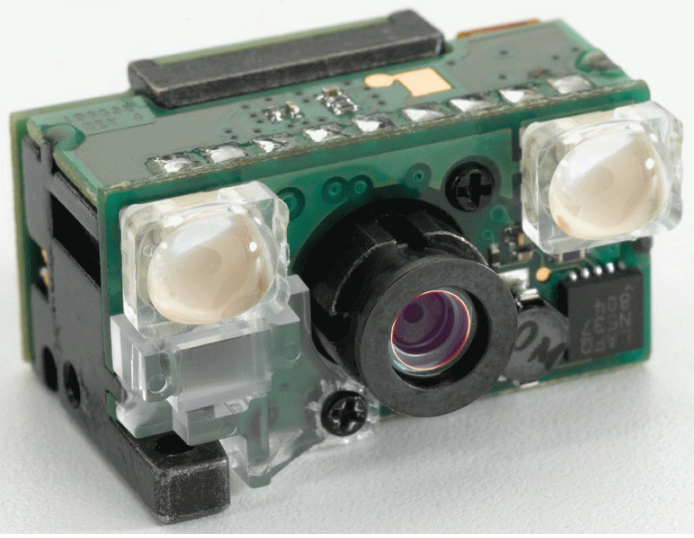
Symbol SE4500

Integration Guide



Symbol SE4500
Integration Guide

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Patents

This product is covered by one or more of the patents listed on the website: http://www.motorola.com/enterprisemobility/patents.

Warranty

For the complete Motorola hardware product warranty statement, go to: http://www.motorola.com/enterprisemobility/warranty.

Revision History

Changes to the original manual are listed below:

Change	Date	Description
-01 Rev A	8/2008	Draft

Table of Contents

About This Guide

Introduction

The *Symbol SE4500 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. Motorola recommends that an opto-mechanical engineer perform an opto-mechanical analysis prior to integration.

Chapter Descriptions

This guide includes the following topics:

- *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, optical, grounding, ESD, and environmental considerations.
- *Chapter 3, USB4500 Adapter Board* includes installation and software information for the USB4500 adapter board.
- *Chapter 4, Symbol SE4500 Specifications* provides technical specifications for the engine, including decode ranges.
- *Chapter 5, Electrical Interface* includes signal information and connector drawings.
- *Chapter 6, Control Interface* describes the Symbol SE4500's bi-directional control interface.
- *Chapter 7, Application Notes* describes Symbol SE4500 operating modes.
- *Appendix A, Register Settings* provides information on register settings for the engine.

Notational Conventions

This document uses the following conventions:

- *Italics* are used to highlight chapters and sections in this and related documents
- 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.

NOTE This symbol indicates something of special interest or importance to the reader. Failure to read the note will not result in physical harm to the reader, equipment or data.

CAUTION This symbol indicates that if this information is ignored, the possibility of data or material damage may occur.

WARNING! **This symbol indicates that if this information is ignored the possibility that serious personal injury may occur.**

Related Documents

- *PL4500 Decoder Integration Guide*, p/n 72E-xxxxx-xx
- *Software Decode Programmer Guide*, p/n 72E-xxxxx-xx
- *The I^2C-Bus Specification, Version 2.1*, http://www.semiconductors.philips.com/acrobat/literature/9398/39340011.pdf
- *Micron MT9V022 (mono) Wide VGA CMOS Digital Image Sensor Datasheet,* http://www.micron.com
- *Molex connector specification*, *54809 Series*, http://www.molex.com
- *Kyocera connector specification*, *6283 Series*, http://global.kyocera.com

For the latest version of this guide and all guides, go to: http://www.motorola.com/enterprisemobility/manuals.

Service Information

If you have a problem with your equipment, contact Motorola Enterprise Mobility Support for your region. Contact information is available at: http://www.motorola.com/enterprisemobility/contactsupport.

When contacting Enterprise Mobility Support, please have the following information available:

- Serial number of the unit
- Model number or product name
- Software type and version number.

Motorola responds to calls by E-mail, telephone or fax within the time limits set forth in support agreements.

If your problem cannot be solved by Motorola Enterprise Mobility Support, you may need to return your equipment for servicing and will be given specific directions. Motorola 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 you purchased your Enterprise Mobility business product from a Motorola business partner, contact that business partner for support.

Chapter 1 Getting Started

CAUTION This device emits CDRH Class II laser and LED light. Do not stare into beam.

Introduction

The Symbol SE4500 captures digital images for transmission to a decoder to decode a bar code of any format supported by the decoding software. The Symbol SE4500 uses laser aiming and LED illumination, and is available in the following three models to accommodate working range or more precise focusing in high-density bar code decoding or digital picture taking:

- Symbol SE4500-SR - standard working range
- Symbol SE4500-DL - driver's license optimized
- Symbol SE4500-HD - high density decoding

Symbol SE4500

The Symbol SE4500 contains:

- a monochrome 1/3" format wide VGA (752 x 480 pixels) CMOS image sensor
- a laser based aiming system
- an illumination system
- a standardized camera interface port and bi-directional control interface (I^2C)

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

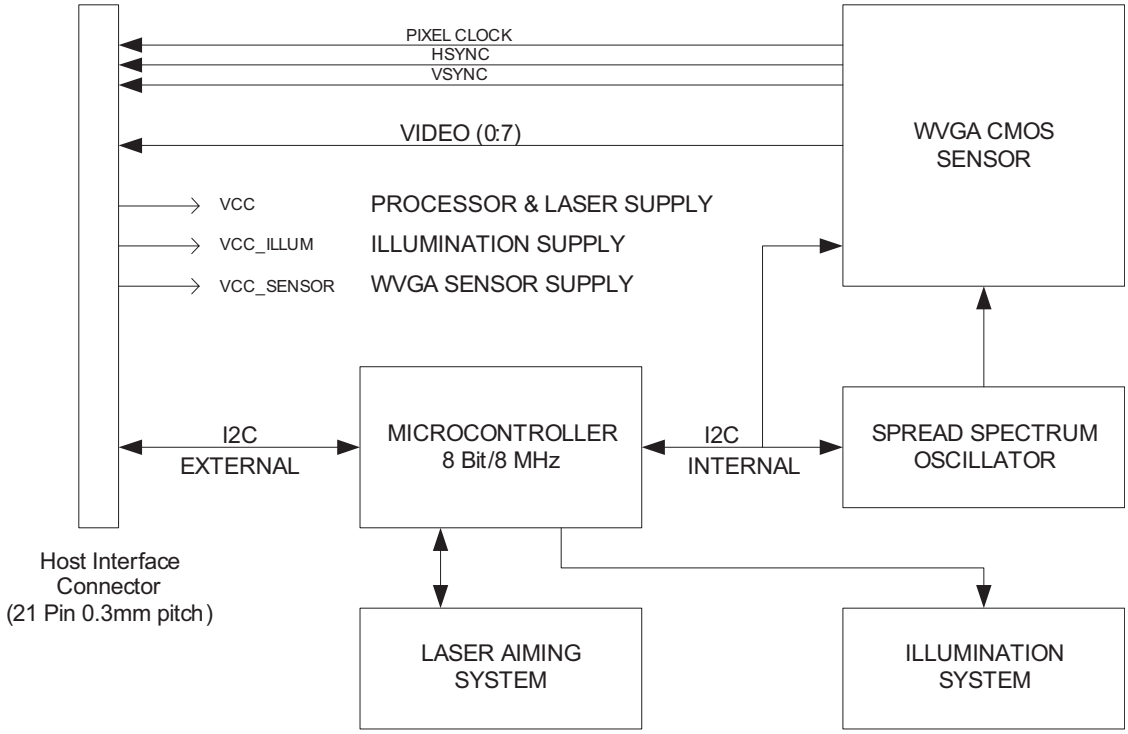


Figure 1-1 *Symbol SE4500 Block Diagram*

A 21-pin ZIF connector on the Symbol SE4500 connects the engine and the device via a 40 mm flex (available from Motorola, p/n 15-109186-01). For information about this connector, see *Figure 5-2 on page 5-3* and *Figure 5-3 on page 5-4*.

A Visible Laser Diode (655 nm) and associated optics (pattern forming element) generate a visible aiming pattern, and dual, high output LEDs provide illumination for the imager under virtually any lighting condition.

The primary component of the Symbol SE4500 imager is a 1/3" format CMOS wide VGA (752 H x 480 V) monochrome digital image sensor. The CMOS sensor converts photons to an analog voltage which is then converted, within the sensor, to a digital representation (8 bits per pixel) of the image present on the sensor.

Aiming System

A 650 nm laser and a pattern forming element 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 pattern forming element to generate the aiming pattern. The pattern's center dot indicates the center of the field of view.

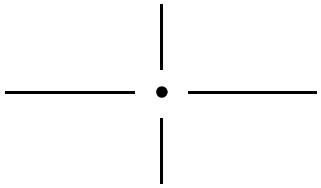


Figure 1-2 *Aiming Pattern*

The bright center spot provides visibility for aiming in sunlight and other bright light applications. The aiming pattern indicates the field of view for capturing images. The ends of the horizontal and vertical lines can form an imaginary box outlining the capture field.

Aiming Error

The aiming pattern is designed to minimize divergence (parallax) between the aiming axis and the imaging axis. See *Aiming Element on page 4-2* for Aiming Element specifications.

Aiming Control

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

The Symbol SE4500 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

The illumination system consists of two high-output, red LEDs (625 nm) and a sophisticated drive system that allows image capture and decoding throughout a full range of lighting conditions (total darkness to full sunlight).

Illumination Control

The Symbol SE4500 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 an image printed in red ink.

Chapter 2 Installation

Introduction

This chapter provides information for mounting and installing the Symbol SE4500, including physical and electrical considerations, and recommended window properties for the SE4500.

General Information

Grounding

The chassis is at ground. Isolate the Symbol SE4500 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 Symbol SE4500 is protected from ESD events that can occur in an uncontrolled 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 pattern forming element, optical lens, and illumination system LEDs. Dust and other external contaminants eventually degrade engine performance. Motorola does not guarantee performance of the Symbol SE4500 when used in an exposed application.

Thermal Management

Keep the chassis temperature below 70^{o} C to prevent the aiming laser from shutting off. In mobile computers, the chassis temperature rises up to 9^{o} C relative to the ambient air at 20 scans/minute. If necessary, use a gas tank at high ambient temperatures to increase the interval between scans. In kiosks, the aiming laser can be shut off or blink at 6 pulses/second until it detects motion; you can add a heat sink to the engine. For example, the chassis temperature would rise by 30^{o} C relative to the ambient air temperature if all engine systems were on 100% of the time for more than 15 minutes.

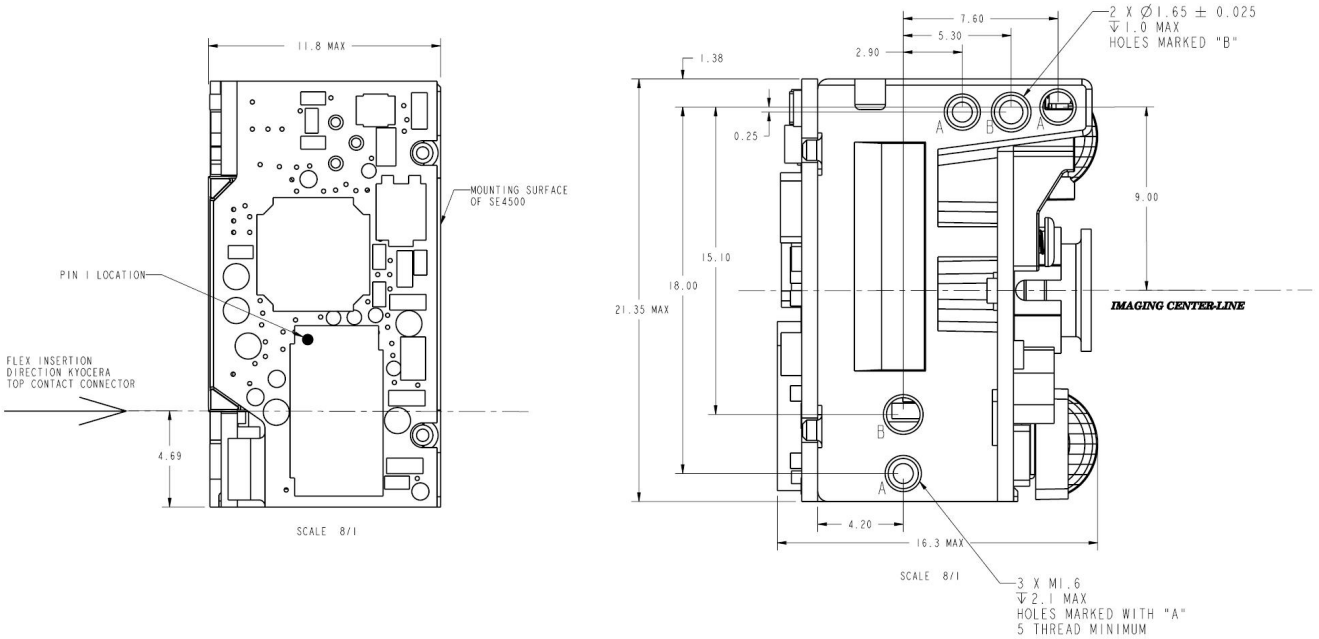
Motorola recommends thermal management mode if there is a possibility that the chassis can reach 70° C; see *THERMAL_MANAGEMENT_MODE 0x80 on page 6-11*. In this mode, the frame rate decreases from 60 fps to 30 fps and the illumination pattern blinks when the chassis reaches the temperature 64° C.

