempered Float Glass	1.20%	1.50%	Best
PMMA with Polysiloxane Hardcoat	3%	10%	
ADC	5%	30%	
PMMA	30%		Worst
* All measurements use a 100 gram load and CS-10F Abraser.			

A Word About Coatings

In all cases, adhere to the minimum tilt angle specified in Table 2-4 on page 2-9. When the SE4400 is set to an exposure time less than 10 milliseconds and gain less than 127, anti-reflection coating is not necessary (see *Exposure & Gain Control* on page 5-16). Otherwise, consider single-side or double-side AR coatings. If using an anti-reflective coating, polysiloxane coating is not required. Recess the exit window to minimize scratches and digs.

If using an anti-reflective coating, the specifications in Table 2-3 apply.

Table 2-3. AR Coatings Specifications

Material	Both tempered glass and plastic (e.g., CR-39 or hard coated acrylic) exit windows can be AR coated. AR coated glass is easier and more durable because of a better adhesion property on the glass structure. In addition, it can be more cost effective to put an AR coating on the glass substrate rather than on the plastic.
AR Coating Specification	1. One side tempered AR coating: 92% minimum within spectrum range from 450nm to 700nm. 2. Double side AR coating: One side AR coating must be 97% minimum within spectrum range from 450nm to 700nm.

Optical Path and Exit Window

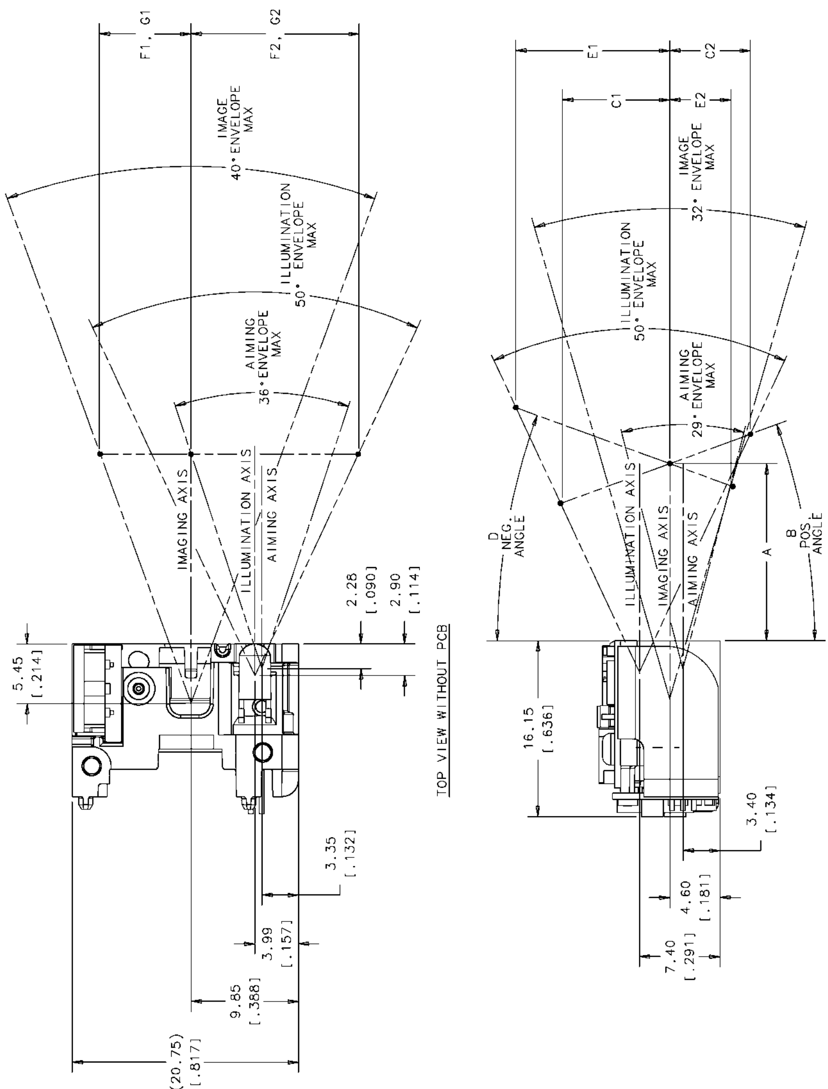


Figure 2-2. SE4400 Optical Path and Exit Window

Recommended Exit Window Information

See *Exit Window Notes* on page 2-10 for important information about Table 2-4.

Table 2-4. Recommended Exit Window Information

Distance From SE4400 At Imaging Axis			**A**	**Near Zone**				**Far Zone**							
				1.00 mm (0.04 in.)		**2.00 mm (0.08 in.)**		**3.80 mm (.15 in.)**		**6.35 mm (.25 in.)**		**8.90 mm (.35 in.)**		**11.5 mm (.45 in.)**	
Minimum Window Tilt Non-A/R Coated (*)		Positive Angle	**B**	$0.0^{\circ} \pm 0.5^{\circ}$		$0.0^{\circ} \pm 0.5^{\circ}$		$>20^{\circ}$		$>25^{\circ}$		$>25^{\circ}$		$>25^{\circ}$	
Minimum Window Clear Aperture Height (= C1+C2) (mm)		Positive Angle	**C**	6.7		7.5		8.3		11.0		12.8		14.7	
C1 (mm)	C2 (mm)			4.6	2.1	5.1	2.4	5.1	3.2	6.5	4.5	7.5	5.3	8.5	6.2
Minimum Window Clear Aperture Width (= F1+F2) (mm)		Positive Angle	**F**	10.1		10.8		13.1		16.3		18.4		20.7	
F1 (mm)	F2 (mm)			2.4	7.7	2.7	8.1	3.8	9.3	5.7	10.6	6.7	11.7	7.8	12.9
Minimum Window Tilt Non-A/R Coated (*)		Negative Angle	**D**	$0.0^{\circ} \pm 0.5^{\circ}$		$0.0^{\circ} \pm 0.5^{\circ}$		$<-30^{\circ}$		$<-35^{\circ}$		$<-35^{\circ}$		$<-35^{\circ}$	
Minimum Window Clear Aperture Height (= E1+E2) (mm)		Negative Angle	**E**	6.7		7.5		13.0		16.4		18.5		25.2	
E1 (mm)	E2 (mm)			4.6	2.1	5.1	2.4	9.9	3.1	12.6	3.6	14.3	4.2	20.7	4.5
Minimum Window Clear Aperture Width (= G1+G2) (mm)		Negative Angle	**G**	10.1		10.8		16.6		19.5		22.0		24.5	
G1 (mm)	G2 (mm)			2.4	7.7	2.7	8.1	5.3	11.3	6.7	12.8	7.9	14.1	9.1	15.4

Exit Window Notes

- For near zone, A is measured from the back surface (farther from the engine) of the exit window.
- For far zone, A is measured from the front surface (closer to the engine) of the exit window.
- Near and far zones, specified in Table 2-4 on page 2-9, are primarily defined for the exit-window distance measured from the engine. This ensures the system does not have stray light (the internal reflection) impact from the LED illumination. When these recommendations are followed, there is no impact on the performance of near or far distances. The terminology near or far image focusing is used to depict different performance configurations.
- Test condition was set at 10 maximum millisecond exposure time and 127 maximum gain.
- Consider anti-reflection coating if the exposure time is more than 10 msec. For example, for a 30 msec exposure time, use a double-sided AR coated exit window. (See Table 2-3 on page 2-7.)
- The distance between 2 mm (0.08 inch) and 3.8 mm (0.15 inch) is regarded as "gray area" and not recommended for use.
- Either positive or negative tilt angles can be used for the exit-window, based on the housing design.
- INTEGRATION TOLERANCES ARE NOT INCLUDED.

Chapter 3
SE4400 Specifications

Overview

This chapter provides the technical specifications of the SE4400. Decode zone and exit window characteristics are also provided.

Technical Specifications

Table 3-1. SE4400 Technical Specifications at 23° C

Item	Description
Power Requirements	
Input Voltage	2.85 V to 3.45 V
Camera Operating Current	79 mA typical
Additional Motor Current	30 mA typical
Additional Laser Current	45 mA typical
Peak Camera Current	320 mA (duration ~88 µs)
Illumination Current	36 mA @ 3.0 V typical 47 mA @ 3.3 V typical
Maximum Power Supply Noise	75 mVp-p (at 3.3 VDC)* for decoding 30 mVp-p (at 3.3 VDC) for picture taking
*The bar code may decode even with visible noise on the image. For best image quality when taking pictures, use a filter to suppress incoming Vcc noise (only necessary on pins J1-8 & J1-9). Vcc noise generated by the SE4400 occurs during non-critical times and does not affect performance.	

Table 3-1. SE4400 Technical Specifications at 23° C (Continued)

Item	Description
Minimum Optical Resolutions	6.67 mil (PDF417), 5 mil (Code 39)
Aiming Delays **Laser Turn On Time** **Laser Turn Off Time**	 494 µs typical 43 µs typical
Illumination Delays **LED Turn On Time** **LED Turn Off Time**	 27 µs typical 48 µs typical
Focus Motor Delay	20ms max
Specular Dead Zone **Illumination On** **Illumination Off**	 15º None
Skew Tolerance	± 50º from normal (see Figure on page 3-4)
Pitch Angle	± 60º from normal (see Figure on page 3-4)
Roll	360º (see Figure on page 3-4)
Ambient Light Immunity **Sunlight**	 9000 ft. candles (96,900 lux)
Scan Element **Image Resolution** **Gray Level** **Field of View (FOV)**	 640 x 480 pixels (VGA type CCD) 256 shades of gray 32.2º horizontal, 24.5º vertical
Focusing Distance from Front of Engine **Near Focus** **Far Focus**	 5 inches 9 inches
Aiming Element **Visible Laser Diode (VLD)** **VLD Power** **Pattern Angle** **Aiming Error**	 650 nm ± 5 nm 0.7 mW Maximum 30.0º horizontal, 22.5º vertical Total aiming error is 6.0 mm offset (horizontal) Maximum angular aiming error is 1.5º

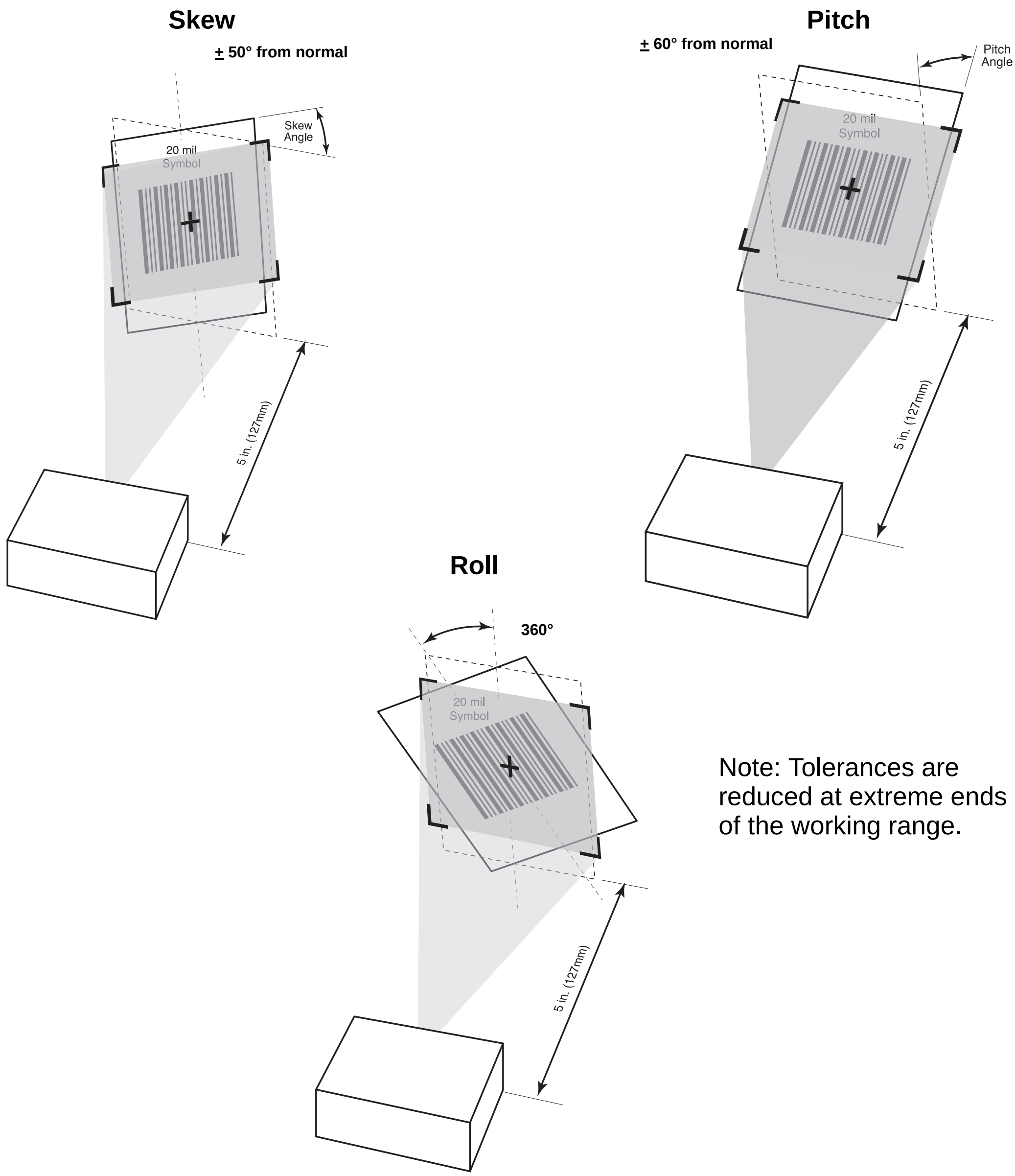
Table 3-1. SE4400 Technical Specifications at 23° C (Continued)

