FEATURES

People counting algorithm for indoor areas, such as meeting rooms or office cubicles
Zoned performance
    Coverage area for optimal accuracy of 90%: 3 m radius
    Maximum coverage area (accuracy of 80%): 5 m radius
Edge processing
    Metadata output over UART
    No captured images are transmitted
Occupancy state
People detection and count
    Location of person (x and y coordinates)
    Activity of person (moving or static)
Multiple sensor application for a larger coverage area and greater accuracy
Low light performance
Light levels (at ceiling height)

APPLICATIONS

Building technology solutions
Intelligent buildings
Occupancy analytics
Building management systems

GENERAL DESCRIPTION

The ADSW4000 ADI EagleEye™ PeopleCount algorithm enables a people counting function within internal spaces, such as meeting rooms or office spaces. The system edge node analytics unlocks informed insights and analytics with an accurate and secure people counting capability. This data can provide the insight to improve asset and people management, social distancing, security, employee engagement, space utilization, labor productivity, and energy efficiency.

The ADSW4000 is designed to operate solely with the Analog Devices, Inc., ADSP-BF707 Blackfin+® core embedded processor (ADSPBF707BBCZ4-EGE) and is optimized for a CMOS 2D video graphics array (VGA) sensor and lens (the recommended Chicony CYFI013 module incorporates an ON Semiconductor® ASX340AT3C00XPED0-DPBR CMOS image sensor, Chicony YT70005 lens, and lens holder with infrared (IR) filter).

The ADSW4000 ADI EagleEye™ PeopleCount algorithm provides up to a 90% accurate people count within the target area.

The following are the accuracies achieved for tested radii from 3 m to 5 m:

- 90% accuracy in 3 m radius
- 85% accuracy in 4 m radius
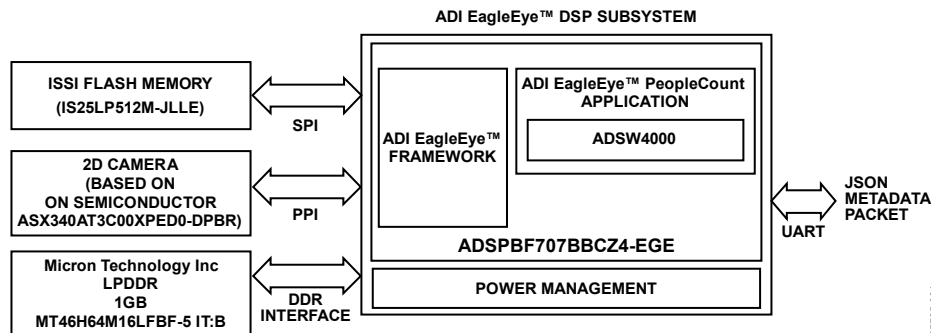- 80% accuracy in 5 m radius

FUNCTIONAL BLOCK DIAGRAM

Figure 1.

Rev. 0
    Document Feedback

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REVISION HISTORY

4/2021—Revision 0: Initial Version

SPECIFICATIONS

OPERATING CONDITIONS

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
COVERAGE AREA					
Optimal Accuracy of 90%[1, 2, 3]			3 (9.8)	m (ft)	Radius (of the longest length and width).
			18 (193.8)	m2 (ft^2)	Equivalent floor area for 3 m radius.
			4.24 × 4.24 (14 × 14)	m (ft)	Equivalent room dimensions for 3 m radius.
Maximum (Accuracy of 80%)[1, 2, 3]			5 (16.4)	m (ft)	Radius (of the longest length and width).
			50 (538.2)	m2 (ft^2)	Equivalent floor area for 5 m radius.
			7 × 7 (23 × 23)	m (ft)	Equivalent room dimensions for 5 m radius.
SENSOR HEIGHT	2.44 (8)		3.00 (10)	m (ft)	
LUX LEVEL (AMBIANCE)	60			Lux	Estimated value of the luminance level at ceiling height in addition to any light source within the field of view (FOV). The people count registers zero for light levels less than 60 lux.
PEOPLE COUNT		24			Single sensor, returns occupancy number.
NUMBER OF ZONES		6			

[1] Based on the Chicony CYFI013 module incorporating the ON Semiconductor ASX340AT3C00XPED0-DPBR image sensor, Chicony YT70005 lens, and lens holder with IR filter.
[2] Accuracy numbers are obtained as an average of the benchmark vectors.
[3] Testing was completed under the typical operating conditions to achieve the specified performance.