Mounting

There are three mounting holes (M1.6x0.35) and two locator holes on the bottom of the chassis (see *Figure 2-1*). The Symbol SE4500 can be mounted in any orientation without degradation in performance.

NOTE Mounting the Symbol SE4500 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 2.1 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.
- Holes marked “A” are mounting holes. Holes marked “B” are imaging engine locating aides.
- This is a reference drawing and is not intended to specify or guarantee all possible integration requirements for this engine.

Figure 2-1 *Symbol SE4500 Mounting Diagram*

Housing Design

NOTE Perform an opto-mechanical analysis for the housing design to ensure optimal scanning or imaging performance.

Design the housing so that internal reflections from the aiming and illumination system are not directed back toward the engine. The reflections from the window or housing 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. Also, keep all housing elements outside the engine clear aperture (see *Figure 2-2 on page 2-6*).

Recommended Exit Window Information on page 2-7 provides minimum exit window tilt angles. These dimensional requirements can vary. Consider using baffles or matte-finished dark internal housing colors.

Optical

The Symbol SE4500 uses a sophisticated optical system that provides imaging performance that matches or exceeds the performance of much larger imagers. However, an improperly designed enclosure, or improper selection of window material, can affect the performance of the SE4500.

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 *Recommended Exit Window Information on page 2-7*). If the designed enclosure cannot accommodate the recommended window angle, contact Motorola to discuss positioning requirements. An improperly positioned window can significantly decrease performance.

Window Positioning Options

There are two options for window positioning:

- Parallel window - This is the preferred method for imaging engines. The maximum window distance is limited. Parallel window installation requires 2-sided anti-reflection coating (see *Anti-Reflection Coatings on page 2-5*).
- Tilted window - This is used for either laser or imaging engines. Adhere to the minimum window tilt specifications in *Table 2-4 on page 2-7*. With tilted window installation, 2-sided anti-reflection coating is optional (see *Anti-Reflection Coatings on page 2-5*).

Avoiding Scratched Windows

Scratches on the window can greatly reduce the performance of the imaging system. Motorola recommends 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, use only cell-cast plastics or optical glass (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*

Property	Description
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

If using an anti-reflective coating, the specifications in *Table 2-3* apply. Polysiloxane coating is not required. Recess the exit window to minimize scratches and digs.

Table 2-3 *AR Coatings Specifications*

Specification	Description
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	• One side tempered AR coating: 92% minimum within spectrum range from 450 nm to 700 nm. • Double side AR coating: One side AR coating must be 97% minimum within spectrum range from 450 nm to 700 nm. • For parallel windows, see *Figure 2-3 on page 2-7*.

Optical Path and Exit Window

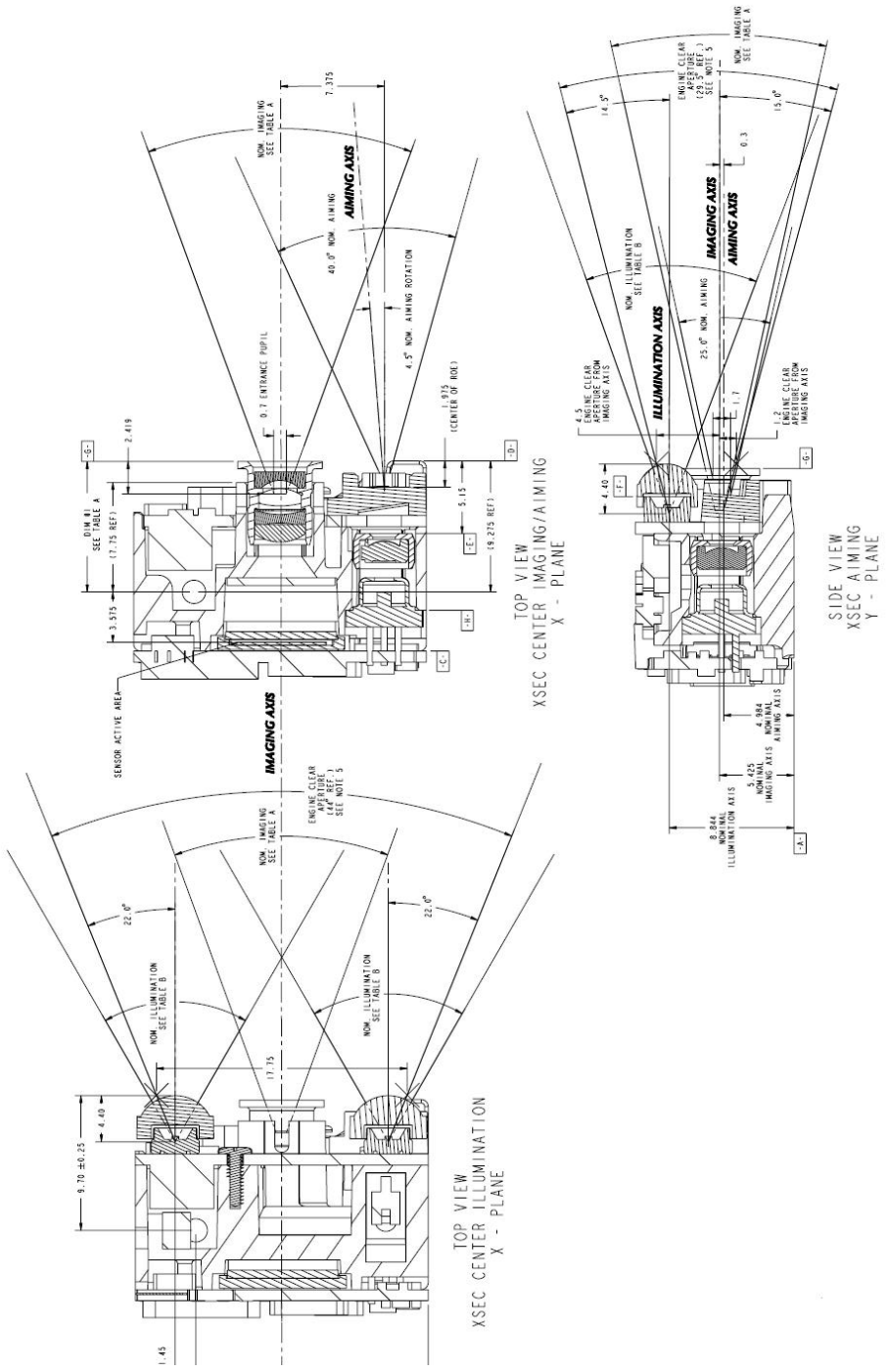


TABLE A - SE4500
IMAGING FOCUS POSITIONS

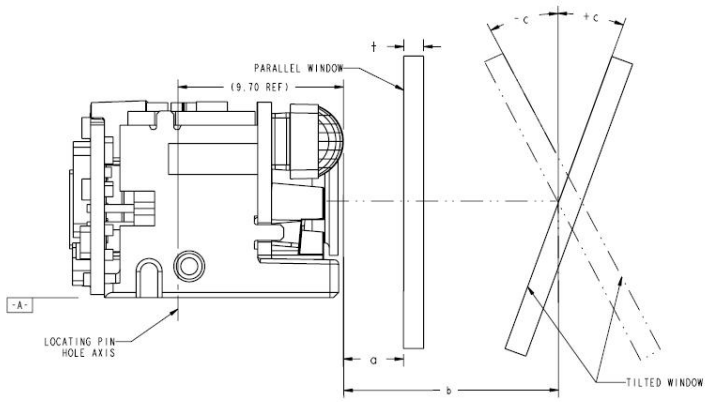
TABLE A	SR	DL	HD
FULL NOM FOV (X x Y)	39.6° x 25.7°	39.2° x 25.4°	38.4° x 24.9°
DIM #1 (MM)	9.233±0.3	9.353±0.3	9.553±0.3

TABLE B - SE4500
ILLUMINATION PLANES

ILLUMINATION FOV	X	Y
80% INTENSITY	60°	40°
50% INTENSITY	66°	50°
20% INTENSITY	70°	54°
10% INTENSITY	86°	88°
5% INTENSITY	100°	100°

Figure 2-2 *Symbol SE4500 Optical Path and Exit Window*

Recommended Exit Window Information



Maximum Distance “a” for a Parallel Window

Anti-reflection coating (2 sides), 0.4% reflections maximum per side over wavelength 620 - 640 nm.

$a <= a0 + (t0 / n0) - (t / n)$

n0 = 1.5, t0 = 1.5 mm
a0 = 3.0 mm

where *n* is the index of refraction of the window.

Figure 2-3 *Window Distances*

Table 2-4 *Recommended Exit Window Information - Tilted Window*

A	Distance from LED Lens Front Surface (b) in mm	5	10	15	20	27
	Window Specification	Angle				
B	Non-coated, minimum window positive tilt (+c)	34°	29°	30°	27°	25°
C	Non-coated, minimum window negative tilt (-c)	34°	28°	27°	27°	26°
D	AR coated, one side, minimum window positive tilt (+c)	34°	28°	24°	24°	24°
E	AR coated, one side, minimum window negative tilt (-c)	33°	28°	26°	25°	24°
F	AR coated, two sides, minimum window positive tilt (+c)	32°	27°	23°	21°	20°
G	AR coated, two sides, minimum window negative tilt (-c)	10°	15°	15°	15°	15°

Exit Window Notes

- Do not place the exit window between the maximum distance for a parallel window (“a” in *Figure 2-3*) and the minimum distance for a tilted window (5 mm in *Table 2-4*) in respect to the front of the engine.
- Integration tolerances are not included.

Chapter 3 USB4500 Adapter Board

Introduction

The optional USB4500 board interfaces the Symbol SE4500 with a host device, allowing easy and flexible integration of data capture and software decoding into the host via Motorola application. The board contains a standard USB 2.0 micro-port for connection to the host.

For application information for the USB4500, refer to the *Software Decode Programmer Guide [correct name???]*.

