Revision
3

SeeK THERMAL DOC_314

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MICRO CORE DESIGN SPECIFICATION DATASHEET

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Micro Core Design Specification Datasheet

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Revision History

Revision	Notes	Initials	Date
1.0	Initial Release.	MSB	12/19/19
1.1	Minor schematic updates, additional SPI protocol details.	MSB	1/21/20
1.2	Update USB schematic and BOM with AEC-Q components. Updated images with landscape orientation flex.	MSB	10/7/20
1.3	Updated USB schematic to clarify customer interfaces. Added details to 4.5 USB Coprocessor Circuit.	MSB	10/9/20
1.4	Add details of the on-board calibration flash. Defined the P1 connector and pinout.	MSB	12/14/20
2	Add 1.8 mm Micro Core, specs and updated system architecture for sensor flash. Updated images. Changed “integration circuit” to “coprocessor circuit”. Updated SPI interface power numbers. Added starter kit info. Removed performance specifications, see separate spec.	SKD & MSB	4/20/21
3	Updated block diagram images. Removed some incorrect details about Android SDK. Added details about Starter Kits and USB Coprocessor board.	MSB	5/13/21

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1 Introduction

The Micro Core Design Specification Datasheet documents and defines Seek Thermal's Micro Core design architecture. Its purpose is to give the end user guidance on architecting and integrating the Micro Core into a system.

2 General Overview

The Seek Thermal Micro Core Sensor Module gives users unparalleled performance and price in both thermal imaging and radiometry. The Micro Core is comprised of a VOx 200x150, 12µm pitch LWIR sensor array and includes either a 2.3 mm effective focal length f/1.05 or a 1.8 mm effective focal length f/1.1 chalcogenide lenses. Seek offers design support for integrating the Micro Core as either a SPI slave or master device, or USB device into a customer's design. The Micro Core module and supporting circuitry is compatible for integration with a variety of microprocessors. Video and Radiometric processing is completed by running one of Seek's available Software Development Kits.

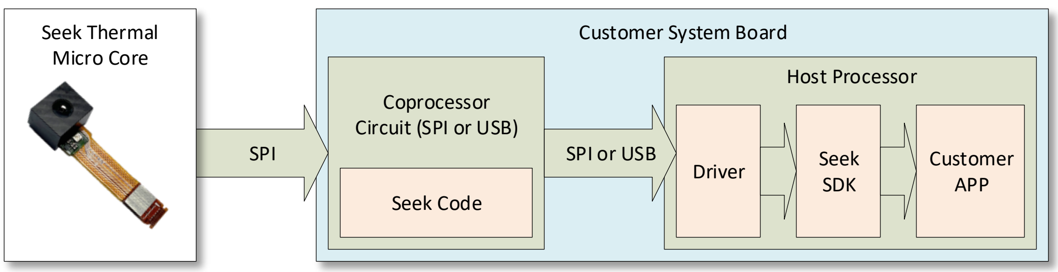


Figure 1: Micro Core System Block Diagram

3 System Architecture

The M2 sensor is intended for high volume applications and to be used directly with multipurpose host processors such as found in mobile and handheld devices. The diagram below shows two typical architecture use cases. The Seek Thermal Micro Core modules communicates to the host processor through SPI or USB ports and a SPI or USB driver. On the host side, with the support of Seek Thermal SDK, the users can integrate the Seek Thermal Micro Core into their own mobile or embedded based product.

3.1 Typical Architectures and System Requirements

The SDK is comprised of the command and control code for the Seek Micro Core as well as an image processing pipeline that contains the typical thermal imaging sensor processing algorithms. In order to run the SDK with acceptable performance, Seek recommends the following minimum system requirements. For more specifics, contact Seek Thermal.

- x86_64, i686, ARMv7, ARMv8 or later processor architecture
- Greater than 2 MB of RAM
- 800 MHz or faster, with at least 75% capacity of a dedicated core

3.2 Thermal Sensor Overview

The Micro Core thermal imaging sensor is based on a flexible PCB. The Seek Thermal sensor is bonded to the flex substrate and wire bonded to the signal pads on the flexible PCB. The Lens is mounted and bonded into the lens housing and this assembly is mounted to the substrate by a focus station robot which positions the lens at optimal focus measured by real time optical MTF calculation.

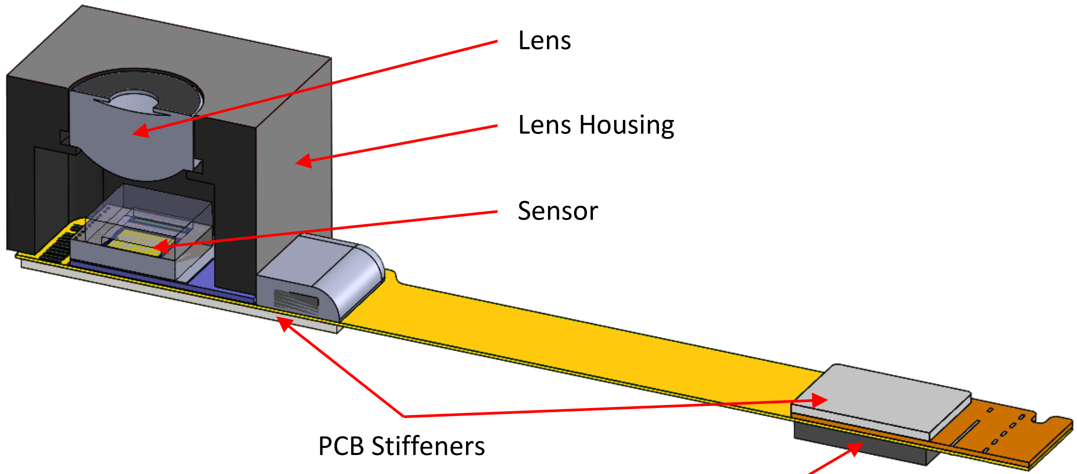


Figure 2: Example Micro Core Physical Diagram (Cross Section View)

3.3 Model and Part Ordering Number

Contact Seek Thermal for custom design part numbers and options. For volume applications, Seek may be able to customize mechanical packaging and the connector interface.