Item	Description
Illumination Element	
Light Emitting Diode (LED)	635 nm ± 20 nm
Total LED Output Power	Less than 10 mW
Pattern Angle	50º (FWHM)
Shock	2000 ± 5% G applied via any mounting surface at -20º, 20º and 55º C for a period of 0.9 ± 10% msec
Vibration	Unpowered SE4400 withstands a random vibration along each of the X, Y and Z axes for a period of one hour per axis (6 G rms), defined as follows: 20 to 80 Hz: Ramp up to 0.04 G^2/Hz at the rate of 3dB/octave 80 to 350 Hz: 0.04 G^2/Hz 350 to 2000 Hz: Ramp down at the rate of 3 dB/octave
ESD	± 500 V (pin injection)
Laser Class	The engine, by itself, is an unclassified component. It is intended for use in CDRH Class II/IEC Class 1 devices with proper housing, labeling, and instructions to comply with federal and/or international standards.
Temperature	
Operating	-20º to 55º C (-4º to 131º F)
Storage	-40º to 70º C (-40º to 158ºF)
Humidity	
Operating	95% RH, non-condensing at 60º C
Storage	85% RH, non-condensing at 70º C
Height	0.46 in. (11.8 mm) maximum
Width	0.85 in. (21.5 mm) maximum
Depth	0.64 in. (16.3 mm) maximum
Weight	0.29 oz. (8.3 grams)
Electrical Interface	31 pin 0.3 mm pitch ZIF connector (refer to Chapter 4, *Electrical Interface* for more information.)

Note: *Environmental and/or tolerance parameters are not cumulative. A thermal analysis is recommended if the application is subject to an extreme temperature environment.*

Skew, Pitch and Roll

Measured on a 20 mil Code 39 symbol at a distance of 10 inches. Tolerance is reduced at extreme ends of the working range.



Note: Tolerances are reduced at extreme ends of the working range.

Figure 3-1. Skew, Pitch and Roll

Decode Zones

SE4400-E000E

Near Focus

Figure 3-2 shows the decode zone for the Near Focus SE4400-E000E. Typical values appear. Table 3-2 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or “symbol density”) is the width in mils of the narrowest element (bar or space) in the symbol.

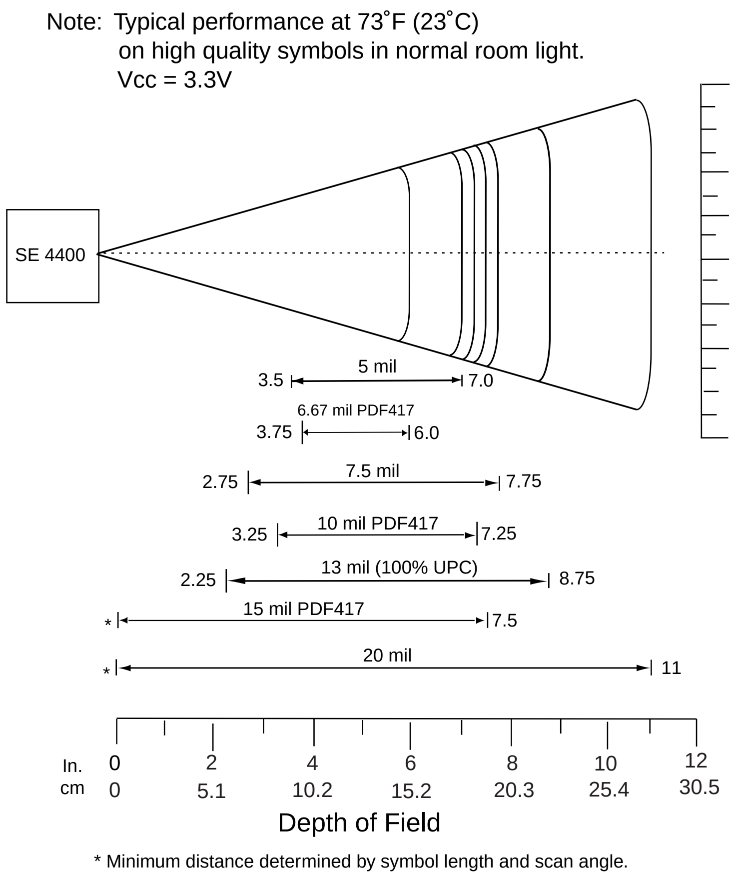


Figure 3-2. SE4400-E000E Near Focus Decode Zone

Table 3-2. SE4400-E000E Near Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Typical Working Ranges		Guaranteed Working Ranges	
		Near	**Far**	**Near**	**Far**
5.0 mil Code 39	**ABCDEFGH** 80% MRD	3.5 in 8.9 cm	7.0 in 17.8 cm	4.25 in 10.8 cm	6.0 in 15.2 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	3.75 in 9.5 cm	6.0 in 15.2 cm	4.5 in 11.4 cm	5.75 in 14.6 cm
7.5 mil Code 39	**ABCDEF** 80% MRD	2.75 in 7.0 cm	7.75 in 19.7 cm	3.5 in 8.9 cm	6.5 in 16.5 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	3.25 in 8.3 cm	7.25 in 18.4 cm	4.0 in 10.2 cm	6.5 in 16.5 cm
13 mil UPC-A	**012345678905** 80% MRD	2.25 in 5.7 cm	8.75 in 22.2 cm	3.0 in 7.6 cm	7.0 in 17.8 cm
15 mil PDF417	80% MRD	Note 1	7.5 in 19.1 cm	Note 1	7.0 in 17.8 cm
20 mil Code 39	**123** 80% MRD	Note 1	11.0 in 27.9 cm	Note 1	9.5 in 24.1 cm

Notes:

1. Near distances are field-of-view (FOV) limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70% RH.

Far Focus

Figure 3-3 shows the decode zone for the Far Focus SE4400-E000E. Typical values appear. Table 3-3 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or "symbol density") is the width in mils of the narrowest element (bar or space) in the symbol.

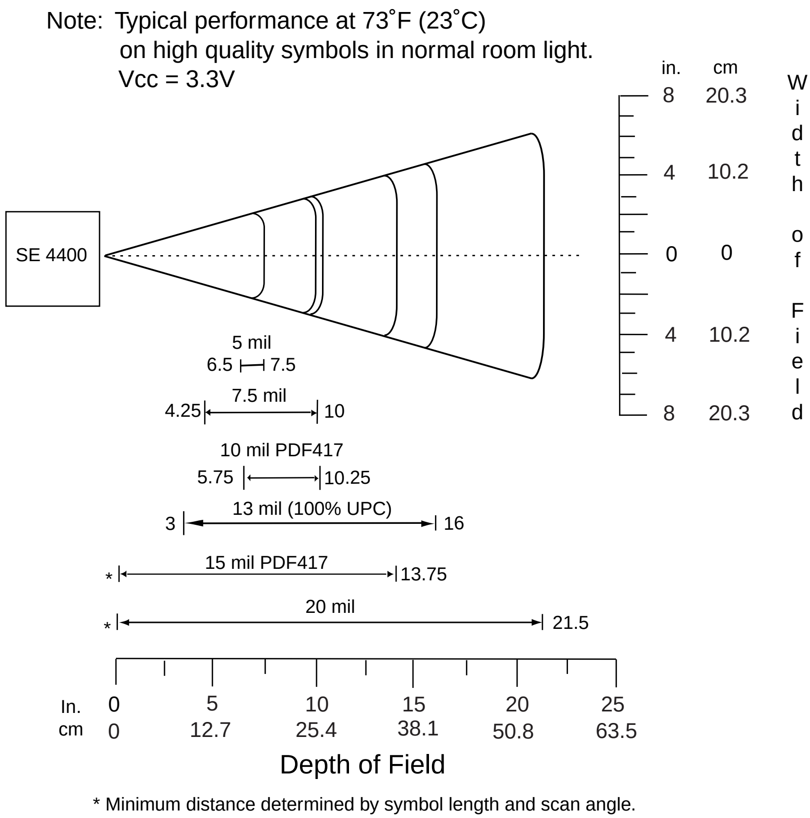


Figure 3-3. SE4400-E000E Far Focus Decode Zone

Table 3-3. SE4400-E000E Far Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Typical Working Ranges		Guaranteed Working Ranges	
		Near	Far	Near	Far
5.0 mil Code 39	**ABCDEFGH** 80% MRD	6.5 in 16.5 cm	7.5 in 19.1 cm	N/A	N/A
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	N/A	N/A	N/A	N/A
7.5 mil Code 39	**ABCDEF** 80% MRD	4.25 in 10.8 cm	10.0 in 25.4 cm	5.5 in 14.0 cm	8.5 in 21.6 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	5.75 in 14.6 cm	10.25 in 26.0 cm	6.5 in 16.5 cm	9.5 in 24.1 cm
13 mil UPC-A	**012345678905** 80% MRD	3.0 in 7.6 cm	16.0 in 40.6 cm	3.75 in 9.5 cm	13 in 33.0 cm
15 mil PDF417	80% MRD	Note 1	13.75 in 34.9 cm	Note 1	12.75 in 32.4 cm
20 mil Code 39	**123** 80% MRD	Note 1	21.5 in 51.6 cm	Note 1	17.0 in 43.2 cm

Notes:
1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70% RH.

Toggled Focus

Figure 3-4 shows the decode zone for the Toggled Focus SE4400-E000E. Typical values appear. Table 3-4 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or “symbol density”) is the width in mils of the narrowest element (bar or space) in the symbol.

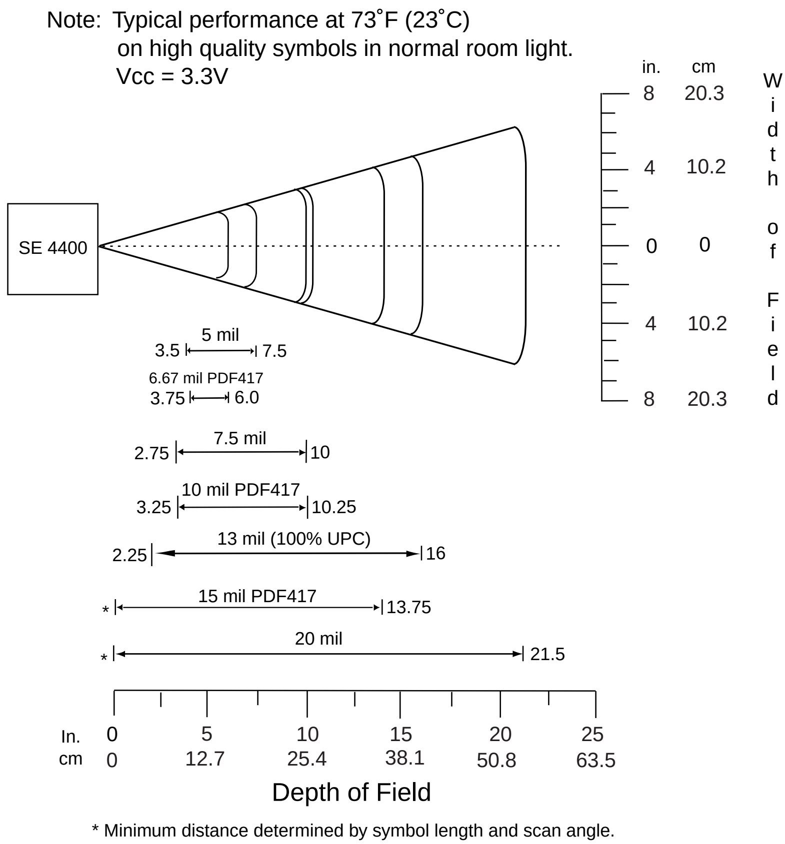


Figure 3-4. SE4400-E000E Toggled Focus Decode Zone

Table 3-4. SE4400-E000E Toggled Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Typical Working Ranges		Guaranteed Working Ranges	
		Near	**Far**	**Near**	**Far**
5.0 mil Code 39	**ABCDEFGH** 80% MRD	3.5 in 8.9 cm	7.5 in 19.1 cm	4.25 in 10.8 cm	6.0 in 15.24 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	3.75 in 9.5 cm	6.0 in 15.24 cm	4.5 in 11.4 cm	5.75 in 14.61 cm
7.5 mil Code 39	**ABCDEF** 80% MRD	2.75 in 7.0 cm	10.0 in 25.4 cm	3.5 in 8.9 cm	8.5 in 21.6 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	3.25 in 8.3 cm	10.25 in 26.0 cm	4.0 in 10.2 cm	9.5 in 24.1 cm
13 mil UPC-A	**012345678905** 80% MRD	2.25 in 5.7 cm	16.0 in 40.6 cm	3.0 in 7.6 cm	13 in 33.0 cm
15 mil PDF417	80% MRD	Note 1	13.75 in 34.9 cm	Note 1	12.75 in 32.4 cm
20 mil Code 39	**123** 80% MRD	Note 1	21.5 in 51.6 cm	Note 1	17.0 in 43.2 cm
Notes: 1. Near distances are FOV limited. 2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm. 3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70%RH.					