USB4500 Block Diagram

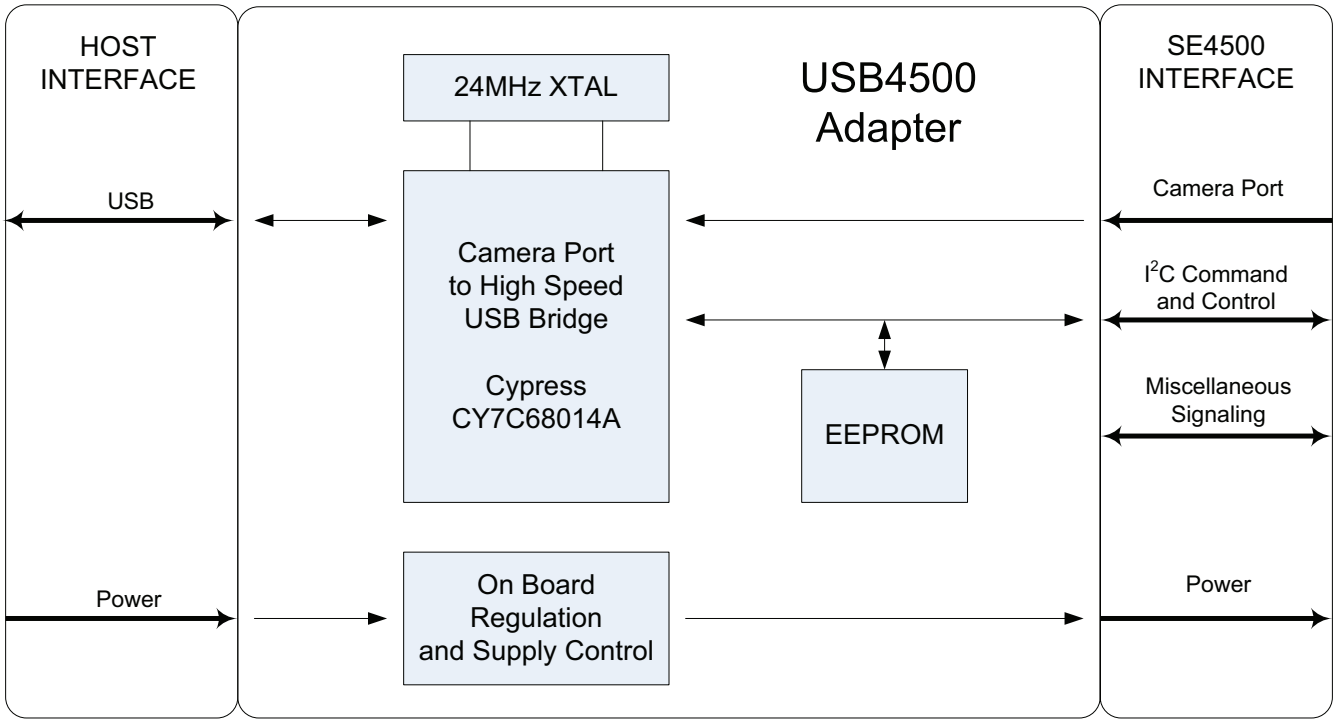


Figure 3-1 *USB4500 Block Diagram*

Board Mounting and Connection

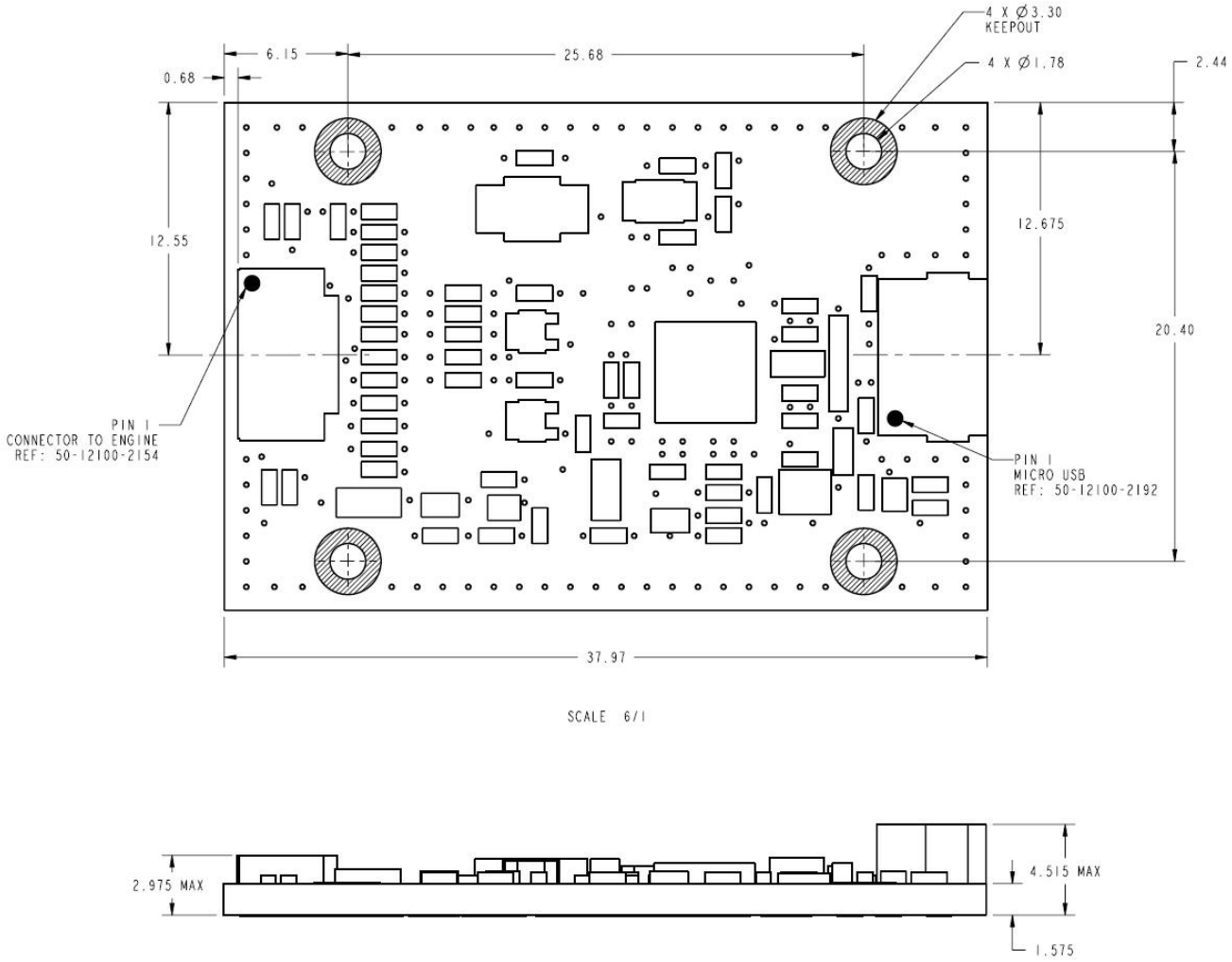


Figure 3-2 *USB4500 Mounting Diagram*

[need more installation/connection information?? size of mounting holes and fasteners required???]

Chapter 4 Symbol SE4500 Specifications

Introduction

This chapter provides the technical specifications of the Symbol SE4500, including decode zone and exit window characteristics.

Technical Specifications

Table 4-1 *Symbol SE4500 Technical Specifications at 23° C*

Item	Description
Power Requirements	
Input Voltage	3.0 V to 3.6 V (3.3 V typical)
Camera Operating Current	55 mA (typical)
including Illumination Current	210 mA (typical)
Total Operating Current (AIM 100%)	250 mA (typical)
Operating Mode Supply Currents (conditions VCC=VCC_SENSOR=VCC_ILLUM = 3.3VDC):	
Low Power	8 mA
Initial Standby	18 mA
Image Acquisition	55 mA
Illumination Enabled	210 mA
AIM Laser Enabled	250 mA
Maximum VCC_SENSOR Power Supply Noise	75 mVp-p (3.3 V, 10 Hz - 100 kHz) for decoding* 30 mVp-p (3.3 V, 10 Hz - 100 kHz) for image capture
*The imager may decode even with visible noise on the image. For best image quality in image capture applications, use an additional filter on VCC_SENSOR. For additional performance improvement, provide a separately regulated 3.3 V supply for the sensor.	

Table 4-1 *Symbol SE4500 Technical Specifications at 23° C (Continued)*

Item	Description
Optical Resolutions	4.0 mil (PDF417), 5.0 mil (Code 39), HD focus only
Specular Dead Zone Illumination On Illumination Off	 15º None
Skew Tolerance	± 60º (see *Figure 4-1 on page 4-4*)
Pitch Angle	± 60º (see *Figure 4-1 on page 4-4*)
Roll	360º (see *Figure 4-1 on page 4-4*)
Ambient Light Immunity (Sunlight)	9000 ft. candles (96,900 lux)
Imaging Sensor Image Resolution Gray Scale Field of View (FOV)	 752 H x 480 V pixels (Wide VGA) 256 levels (8 bits per pixel) SE4500-SR: 39.6º horizontal, 25.7º vertical SE4500-DL: 39.2º horizontal, 25.4º vertical SE4500-HD: 38.4º horizontal, 24.9º vertical
Focusing Distance from Front of Engine Standard Range configuration Driver's License Optimized configuration High Density configuration	 8 in. / 20.3 cm 5.3 in. / 13.5 cm 2.9 in. / 7.4 cm
Aiming Element Visible Laser Diode (VLD) Total Optical Power Central Dot Optical Power Pattern Angle	 655 ± 10 nm 4.0 mW (typical) 0.6 mW (typical) 40º horizontal, 30º vertical
Illumination System Dual LED Peak Operating Current Total Peak Output Power Pattern Angle	 625 ± 5 nm 560 mA (1 ms exposure) **TBD** mW (typical) 66º horizontal, 50º vertical (half intensity)
Shock	2000 G ± 5% applied via any mounting surface at -30º and 70º C for a period of 0.85 ± 0.05 msec 2500 G ± 5% applied via any mounting surface at 23º C for a period of 0.85 ± 0.05 msec
Vibration	Unpowered SE4500 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 at 0.04 G^2/Hz at 3 dB/octave 80 to 350 Hz — 0.04 G^2/Hz 350 Hz to 2 kHz — Ramp down at 0.04 G^2/Hz at 3 dB/octave

Table 4-1 *Symbol SE4500 Technical Specifications at 23° C (Continued)*

Item	Description
ESD	± 2 kV @ connector
Laser Class	CDRH Class II
Temperature Operating Storage	 -30º to 55º C (-22º to 131º F) -40º to 70º C (-40º to 158ºF) See *Thermal Management on page 2-1* for more information.
Humidity Operating Storage	 95% RH, non-condensing at 55º C 85% RH, non-condensing at 70º C
Maximum Engine Dimensions	0.46 in. H x 0.84 in.W x 0.64 in. D 11.8 mm H x 21.35 mm W x 16.3 mm D
Weight	0.29 oz. (8.3 grams)
Electrical Interface	21 pin 0.3 mm pitch zero insertion force ZIF connector See *Chapter 5, Electrical Interface* for more information.

NOTE Environmental and/or tolerance parameters are not cumulative. Motorola recommends a thermal analysis 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.