3.4 Software Overview

The major blocks and interfaces, provided by Seek Thermal, facilitate the integration and development of the Micro Core thermal sensor into a customer's targeted platform. Each module is comprised of some level of software that permits each block to interface to each other.

3.4.1 Seek Thermal Micro Core System

The Micro Core system is comprised of two pieces. The thermal module processor (coprocessor) communicates and retrieves thermal imaging frames from the sensor with a 200x150 frame size. Two coprocessor options allow for either a SPI interface or a USB interface between the Micro Core system and the host processor. See sections SPI Coprocessor Circuit or USB Coprocessor Circuit for more details.

3.4.2 Seek Thermal SDK modules

The SDKs are a vital part of the Micro Core pipeline. Depending on the target development platform, the Seek SDK performs thermal sensor non-uniformity correction, gain, color application and thermography calculations. The SDK is run at the operating system level as library function calls.

If the customer's target platform is on a mobile device, Seek Thermal gives the option of blending the thermal image and the visible image of the native mobile device.

3.4.3 Calibration Data module

The calibration data module requires nonvolatile memory access for calibration tables and camera settings, and RAM access for live processing and frame memory. The SDK automatically retrieves and manages the calibration data. Each Micro Core has a unique set of calibration data. Calibration data is stored in non-volatile memory on the Micro Core itself. The calibration data is copied from the core to the host system when the Micro Core is first powered on and the SDK detects a new Micro Core has been connected. This process of automatically checking and copying calibration data allows for Micro Core units to be swapped and replaced at service depots without the need for access to a central calibration database.

4 Electrical Interface

4.1 Micro Core Standard Connector Manufacturer and Part Number

The Micro Core uses a zero-insertion-force (ZIF) FPC/FFC connector interface. The interface is designed specifically to be used with the Panasonic AYF531065T connector. This connector has top and bottom mating contacts to allow for a customer's PCB to be designed for one of either insertion orientations. The Micro Core's pads are on the bottom side of the flex, as shown in Figure 3:.

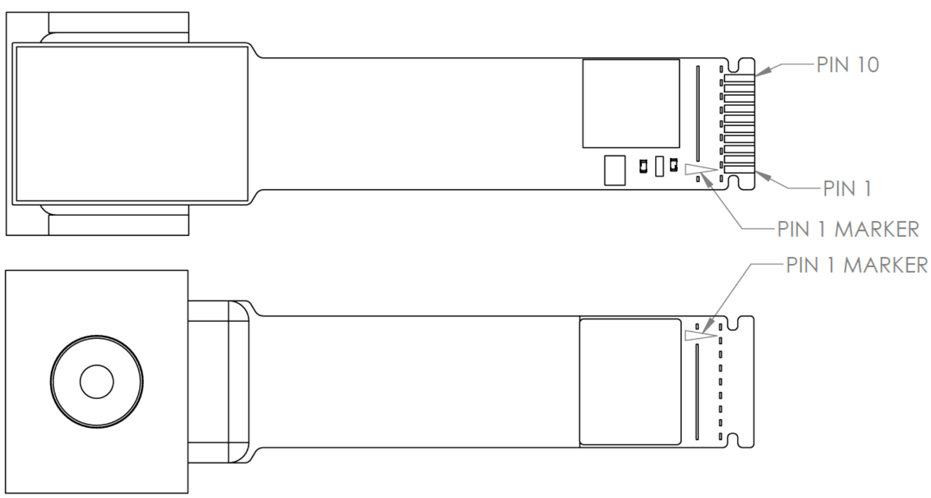


Figure 3: Micro Core Pins

4.2 Connector P1 Signal Names and Descriptions

PIN NAME	PIN NUMBER	SIGNAL TYPE	SIGNAL LEVEL	DESCRIPTION
GND	1	Power	0	Ground Reference
EN_SENSOR_VIO	2	Input	1.8-VIN	Power Supply Enable signal
SCLK_28	3	Output	2.8V	SPI Master Clock Out
MOSI_28	4	Output	2.8V	SPI Data Master Output from Sensor
MISO_28	5	Input	2.8V	SPI Data Master Input to Sensor
nSS_28	6	Output	2.8V	SPI Slave Select, Active Low
RST_SENSOR_28	7	Input	2.8V	Sensor Reset, Active Low
VCC_28	8	Power	2.8V	IO Voltage Reference Output
VIN_33	9	Power	3.0-3.6	Supply Power Source to Sensor
GND	10	Power	0	Ground Reference

Table 1: Micro Core Connector Pinout

Pin numbers and signal locations may change for custom designs to accommodate placement and routing requirements.

* *Signal type is in reference to the sensor. Input is input to the sensor. Output is output from the sensor.*

** *2.8V logic requirements: Low Signal maximum voltage 0.4V; High Signal minimum voltage 2.4V. The SPI Coprocessor Circuit can be used to manage the 2.8V interface independent of customer IO voltages.*

*** *EN pin logic requirements: Enable input; disables the regulator when ≤ 0.4 V. Enables the regulator when ≥ 1.2 V. An internal 1-MΩ pulldown resistor connects this input to ground.*

4.3 SPI Coprocessor Circuit

For an embedded application that uses a 4-wire SPI interface, Seek Thermal provides a reference circuit design to facilitate interfacing the Micro Core (SPI master device) with a customer's host CPU (typically a SPI master device). This block diagram shows how the Micro Core interfaces with a customer host CPU via the SPI coprocessor circuit:

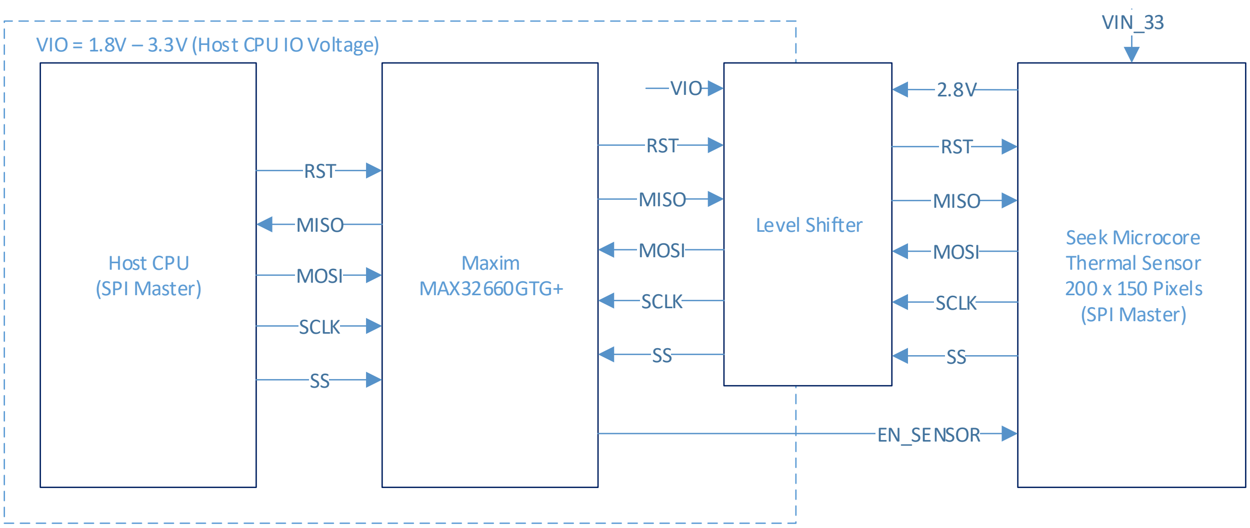


Figure 4: SPI Coprocessor Circuit Block Diagram

Seek Thermal can provide a development SPI 'Starter Kit' board with the SPI coprocessor circuit for use when developing a system based on the Micro Core. Seek Thermal also provides a BOM and Schematic of the SPI coprocessor circuit for inclusion in the customer's PCB design of the final product. Refer to the SPI Coprocessor Appendices at the end of this document.

When adding the SPI Coprocessor Circuit to a customer design, the customer must implement the following interfaces, indicated in the boxes on the schematic:

- Supply power to VIN and VIO
- Connect GND to the rest of the design
- Connect customer's host processor to the SPI and control signals
- Connect the SWD signals to the customer's preferred interface (connector, pogo pads, etc.)
- Add the Microcore connector defined in the "Microcore Outline Drawing" for the specific Microcore part number being used

4.4 SPI Electrical Characteristics

Line	PROPERTY	MIN	TYPICAL	MAX
1	Supply Voltage [VIN_33]	3.0 V	3.3 V	3.6 V
2	Supply Power Consumption [VIN_33] @ 25°C		27 mW	
3	Supply Current @ 25°C [VIN_33 = 3.3V]		8 mA	
4	Shutdown Current [VIN_33]		0.2 uA	1 uA
5	Supply Voltage [VIO_HOST]	1.71 V	1.8 V	3.6 V
6	Supply Power Consumption [VIO_HOST] @ 25°C		33 mW	
7	Supply Current @ 25°C [VIO_HOST= 3.3V]		10 mA	
8	SPI Mode		0	
9	SPI Word Length		16 bit	
10	SPI Host Clock Rate	1.0 MHz *	5.14 MHz	10.0 MHz

Table 2: SPI Interface Electrical Characteristics

* SPI clock rates below 5.14MHz may result in the coprocessor buffer overflowing and can result in image tearing artifacts.

Line	PROPERTY	MIN	TYPICAL	MAX
1	Input Voltage (VIN_33)			5.5 V
2	Voltage on EN_SENSOR			VIN_33 + 0.3 V
3	Voltage on Inputs (MISO and RSTB)			Lower of VIN_33 or 3.3 V
4	Input Voltage (VIO_HOST)			3.63 V
5	Voltage on HOST IO Lines	-0.3 V		VIO_HOST + 0.3 V

Table 3: SPI Interface Absolute Maximum Ratings at P1

4.5 USB Coprocessor Circuit

For an application that uses a USB interface, Seek Thermal offers either a ready-to-use PCBA, to enable a faster development cycle, or a reference design to enable a customer to include the USB circuitry in their own design for a reduced total system cost. To facilitate development, Seek offers a Micro Core USB 'Starter Kit' that works with the Seek SDK Sample Viewer out of the box, and provides a foundation for customer development. Refer to the USB Coprocessor appendices at the end of this document.

When adding the USB Coprocessor Circuit to a customer design, the customer must implement the following interfaces, indicated with red arrows on the schematic:

- Supply power to VIN
- Connect GND to the rest of the design
- Connect customer's host processor to the USB signals
- Connect the JTAG signals to the customer's preferred interface (connector, pogo pads, etc.)
- Add the Microcore connector defined in the "Microcore Outline Drawing" for the specific Microcore part number being used

4.6 USB Electrical Characteristics

Line	PROPERTY	MIN	TYPICAL	MAX
1	Supply Voltage [VIN]	3.0V	3.3V	3.6V
2	Supply Power Consumption [VIN_33] @ 25°C			300 mW
3	Supply Current @ 25°C VBUS = 3.3 V		80 mA	
4	Shutdown Current		0.2 uA	1 uA
5	USB BUS supply voltage - VDD(IO) ≥ 2.2V - VDD(IO) ≥ 0V	0 0		5.25V 3.60V
6	USB D+ Input voltage - VDD(IO) ≥ 2.2V - VDD(IO) ≥ 0V	0 0		5.25V 3.60V
7	USB D- Input voltage - VDD(IO) ≥ 2.2V - VDD(IO) ≥ 0V	0 0		5.25V 3.60V
8	Pull-down resistance (kΩ)	48	64	80
9	Common-mode input voltage (mV) - High speed mode - Full/low speed mode - Chirp mode	-50 800 -50	200 - -	500 2500 600
10	Differential input mode voltage (mV)	100	400	1100
11	Rise time (10% to 90%) (ns)	4		20
12	Fall time (90% to 10%) (ns)	4		20
13	Output signal crossover voltage (V)	1.3		2.0
14	Source SE0 interval of EOP (ns)	160		175
15	Source jitter for differential transition to SE0 transition (ns)	-2		5

Table 4: USB Interface Electrical Characteristics

Note: Test condition: CL = 50pF, Rpu = 1.5kΩ on D+ to VDD, 3.0V ≤ VDD ≤ 3.6V, See details for NXP4330 processor datasheet: LPC4350_30_20_10.pdf.