Decode Distances in Darkness

Table 3-5. SE4400-E000E Decode Distances in Darkness

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Focus Position	Typical Working Ranges	
			Near	Far
5.0 mil Code 39	**ABCDEFGH** 80% MRD	**Near**	3.5 in 8.9 cm	5.875 in 14.1 cm
		Far	6.5 in 16.5 cm	N/A
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	**Near**	3.75 in 9.5 cm	5.75 in 14.6 cm
		Far	N/A	N/A
7.5 mil Code 39	**ABCDEF** 80% MRD	**Near**	2.75 in 7.0 cm	6.875 in 17.5 cm
		Far	4.25 in 10.8 cm	7.125 in 18.1 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	**Near**	3.25 in 8.3 cm	6.375 in 16.2 cm
		Far	5.75 in 14.6 cm	7.25 in 18.4 cm
13 mil UPC-A	**012345678905** 80% MRD	**Near**	2.25 in 5.7 cm	7.375 in 18.7 cm
		Far	3.00 in 7.6 cm	8.375 in 21.3 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, humidity 45-70%RH.
4. Range measurements are when VCC_ILLUM is powered off of 3.0 V (see Table 4-1 on page 4-1). Powering VCC_ILLUM off of 3.3 V yields slightly improved working ranges in darkness.

Table 3-5. SE4400-E000E Decode Distances in Darkness (Continued)

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Focus Position	Typical Working Ranges	
			Near	Far
15 mil PDF417	80% MRD	**Near**	Note 1	7.125 in 18.1 cm
		Far	Note 1	7.75 in 19.7 cm
20 mil Code 39	**123** 80% MRD	**Near**	Note 1	8.25 in 21.0 cm
		Far	Note 1	9.25 in 23.5 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, humidity 45-70%RH.
4. Range measurements are when VCC_ILLUM is powered off of 3.0 V (see Table 4-1 on page 4-1). Powering VCC_ILLUM off of 3.3 V yields slightly improved working ranges in darkness.

SE4400-E004E

Near Focus

Figure 3-5 shows the decode zone for the Near Focus SE4400-E004E. Typical values appear. Table 3-6 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or "symbol density") is the width in mils of the narrowest element (bar or space) in the symbol.

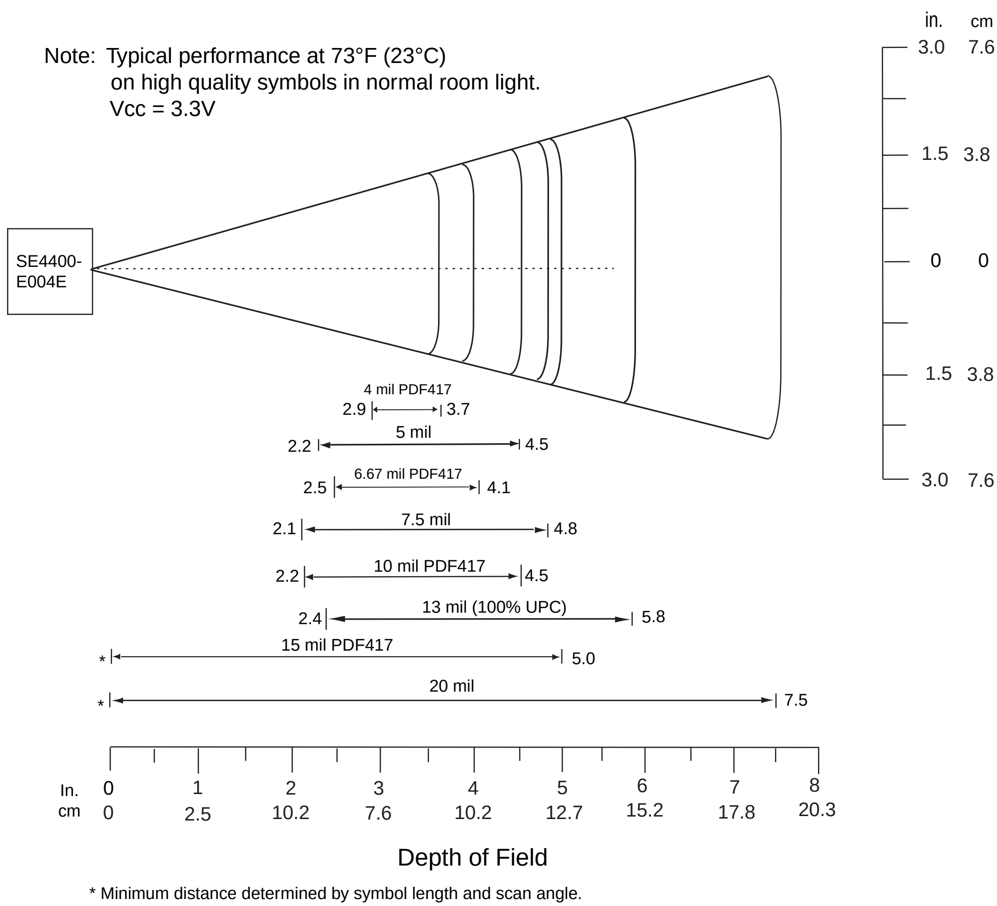


Figure 3-5. SE4400-E004E Near Focus Decode Zone

Table 3-6. SE4400-E004E Near Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Typical Working Ranges		Guaranteed Working Ranges	
		Near	**Far**	**Near**	**Far**
4.0 mil PDF417	80% MRD	2.9 in 7.37 cm	3.7 in 9.40 cm	Note 1	3.3 in 8.38 cm
5.0 mil Code 39	**ABCDEFGH** 80% MRD	2.2 in 5.59 cm	4.5 in 11.43 cm	3.0 in 7.62 cm	3.75 in 9.53 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	2.5 in 6.35 cm	4.1 in 10.41 cm	3.5 in 8.89 cm	3.7 in 9.40 cm
7.5 mil Code 39	**ABCDEF** 80% MRD	2.1 in 5.33 cm	4.8 in 12.19 cm	3.0 in 7.62 cm	4.0 in 10.16 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	2.2 in [Note 1] 5.59 cm	4.5 in 11.43 cm	Note 1	3.75 in 9.53 cm
13 mil UPC-A	**012345678905** 80% MRD	2.4 in 6.10 cm	5.8 in 14.73 cm	Note 1	4.5 in 11.43 cm
15 mil PDF417	80% MRD	Note 1	5.0 in 12.7 cm	Note 1	4.25 in 10.80 cm
20 mil Code 39	**123** 80% MRD	Note 1	7.5 in 19.05 cm	Note 1	6.0 in 15.24 cm

Notes:

1. Near distances are field-of-view (FOV) limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70% RH.

Far Focus

Figure 3-6 shows the decode zone for the Far Focus SE4400-E004E. Typical values appear. Table 3-7 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or "symbol density") is the width in mils of the narrowest element (bar or space) in the symbol.

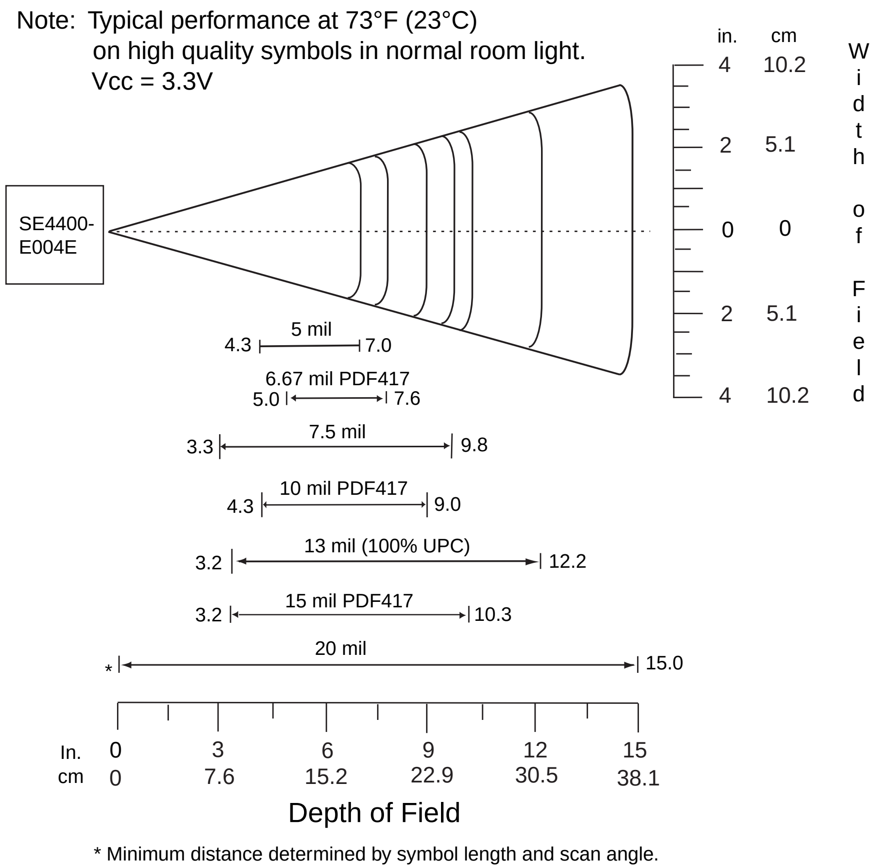


Figure 3-6. SE4400-E004E Far Focus Decode Zone

Table 3-7. SE4400-E004E Far Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Typical Working Ranges		Guaranteed Working Ranges	
		Near	Far	Near	Far
4.0 mil PDF417	80% MRD	N/A	N/A	N/A	N/A
5.0 mil Code 39	**ABCDEFGH** 80% MRD	4.3 in 10.92 cm	7.0 in 17.78 cm	5.25 in 13.34 cm	6.75 in 17.15 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	5.0 in 12.7 cm	7.6 in 19.30 cm	6.0 in 15.24	6.5 in 16.51
7.5 mil Code 39	**ABCDEF** 80% MRD	3.3 in 8.38 cm	9.8 in 24.89 cm	4.5 in 11.43 cm	7.75 in 19.69 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	4.3 in 10.92 cm	9.0 in 22.86 cm	5.75 in 14.61 cm	7.5 in 19.05 cm
13 mil UPC-A	**012345678905** 80% MRD	3.2 in 8.13 cm	12.2 in 30.99 cm	3.75 in 9.53 cm	8.75 in 22.23 cm
15 mil PDF417	80% MRD	3.2 in [Note 1] 8.13 cm	10.3 in 26.16 cm	Note 1	8.25 in 20.96 cm
20 mil Code 39	**123** 80% MRD	Note 1	15.0 in 38.1 cm	Note 1	13.0 in 33.02 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70% RH.

Toggled Focus

Figure 3-7 shows the decode zone for the Toggled Focus SE4400-E004E. Typical values appear. Table 3-8 lists the typical and guaranteed distances for selected bar code densities. The minimum element width (or "symbol density") is the width in mils of the narrowest element (bar or space) in the symbol.