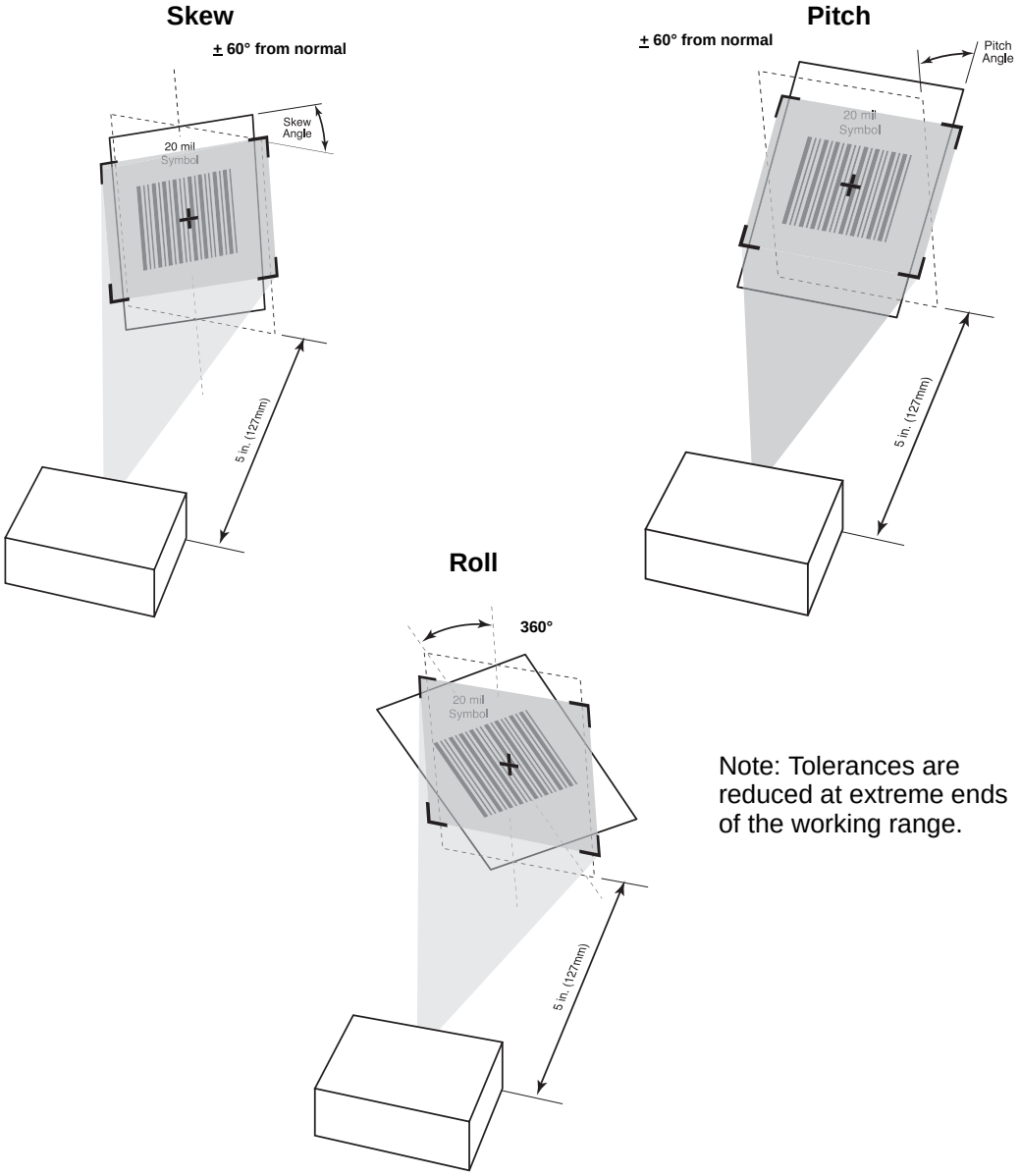


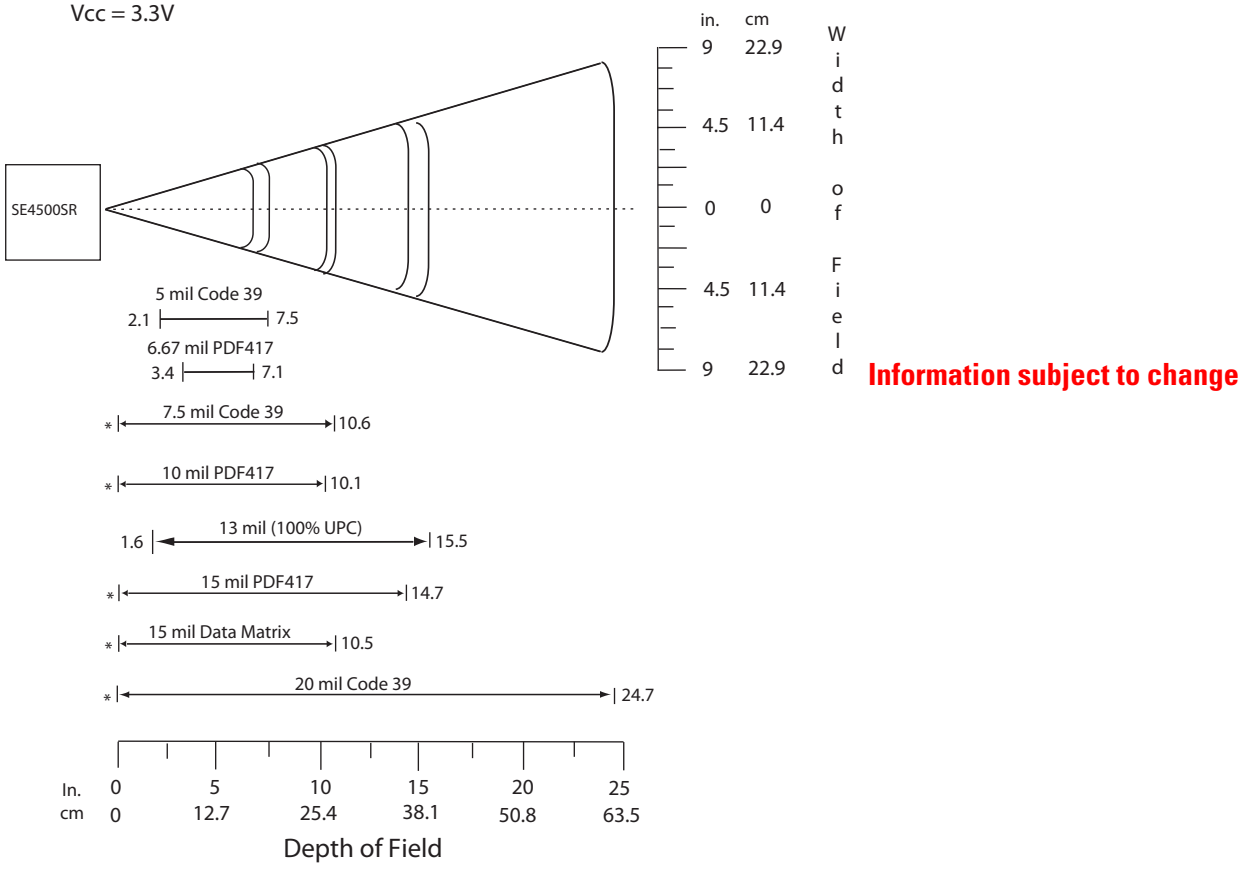
Figure 4-1 *Skew, Pitch, and Roll*

Decode Zones

Symbol SE4500-SR

Figure 4-2 shows the decode zone for the standard range Symbol SE4500-SR. Typical values appear. *Table 4-2* 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.

Note: Typical performance at 73˚F (23˚C)
on high quality symbols in normal room light.
Vcc = 3.3V



Information subject to change

* Minimum distance determined by symbol length and scan angle.

Figure 4-2 *Symbol SE4500-SR Standard Range Decode Zone*

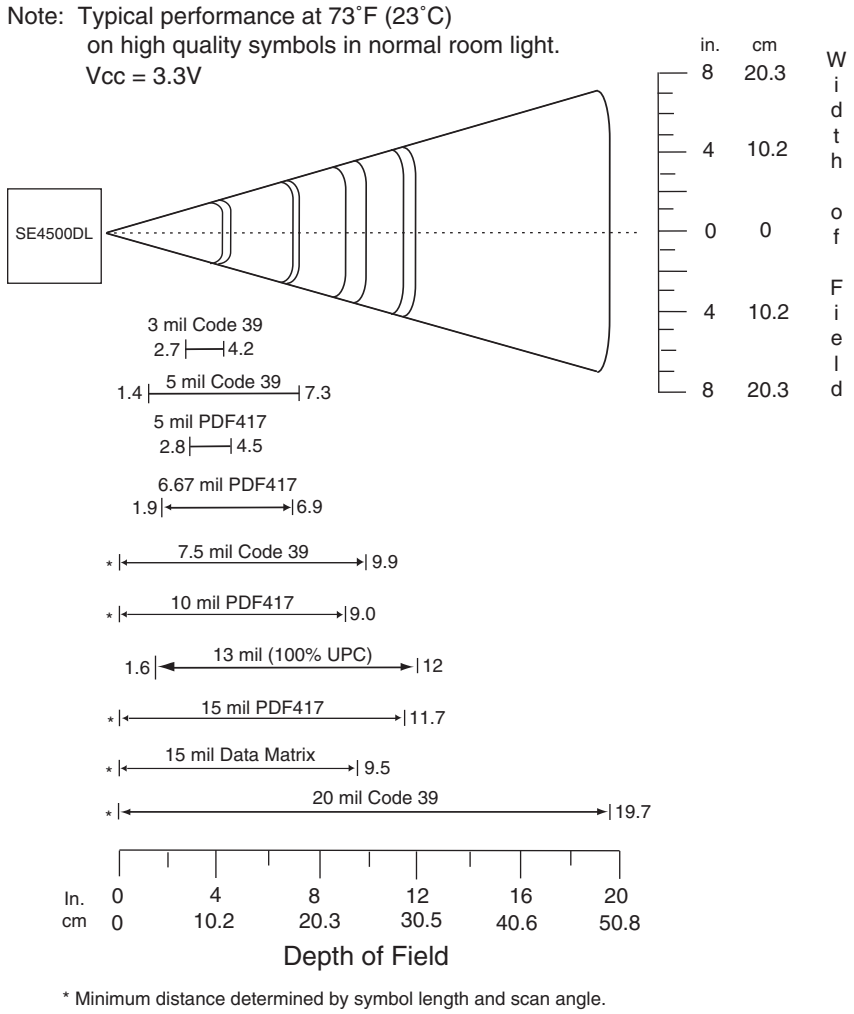
Table 4-2 *Symbol SE4500-SR Standard Range Decode Distances*

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	2.1 in 5.33 cm	7.5 in 19.05 cm	2.5 in 6.35 cm	6.8 in 17.27 cm
6.67 mil PDF417	4 Col, 20 Rows 80% MRD	3.4 in 8.64 cm	7.1 in 18.03 cm	4.1 in 10.41 cm	6.2 in 15.75 cm
7.5 mil Code 39	ABCDEF 80% MRD	Note 1	10.6 in 26.92 cm	Note 1	9.6 in 24.38 cm
10 mil PDF417	3 Col, 17 Rows 80% MRD	Note 1	10.1 in 25.65 cm	Note 1	9.0 in 22.86 cm
13 mil UPC-A	012345678905 80% MRD	1.6 in 5.08 cm	15.5 in 39.37 cm	2.5 in 5.08 cm	14.2 in 36.07 cm
15 mil PDF417	80% MRD	Note 1	14.7 in 37.34 cm	Note 1	13.2 in 33.53 cm
15 mil Data Matrix		Note 1	10.5 in 26.67 cm	TBD	TBD
20 mil Code 39	123 80% MRD	Note 1	24.7 in 62.74 cm	Note 1	21.8 in 55.37 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.

Symbol SE4500-DL

Figure 4-3 shows the decode zone for the driver's license optimized Symbol SE4500-DL. Typical values appear. *Table 4-3* 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.



Information subject to change

Figure 4-3 *Symbol SE4500-DL Driver's License Optimized Decode Zone*

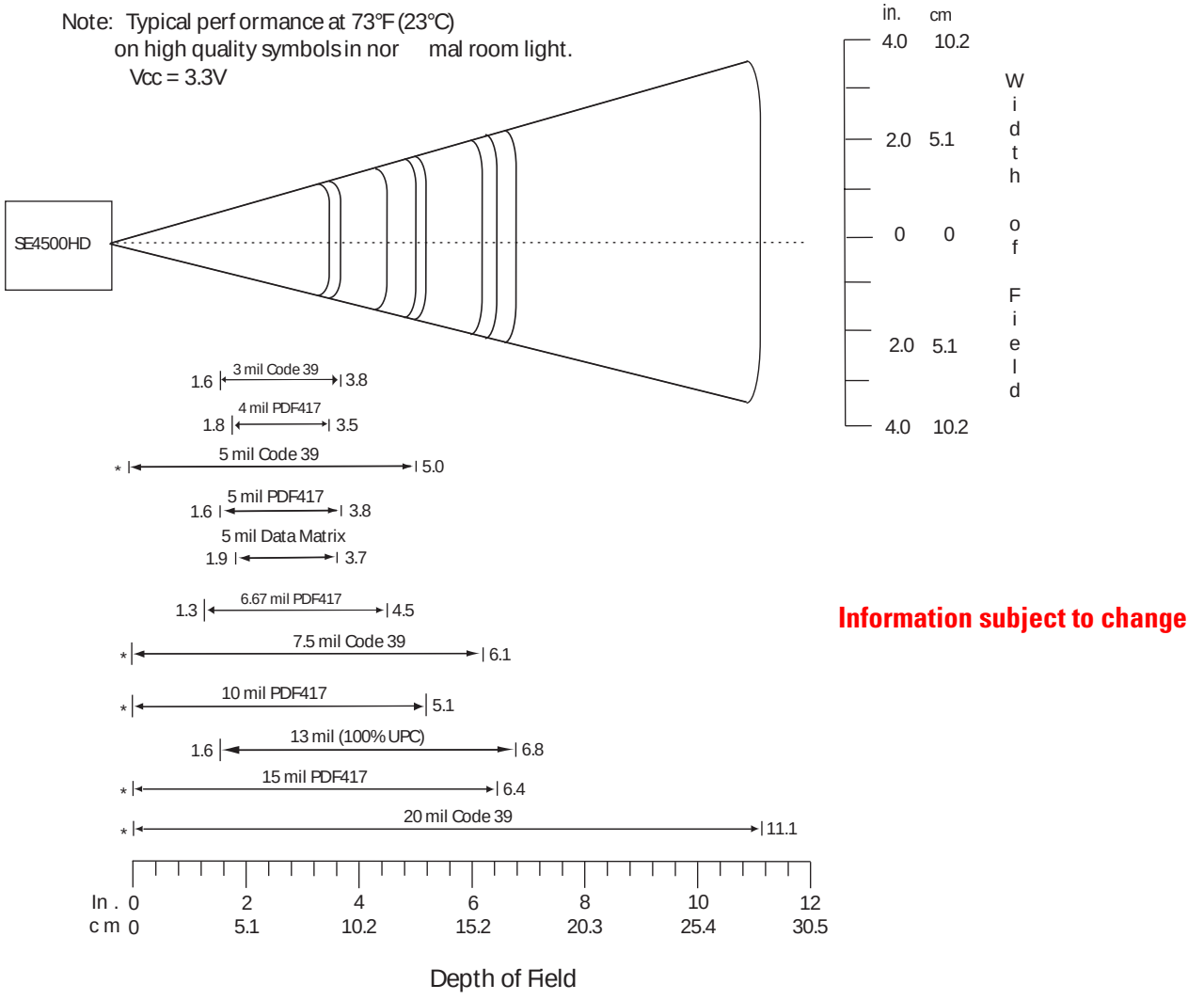
Table 4-3 *Symbol SE4500-DL Driver's License Optimized Decode Distances*

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Typical Working Ranges		Guaranteed Working Ranges	
		Near	Far	Near	Far
3.0 mil Code 39	80% MRD	2.7 in 6.86 cm	4.2 in 10.67 cm	3.3 in 8.38 cm	3.7 in 9.40 cm
5.0 mil Code 39	ABCDEFGH 80% MRD	1.4 in 3.56 cm	7.3 in 18.54 cm	1.7 in 4.32 cm	6.7 in 17.02 cm
5.0 mil PDF417	80% MRD	2.8 in 7.11 cm	4.5 in 11.43 cm	3.4 in 8.64 cm	3.9 in 9.91 cm
6.67 mil PDF417	4 Col, 20 Rows 80% MRD	1.9 in 4.83 cm	6.9 in 17.53 cm	2.5 in 6.35 cm	6.2 in 15.75 cm
7.5 mil Code 39	ABCDEF 80% MRD	Note 1	9.9 in 25.15 cm	Note 1	8.8 in 22.35 cm
10 mil PDF417	3 Col, 17 Rows 80% MRD	Note 1	9.0 in 22.86 cm	Note 1	8.0 in 20.32 cm
13 mil UPC-A	012345678905 80% MRD	1.6 in 5.08 cm	12.0 in 30.48 cm	2.5 in 5.08 cm	10.7 in 27.18 cm
15 mil PDF417	80% MRD	Note 1	11.7 in 29.72 cm	Note 1	10.5 in 26.67 cm
15 mil Data Matrix		Note 1	9.5 in 24.13 cm	TBD	TBD
20 mil Code 39	123 80% MRD	Note 1	19.7 in 50.04 cm	Note 1	17.1 in 43.43 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.

Symbol SE4500-HD

Figure 4-4 shows the decode zone for the high-density Symbol SE4500-HD. Typical values appear. *Table 4-4* 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.