4.7 Seek Thermal Supplied Coprocessor Boards

A customer may opt to purchase the Micro Core Interface Kit from Seek with a Micro Core. The interface kit includes a sensor to coprocessor flex and a PCB that already houses the USB Coprocessor circuit. This same coprocessor board and flex are used in the Micro Core USB Starter Kit. The coprocessor board utilizes a 20 pin Hirose board-to-board connector:

- Connector on the USB Coprocessor board:
  - Hirose DF40C-20DP-0.4V(51)
- Mating Connector to be used on customer design:
  - Hirose DF40C-20DS-0.4V(51) (various stack height options available)

NOTE: These connectors are 20 pin connectors, but they physically have 24 pins. The 4 corners pins are used for mechanical retention and are connected to GND.

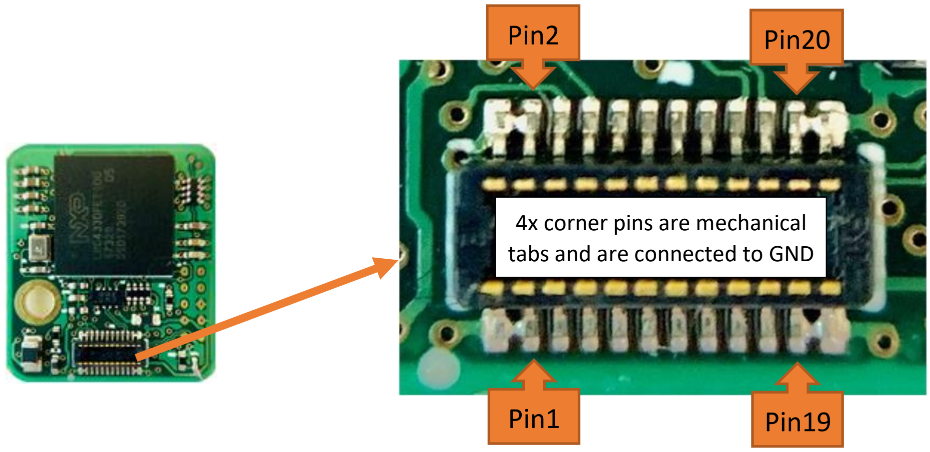


Figure 5: USB Coprocessor Board Connector Orientation

4.8 USB Coprocessor Board Connector Pinout

PIN #	PIN NAME	SIGNAL TYPE	SIGNAL LEVEL	DESCRIPTION
1	GND	Power	0	Power Return and Signal Reference
2	GND	Power	0	Power Return and Signal Reference
3	NC	NC		No connect
4	NC	NC		No connect
5	NC	NC		No connect
6	NC	NC		No connect
7	NC	NC		No connect
8	NC	NC		No connect
9	NC	NC		No connect
10	NC	NC		No connect
11	RESETn	In	2.8	Coprocessor Reset signal
12	NC	NC		No connect
13	NC	NC		No connect
14	NC	NC		No connect
15	PWR_EN	In	VBUS	Active high power enable, pulled up with 182k
16	USB_P	IO		USB positive signal
17	VBUS	Power	3.1-5.0	Supply Voltage
18	USB_N	IO		USB negative signal
19	GND	Power	0	Power Return and Signal Reference
20	GND	Power	0	Power Return and Signal Reference

Table 5: Starter Kit Coprocessor Board Connector Pinout

Note, best design practices must be followed for USB based designs. Please use appropriate impedance control for the USB signal lines.

5 Mechanical Interface

3D CAD models available upon request from Seek.

5.1 Mechanical Dimensions

Dimensions below are shown for reference only. Obtain the latest mechanical tolerance drawing from Seek, or work with Seek engineering to define a custom mechanical package. The 1.8 mm Micro Core weighs about 1.9 grams and the 2.3 mm Micro Core weighs about 2.0 grams.

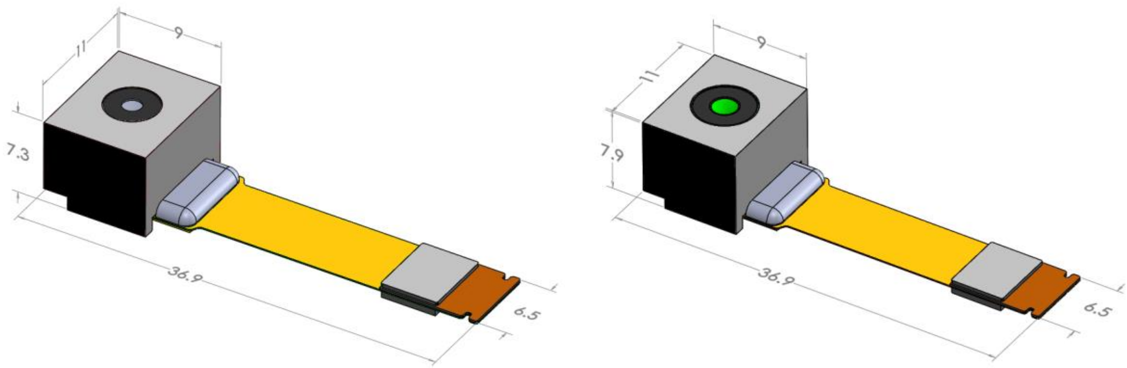


Figure 6: Sample 1.8 mm(left) and 2.3 mm(right) Lens Micro Core Mechanical Dimensions

5.2 Mechanical Interface Considerations

Thermal sensors are inherently sensitive to exterior mechanical and environmental factors including temperature, stress, shock and vibration. Brief details about each factor are covered below. Seek recommends customers have a joint engineering design review with Seek to ensure the best possible outcome in performance and reliability.