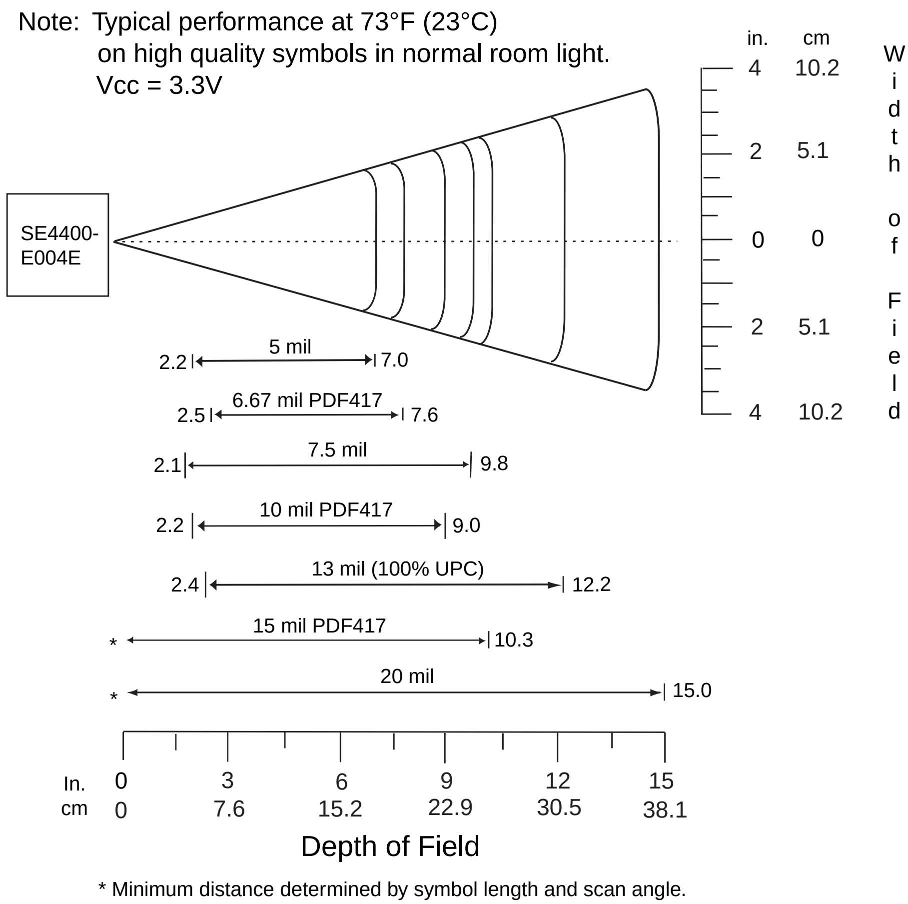


Figure 3-7. SE4400-E004E Toggled Focus Decode Zone

Table 3-8. SE4400-E004E Toggled Focus Decode Distances

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Typical Working Ranges		Guaranteed Working Ranges	
		Near	**Far**	**Near**	**Far**
4.0 mil PDF417	80% MRD	2.9 in 7.37 cm	N/A	Note 1	N/A
5.0 mil Code 39	**ABCDEFGH** 80% MRD	2.2 in 5.59 cm	7.0 in 17.78 cm	3.0 in 7.62 cm	6.75 in 17.15 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	2.5 in 6.35 cm	7.6 in 19.30 cm	3.5 in 8.89 cm	6.5 in 16.51
7.5 mil Code 39	**ABCDEF** 80% MRD	2.1 in 5.33 cm	9.8 in 24.89 cm	3.0 in 7.62 cm	7.75 in 19.69 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	2.2 in Note 1 5.59 cm	9.0 in 22.86 cm	Note 1	7.5 in 19.05 cm
13 mil UPC-A	**012345678905** 80% MRD	2.4 in 6.10 cm	12.2 in 30.99 cm	Note 1	8.75 in 22.23 cm
15 mil PDF417	80% MRD	Note 1	10.3 in 26.16 cm	Note 1	8.25 in 20.96 cm
20 mil Code 39	**123** 80% MRD	Note 1	15.0 in 38.1 cm	Note 1	13.0 in 33.02 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, ambient light ~30 ft-c, humidity 45-70%RH.

Decode Distances in Darkness

Table 3-9. SE4400-E004E Decode Distances in Darkness

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Focus Position	Typical Working Ranges	
			Near	Far
4.0 mil PDF417	80% MRD	**Near**	2.9 in 7.37 cm	3.5 in 8.89 cm
		Far	N/A	N/A
5.0 mil Code 39	**ABCDEFGH** 80% MRD	**Near**	2.2 in 5.59 cm	4.0 in 10.16 cm
		Far	4.3 in 10.92 cm	6.0 in 15.24 cm
6.67 mil PDF417	**4 Col, 20 Rows** 80% MRD	**Near**	2.5 in 6.35 cm	4.1 in 10.41 cm
		Far	5.1 in 12.95 cm	7.5 in 19.05 cm
7.5 mil Code 39	**ABCDEF** 80% MRD	**Near**	2.2 in 5.59 cm	4.8 in 12.19 cm
		Far	3.3 in 8.38 cm	8.7 in 22.10 cm
10 mil PDF417	**3 Col, 17 Rows** 80% MRD	**Near**	2.3 in[Note 1] 5.84 cm	4.5 in 11.43 cm
		Far	4.3 in 10.92 cm	9.0 in 22.86 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, humidity 45-70%RH.
4. Range measurements are when VCC_ILLUM is powered off of 3.0 V (see Table 4-1 on page 4-1). Powering VCC_ILLUM off of 3.3 V yields slightly improved working ranges in darkness.

Table 3-9. SE4400-E004E Decode Distances in Darkness (Continued)

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast[Note 2]	Focus Position	Typical Working Ranges	
			Near	**Far**
13 mil UPC-A	**012345678905** 80% MRD	**Near**	2.7 in 6.86 cm	5.2 in 13.21 cm
		Far	3.2 in 8.13 cm	10.7 in 27.18 cm
15 mil PDF417	80% MRD	**Near**	Note 1	5.0 in 12.70 cm
		Far	3.3 in[Note 1] 8.38 cm	10.3 in 26.16 cm
20 mil Code 39	**123** 80% MRD	**Near**	Note 1	7.0 in 17.78 cm
		Far	Note 1	13.0 in 33.02 cm

Notes:

1. Near distances are FOV limited.
2. Contrast is measured as Mean Reflective Difference (MRD) at 670 nm.
3. Working range specifications at temperature = 23°C, pitch=15°, roll=0°, skew=0°, photographic quality, humidity 45-70%RH.
4. Range measurements are when VCC_ILLUM is powered off of 3.0 V (see Table 4-1 on page 4-1). Powering VCC_ILLUM off of 3.3 V yields slightly improved working ranges in darkness.

Chapter 4
Electrical Interface

Overview

The SE4400 has one 31-pin connector. See Figure 2-1 on page 2-3 for the pin one location, on the side opposite the aiming/illumination system.

SE4400

Table 4-1 lists the pins and signals of the 31-pin connector on the SE4400.

Table 4-1. SE4400 Signal Information

Pin Number	SE4400 Signal Name	I/O	Note
1	GND	Pwr	Ground
2	PCLK	O	Pixel Clock
3	GND	Pwr	Ground
4	HREF	O	Horizontal Pixel Valid Clock (Sync)
5	VCC_MOTOR	Pwr	Focus Control Motor Power
6	VCC_ILLUM	Pwr	Illumination Power
7	REG_RESET*	I/O	I^2C Register Reset Pin
8	VCC	Pwr	CCD/Aiming Power
9	VCC	Pwr	CCD/Aiming Power

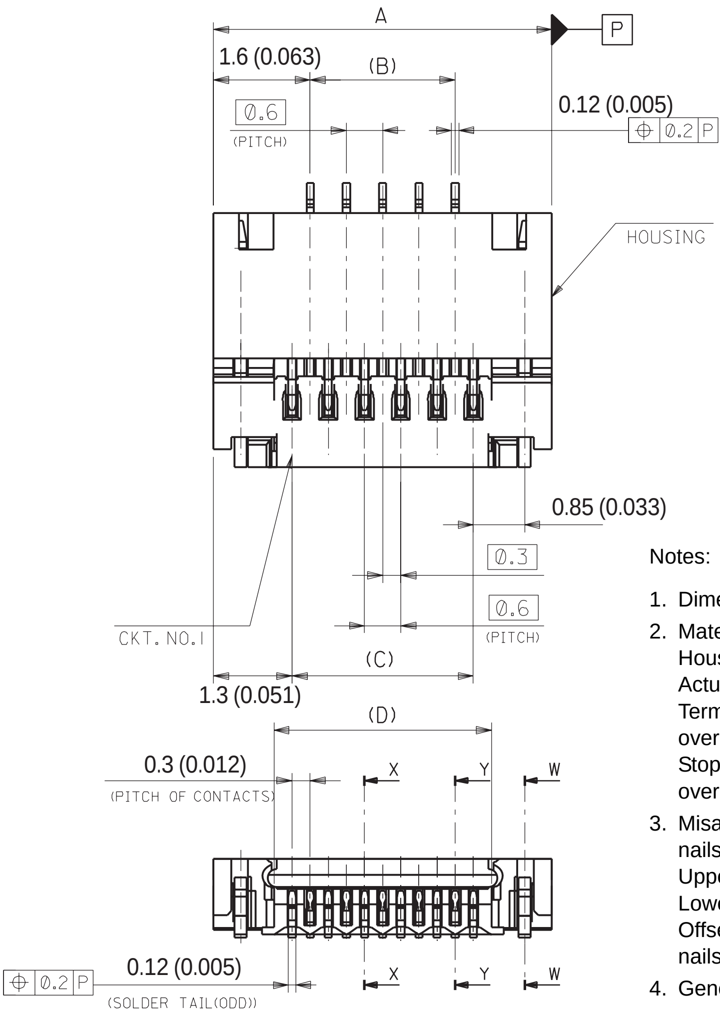
Table 4-1. SE4400 Signal Information (Continued)

Pin Number	SE4400 Signal Name	I/O	Note
10	EXSFT	I	External Frame Sync
11	ILLUM_ENB*	I	LED Illumination Control
12	AIM_ENB*	I	Laser Aiming Control
13	PIX_D0	O	Pixel Data Bit 0 (LSB)
14	PIX_D1	O	Pixel Data Bit 1
15	PIX_D2	O	Pixel Data Bit 2
16	PIX_D3	O	Pixel Data Bit 3
17	PIX_D4	O	Pixel Data Bit 4
18	PIX_D5	O	Pixel Data Bit 5
19	PIX_D6	O	Pixel Data Bit 6
20	PIX_D7	O	Pixel Data Bit 7
21	FOCUS_CTRL1	I	Focus Control Line 1
22	VREF	O	Vertical Frame Valid Clock (Sync)
23	EXHT	I	External Horizontal Clock
24	I2C_SDA	I/O	I^2C-BUS Data Line
25	I2C_SCL	I	I^2C-BUS Clock Line
26	GND	Pwr	Ground
27	MCKI	I	Master clock
28	GND	Pwr	Ground
29	FOCUS_CTRL2	I	Focus Control Line 2
30	CS*	I	Chip Select
31	UV6	O	Frame Shift

The I^2C interface lines, I2C_SDA & I2C_SCL, must have pull-up resistors so the signal rise times comply to the I^2C standard (refer to *The I^2C-Bus Specification, Version 2.1*, http://www.semiconductors.philips.com/acrobat/literature/9398/39340011.pdf).

If CS* is brought low, the pixel data lines (PIX_D0 through PIX_D7) are in the output state in acquisition mode, and are brought low in stand-by mode. If CS* is brought high, the pixel data lines are in the output state during acquisition mode, and are in a Hi-Z state during stand-by mode. The latter option accommodates a multi-camera system.

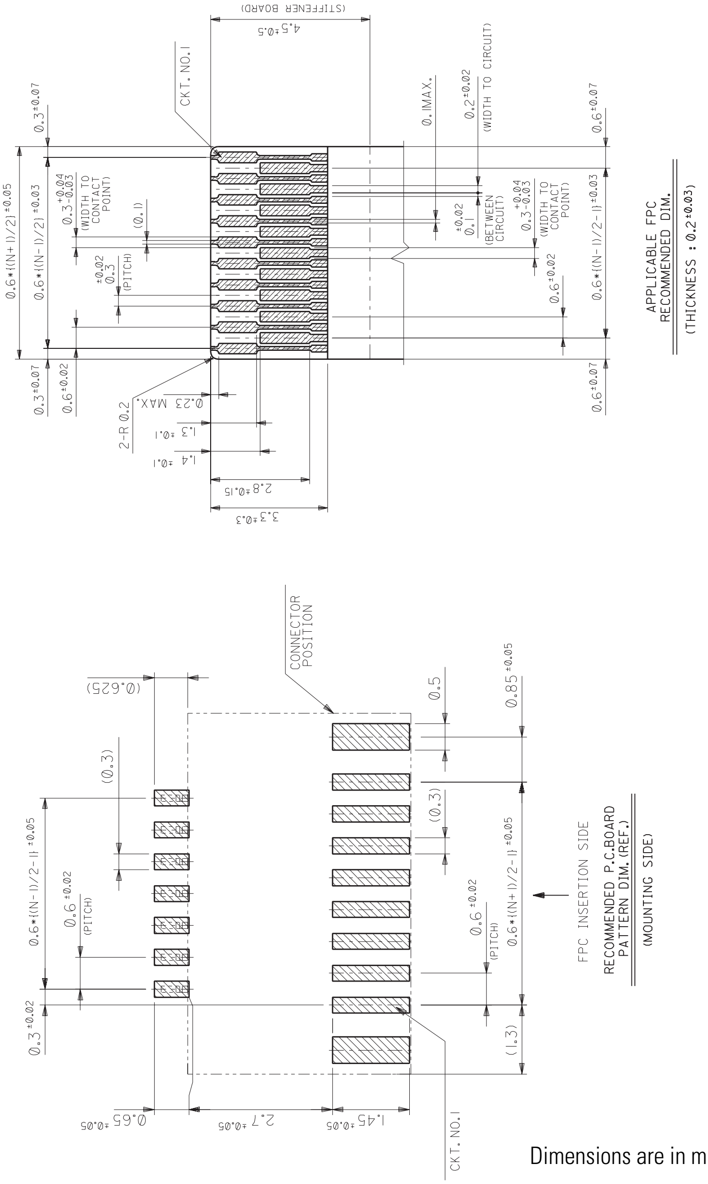
Connector Drawings



Notes:

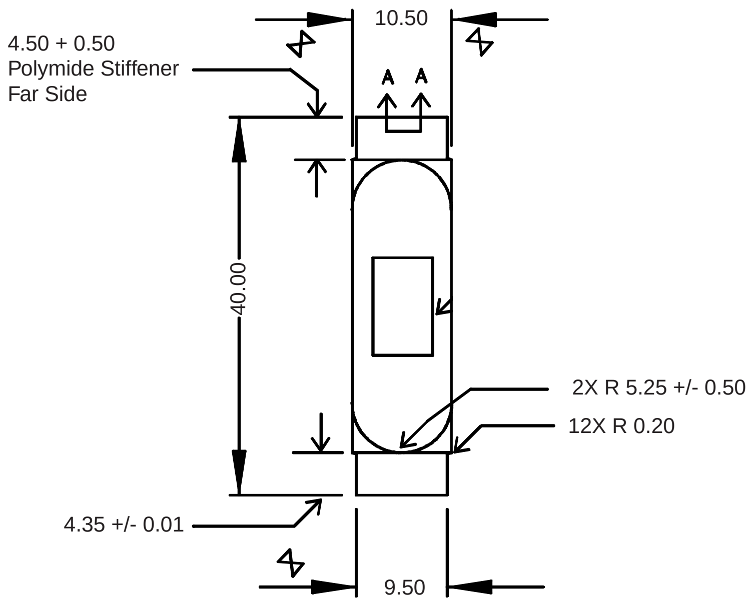
1. Dimensions are in mm (in.)
2. Material:
   Housing: LCP UL94V-0
   Actuator: PPS UL94V-0
   Terminal: phosphor bronze, Sn-Pb over Cu plating
   Stopper: phosphor bronze, Sn-Pb over Cu plating
3. Misalignment of solder tails and fitting nails from R
   Upper direction: 0 max.,
   Lower direction: 0.1 max.
   Offset between solder tails and fitting nails: 0.1 max.
4. General tolerances: ±0.3

Figure 4-1. 31-Pin ZIF Connector, p/n 50-12100-1002



Dimensions are in mm unless otherwise specified.

Figure 4-2. 31-Pin ZIF Connector, p/n 50-12100-1002 (continued)



Notes:

1. Dimensions are in mm.
2. Material: Base dielectric to be 1 mil polymide per IPC-4204/11 with 1/2 oz. copper clad. Coverlayer(s) to be polymide per IPC-4203/1.
3. Finish: All exposed copper areas are to be white tin plated to a thickness of 25 microinches (average thickness).
4. Workmanship standards shall be in accordance with IPC-6011 Class 2 and IPC-6013 type 1.
5. Supplied gerber data: Minimum conductor width 0.10 mm. Minimum spacing to be 0.08 mm. (except in connector area).
6. Dimensions are to center of contact.
7. Scalloped ends are optional at covercoat termination in exposed finger areas.
8. Copper foil grain direction must be parallel with ZIF ends circuit conductors.

Figure 4-3. SE4400 to PL 4407-B000 Flex, p/n 50-16000-650

Molex Connector Specifications

The following table provides electrical, mechanical, and environmental performance specifications for the Molex connector.

Table 4-2. Molex Connector Specifications

Item	Test Condition	Requirement	
Electrical Performance			
Contact Resistance	Mate applicable FPC, measure by dry circuit, 20 mV max., 10 mA. (JIS C5402 5.4)	Odd CKT: 80 milliohms max. Even CKT: 40 milliohms max.	
Insulation Resistance	Mate applicable FPC, apply 500V DC between adjacent terminal or ground. (JIS C5402 5.2/MIL-STD-202 Method 302)	50 Megohms min.	
Dielectric Strength	Mate applicable FPC, apply 250V AC (rms) for 1 minute between adjacent terminal or ground. (JIS C5402 5.1/MIL-STD-202 Method 301)	No breakdown	
Mechanical Performance			
FPC Insertion/ Withdrawal Force	Insert and withdraw FPC at the rate of 25 ±3 mm / minute.	See Table 4-3 on page 4-10.	
FPC Retention Force	Insert the actuator, pull the FPC at the rate of 25 ±3 mm / minute.	See *Connector Retention Force (min.)* on page 4-10.	
Terminal Retention Force	Apply axial pull out force at the rate of 25 ±3 mm / minute on the terminal assembled in the housing.	0.8 N (0.08 kgf) min.	
Environmental Performance (and Other)			
Repeated Insertion / Withdrawal	Insert and withdraw actuator up to 20 cycles, at the rate of less than 10 cycles/ minute.	Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
Temperature Rise	Carrying rated current load (UL 498).	Temperature rise	30^{o} max.

Table 4-2. Molex Connector Specifications (Continued)

Item	Test Condition	Requirement	
Vibration	DC 1 mA Amplitude: 1.5 mm P-P Sweep time: 10~55~10 Hz in 1 minute Duration: 2 hours in each X.Y.Z. axes (MIL-STD-202 Method 201)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
		Discontinuity	1 microsec. max.
Shock	FPC / DC 1 mA 490 m/s^2 {50G}, 3 strokes in each X.Y.Z. axes. (JIS C0041/MIL-STD-202 Method 213)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
		Discontinuity	1 microsec. max.
Heat Resistance	85 ±2^{o}C, 96 hours (JIS C0021/MIL-STD-202 Method 108)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
Cold Resistance	-40 ±2^{o}C, 96 hours (JIS C0020)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.

Table 4-2. Molex Connector Specifications (Continued)

Item	Test Condition	Requirement	
Humidity	Temperature: 60 ±2^{o}C Relative Humidity: 90 / 95% Duration: 96 hours (JIS C0022/MIL-STD-202 Method 103)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
		Dielectric Strength	Must meet 3-1-4
		Insulation Resistance	20 megaohms min.
Temperature Cycling	5 cycles of: a) -55 ±3^{o}C / 30 minutes b) +85 ±2^{o}C / 30 minutes (JIS C0025)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
Salt Spray	48 ±4 hours exposure to a salt spray from the 5 ±1% solution at 35 ±2^{o}C. (JIS C0023/MIL-STD-202 Method 101)	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
SO_2 Gas	24 hours exposure to 50 ±5 ppm. SO_2 gas at 40 ±2^{o}C.	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.
NH Gas	40 minutes exposure to NH gas evaporating from 28% ammonia solution.	Appearance	No damage
		Contact Resistance	Odd CKT: 100 milliohms max. Even CKT: 60 milliohms max.

Table 4-2. Molex Connector Specifications (Continued)

Item	Test Condition	Requirement	
Solderability	Soldering Time: 3 ±0.5 second Solder Temperature: 230 ±5^{o}C 0.2 mm from terminal tip 0.2 mm from fitting nail tip.	Solder wetting	75% of immersed area must show no voids, pin holes.
Resistance to Soldering Heat	Solder Time: 3 ±0.5 second Solder Temperature: 350 ±5^{o}C 0.2 mm from terminal tip 0.2 mm from fitting nail tip	Appearance	No damage

Connector Insertion/Withdrawal Force

Table 4-3. Connector Insertion/Withdrawal Force for 51-Pin* Connector

Insertion/ Withdrawal Count	Unit	Insertion Force			Withdrawal Force		
		Avg.	Max	Min	Avg.	Max.	Min.
1st	N [kgf]	5.06 [0.52]	5.59 [0.57]	4.41 [0.45]	5.37 [0.55]	6.17 [0.63]	4.90 [0.50]
6th	N [kgf]	5.27 [0.54]	6.37 [0.65]	4.41 [0.45]	5.90 [0.60]	6.86 [0.70]	5.00 [0.51]
20th	N [kgf]	5.55 [0.57]	6.57 [0.67]	5.00 [0.51]	5.98 [0.61]	6.66 [0.68]	5.59 [0.57]
*Data not available for 31-pin connector; data in this table are for reference only.							

Connector Retention Force (min.)

1st: 3.53 N [0.36 kgf]

10th: 2.55 N [0.26 kgf]

20th: 2.25 N [0.23 kgf]

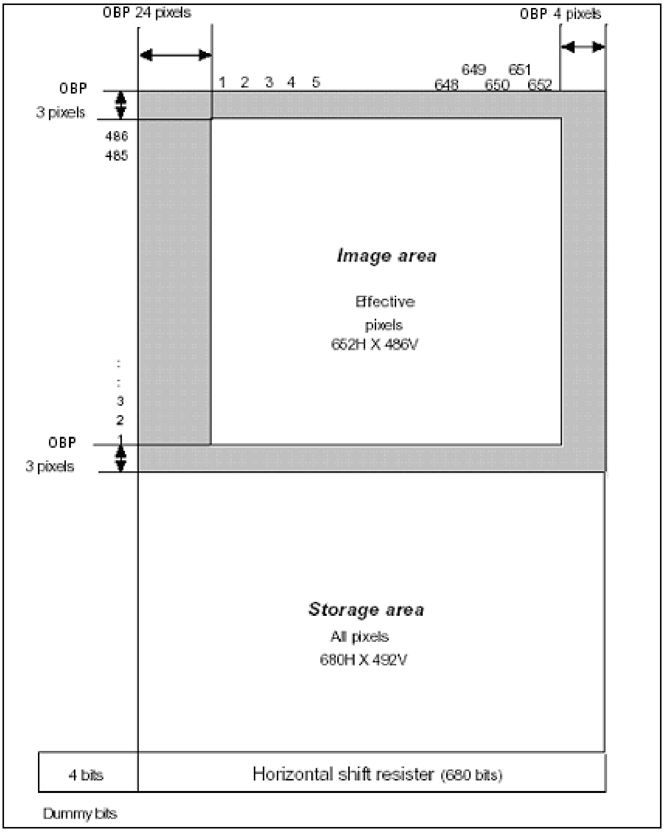
Chapter 5
Application Notes

Overview

This chapter includes image acquisition and power consumption information.

Image Acquisition

The SE4400 CCD is a monochrome VGA resolution sensor. The pixel area, shown in Figure 5-1, is composed of 680 horizontal pixels and 492 vertical pixels; however the actual area upon which light is gathered is slightly smaller (652 x 486 pixels). During image capture, the pixels are read out of a 640 x 480 window unless the image cropping features of the Digital Signal Processor (DSP) are configured (refer to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1*).



*OBP = Optically Blocked Pixels, which are not photosensitive.

Figure 5-1. Pixel Layout

To operate properly, the CCD chipset requires a clock near 24 MHz. To achieve this, an internal PLL multiplies the incoming 12 MHz MCKI by two to generate the 24 MHz internal camera clock, MCK. (If using a 6 MHz MCKI, refer to the *LC99704B-WK3 Sanyo DSP Specification*, Version 1). During pixel array read-out, the camera converts a pixel to an 8-bit digital value at a rate of one half of MCK; therefore the pixel clock, PCLK, is generated at a frequency of 12 MHz.

Note: *Clock details apply for the I^2C settings provided in Appendix A, Register Settings. For alternate clock scenarios, refer to LC99704B-WK3 Sanyo DSP Specification, Version 1.*

The operating settings, stored in the SE4400's on-board DSP registers, are programmed using the I^2C interface developed by Philips. For information, refer to *The I^2C-Bus Specification, Version 2.1*, http://www.semiconductors.philips.com/acrobat/literature/9398/39340011.pdf.

The SE4400 can run in various modes; two are described in this chapter. For information concerning other modes and more information concerning the CCD and DSP, refer to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1* and *LC99214 Sanyo B&W CCD Sensor Specification, Version 2*.

- **Mode 1** only uses the MCKI clock and the I^2C programming lines as inputs, so image acquisition is largely automated. An auto-exposure/gain setting can be used to provide full automation, where real-time I^2C programming is unnecessary. The disadvantage to Mode 1 is that the CCD's internal charge-pump takes 15 frame times (approximately 566 ms) to charge to full capacity, only after which images appear with full brightness.
- Use **Mode 3** to overcome this start-up delay in time-critical applications. With this mode, a speedy start-up of about 156 ms occurs in place of automation. Mode 3 requires two additional timing signals, EXSFT and EXHT. These signals provide more control of the exposure time (and therefore a quicker response time to changing illumination conditions), which can yield a higher frame rate.

Mode 3

Startup Procedure

See Figure 5-2 for the Mode 3 startup procedure timing diagram. Table 5-1 provides a summary of the Mode 3 input and output signal functions.