Information subject to change

Figure 4-4 *Symbol SE4500-HD High Density Decode Zone*

Table 4-4 *Symbol SE4500-HD High Density Decode Distances*

Symbol Density/ Bar Code Type	Bar Code Content/ Contrast Note 2	Typical Working Ranges		Guaranteed Working Ranges	
		Near	Far	Near	Far
3.0 mil Code 39	80% MRD	1.6 in 4.06 cm	3.8 in 9.65 cm	1.8 in 4.57 cm	3.4 in 8.64 cm
4.0 mil PDF417	80% MRD	1.8 in 4.57 cm	3.5 in 8.89 cm	2.0 in 5.08 cm	3.1 in 7.87 cm
5.0 mil Code 39	ABCDEFGH 80% MRD	Note 1	5.0 in 12.70 cm	Note 1	4.5 in 11.43 cm
5.0 mil PDF417	80% MRD	1.6 in 4.06 cm	3.8 in 9.65 cm	1.9 in 4.83 cm	3.4 in 8.64 cm
5.0 mil Data Matrix		1.9 in 4.83 cm	3.7 in 9.40 cm	TBD	TBD
6.67 mil PDF417	4 Col, 20 Rows 80% MRD	1.3 in 3.30 cm	4.5 in 11.43 cm	1.4 in 3.30 cm	4.0 in 11.43 cm
7.5 mil Code 39	ABCDEF 80% MRD	Note 1	6.1 in 15.49 cm	Note 1	5.5 in 15.49 cm
10 mil PDF417	3 Col, 17 Rows 80% MRD	Note 1	5.1 in 12.95 cm	Note 1	4.5 in 12.95 cm
13 mil UPC-A	012345678905 80% MRD	1.6 in 4.06 cm	6.8 in 17.27 cm	2.5 in 4.06 cm	6.1 in 17.27 cm
15 mil PDF417	80% MRD	Note 1	6.4 in 16.26 cm	Note 1	5.7 in 16.26 cm
20.0 mil Code 39	123 80% MRD	Note 1	11.1 in 28.19 cm	Note 1	9.7 in 28.19 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.

Chapter 5 Electrical Interface

Introduction

Table 5-1 lists the pins and signals of the 21-pin connector on the Symbol SE4500. See *Figure 2-1 on page 2-2* for the pin 1 location on the rear of the engine, on the side opposite the aiming/illumination system.

Table 5-1 *Symbol SE4500 Signal Information*

Pin Number	SE4500 Signal Name	I/O	Note
1	GND	GND	Ground
2	GND	I	Ground
3	I2C_CLK	I/O	I^2C Clock
4	I2C_DATA	I/O	I^2C Data
5	VREF_OUT	O	Vertical sync
6	PIX_D7_OUT	O	Sensor Pixel Data - MSB
7	PIX_D6_OUT	O	Sensor Pixel Data
8	PIX_D5_OUT	O	Sensor Pixel Data
9	PIX_D4_OUT	O	Sensor Pixel Data
10	PIX_D3_OUT	O	Sensor Pixel Data
11	PIX_D2_OUT	O	Sensor Pixel Data
12	PIX_D1_OUT	O	Sensor Pixel Data
13	PIX_D0_OUT	O	Sensor Pixel Data - LSB
14	LED_EN	O	External illumination trigger
15	VCC_WVGA	I	WVGA sensor power (3.3 VDC)
16	VCC	I	Laser and logic power (3.3 VDC)
17	VCC_ILLUM	I	Illumination power (3.3 or 5.0 VDC)
18	HREF_OUT	O	Horizontal sync
19	GND	I	Ground
20	PIXCLK_OUT	O	Sensor pixel clock
21	GND	I	Ground

Connector Drawings

For detailed connector information, refer to the manufacturer's specifications.

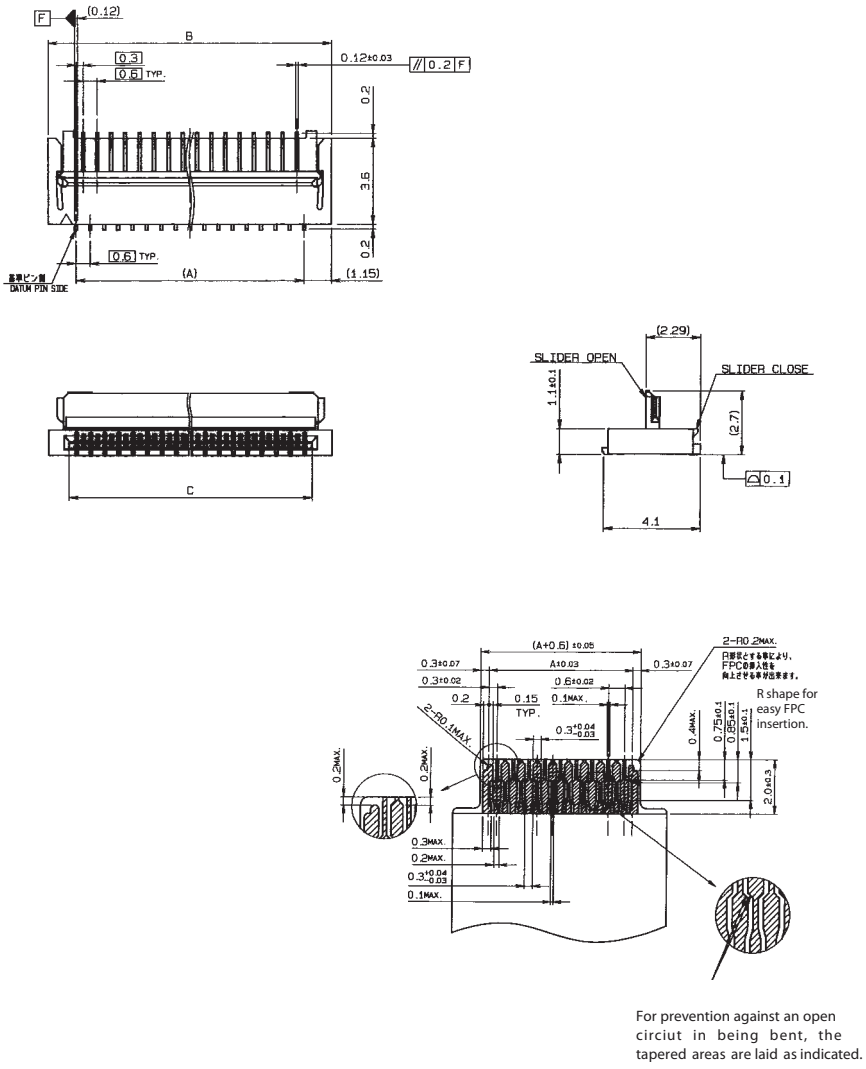


Figure 5-1 *21-Pin ZIF Connector (SE4500 Imager to Flex), p/n 50-12100-2193 (Kyocera 6283 Series]*

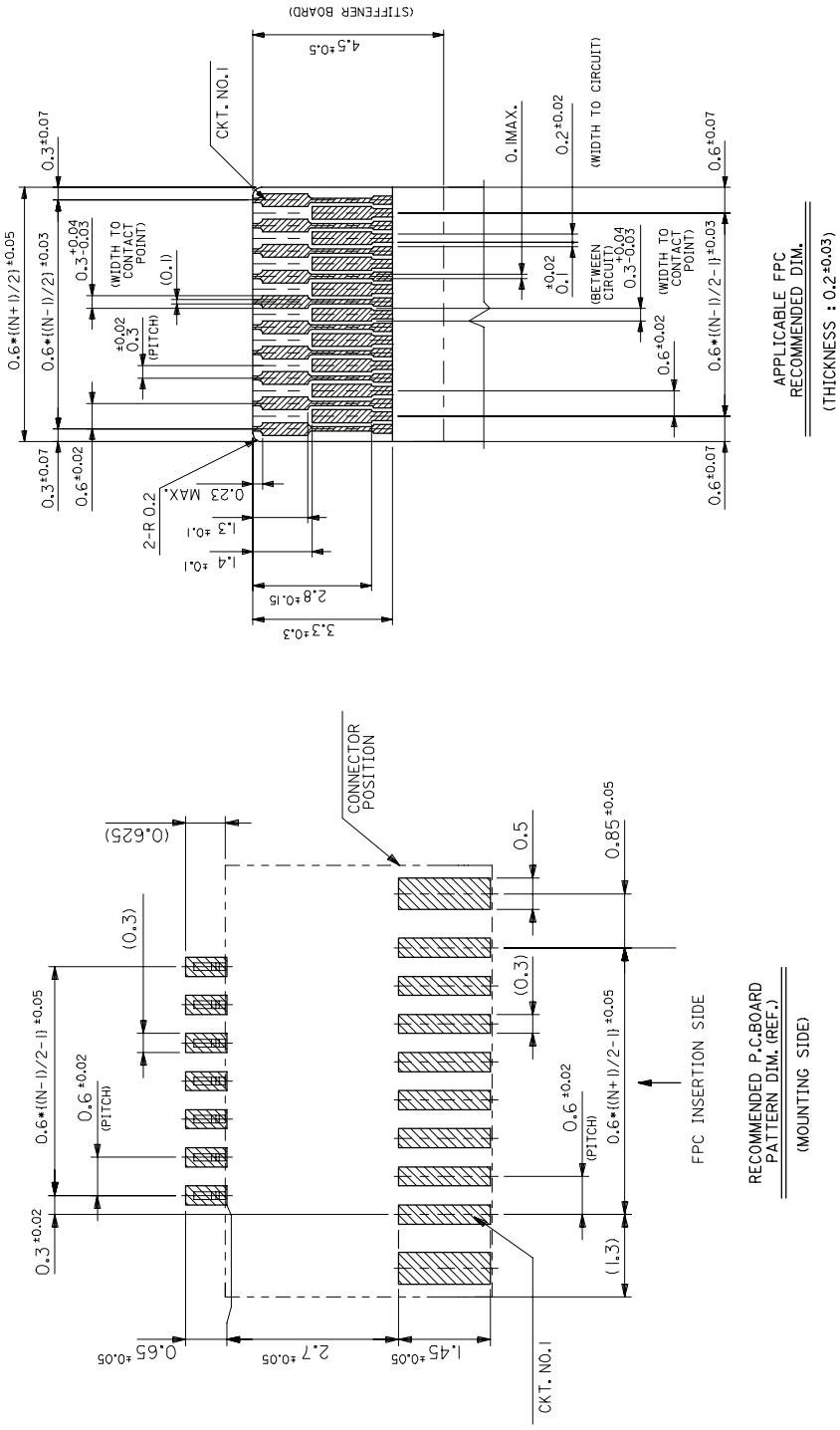
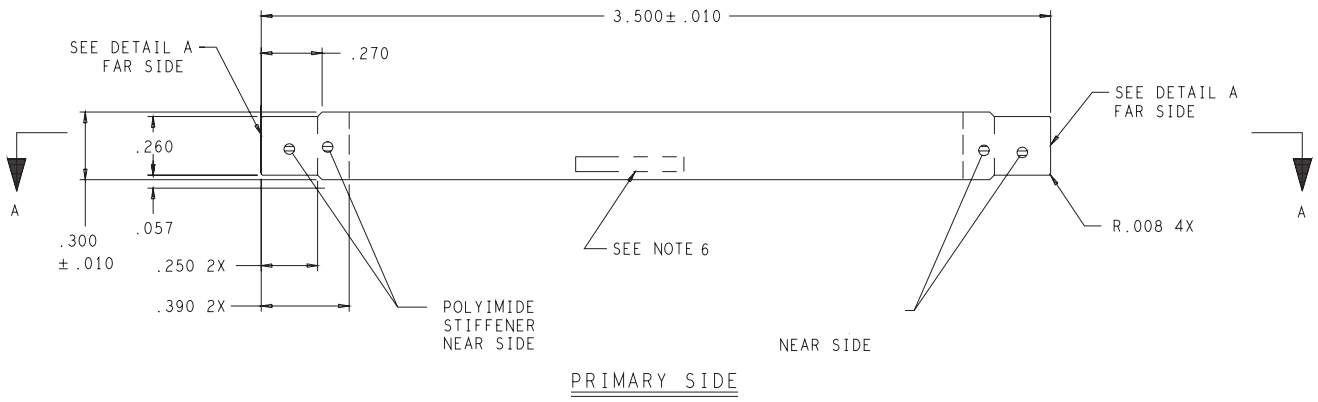
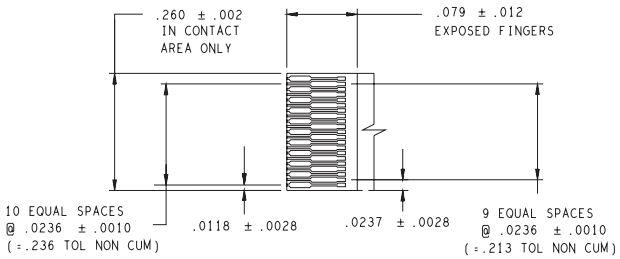


Figure 5-2 *21-Pin ZIF Connector (Flex to PL4500 Decoder), p/n 50-12100-2154 (Molex 54809 Series)*

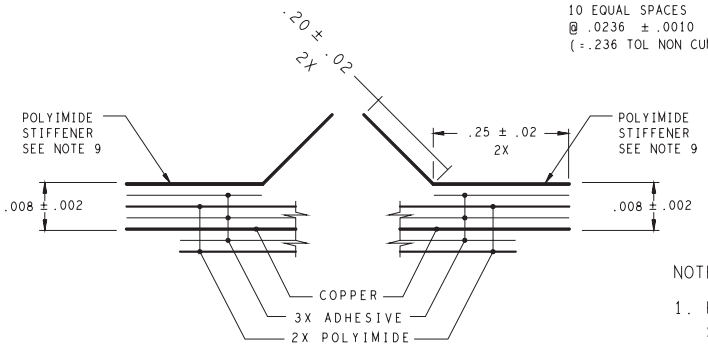


PRIMARY SIDE



DETAIL "A"

SCALE:NONE
2X



VIEW A-A

SCALE: NONE
EXPANDED FOR CLARITY

NOTES:

1. REFERENCE ASSOCIATED P/L 15-109186-01 AND SUBSEQUENT P/L'S.
2. FABRICATE IN ACCORDANCE WITH ITEM 30.
3. MATERIAL:
   BASE DIELECTRIC ITEM 10
   COPPER PANEL PLATE USING ITEM 20.
   COVERLAYER / BOND FILM(S) ITEM 11.
   FINISH:ITEM 21 OVER ITEM 22.
   POLYIMIDE STIFFENER(S) .010 THICK PER ITEM 12.
4. SUPPLIED GERBER DATA: MINIMUM CONDUCTOR WIDTH .005" AND MINIMUM SPACING TO BE .004" (EXCEPT IN CONNECTOR AREA).
5. LABEL AND SHIPPING REQUIREMENTS PER ITEM 31.
6. VENDOR IDENTIFICATION PER ITEM 32 USING ITEM 28.
7. DIMENSIONS ARE TO CENTER OF THE CONTACT.
8. APPLY SILKSCREEN TO SECONDARY SIDE WITH ARTWORK MASTER USING ITEM 28.
9. POLYIMIDE STIFFENER TO BE FREE OF BONDING FROM FLEX CIRCUIT IN AREA SPECIFIED.
10. ALL MATERIALS: LAMINATES, RESINS AND METALLIZATIONS TO BE COMPLIANT TO EU RoHS DIRECTIVE 2002/95/EC IAW SP-12509-01.