5.2.1 Thermal Interface

Thermal considerations include minimizing induced temperature changes to the sensor and its lens housing. The sensor calibration takes most changes into account, but as the system heats up, it presents non-uniform gradients to the sensor which may degrade image quality and measurement accuracy. Sensor mounting locations in cooler and more thermally stable areas have improved signal to noise ratios. If a significant heat source must be placed in proximity to the sensor or lens housing, please use any thermal isolation techniques available. Additionally, thermal conduction through the flex from an external heat source can lead to image quality issues. It is recommended that insulation is used between the flex and any heat sources as well.

5.2.2 Mechanical Stress

The Micro Core addresses mechanical stress forces by utilizing the Aluminum housing “feet” to mount the sensor assembly. This prevents any mounting forces from being exerted on the back of the sensor itself. When mounting the Micro Core, minimize the amount of force on the FPCB. Any force on the back of the FPCB (due to cushioning touching the FPCB directly, for example) may adversely affect image quality.

5.2.3 Shock and Vibration

The Micro Core sensor is sensitive to shock and vibration with forces in frequencies greater than several kilohertz. With properly designed cushioning, the Micro Core has been tested to survive a variety of commercial drop tests. Typical recommended cushion designs consist of a minimum of 0.5 mm Shore

A50 material used to constrain the Micro Core in all three axes. Consult Seek engineering for additional design recommendations.

5.2.4 Other Considerations

The flex PCB is bonded between the substrate and housing and designed to withstand careful handling by the lens housing. It is not designed to withstand rough handling by the connector end. Also, like all flex PCBs, be careful not to create any creases in the flex. Creases create cracks in signal traces and can lead to malfunctional or nonfunctional sensors and or to latent failures. The recommended minimum bend radius for the flex is 1.2 mm. Consult Seek during the design phase of custom flex shapes to define bend regions.

6 Optical Interface

6.1 Optical Properties (200x150 Pixels)

Line	PROPERTY	TYPICAL	
1	EFL (mm)	2.3	1.8
2	F/#	1.05	1.1
3	iFOV, Center (mRad)	5.23	6.67
4	Horizontal FOV (deg)	61	81
5	Vertical FOV (deg)	45	59
6	Diagonal FOV (deg)	78	106
7	Detection Range (m)	186	145
8	Recognition Range (m)	46	36
9	Identification Range (m)	27	21
10	Minimum Focus Range (m)	0.1	0.1
11	Recommended Minimum Keep Out Cone Angle (deg)	80	110

Example optical dimensions are shown below to illustrate the recommended mechanical light cone keep out.

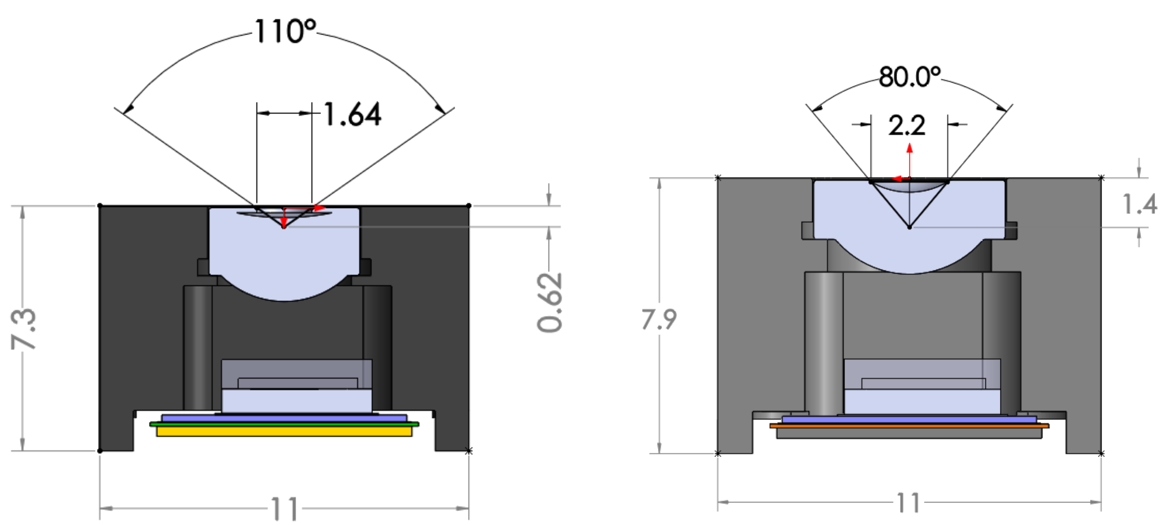


Figure 7: Suggested mechanical light cone keep out of 1.8 mm(left) and 2.3 mm(right)

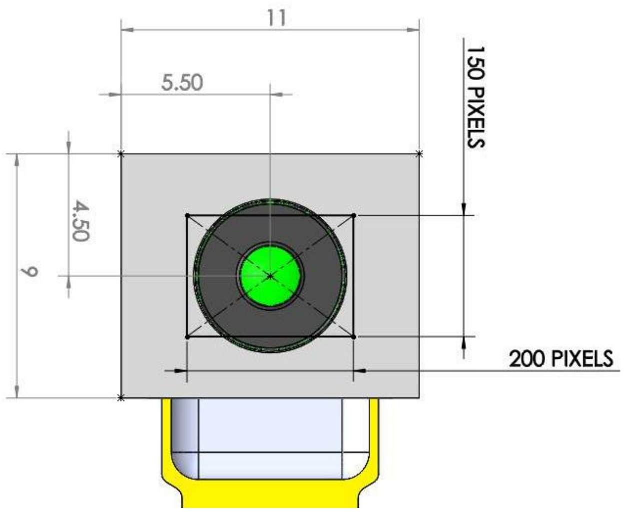


Figure 8: Top view of sample sensor housing

7 Software Interface

7.1 Software Overview

The Micro Core is primarily intended to be used in a Linux/Windows or Android environment. It has the potential to be used on bare metal developments (without any OS) with the inclusion of some basic imaging offset corrections handled internally by the host side.