To reset the DSP's I^2C registers, the REG_RES* line must be held low for a minimum of 500 µs. To ensure a valid reset on power-up, the *t* (time to rise to 63% of 3.3V) of the Vcc supply voltage (J1-8 and J1-9) must be less than 1.12 ms. If the Vcc rise time is between the slowest allowable and quickest possible, the reset will complete between 1.39 ms and 2.41 ms after power is supplied. A typical supply results in a reset delay of about 2 ms. If the Vcc supply voltage cannot meet this rise time requirement, bring REG_RES* low by external means for a minimum of 500 µs.

After a successful reset, the I^2C registers contain default parameters that place the SE4400 in stand-by mode. Initialize the SE4400 with the register values listed in Table A-1 and Table A-2. This I^2C programming can be performed as soon as the SE4400 is reset, and typically takes about 31 ms.

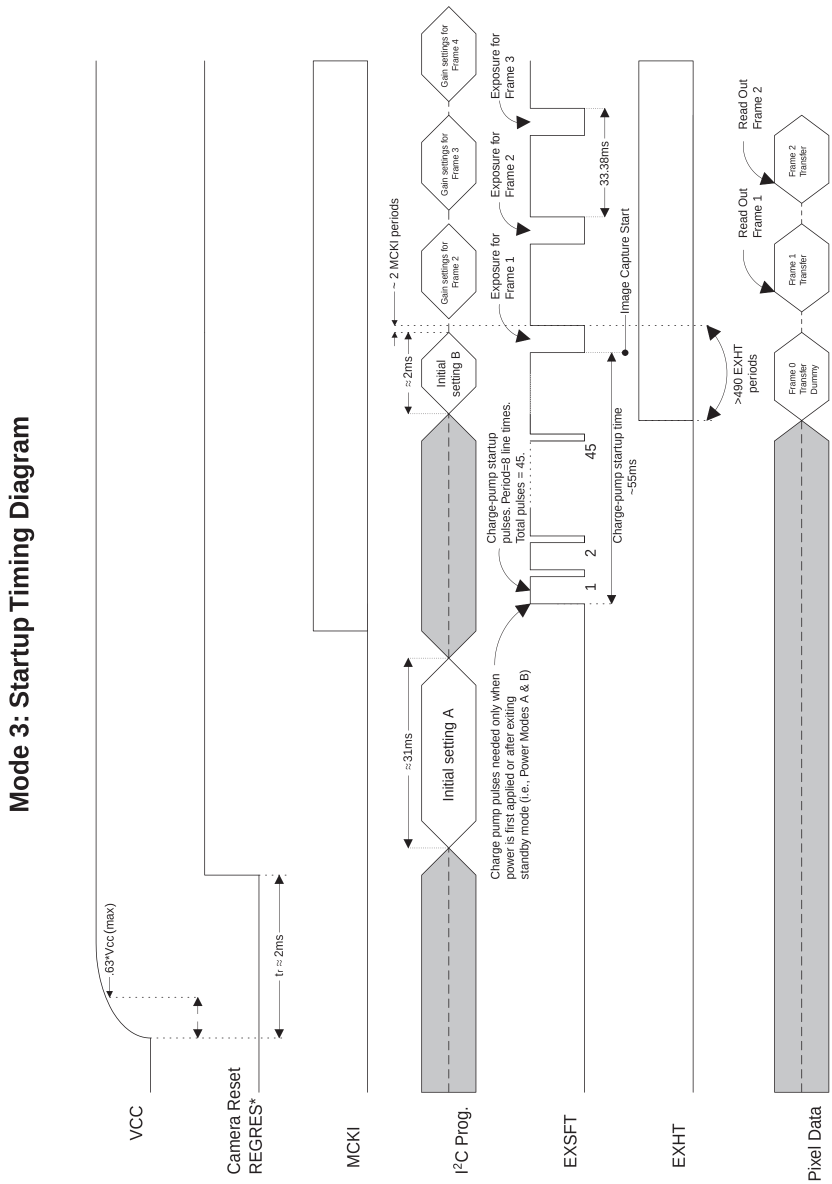
The master clock input, MCKI, must begin any time before the EXSFT pulses. The frequency of MCKI can be between 10MHz and 12.727MHz; 12MHz is recommended. If the system must run at a slower frequency, adjust the I^2C registers according to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1*. Minimize the jittering of MCKI as the SE4400 is sensitive to this.

To minimize the time that the charge pump, which generates ±5 V so that the charge can properly shift out of the CCD sensor, takes to arrive at regulation, implement a startup sequence. EXSFT should be given 45 pulses, each with a period of 8 line times. Be sure that the motor is not in toggle mode (see *Motor Control* on page 5-16) during this startup period. The charge pump is fully charged approximately 55 ms after the pulses begin.

Delay the final I^2C initialization parameters (Setting B) listed in Table A-2 as long as possible, but complete their programming at least 2 MCKI periods before the first frame.

EXHT must begin at least 490H before the first frame transfer begins for the internal analog clamping circuit to function properly. The timing specifications of EXHT are described in the *Image Acquisition Procedure* on page 5-6.

If toggle mode is used (see *Motor Control* on page 5-16) and tracking of the motor position is desired, set the focus motor in a known initial state at least 20 ms before the first exposure period to track the focus position as it is changed in each frame.



*See *Exposure & Gain Control* on page 5-16.

Figure 5-2. Mode 3 Startup Timing Diagram

Image Acquisition Procedure

Figure 5-3 summarizes the Mode 3 imaging acquisition procedure. Table 5-1 provides a summary of the Mode 3 input and output signal functions.

The CCD is exposed to light during the time that EXSFT is low. This exposure time must be an integer multiple of line times "H", unless it begins after the negative edge of VREF, in which case this time is not restricted. The rising edge of EXSFT begins the transfer of data received during exposure. The first 13 lines are dummy, meaning they are either optically blocked or they are used as a timing delay. VREF subsequently goes high and remains high as long as the DSP's internal A/D converter is sampling valid vertical lines. The delay between the negative edge of VREF and the positive edge of EXSFT can be reduced to a minimum of 16H, but each frame must be at least 490H in length. This delay is listed as 32H in Figure 5-3 in order to achieve a frame rate of 30fps. If the focus motor position is altered (see *Motor Control* on page 5-16), a 20 ms settling time must pass before the exposure period can begin, so for each frame in which the focus was changed the exposure time cannot exceed a frame time minus 20 ms.

The negative edge of EXHT triggers the reading of the next horizontal line of the CCD. This triggering edge must comply with the timing requirements shown in Figure 5-3. The duty cycle of EXHT has no significance. After the negative edge of EXHT, 45 dummy pixels are read out. HREF subsequently goes high and remains high as long as the A/D converter is sampling valid horizontal pixels. During the time when both HREF and VREF are high, the 8-bit pixel data, Pix_D0 through Pix_D7, should be sampled on each positive edge of PCLK. The delay between the negative edge of HREF and the positive edge of EXHT cannot be reduced from 78T. EXHT should pulse continuously while the SE4400 is capturing images.

Use the I^2C registers to set the gain. The subsequent frame is then transferred with the new gain. Use an auto gain mode to simplify the process. For information on setting gain, see *Exposure & Gain Control* on page 5-16.

During the first frame (Frame 0), meaningless data is transferred because the CCD has not been exposed to light since it was reset. Discard this data.

Table 5-1. Mode 3 Signal Function Summary

Signal Name	I/O	Function	Significance of Negative Edge	Significance of Positive Edge	Comment
EXSFT	I	Sets exposure time. Begins frame transfer.	Causes the CCD to begin exposing.	Causes the CCD to stop exposing. Begins transfer of pixel data from that exposure (frame transfer).	The period between successive positive edges is called a frame.
VREF	O	Signifies when valid vertical lines are being read.	Reading of valid vertical lines is complete.	Reading of valid vertical lines has begun.	
EXHT	I	External horizontal clock.	Triggers the reading of the next horizontal line of the CCD.	None	The period of EXHT is known as a line time and is denoted "H".
HREF	O	Signifies when valid part of horizontal line is being read.	Reading of valid part of line is complete.	Reading of valid part of line has begun.	
PCLK	O	Pixel clock.	None	Indicates the 8-bit pixel data is available to be read out.	The period of PCLK is denoted "T".

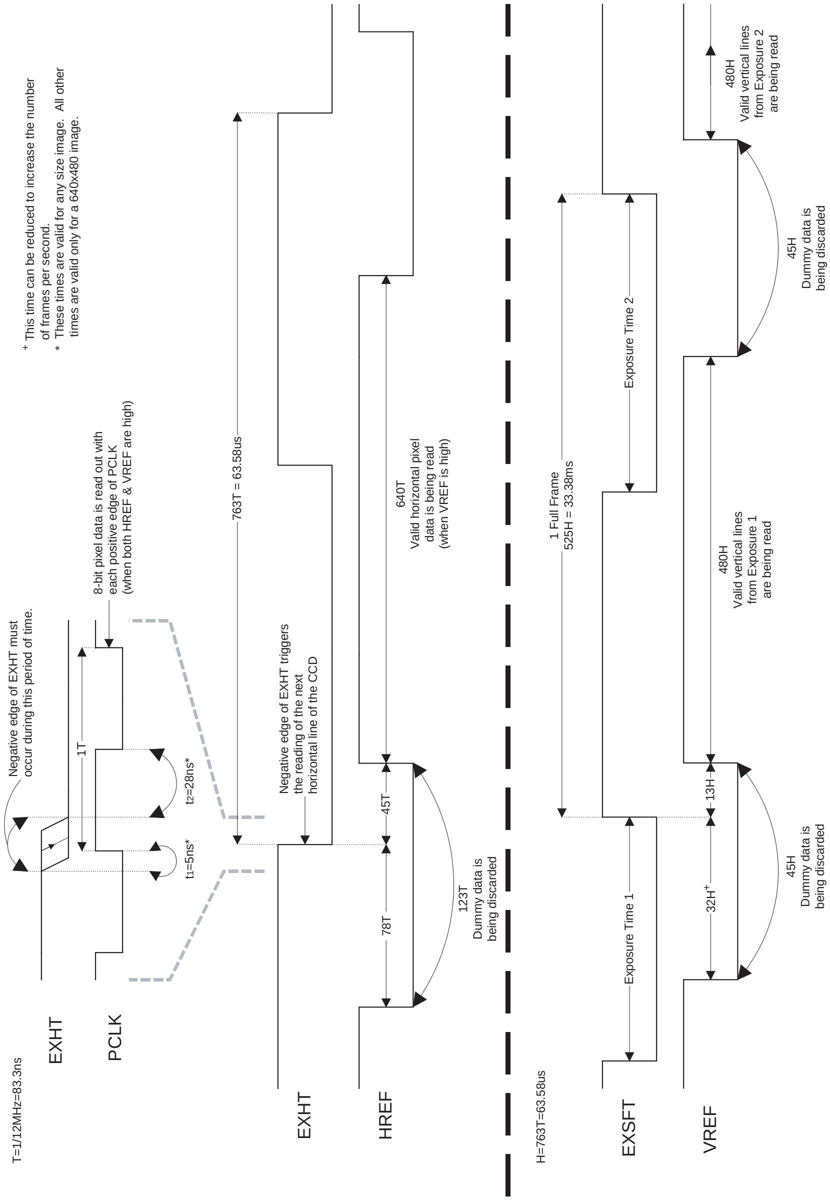


Figure 5-3. Mode 3 Image Acquisition Procedure Diagram

Mode 1

Startup Procedure

See Figure 5-4 for the Mode 1 startup procedure timing diagram.

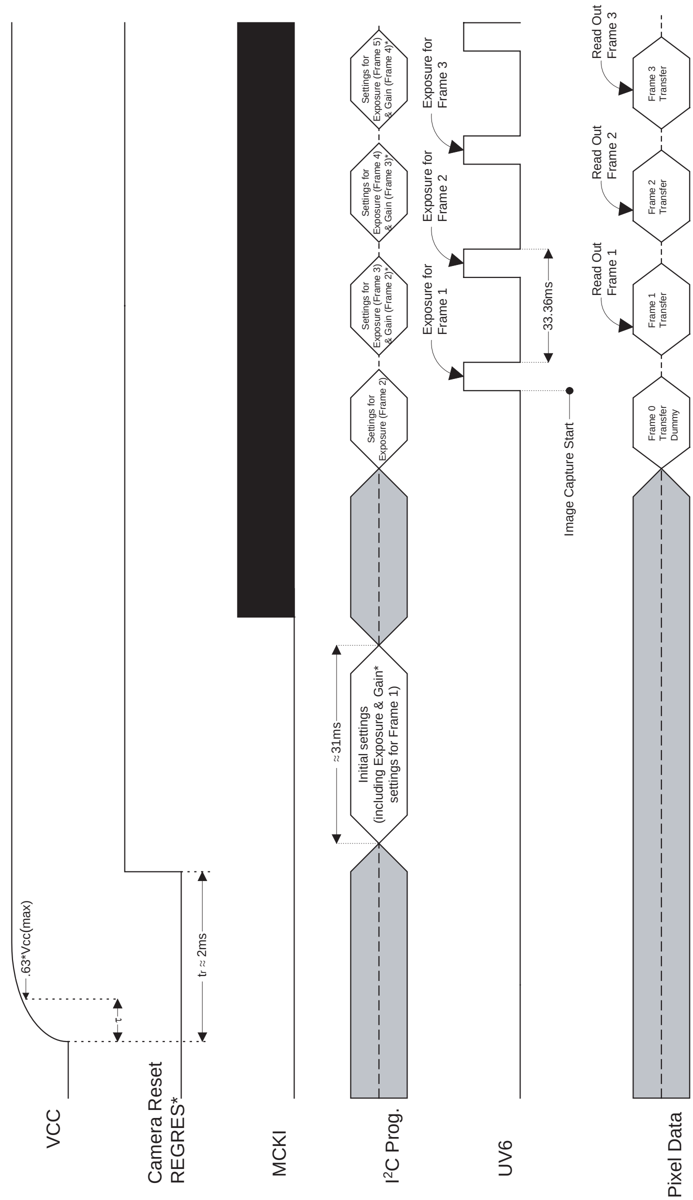
The Vcc supply voltage and REG_RES* reset line requirements are the same in Mode 1 as in Mode 3.