Figure 5-3 *Symbol SE4500 to PL4500 21-Pin Flex, p/n 15-109186-01*

Chapter 6 Control Interface

Introduction

The Symbol SE4500 bi-directional control interface uses the industry-standard I^2C protocol. The SE4500 protocol is a host-initiated command/response type protocol, and does not support unsolicited responses.

Command List

The Symbol SE4500 protocol supports the commands listed in *Table 6-1*. For detail on each command, see *Command Descriptions on page 6-5*.

Table 6-1 *Symbol SE4500 Command List*

I^2C Command Set	Opcode	Description
ACQUISITION	0x58	Starts and stops image data output.
ACQUISITION_MODE	0x5B	Optimizes the Symbol SE4500 for a specific operation.
AIM	0x55	Turns the aim pattern on and off.
AIM_BLINK_RATE	0xF4	Controls the blink rate of the aim pattern.
AIM_DURING_EXPOSURE	0x56	Captures the aim pattern in the image.
AIM_POWER	0xF3	Controls the brightness of the aim pattern.
AUTO_POWER_REDUCTION	0x74	Places the SE4500 in a low power state when idle.
ENTER_BOOTLOADER	0x91	Enters bootloader mode.
EXECUTE_SCRIPT	0x77	Executes a programmed script.
EXTERNAL_ILLUMINATION	0x5A	Controls the operation of the Illum-On signal.
FRAME_RATE	0x5E	Sets the SE4500 frame rate.
GET_EXTENDED_STATUS	0x79	Gets the SE4500 operating states.
GET_PARAM	0x70	Gets SE4500 parameters.

Table 6-1 *Symbol SE4500 Command List (Continued)*

I^2C Command Set	Opcode	Description
ILLUMINATION_DURING_EXPOSURE	0x59	Turns illumination on and off.
ILLUMINATION_POWER_DURATION	0xF1	Sets the illumination duration for the SE4500.
ILLUMINATION_POWER_LEVEL	0xF0	Sets the illumination brightness level for the SE4500.
IMAGE_CAPTURE_MODE	0x73	Sets the image capture mode.
IMAGE_CROPPING	0x5D	Crops the output image.
IMAGE_RESOLUTION	0x5C	Sets the resolution of the output image.
PICKLIST_MODE	0x7B	Sets the rate of picklist frames.
PING	0x7A	Used for test purposes.
POWER_MODE	0x5F	Places the SE4500 in low power mode.
RD_AD	0xF6	Reads the SE4500's internal temperature and laser power.
RD_OSC	0x53	Reads the oscillator registers.
RD_SENSOR	0x51	Reads the Micron MT9V022 registers.
RD_THERMISTOR	0x54	Reads the SE4500's internal temperature.
RECHARGE_BOOST_PWM	0xF2	Sets the SE4500's illumination charging capacitor rate.
RESET	0x57	Returns engine components to a default state.
THERMAL_MANAGEMENT_MODE	0x80	Dynamically adjusts the SE4500's frame rate to reduce its internal temperature.
TIME_TO_LOW_POWER	0x75	Sets the length of time the SE4500 is idle before entering low power mode.
WR_OSC	0x52	Writes to the oscillator registers.
WR_SCRIPT	0x76	Programs more than one SE4500 command into one script.
WR_SENSOR	0x50	Writes to the Micron MT9V022 registers.

Transactions

I^{2}C transactions control the Symbol SE4500, where a transaction consists of a command followed by a response. I^{2}C is a master/slave protocol, meaning the host initiates both transmissions.

The Symbol SE4500 typically processes a command in less than 1 ms, but some commands take up to 100 ms. For this reason, after sending a command, the host (I^{2}C master) should request a response. If the Symbol SE4500 does not respond (as per the I^{2}C protocol), the host should retry the response request for up to 100 ms. If the Symbol SE4500 does not respond within this time, a hard failure occurred.

The I^{2}C format of these commands and responses is as follows.

Symbol SE4500 I^{2}C Command Format

<I2C-Start Bit> <SLA-W> <Cmd-Opcode> <[SE4500-Cmd-Data]> <Checksum> <I2C-Stop-Bit>

where:

- *I2C-Start-Bit* and *I2C-Stop-Bit* are as defined by the I^{2}C specification
- *SLA-W* is 0xB8 (Slave-Addr + Write-Op) or
  - Slave Address is 0x50 (or 0xB8 after shifting into 7 msb's)
  - Write-Bit is 0x5C
- *Opcode* is 1 byte from the *SE4500 Command Op* column in *Table 6-3 on page 6-12*.
- *[SE4500-Cmd-Data]* is from the *SE4500 Command Data* column in *Table 6-3 on page 6-12*. This can be NULL.
- *Checksum* is a 1 byte checksum of the *SE4500 Cmd Data* bytes.

Symbol SE4500 I^{2}C Response Format

<I2C-Start Bit> <SLA-R> <Rsp-Opcode> <Status> <[SE4500-Rsp-Data]> <I2C-Stop-Bit>

Where:

- *I2C-Start-Bit* and *I2C-Stop-Bit* are as defined by the I^{2}C specification
- *SLA-R* is 0xB9 (Slave-Addr + Read-Op) or
  - Slave Address is 0x5C (or 0xB9 after shifting into 7 msb's)
  - Read-Bit is 0xB8
- *Opcode* is 1 byte from the *SE4500 Response Op* column in *Table 6-3 on page 6-12*.
- *Status* indicates whether the SE4500 successfully processed the command. See *Response Status Code*.
- *[SE4500-Rsp-Data]* is from the *SE4500 Response Data* column in *Table 6-3 on page 6-12*. This can be NULL.

Command Checksum

Every command must include a checksum, calculated as follows:

1. Sum the bytes in the command, starting from the opcode through the last command data byte.
2. Use only the low byte of this result.
3. Perform a 2's complement of this result.

This value is the checksum and is added to the checksum field of the command.

Response Status Code

Every response includes a status code that indicates the success of the command. A successful command returns an ACK or 0x80.

Table 6-2 lists all possible status codes. Note that these error codes are bit positions within the status byte, and two errors can occur (e.g., NAK and AIM-POWER-FAIL), resulting in values not listed in this table.

Table 6-2 *Response Status Codes*

Status	Value	Cause / Meaning
ACK	0x80	Command was successful.
NAK	0x82 (Bit1)	Command failed. Possible causes are: • Invalid opcode • Invalid command format • Invalid parameter value
CKSM_ERR	0x84 (Bit2)	The transmitted checksum did not match the checksum of the data.
AIM_POWER_FAILURE	0x88 (Bit3)	The AIM/laser power exceeded its limit.
THERMAL_FAILURE	0x90 (Bit4)	The internal temperature exceeded its limit.
INTERNAL_I2C_FAILURE	0xA0 (Bit5)	The internal I^2C interface failed.

Command Descriptions

See *Table 6-3 on page 6-12* for command and response formats for all Symbol SE4500 commands.

ACQUISITION 0x58

Acquisition Start causes the Symbol SE4500 to output image data on the camera interface. Acquisition Stop stops the image data output.

After receiving the Stop command, the Symbol SE4500 may not respond to subsequent commands for up to one frame time (16.6 ms at 60 fps) because the system requires the current frame to complete before the Symbol SE4500 processes new commands. Issuing commands during this time results in unacknowledged I^2C commands, requiring command retries.

ACQUISITION_MODE 0x5B

Optimizes the Symbol SE4500 for a specific operation as indicated below:

- 0 = Bar code decoding
- 1 = Document capture
- 2 = Motion detection
- 3 = Aim pattern capture

See *Table 6-3 on page 6-12*.

AIM 0x55

Turns the AIM pattern on and off. AIM only turns on if Acquisition is started. Setting AIM On while acquisition is stopped does not turn AIM on, although it turns AIM on upon the next Acquisition Start command.

AIM_BLINK_RATE 0xF4

Controls the blink rate of the AIM pattern. AIM only blinks when AIM is enabled. The default is 0,0 or Always On.

This command takes two parameters as follows:

- Byte 1 = Number of frames the AIM pattern remains on; 0 = Always On
- Byte 2 = Number of frames the AIM pattern is off.

AIM_DURING_EXPOSURE 0x56

Captures the AIM pattern in the image. When disabled, the AIM pattern is not visible in acquired images. The default is disabled.

To enable this command, you must first enable the AIM and Acquisition Start commands.

AIM_POWER 0xF3

Controls the power / brightness of the AIM pattern. The default is 0 or Always On.

A value of 0 indicates that Exposure and Readout times control the Aim's duration (and power or brightness).

Values of 1-255 indicate the Aim's duration increments from 0.5 ms in 0.5 ms intervals; however, Exposure and Readout times clip its maximum value.

AUTO_POWER_REDUCTION 0x74

Places the Symbol SE4500 in a low power state when idle for the duration of time specified by the Time_To_Low_Power command. Any I^2C command wakes the Symbol SE4500 from low power.

The Symbol SE4500 is considered idle only if Acquisition is stopped. While acquisition is started, the Symbol SE4500 does not automatically enter low power mode. Settings are:

- 0 = Disable (default)
- 1 = Enable

ENTER_BOOTLOADER 0x91

Enters Bootloader mode. This changes the Symbol SE4500 protocol where it no longer supports this command set.

EXECUTE_SCRIPT 0x77

After programming a script (WR_SCRIPT), use this command to execute it.

Example

To execute script 2:

<0x77> <0x02> <Checksum=0x87>

EXTERNAL_ILLUMINATION 0x5A

Controls operation of the Illum-On signal on the Symbol SE4500 host connect. Settings are:

- 0 = Floating Input (default)
- 1 = On
- 2 = Off
- 3 = Follow Internal Illumination
- 4 = Follow Acquisition (Acquisition Start = High, Acquisition Stop - Low)
- 5 = Alternate with Internal Illumination

FRAME_RATE 0x5E

Sets the Symbol SE4500 frame rate. Settings are:

- 0 = 60fps (default)
- 1 = 30fps
- 2 = 15fps
- 3 = 10fps

GET_EXTENDED_STATUS 0x79

The Symbol SE4500 internally tracks various operating states and stores these states in the Extended Status structure. This command gets these states from the Symbol SE4500. Following are the operating conditions and descriptions.

Each operating condition has 2 bits in the Extended Status:

- Latched bit - set when the condition is first detected and remains set (even if the condition no longer exists) until the Get Extended Status command is issued, which clears the bit. If a latched bit is set when the Get Extended Status command is issued, this indicates the condition occurred at some point since the last Get Extended Status command.
- Instantaneous bit - set if the condition exists when the Get Extended Status command is issued. If the condition occurred in the past and no longer exists, the bit is cleared.

Operating States/Bits

First byte of Extended Status Response

- SE4500_THERMAL_CRITICAL = 0x01
- SE4500_IR_LOW_CRITICAL = 0x02
- SE4500_IR_HIGH_CRITICAL = 0x04
- SE4500_MDIop_LOW_CRITICAL = 0x20
- SE4500_MDIop_HIGH_CRITICAL = 0x40
- SE4500_THERMAL_WARNING_NONLATCHED = 0x80

Second byte of Extended Status Response

- SE4500_THERMAL_CRITICAL_LATCHED = 0x01
- SE4500_IR_LOW_CRITICAL_LATCHED = 0x02
- SE4500_MDIop_LOW_CRITICAL_LATCHED = 0x20
- SE4500_MDIop_HIGH_CRITICAL_LATCHED = 0x40
- SE4500_THERMAL_WARNING_LATCHED = 0x80

NOTE IR = Laser reference, MDIop = Laser power.