7.2 SPI Driver

When integrating a Micro Core into a Linux or Android system, it is necessary to customize the kernel's SPIDEV device driver (under GPL license) to be compatible with the Micro Core. This driver will be custom for each application and is dictated by the operating system, the microprocessor family and the IO pins selected on the microprocessor. The function of the SPI driver is to communicate directly with the Micro Core via the SPI coprocessor circuit and to pass data to the Seek SDK. The SPI driver will also control the reset signal to the Micro Core. There are several important requirements that the SPI driver and processor must support:

1) DMA driven half & full duplex DMA transfers
2) Host Buffer size of 64K bytes (1-frame)
3) Custom IOCTL signals RESETN (output) and optional SYNC (input)
4) 8/16-bit Transfers
5) SPI mode 0
6) Custom Clock Tree to support minimum clock rate of 5.14 MHz SPI clock, up to a maximum of 10MHz

Seek has successfully integrated Micro Cores with Qualcomm Snapdragon family processors in Android and a variety of processor families running embedded Linux.

7.3 USB Driver

The Seek SDK uses drivers packaged with the SDK download. On Windows, the driver is a Setup Information File (INF); on Linux, the driver is a set of udev rules. Refer to the SDK Quick Start Guide for more information.

7.4 Seek SDK

The Seek SDK officially supports Windows and Linux; pre-compiled binaries are provided for a variety of architectures. The SDK manages device communication and frame processing image and thermography. Refer to the SDK C Programming Guide for more information.

7.5 Coprocessor Circuit Code

The SPI coprocessor circuit uses a Maxim MAX32660GTG+ processor to manage the SPI interface. The code on this processor is managed by Seek and provided as a binary to customers who intend to use the SWDIO interface to program the processor during production. Alternatively, Maxim offers a programming service for volume purchases of the processor to alleviate the need for in-circuit programming. Please contact Seek for details of procuring pre-programmed parts from Maxim.

The USB coprocessor circuit uses an NXP LPC4330FET100,551 processor to manage the USB interface. The code on this processor is managed by Seek and provided as a binary to customers to program the device on their system board. The typical programming interface for the NXP processor is JTAG.

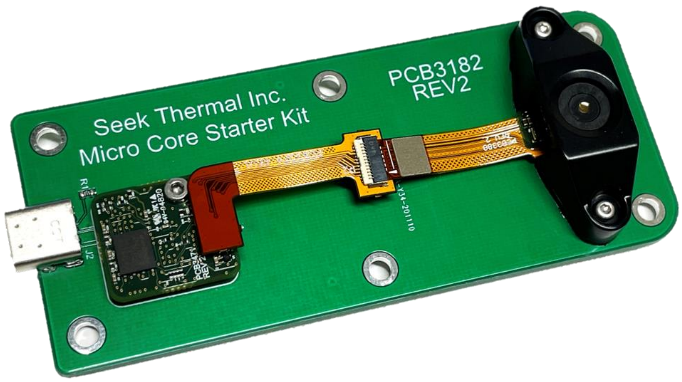
7.6 Product Considerations

Seek offers support for a variety of production logistic aspects of including the Micro Core in a product. These include programming scripts, calibration procedures and design support.

8 Appendix: Micro Core Starter Kits

8.1 USB Starter Kit

The Micro Core USB starter kit is a great option to get up and running with minimal effort. The USB starter kit allows developers to quickly assess the Micro Core image quality and thermography properties in the Seek Simple Viewer app. Alternatively, with minimal effort, a developer may install and configure the SDK sample application to test and configure image processing settings.