OPERATING LATENCY

Table 2.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
LATENCY					
Switch from Vacant to Occupied		300		ms	From the time a person enters the region of interest (ROI)
Switch from Occupied to Vacant	2.5	5	10	Minutes	User configurable, 5 minutes by default, effective latency is twice the user configurable value in very low light (<20 lux)
People Count and Location Value Provided for the First Detection of a Person in the ROI		1.5		sec	Time for a person to move from the door entry point to the ROI
People Count and Location Value Updated After Person Detected in the ROI		113		ms	Results are updated for every frame

EXTERNAL HARDWARE REQUIREMENTS

Table 3.

Function	Hardware
Target Processor	ADSPBF707BBCZ4-EGE
2D Vision Sensing Module	Chicony CYFI013 module (ON Semiconductor ASX340AT3C00XPED0-DPBR image sensor, Chicony YT70005 lens, and lens holder with IR filter)
Flash Memory	Integrated Silicon Solution, Inc. (ISSI), IS25LP512F-JLLE (recommended)
Double Data Rate (DDR) Memory	Micron Technology, Inc. MT46H64M16LFBF-5 IT:B 1 GB: ×16, ×32 mobile low power double data rate (LPDDR) synchronous dynamic random-access memory (SDRAM) (recommended)

TERMINOLOGY

ROI
Region of interest.

FOV
Field of view.

Zone
A zone is an area that a target space can be divided into. ADI EagleEye™ enables a people count specific to each zone. One sensor can support up to six zones and count a maximum of 24 people. If there are more than 24 people, the count reports 24. Multiple sensors can be used to monitor larger areas, with each sensor counting a maximum of 24 people.

Activity Level
The activity level of a person detected by the sensor is provided as a percentage. For example, 0% means the person is not moving, while 100% means the person is making significant movement, such as walking or turning.

Low Light
Low light is <60 lux.

ADI EagleEye™ PeopleCount Algorithm
When coupled with the ADSPBF707BBCZ4-EGE and external flash memory, the ADSW4000 ADI EagleEye™ PeopleCount algorithm enables the people counting function.

ADI EagleEye™ Firmware
The ADI EagleEye™ firmware runs on the ADI EagleEye™ digital signal processor (DSP) through the ADI EagleEye™ reference design external flash memory. The software includes the bootloader and application firmware.

ADI EagleEye™ DSP Reference Design
The ADI EagleEye™ DSP reference design comprises the recommended components to achieve optimal performance and features the ADSPBF707BBCZ4-EGE. These components form part of the ADI EagleEye™ trial kit.

ADI EagleEye™ Trial Kit
The ADI EagleEye™ trial kit comprises the ADI EagleEye™ DSP system, a cortex-based microcontroller unit (MCU) subsystem, a 2D vision sensor module, external flash memory, ADI EagleEye™ analytics algorithm, application firmware, Bluetooth and Wi-Fi interfaces for wireless connectivity for mobile commissioning and cloud connectivity, respectively, a PC GUI tool for configuration, commissioning, and monitoring, and a companion mobile commissioning application (an Android or iOS mobile application).

THEORY OF OPERATION

ADI EagleEye™ is the technology combination of the Analog Devices Blackfin+ core embedded processor (ADSPBF707BBCZ4-EGE) and the proprietary software analytics algorithms. The ADSW4000 enables a 2D vision, sensor-based, people counting and location solution. The ADSW4000 detects occupancy within an ROI and measures occupancy levels in areas such as office meeting rooms or open plan office cubicle areas.

A people counting system can be designed using the ADI EagleEye™ reference design (see Figure 2). Enabling a full sensor to cloud or on-premise system requires an ADI EagleEye™ DSP system, MCU subsystem, 2D vision sensor module, external flash memory, ADI EagleEye™ analytics algorithm, and application firmware. Additional communications interfaces must be

included if wireless mobile commissioning and wireless data transmission are implemented.

ADI EagleEye™ can be integrated into an intelligent building monitoring system that includes additional sensing functions, such as for gas level, temperature, and humidity (see Figure 3).

ADSPBF707BBCZ4-EGE

The ADSPBF707BBCZ4-EGE Blackfin+ core embedded processor is used in ADI EagleEye™ applications. The ADSPBF707BBCZ4-EGE only functions when used in conjunction with the ADI EagleEye™ ADSW40xx software algorithm offerings.