GET_PARAM 0x70

Allows a host to read out parameters stored in the Symbol SE4500 (non-volatile memory). See *Table 6-4 on page 6-15* for a list of these parameters.

ILLUMINATION_DURING_EXPOSURE 0x59

Turns Illumination on and off. Illumination only turns on if Acquisition is started. Setting Illumination On while acquisition is stopped does not turn illumination on, although it causes illumination to turn on upon the next Acquisition Start command.

ILLUMINATION_POWER_DURATION 0xF1

Sets the illumination duration for the Symbol SE4500. Illumination turns on when exposure starts, and turns off based on this parameter. Settings are:

- 0 = Illumination immediately follows exposure
- 1-255 = Illumination duration increments in 0.5 ms (the default is 2)

ILLUMINATION_POWER_LEVEL 0xF0

Sets the Symbol SE4500's illumination power (brightness) level. Settings are:

- 0 = Lowest power level
- 255 = Highest power level

IMAGE_CAPTURE_MODE 0x73

Sets image capture mode to one of the following:

- Continuous (0x00) - an Acquisition Start command results in continuous image frames (one right after another) until you issue the Acquisition Stop command.
- Snapshot (0x01) - an Acquisition Start command results in only one image frame. Issue another Acquisition Start command to acquire another image/frame.

The default is Continuous.

IMAGE_CROPPING 0x5D

Crops the output image to the specified pixel edge.

IMAGE_RESOLUTION 0x5C

Sets the resolution of the output image. Settings are:

- 0 = Normal (default). Outputs full 752 x 480.
- 1 = Row Bin 2 (pixels in 2 adjacent rows are integrated and out as a single row).
- 2 = Row Bin 4, (pixels in 4 adjacent rows are integrated and out as a single row).
- 3 = Column Bin 2 (pixels in 2 adjacent columns are integrated and out as a single pixel).
- 4 = Column Bin 4 (pixels in 4 adjacent columns are integrated and out as a single pixel).

This command is cumulative, i.e., to set Row Bin 2 and Column Bin 2, use the two-command sequence:

0x5C 0x01 <Checksum> 0x5C 0x03 <Checksum>

To return to Normal, use the single command:

0x5C 0x00 <Checksum>

PICKLIST_MODE 0x7B

Specifies the rate of Picklist frames. With a Picklist frame, illumination is off and the AIM pattern is captured in the frame image, enabling you to locate (through software image processing) the AIM pattern in the image (since the visual location of the AIM pattern does not match the location in the captured image).

This command has two parameters:

- P1 (referred to as **M**) - Number of Picklist Frames: how many consecutive Picklist frames are output.
- P2 (referred to as **N**) - Number of Frames: how many frames before Picklist frames start again.

The default is 0,60, or 0 Picklist frames every 60 frames.

Example

Two Picklist frames - every 60 frames use the command [0x7B 0x02 0x3C]

One Picklist frame - every 30 frames use the command [0x7B 0x01 0x1E]

This command works with Acquisition Start as follows. Configure PickList_Mode before starting acquisition. When Acquisition starts, the PickList sequence begins. The first **M** frames are Picklist frames, and the next **N-M** frames are non-Picklist frames. This sequences cycles every **N** frames. The host system must track/count every frame to determine when PickList frames and non-Picklist frames occur.

In a typical triggering environment where Acquisition starts with a trigger and stops with a decode (or trigger release), each trigger pull (Acquisition Start) restarts the PickList sequence.

Do not change PICKLIST_MODE when Acquisition is started because this can result in indeterminate picklist frames.

PING 0x7A

Use this command for test purposes.

POWER_MODE 0x5F

Places the SE4550 in Low Power mode. Although there is a Full Power command, any command returns the Symbol SE4500 to full power mode. Symbol SE4500 command data options are:

- 0 = Full Power (default)
- 1 = Low Power

NOTE This command is rejected (NAK'ed) if Acquisition is running (ACQUISITION = Start). If low power is required during acquisition, first send ACQUISITION = Stop, then POWER_MODE = Low Power.

RD_AD 0xF6

Options for this command are:

- 1 = Reads the Symbol SE4500 internal temperature. The values this reports do not represent units (they cannot be converted into Celsius or Fahrenheit).
- 0 = Reads the Symbol SE4500's laser power. The values reported do not represent units, and are inverted (higher values indicate lower temperatures??).

RD_OSC 0x53

Reads oscillator registers. Refer to the oscillator specification from http://www.maxim-ic.com for register descriptions.

RD_SENSOR 0x51

Reads Micron MT9V022 registers. Refer to the MT9V022 specification from Micron for register descriptions.

RD_THERMISTOR 0x54

Reads the Symbol SE4500 internal temperature. The values this reports do not represent units (they cannot be converted into Celsius or Fahrenheit).

RECHARGE_BOOST_PWM 0xF2

Sets the Symbol SE4500's illumination charging capacitor rate. Settings are:

- 0 = Highest
- 255 = Lowest

RESET 0x57

Returns the component to a default state. Options are:

- 0 = Reset MT9V022 sensor
- 1 = Reset Symbol SE4500

See *Table 6-3 on page 6-12*.

THERMAL_MANAGEMENT_MODE 0x80

When enabled, the Symbol SE4500 dynamically adjusts its frame rate (from 60 fps to 30 fps) in an attempt to reduce its internal temperature. When the internal temperature reaches a threshold, the Symbol SE4500 enters Thermal Warning state and reduces its frame rate to 30 fps. If the Symbol SE4500 returns to normal operating temperature it exits Thermal Warning and returns to 60 fps. Use the Get Extended Status command to determine if the Symbol SE4500 is in Thermal Warning mode.

When disabled, the Symbol SE4500 does not dynamically change its frame rate due to temperature changes. The default is disabled.

TIME_TO_LOW_POWER 0x75

Sets the length of time the Symbol SE4500 must be idle before it enters low power mode. This only applies if Auto_Power_Reduction is enabled. Settings are:

- 0 5 ms
- 1-10 10 - 100 ms in 10 ms increments (default is 1, or 10 ms)
- 11-20 100 - 1000 ms in 100 ms increments
- 21-255 1 - 235 sec

WR_OSC 0x52

Writes directly to the oscillator IC registers. Refer to the oscillator specification from http://www.maxim-ic.com for register descriptions.

Note that the Symbol SE4500 controls many oscillator registers. Using this command to write registers may conflict with Symbol SE4500 requirements, causing unpredictable behavior.

WR_SCRIPT 0x76

Programs more than one SE4500 command into one script, which you can execute using a single command (EXECUTE_SCRIPT). Use this method whenever possible to increase performance and timing synchronization.

There are ten scripts (Script-0 through Script-9) and a total of 150 bytes for all scripts. Exceeding these limits results in a NAK status code.

Example

To program script 2 with AIM_On, Illum_On, and Acquisition_On, use the command:

<0x76><Script2><Len><C_1Len><C_1Op><C_1Data><C_2Len><C_2Op><C_2Data>
<C_3Len><C_3Op><C_3Data><CS>

OR

<0x76><0x02><0x09><0x02><0x55><0x01><0x02><0x59><0x01><0x02><0x58><0x01><0x70>

WR_SENSOR 0x50

Writes directly to the Micron MT9V022 registers. Refer to the MT9V022 specification from Micron for register descriptions.

Note that the Symbol SE4500 controls many sensor registers. Using this command to write sensor registers may conflict with Symbol SE4500 requirements, causing unpredictable behavior.

Command / Response Formats

Table 6-3 depicts the command and response formats for all Symbol SE4500 commands.

In the columns *SE4500 Command Data* and *SE4500 Response Data*, the following letters identify the size of the data: (B) = Byte, (W) = Word, or (A) = Array. Words are in Little-Endian format (low byte first).

* indicates the default.

Table 6-3 *Symbol SE4500 Command and Response Formats*

Function	SE4500 Command				SE4500 Response		
	Op	SE4500 Command Data		CS Note 1	Op	Status Note:2	SE4500 Response Data
WR_SENSOR	0x50	(B) Register	(W) Value	Note 1	0x50	0x80	-
RD_SENSOR	0x51	(B) Register		Note 1	0x51	0x80	(W) Value
WR_OSC	0x52	(B) Register	(W) Value	Note 1	0x52	0x80	-
RD_OSC	0x53	(B) Register		Note 1	0x53	0x80	(W) Value
RD_THERMISTOR	0x54	-		0xAC	0x54	0x80	(B) Temperature 0-255
AIM	0x55	(B) 0=Off* 1=On		Note 1	0x55	0x80	-
AIM_DURING_EXPOSURE	0x56	(B) 0=Off* 1=On		Note 1	0x56	0x80	-
RESET	0x57	(B) 0=Sensor 1=SE4500		Note 1	0x57	0x80	-
ACQUISITION	0x58	(B) 0=Stop 1=Start		Note 1	0x58	0x80	-
ILLUMINATION_DURING_EXPOSURE	0x59	(B) 0=Off* 1=On		Note 1	0x59	0x80	-
EXTERNAL_ILLUMINATION	0x5A	(B) 0=Floating Input* 1=On 2=Off 3=Follow Internal Illumination 4=Follow Trigger 5=Alternate with Internal Illumination		Note 1	0x5A	0x80	-

Notes:
1. Every command has a 1 byte checksum (last byte of command). See *Command Checksum on page 6-4*.
2. Every response has a 1 byte status code. See *Response Status Code on page 6-4*.
3. These commands/responses have a variable length data field indicated by (A):Array. See *Table 6-4 on page 6-15* for the length of the field based on the param number.

Table 6-3 *Symbol SE4500 Command and Response Formats (Continued)*

Function	SE4500 Command			SE4500 Response		
	Op	SE4500 Command Data	CS Note 1	Op	Status Note:2	SE4500 Response Data
ACQUISITION_MODE	0x5B	(B) 0=Barcode Decode* 1=Document Capture 2=Motion Detect 3=Aim Capture	Note 1	0x5B	0x80	-
IMAGE_RESOLUTION	0x5C	(B) 0=Normal* 1=Row Bin 2 2=Row Bin 4 3=Column Bin 2 4=Column Bin 4	Note 1	0x5C	0x80	-
IMAGE_CROPPING	0x5D	(B) Edge 0=Top 1=Right 2=Bottom 3-Left (W) Value [No. of pixels to crop]	Note 1	0x5D	0x80	-
FRAME_RATE	0x5E	(B) 0=60fps* 1=30fps 2=15fps 3=10fps	Note 1	0x5E	0x80	-
POWER_MODE	0x5F	(B) 0=Full* 1=Low	Note 1	0x5F	0x80	-
ILLUMINATION_POWER_LEVEL	0xF0	(B) 0 Lowest 255 Highest Power Level	Note 1	0xF0	0x80	-
ILLUMINATION_POWER_DURATION	0xF1	(B) 0=Illumination follows exposure 1-255 = Illumination duration increments in 0.5 ms (2 is the default)	Note 1	0xF1	0x80	-
RECHARGE_BOOST_PWM	0xF2	(B) 0 - 255, 0* is highest, 255 is lowest illumination level, when Illumination power level is maximum	Note 1	0xF2	0x80	-
AIM_POWER	0xF3	(B) 0 = Aim's duration is controlled by Exposure and Readout times. 1-255 = Aim's duration increments from 0.5 ms in 0.5 ms duration, its maximum value controlled by Exposure and Readout time.	Note 1	0xF3	0x80	-

Notes:
1. Every command has a 1 byte checksum (last byte of command). See *Command Checksum on page 6-4*.
2. Every response has a 1 byte status code. See *Response Status Code on page 6-4*.
3. These commands/responses have a variable length data field indicated by (A):Array. See *Table 6-4 on page 6-15* for the length of the field based on the param number.

Table 6-3 *Symbol SE4500 Command and Response Formats (Continued)*

Function	SE4500 Command				SE4500 Response			
	Op	SE4500 Command Data		CS Note 1	Op	Status Note:2	SE4500 Response Data	
AIM_BLINK_RATE	0xF4	(B) On Time Time is in ~17ms increments	(B) Off Time Time is in ~17ms increments	Note 1	0xF4	0x80	-	
RD_AD	0xF6	(B) 0 = Laser Current A/D Value 1 = Temperature A/D Value		Note 1	0xF6	0x80	(B) AD Value 0-255	
ENTER_BOOTLOADER	0x91	(A) Signature [3 bytes: 0xAA, 0x50, 0x5F]		Note 1	0x91	0x80	TBD	
GET_PARAM (see Note 3 and *Table 6-4*)	0x70	(W) Param#		Note 1	0x70	0x80	(W) Param#	(A) Param Data (Note 3)
IMAGE_CAPTURE_MODE	0x73	(B) 0 = Continuous 1 = Snapshot		Note 1	0x73	0x80	-	
AUTO_POWER_REDUCTION	0x74	(B) 0=Disabled 1=Enabled		Note 1	0x74	0x80	-	
TIME_TO_LOW_POWER	0x75	(B) 1-10 = 10-90 ms 11-20 = 100-900 ms 21-255 = 1s - 235 s 0 = 5 ms		Note 1	0x75	0x80	-	
WR_SCRIPT	0x76	(B) Script#	(A) Script Data	Note 1	0x76	0x80	-	
EXECUTE_SCRIPT	0x77	(B) Script#		Note 1	0x77	0x80	-	
GET_EXTENDED_STATUS	0x79	-		Note 1	0x79	0x80	Returns 4 bytes as follows: (B) Aim Power and Thermal Critical status (B) Thermal Warning Status (B) Spare1 (B) Spare2	
THERMAL_MANAGEMENT_MODE	0x80	(B) 0=Disabled 1=Enabled		Note 1	0x80	0x80		
PING	0x7A	-		Note 1	0x7A	0x80		
PICKLIST_MODE	0x7B	(B) #Picklist-Frames	(B) #Frames	Note 1	0x7B	0x80		

Notes:
1. Every command has a 1 byte checksum (last byte of command). See *Command Checksum on page 6-4*.
2. Every response has a 1 byte status code. See *Response Status Code on page 6-4*.
3. These commands/responses have a variable length data field indicated by (A):Array. See *Table 6-4 on page 6-15* for the length of the field based on the param number.