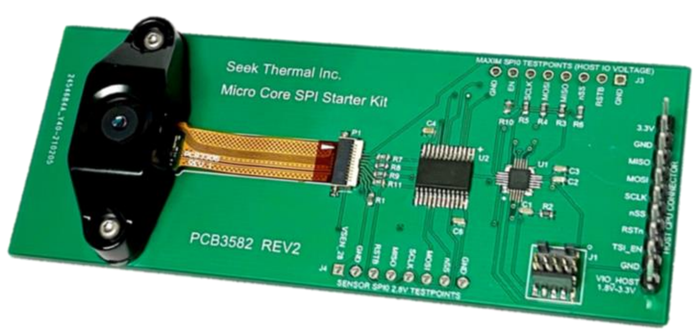


8.2 USB Starter Kit Disassembly and Interfacing

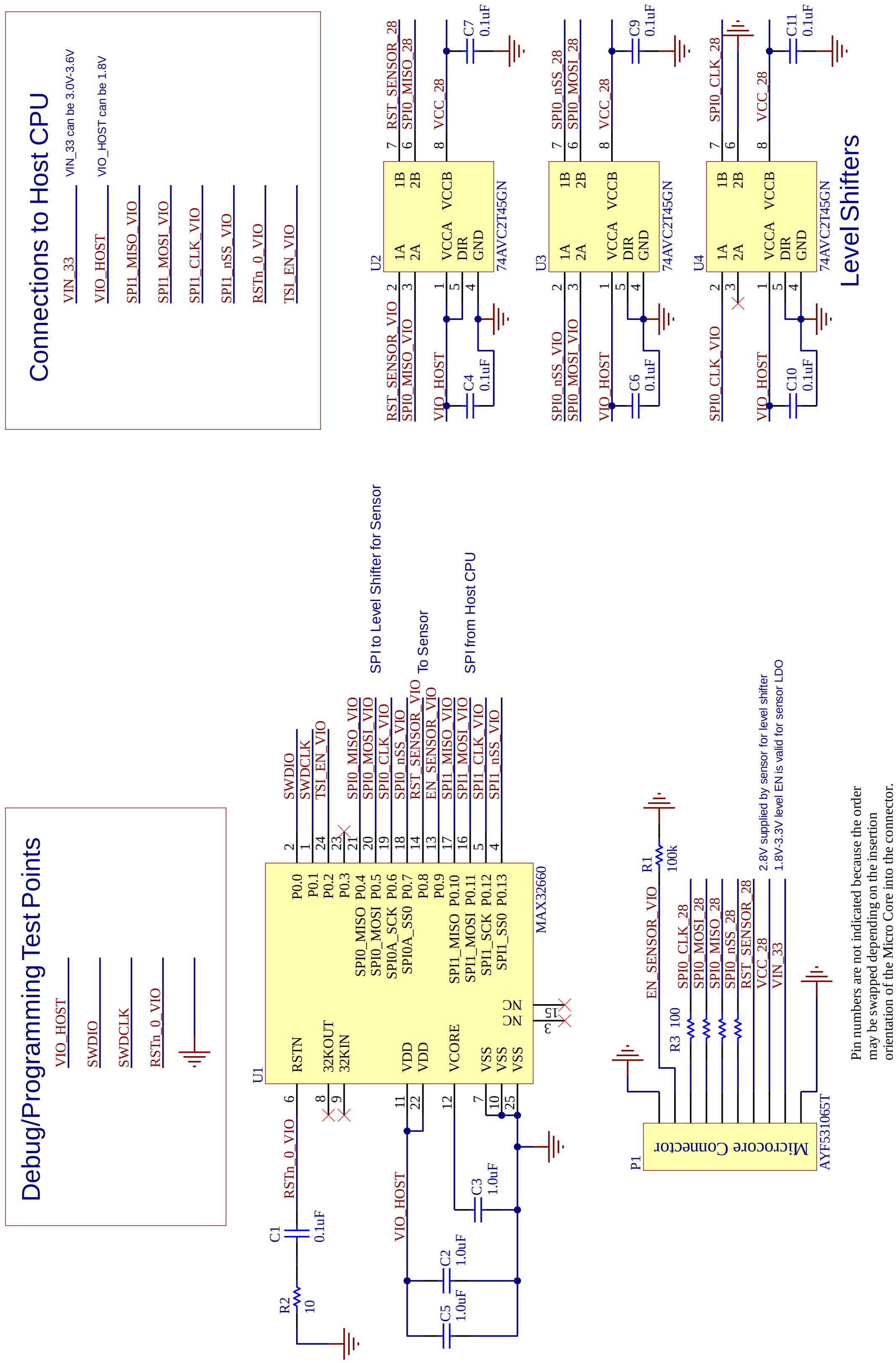
The USB Starter Kit may be disassembled, and the Micro Core and coprocessor board integrated further into a development system. See section 4.7 Seek Thermal Supplied Coprocessor Boards for more details.

8.3 SPI Starter Kit

The Micro Core SPI starter kit is the SPI Coprocessor circuit implemented on a simple to use development board. The SPI signals, voltage rails and control signals are easily accessible on a pin header. These signals can be jumped over to a host processor board to start developing a SPI based Micro Core system with minimal hardware development. The SPI starter kit requires more effort than the USB starter kit to get to a point where image quality can be assessed as the SPI interface requires custom driver and application code development for the selected host processor. Please refer to the Micro Core SPI documentation for further details.