After a successful reset, the I^2C registers contain default parameters that place the SE4400 in stand-by mode. Initialize the SE4400 using the register values listed in Table A-3. This I^2C programming can be performed as soon as the SE4400 is reset, and typically takes about 31 ms.

The master clock input, MCKI, should begin immediately following the initial I^2C programming, but can begin earlier. The frequency of MCKI can be between 10MHz and 12.727MHz; 12MHz is recommended. If the system must run at a slower frequency, adjust the I^2C registers according to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1*. Minimize the jittering of MCKI as the SE4400 is sensitive to this.

The charge pump, which generates ±5 V so that the charge can be properly shifted out of the CCD sensor, takes about 15 frame times to arrive at regulation. There is no way to shorten this time in Mode 1. For the first 15 frames the images may begin dark and progressively get lighter as the charge pump is charged to full capacity.

If toggle mode is used (see *Motor Control* on page 5-16) and tracking of the motor position is desired, set the focus motor in a known initial state at least 20 ms before the first exposure period to track the focus position as it is changed in each frame.



*See *Exposure & Gain Control* on page 5-16.

Figure 5-4. Mode 1 Startup Timing Diagram

Image Acquisition Procedure

Figure 5-5 summarizes the Mode 1 imaging acquisition procedure. Table 5-2 summarizes the Mode 1 input and output signal functions.

As with Mode 3, VREF and HREF indicate the reading of valid vertical and horizontal pixel data, respectively. When both signals are high, the 8-bit pixel data, Pix_D0 through Pix_D7, should be read out on each positive edge of PCLK.

In Mode 1, set the exposure time by programming an I^2C register (see *Exposure & Gain Control* on page 5-16). Once programmed, the duration is set for the exposure time during the next frame, which is read out in the subsequent frame. As with Mode 3, the gain is set via I^2C registers. Once programmed, the subsequent frame is transferred with the new gain. Use auto exposure and auto gain modes to simplify the process. The signal UV6 indicates when the SE4400 is exposing. The signal is brought high during the exposure time and is held low the remainder of the frame.

In Mode 1, the EXSFT line is used only to control the focusing motor (see *Motor Control* on page 5-16). Also, if the focus motor position was altered, a 20 ms settling time must pass before the exposure period can begin, meaning that for each frame in which the focus was changed, the exposure time cannot exceed a frame time minus 20 ms.

Table 5-2. Mode 1 Signal Function Summary

Signal Name	I/O	Function	Significance of Negative Edge	Significance of Positive Edge	Comment
UV6	O	Indicates exposure time.	Indicates the CCD has stopped exposing.	Indicates the CCD has begun exposing.	The period between successive negative edges is called a frame.
VREF	O	Signifies when valid vertical lines are being read.	Reading of valid vertical lines is complete.	Reading of valid vertical lines has begun.	
HREF	O	Signifies when valid part of horizontal line is being read.	Reading of valid part of line is complete.	Reading of valid part of line has begun.	The period of HREF is known as a line time and is denoted "H".
PCLK	O	Pixel clock.	None	Indicates the 8-bit pixel data is available to be read out.	The period of PCLK is denoted "T".

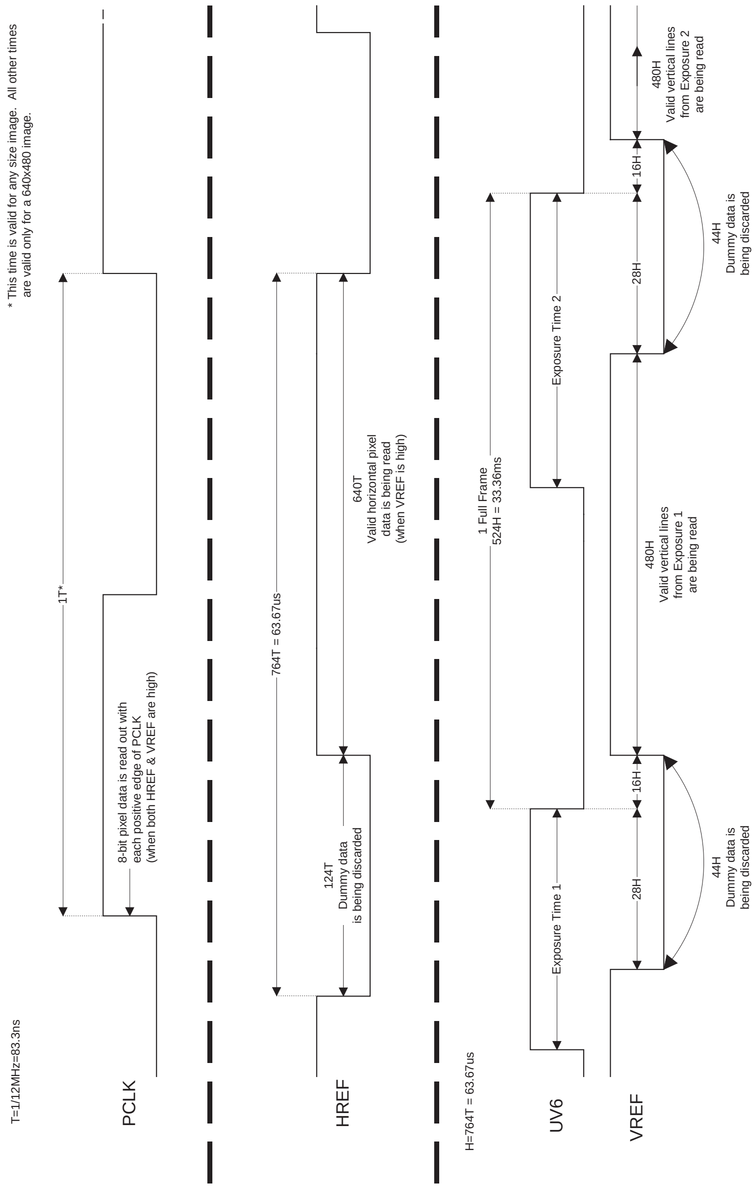


Figure 5-5. Mode 1 Image Acquisition Procedure Diagram

Power Modes

The SE4400 supports five power modes, defined in Table 5-3, which offer trade-offs between power consumption and image acquisition time.

Table 5-3. Power Mode Descriptions

Power Mode	Description	Current Draw (ma)	Mode 3 Recovery Time	Mode 1 Recovery Time
A	Completely powered off by a hardware switch.	0	~156 ms	~566 ms
B	Host acquisition halted, SE4400 placed in standby via I^2C settings.	0.2	~132 ms	~544 ms
C	Host acquisition halted, external sync signals halted (EXSFT & EXHT idle).	57	66 ms	N/A
D	Host acquisition halted, SE4400 running at full frame rate.	85	33 ms to 66 ms	33 ms to 66 ms
E	Acquiring images at full frame rate.	85	0 ms	0 ms

Table 5-3 indicates the current draw and recovery time (the time that elapses before the first frame is acquired) for each mode. The power consumption is shown with the motor, illumination, and aiming turned off. Select one of the states in Table 5-3 or switch among them toward lower power consumption (longer startup time) as the time elapses since the SE4400 was last used. These modes are displayed in Figure 5-6.

- To enter Mode A, implement a power down sequence and disconnect power from the SE4400:
  1. Place the SE4400 in stand-by mode by programming the I^2C settings found in Table A-4 on page A-8.
  2. Force MCKI & CS* to the ground level.
  3. In Mode 3, force EXSFT and EXHT to the ground level.
  4. Disconnect power.
- To enter Mode B, place the SE4400 in stand-by mode where the engine typically draws 230 µA. To exit Mode B, program the I^2C settings in Table A-5 on page A-8.
- Power Mode C only applies to Mode 3. The recovery time is 66 ms for one exposure frame and one data transfer frame.

- To enter Mode D, halt the acquisition of the 8-bit pixel data. The recovery time for this mode can vary from 66 ms down to 33 ms, depending on how near the exit of Mode D is to the end of the frame (if it occurs immediately prior to the end of the frame, the recovery time is 33 ms). While Mode D is shown as drawing the same current as Mode E, Mode D saves power because the host draws less current by not reading the pixel data.
- In Mode E images are continuously acquired. It has a recovery time of zero because the last frame in memory can be used.

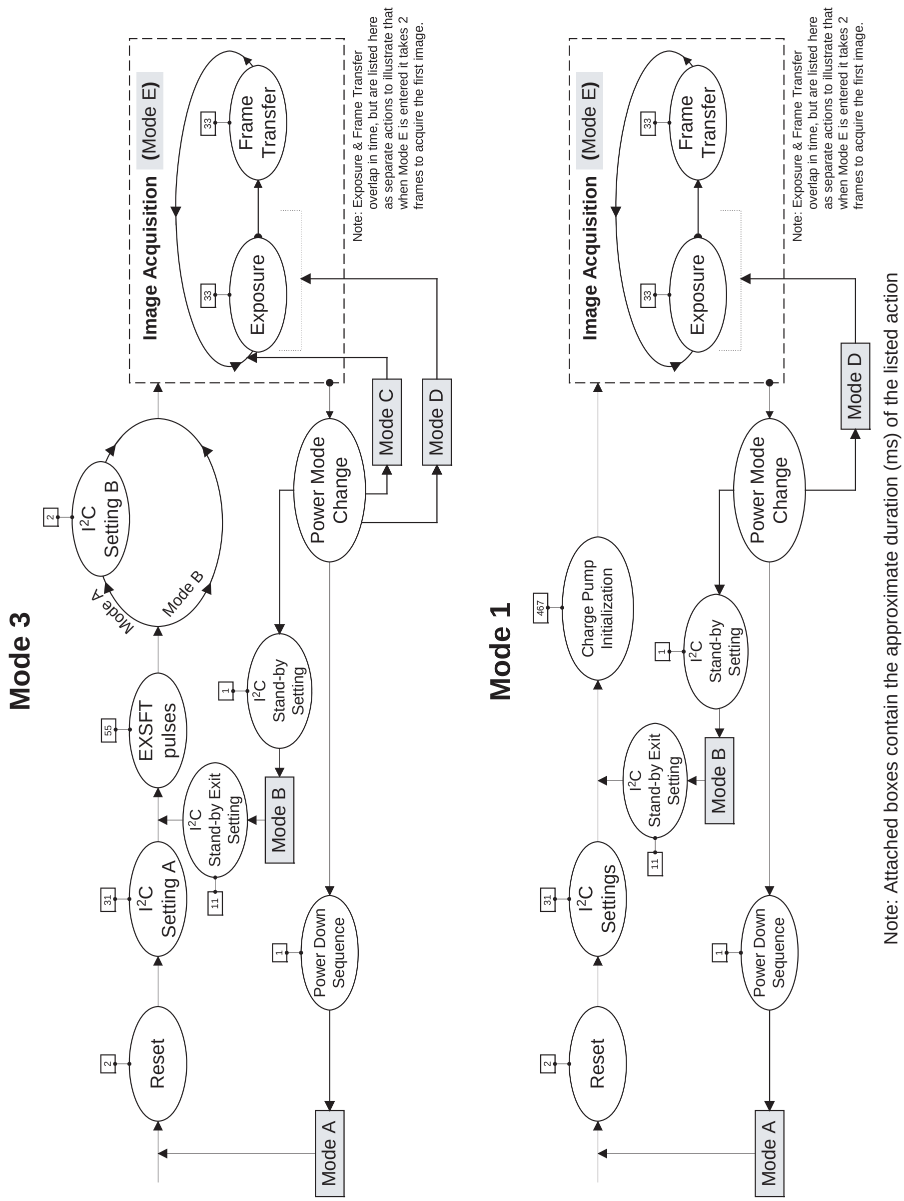


Figure 5-6. Power Mode Overview

Motor Control

The SE4400's lens system can be dynamically set to near or far focus positions:

- The near focus allows the SE4400 to focus on objects that are about five inches away.
- The far focus allows the SE4400 to focus on objects that are about nine inches away. This improves distance picture taking capability.
- Toggle mode uses the superset of the two focus positions, allowing the SE4400 to achieve excellent working range across a variety of bar code densities.