Table 6-4 *Symbol SE4500 Parameter Numbers and Data Formats*

Parameter	Number	Length (bytes)
MODEL_NUMBER	0	18
SERIAL_NUMBER	1	16
DATE_MANUFACTURE	2	7
DATE_SERVICE	3	7
SCANNER_BOOTLOADER_FIRMWARE_VERSION	10	8
DPM_CALIBRATION_COORDINATES	12	16
SCANNER_PRODUCTCODE_FIRMWARE_VERSION	20004	8
ENGINE_ID	20005	1
HARDWARE_VERSION	20006	1
DEVICE_CLASS	20007	18
GUID	14	32
SET_DEFAULTS_ON_NEXT_POWERUP	18	2

Chapter 7 Application Notes

Introduction

This chapter includes image acquisition and power consumption information.

Image Acquisition

The Symbol SE4500 contains a wide VGA CMOS sensor. *Figure 7-1* and *Figure 7-2* illustrate pixel output format, and *Figure 7-3* and *Figure 7-4* show basic timing information.

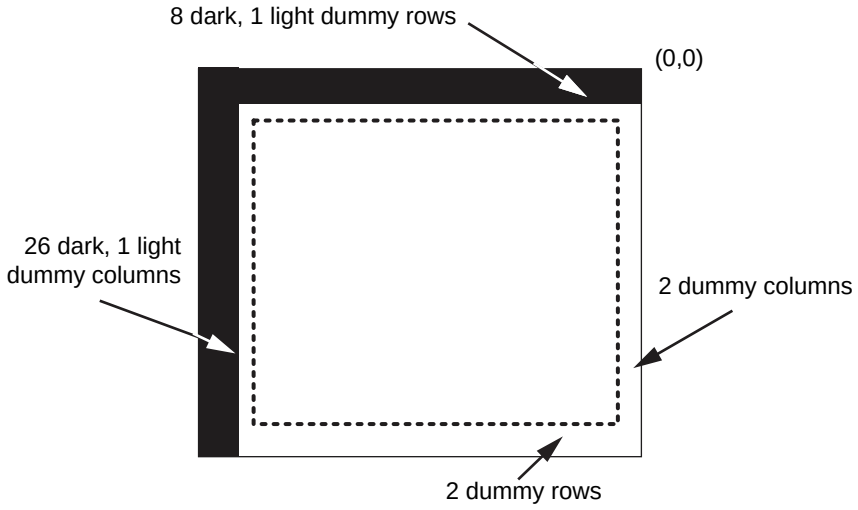


Figure 7-1 *Pixel Output Format*

Output Data Format

Image data can be read out in a progressive scan or in interlaced scan mode. Vertical and horizontal blanking surrounds valid image data, as shown in *Figure 7-2*.

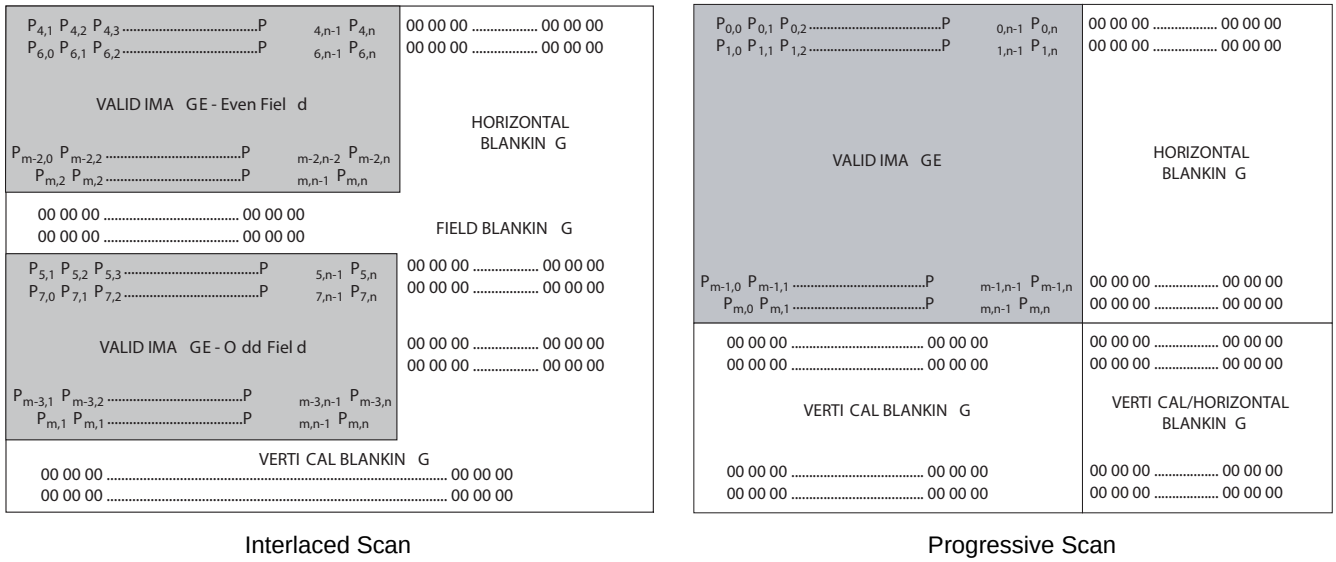


Figure 7-2 *Image Readout*

Output Data Timing

Data output is synchronized with the PIXCLK output. When LINE_VALID is high, one 10-bit pixel datum is output every PIXCLK period.

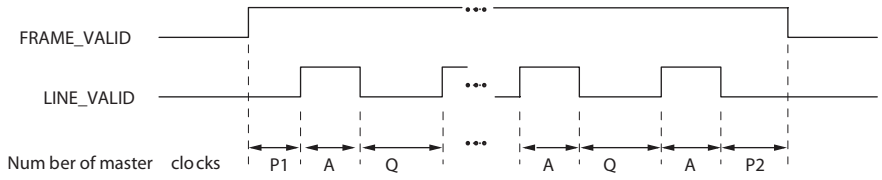


Figure 7-3 *Row Timing and FRAME_VALID / LINE_VALID Signals*

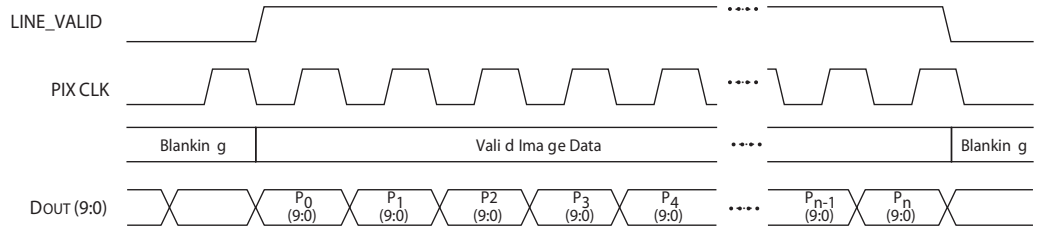


Figure 7-4 *Pixel Data Timing Example*

Table 7-1 *Frame Time*

Parameter	Description	Pixel Clock	Master Clocks	Time	Units
A	Active data time	752	752	28.02	µs
P1	Frame start blanking	71	71	2.66	µs
P2	Frame end blanking	23	23	0.86	µs
Q	Horizontal blanking	94	94	3.52	µs
A + Q	Row time	846	846	31.72	µs
V	Vertical blanking	38,074	38,074	1.43	ms
Nrows	Frame valid time	406,080	406,080	15.23	ms
F	Total frame time	444,154	444,154	16.66	ms

Recommended Procedures

The following trigger mode procedures describe the recommended transaction sequence between a host and the Symbol SE4500. These transaction sequences use discrete commands for clarity. Replace any set of discrete commands with a multi-command EXECUTE_SCRIPT to improve throughput.

Normal Decode Mode

Level Trigger Mode Procedure

The system is initialized as follows:

- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host sends the Acquisition Stop command.
- The host sends the Barcode Decode mode command.
- The SE4500 optimizes the image output for bar code decoding.
- The SE4500 enters standby mode (or low power mode if enabled).

Upon a trigger pull:

- The host sends the Illumination On command.
- The SE4500 exits standby mode (or low power mode if enabled).
- The host sends the Aim On command.
- The host sends the Acquisition Start command.
- The SE4500 begins outputting images.
- The host attempts to decode the images.

Upon a good decode or trigger release:

- The host sends the Acquisition Stop command.
- The SE4500 stops outputting images.
- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The SE4500 enters standby mode (or low power mode if enabled).

Presentation Mode Procedure

The system is initialized as follows:

- The host sends the Aim Off command.
- The host sends the Illumination On command.
- The host sends the Illumination Power Off command (Off is the default, but power can be set low to allow motion detection in darkness).
- The host sends the Acquisition Start command (and never sends the Stop command).
- The host sends the Motion Detect mode command.
- The SE4500 optimizes the image output for motion detection.
- The SE4500 continuously outputs images.
- In this mode, the SE4500 does not enter standby or low power mode.

Upon the host detecting motion:

- The host sends the Aim On command.
- The host sends the Illumination Power Full command.
- The host sends the Barcode Decode mode command.
- The SE4500 optimizes the image output for bar code decoding.
- The host attempts to decode the images.

Upon a good decode:

- The host sends the Aim Off command.
- The host sends the Illumination Power Off command (Off is the default, but power can be set low to allow motion detection in darkness).
- The host sends the Motion Detect mode command.
- The SE4500 optimizes the image output for motion detection.

During this mode:

- The SE4500 does not automatically enter standby or low power mode.
- The host uses the Power Mode command to put the SE4500 into a low power mode (for support of Bus Powered USB).

Auto-AIM Mode Procedure

The system is initialized as follows:

- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host sends the Acquisition Start command (and never sends the Stop command).
- The host sends the Motion Detect mode command.
- The SE4500 optimizes the image output for motion detection.
- The SE4500 continuously outputs images.

Upon the host detecting motion:

- The host sends the Barcode Decode mode command.
- The host sends the Aim On command.

Upon a trigger pull:

- The host sends the Illumination On command.
- The SE4500 optimizes the image output for bar code decoding.
- The host attempts to decode the images.

Upon a good decode or trigger release:

- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host sends the Motion Detect mode command.
- The SE4500 optimizes the image output for motion detection.

During this mode:

- The SE4500 does not automatically enter low power mode.
- The host uses the Power Mode command to put the SE4500 into a low power mode (for support of Bus Powered USB).

Snapshot Mode

Level/Presentation/Auto-Aim Trigger Mode Procedure

The system is initialized as follows:

- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host sends the Acquisition Stop command.
- The host sends the Imaging mode command.
- The SE4500 optimizes the image output for image capture.
- The SE4500 (typically) enters low power mode.

Upon a trigger pull:

- The host sends the Illumination On command.
- The SE4500, if in low power mode, exits low power mode (either Reduced or Sleep).
- The host sends the Aim On command.
- The host sends the Acquisition Start command.
- The SE4500 captures an image.

Upon completion of an image capture:

- The SE4500 stops outputting image.
- The host sends the Acquisition Stop command.
- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host goes back to Normal Decode Mode.
- The SE4500 (when all conditions are met) enters Reduced Power mode.

Video Mode

Level/Auto-Aim Trigger Mode

The system is initialized as follows:

- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The host sends the Acquisition Stop command.
- The host sends the Imaging mode command.
- The SE4500 optimizes the image output for video.
- The SE4500 (typically) enters low power mode.

Upon a trigger pull:

- The host sends the Illumination On command.
- The SE4500, if in low power mode, exits low power mode (either Reduced or Sleep).
- The host sends the Aim On command.
- The host sends the Acquisition Start command.
- The SE4500 begins outputting video stream.

Upon a trigger release:

- The host sends the Acquisition Stop command.
- The SE4500 stops outputting the video stream.
- The host sends the Aim Off command.
- The host sends the Illumination Off command.
- The SE4500 (when all conditions are met) enters Reduced Power mode.

Recommendations

Power Mode

The Symbol SE4500 powers up into full power mode. To save power, enable AUTO_POWER_REDUCTION.

Scripts

For improved performance and timing synchronization, replace a set of discrete commands with a multi-command EXECUTE-SCRIPT.

Appendix A Register Settings

For information on register settings for the engine, refer to the *Micron MT9V022 (mono) Wide VGA CMOS Digital Image Sensor Datasheet*, available at http://www.micron.com.

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Z

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