9 Appendix: SPI Coprocessor Circuit Schematic

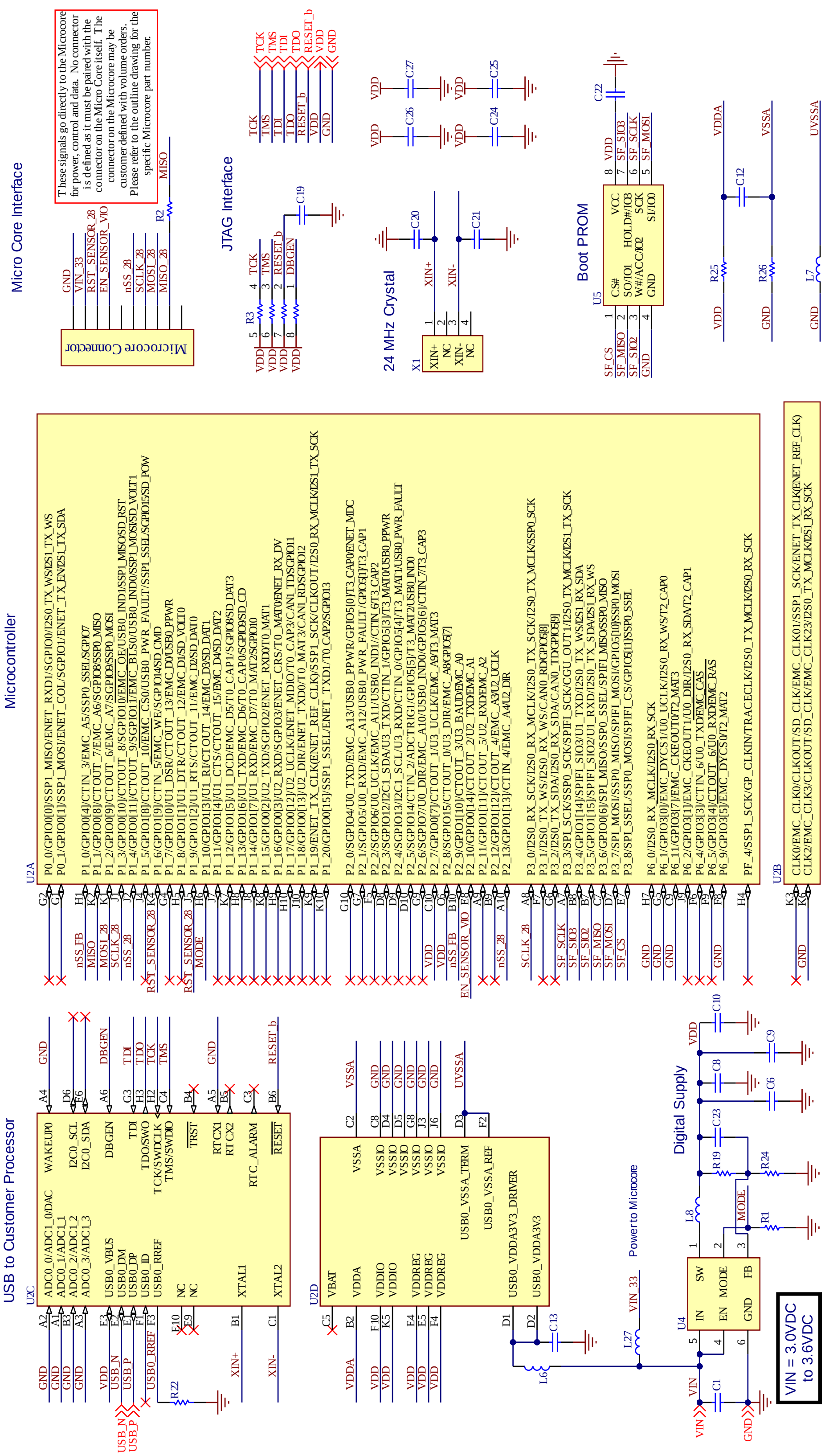


10 Appendix: SPI Coprocessor Circuit BOM

PART NUMBER	MFG	VALUE	DESCRIPTION	REF DES	QTY	NOTES
CAPACITOR	GENERIC	0.1uF	CAP CER 0.1UF X7R	C1, C4, C6, C7, C9, C10, C11	7	
CAPACITOR	GENERIC	1.0uF	CAP CER 1.0UF X7R	C2, C3, C5	3	
AYF531065T	PANASONIC		CONN FPC 10POS 0.50MM R/A	P1	1	
RESISTOR	GENERIC	100k	RES 100 KOHM	R1	1	
RESISTOR	GENERIC	10	RES 10 OHM	R2	1	
RESISTOR	GENERIC	100	RES 100 OHM QUAD	R3	1	1
MAX32660GTG+	MAXIM IC		IC, MCU, CORTEX M4F 96MHZ ME11 TQFN	U1	1	2
74AVC2T45GN	NEXPERIA		IC TRNSLTR BIDIRECTIONAL 8XSON	U2, U3, U4	3	3

1. *A quad pack resistor is shown, this may be substituted with discrete resistors*
2. *This part number represents the stock part from Maxim, please speak with Seek to obtain the pre-programmed Maxim part number.*
3. *Alternate footprints may be used if available. Alternate manufacturers and part numbers have not been validated by Seek but may be used at customer's risk. Seek recommends against auto-direction sensing level shifters.*

11 Appendix: USB Coprocessor Circuit Schematic



12 Appendix: USB Coprocessor Circuit BOM

This BOM is focused on automotive applications so it contains parts that are AEC-Q rated for automotive use. The parts listed as “Generic” are commonly available in AEC-Q rated versions and are up to the customer to select. Except for U2 and U5, the customer may replace non-generic components with alternates at their own risk.

MFR PN	MFR	DESCRIPTION	REF DES	QTY	NOTES
CAPACITOR	Generic	CAP CER 4.7UF 6.3V 20% X5R	C1,C6	2	
CAPACITOR	Generic	CAP CER 1000PF 25V 5% NPO	C10	1	
CAPACITOR	Generic	CAP CER 18PF 50V 5% NPO	C20,C21	2	
CAPACITOR	Generic	CAP CER 22PF 50V 5% NPO	C23	1	
CAPACITOR	Generic	CAP CER 0.1UF 16V 10% X7R	C8,C12,C13,C19,C22, C24,C25,C26,C27	9	
CAPACITOR	Generic	CAP CER 10000PF 16V 10% X7R	C9	1	
BK0603TS121-TV	Taiyo Yuden	FERRITE BEAD 100 OHM 2A	L1	1	1
MLF1005G2R2JTD25	TDK	IND 2.2UH 30mA 5% SMD	L27	1	1
BK1005HS601-TV	Taiyo Yuden	FERRITE CHIP 600 OHM 300MA	L6,L7	2	1
MLZ2012M2R2HTD25	TDK	IND 2.2UH 600mA 160MOHM 20%	L8	1	1
RESISTOR	Generic	RES 182K OHM 1,16W 1%	R1,R24	2	
RESISTOR	Generic	RES 665K OHM 1/16W 1%	R19	1	
RESISTOR	Generic	RES 100 OHM 1/10W 5%	R2	1	
RESISTOR	Generic	RES 12K OHM 1/10W 1%	R22	1	
RESISTOR	Generic	RES 10 OHM 1/10W 5%	R25	1	
RESISTOR	Generic	RES 0.0 OHM 1/16W JUMP	R26	1	
EXB-28V103JX	Panasonic	RES ARRAY 10K OHM 4 RES	R3	1	1, 4
LPC4330FET100,551	NXP	IC MCU 32BIT ROMLESS 100TFBGA	U2	1	2
TPS62260TDRVRQ1	TI	IC REG BUCK SYNC ADJ 0.6A 6SON	U4	1	1, 3
MX25L3233FZBR-08Q	Macronix	IC FLASH 32MBIT 104MHZ 8WSON	U5	1	1, 3
XRCGB24M000F3A00R0	Murata	CRYSTAL HYBRID 24MHZ 6PF SMD	X1	1	1, 3

1 *Components are AEC-Q rated for automotive applications.*

2 *U2 is not AEC-Q100 qualified and there is not suitable alternate part. It is the customer’s responsibility to qualify this part for use in automotive applications.*

3 *Alternate footprints may be used if available.*

4 *A quad pack resistor is shown, this may be substituted with discrete resistors*