Table 5-4 describes the focus position control.

Table 5-4. Focus Control Definitions

FOCUS_CTRL1	FOCUS_CTRL2	Operation	Comments
0	0	Motor completely OFF	Motor not held in either position.
0	1	Far Focus Position Selected	Motor forced into far position.
1	0	Near Focus Position Selected	Motor forced into near position.
1	1	Toggle Mode	Motor toggles between near and far positions on each rising edge of EXSFT.

Once instructed, the motor moves and settles within 20 ms, meaning that for each frame in which the focus was changed the exposure time cannot exceed a frame time minus 20 ms. If a focus position is forced to near or far, the exposure time can be as large as a frame time as long as the motor is given 20 ms to settle from the time the focus position is forced to the time the first image exposure begins. Even if toggle mode is not used, any change to the focus position should occur at the beginning of the frame to allow the motor to settle before the next exposure.

Exposure & Gain Control

In Mode 3, the exposure time is the period that EXSFT is held low. In Mode 1, the exposure time is set in line times to I^2C register 151d. For example, in Figure 5-5, a value of 157 results in an exposure time of 157 x 764*T* = 10 ms. Once set, the exposure value occurs during the next frame, which is read out during the frame after that. The SE4400 starts in auto-exposure mode unless Address 130d[2] is set to 0. For more information concerning auto-exposure, refer to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1*.

Digital and analog gain controls can be varied over the I^2C interface. Use both the digital and analog gain to achieve a maximum gain of over 30 dB. Bar code reading applications do not use the digital gain control since it provides no true signal amplification value. Write values to I^2C register 157d to set a particular analog gain as outlined in Figure 5-7. Once written, the analog gain changes a minimum of 3 dB each subsequent frame until the desired value is reached. If the analog gain is set to a level less than 3 dB from the current value, the correct analog gain takes effect on the read-out of the subsequent frame.

In Mode 1 the SE4400 starts in auto-digital gain and auto-analog gain mode. Set Address 130d[0] and Address 130d[1] to 0 for manual digital gain and manual analog gain, respectively. In Mode 3 the SE4400 defaults to manual gain mode. To change this, set these addresses to 1. For more information concerning auto-gain, refer to *LC99704B-WK3 Sanyo DSP Specification*, *Version 1*.

GOUT	MANUAL GAIN CODE	MIN	TYP	MAX
0.0	127	18.12	21.87	24.48
0.5	106	11.36	15.1	17.73
1.0	85	4.04	7.78	10.39
1.5	64	-1.81	1.94	4.55
2.0	42	-4.01	-0.26	2.35
2.5	21	-4.86	-1.11	1.5
3.0	0	-5.58	-1.83	0.78

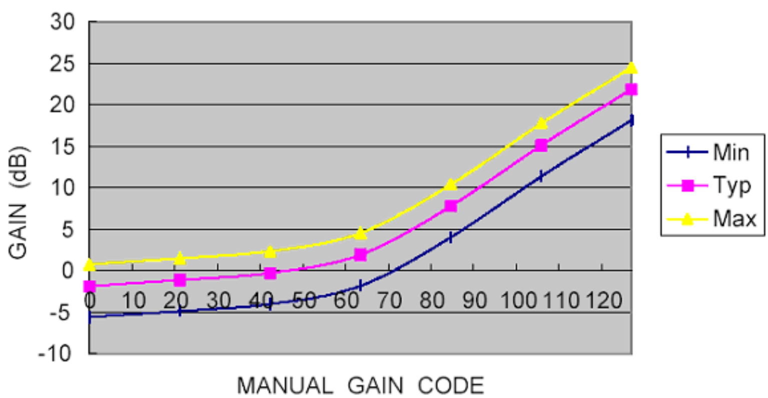


Figure 5-7. Analog Gain Control

Power Consumption

Figure 5-8 segments the current profile into 7 divisions of time. See Table 5-5 for details of this segmentation. These measurements were taken with the motor disabled and the illumination and aiming turned off. The results apply to both Mode 1 and Mode 3 operation.

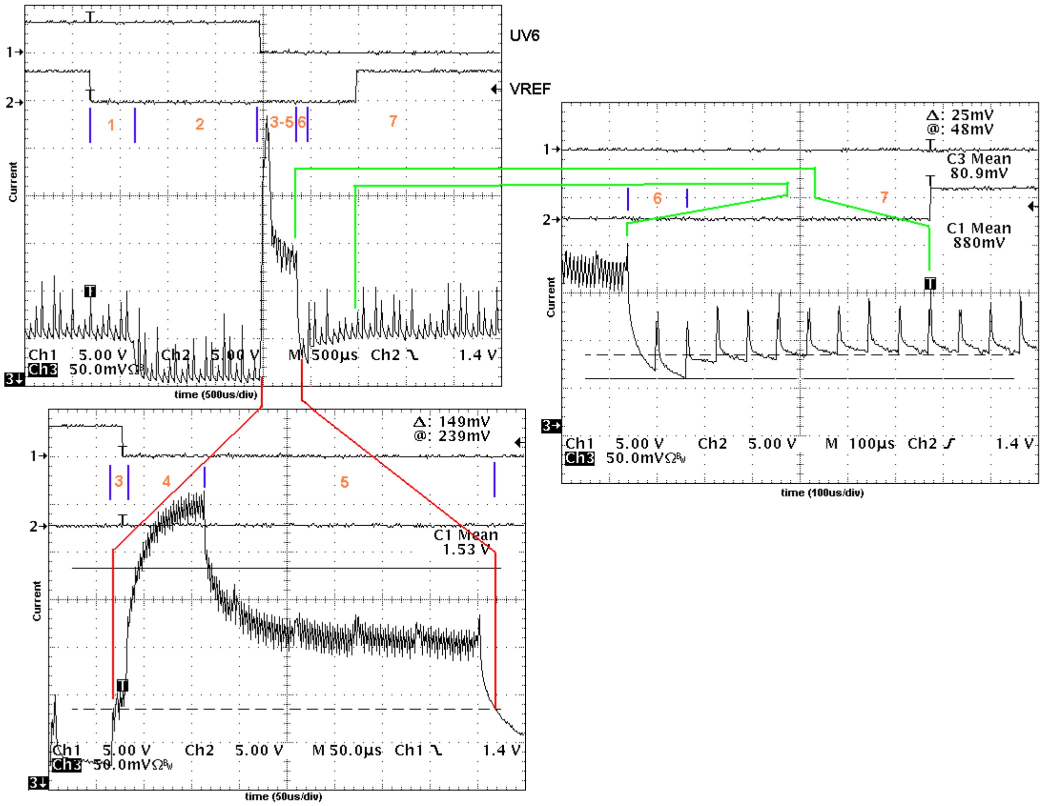


Figure 5-8. Plots of Current vs. Time as Viewed on an Oscilloscope

Table 5-5. Detailed Breakdown Of Current Profile

Region	Triggering Event	Start time w/Respect to Negative Edge of VREF (ms)	End time w/Respect to Negative Edge of VREF (ms)	Duration (ms)	Average Current (mA)	Peak Current (mA)	Frequency (Hz)
1	Negative edge of VREF	0.000	0.460	0.460	80	145	15.7k
2		0.460	1.777	1.317	36	100	15.7k
3		1.777	1.788	0.011	92	115	374k
4	Negative edge of UV6	1.788	1.876	0.088	250	320	374k
5		1.876	2.184	0.308	170	221	374k
6		2.184	2.800	0.616	60	120	15.7k

The average current consumed during each 33.36 ms frame is 79 mA. The illumination system typically adds 54 mA when enabled. The aiming system typically adds 45 mA when enabled. Place the SE4400 in standby mode to reduce the current consumption to a steady current of approximately 230 µA.

Appendix A
Register Settings

Mode 3 I^{2}C Register Settings

Table A-1. Mode 3 I^{2}C Register Settings: Initial Setting A

Register Address (HEX)	Register Data (HEX)	Comment
0x00	0x00	register reset
0x00	0x01	register reset
0xF8	0x00	circuit reset
0xF8	0x01	circuit reset
0x09	0x00	LC89905 reset
0x09	0x01	LC89905 standby
0x09	0x11	voltage setting
0x09	0x21	voltage setting
0x09	0x3E	buffer setting
0x09	0x45	voltage setting
0x09	0x54	voltage setting
0x09	0x6B	DC adjustment
0x09	0x79	NSUB Pulse
Note: The register data must be written in the order shown.		

Table A-1. Mode 3 I^2C Register Settings: Initial Setting A (continued)

Register Address (HEX)	Register Data (HEX)	Comment
0x09	0x85	NSUB DC level
0x0A	0x03	UV0, UV1 input
0x0B	0x00	Y output
0x0E	0x00	VGA CCD
0x0F	0x9F	8 bit raw output
0x10	0x05	Mode 3, 763 clocks/line
0x11	0xFB	HSGCLK=763clk
0x12	0x06	HSGCLK=763clk
0x1E	0x00	PCLK output
0x23	0x08	Edge setting
0x28	0x00	HT phase
0x29	0x08	HTR phase
0x2A	0x09	DS1 phase
0x2B	0x05	DS2 phase
0x2F	0x24	763 H clk
0x30	0x95	HREF J=149
0x32	0x15	HREF K=789
0x33	0x03	HREFK
0x34	0x08	VREF J=8
0x36	0xE8	VREF K=488
0x3A	0xA2	DRC1SL, 2H
0x3B	0x63	DRC2SL6 1/16
0x3E	0x19	DRHD=25
0x3F	0xC1	DRHD2=705
0x40	0x02	DRHD2=705
Note: The register data must be written in the order shown.		

Table A-1. Mode 3 I²C Register Settings: Initial Setting A (continued)

Register Address (HEX)	Register Data (HEX)	Comment
0x50	0x00	Digital CLP H mode
0x82	0x30	AGC,ADGC,AE OFF
0x9D	Varies	Analog gain setting
0x9E	Varies	Digital gain setting
0xBF	88	AMPCLP x1
0xCD	0x11	D Clamp
0xD4	0x64	A Clamp
0xD5	0x4C	CLP Mode
0xD9	0x17	FT=6MHz
0xDA	0x21	Phase of FT Pulse
0xC2	0x02	MCKI=12MHz, PLL=ON
0xB9	0x05	MCKI input
0xB8	0xF0	Standby OFF
0x09	0x03	LC89905 Standby OFF
0xCE	0x00	HREF, VREF
Note: The register data must be written in the order shown.		

Table A-2. Mode 3 I²C Register Settings: Initial Setting B

Register Address (HEX)	Register Data (HEX)	Comment
0xBF	0x82	AMPCLP x1
D4	0x00	A_Clamp
D5	0x40	CLP Mode
Note: The register data must be written in the order shown.		

Mode 1 I²C Register Settings

Table A-3. Mode 1 I²C Register Settings

Register Address (Dec)	Register Data (Dec)
0	0
0	1
248	0
248	1
9	0
9	1
9	17
9	37
9	62
9	69
9	84
9	107
9	126
9	133
10	0
11	0
13	88
14	0
15	159
16	1
17	251
Note: The register data must be written in the order shown.	

Table A-3. Mode 1 I^2C Register Settings (continued)

Register Address (Dec)	Register Data (Dec)
18	6
19	12
21	18
23	6
30	0
35	8
40	2
41	8
42	9
43	5
48	149
50	21
51	3
52	8
54	232
58	162
59	99
61	21
62	25
63	188
64	2
80	0
130	48
134	224
Note: The register data must be written in the order shown.	

Table A-3. Mode 1 I^2C Register Settings (continued)

Register Address (Dec)	Register Data (Dec)
135	238
136	14
137	40
138	144
139	176
140	118
141	108
142	57
143	114
144	125
146	0
151	157
153	123
155	255
157	90
158	64
191	129
194	3
205	17
213	64
217	71
218	33
194	3
195	3
Note: The register data must be written in the order shown.	

Table A-3. Mode 1 I^2C Register Settings (continued)

Register Address (Dec)	Register Data (Dec)
185	5
184	240
9	3
10	191
206	0
Note: The register data must be written in the order shown.	

Stand-by I^2C Register Settings

Table A-4. I^2C Settings to Enter Stand-by

Register Address (Hex)	Register Data (Hex)	Comment
0x09	0x01	Driver standby 1
0x9	0x3c	Driver standby 2
0xB8	0x22	Analog block standby
0xB9	0x00	MCKI standby
0xC2	0x00	PLL standby
Note: The register data must be written in the order shown.		

Table A-5. I^2C Settings to Exit Stand-by

Register Address (Hex)	Register Data (Hex)	Comment
0x09	0x15	Step-up control change
0xC2	0x02	Clear PLL standby
0xB9	0x05	Clear MCKI standby
0xB8	0xF0	Clear Analog block standby
0x09	0x03	Clear driver standby
0x09	0x3F	Set V drive capacity
Wait at least 10ms		
0x09	0x11	LC89905 (+ voltage setting)
Note: The register data must be written in the order shown.		

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