For general descriptions and other specifications of the ADSPBF707BBCZ4-EGE, see the ADSP-BF700/701/702/703/704/705/706/707 data sheet.
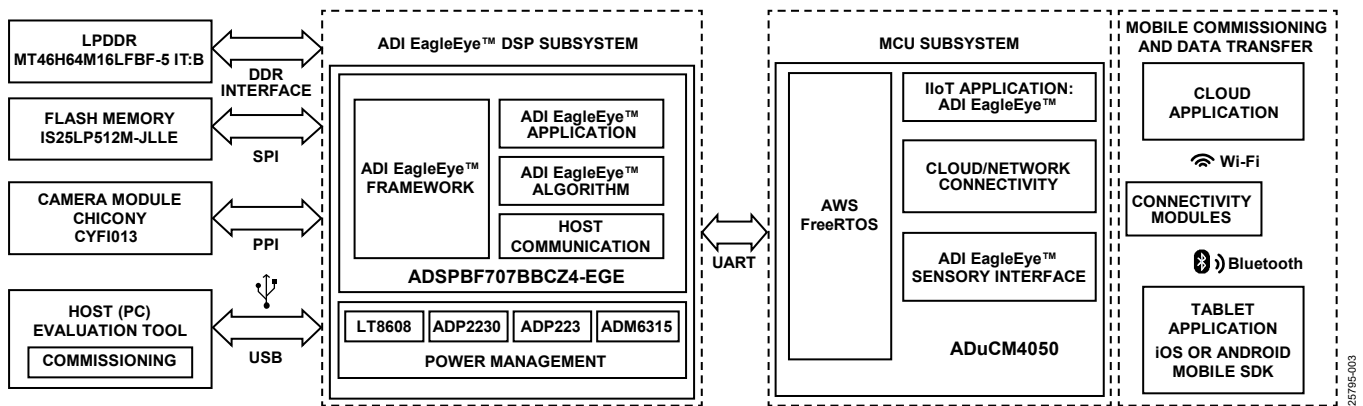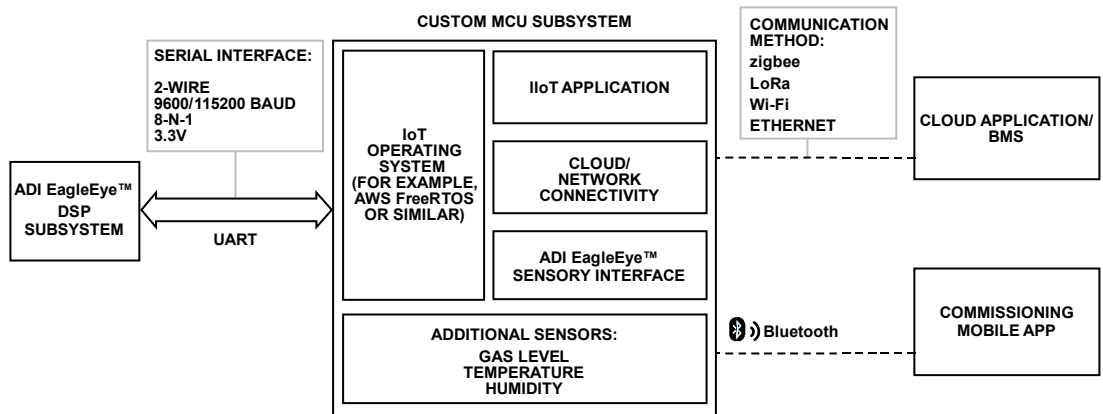

Figure 2. ADI EagleEye™ Reference Design Block Diagram

Figure 3. Incorporating ADI EagleEye™ into a Custom MCU Platform with Additional Sensors

PEOPLE COUNT ACCURACY FORMULA

To calculate the accuracy of the PeopleCount algorithm output, the following terms and calculations are applied:

- errCount = absolute (PeopleCount – ActualCount)
- avgErr = average errCount over any duration
- avgCount = average of ActualCount over entire duration
- Accuracy (%) = (1 – avgErr/avgCount) × 100 (returns 0% accuracy if the count calculation returns a negative number)

Because a sensor sees through a circular lens, the FOV of the sensor is a circular image, even if the room is rectangular or square. The sensor can cover a rectangular room only if the circular image includes the rectangular room (see Figure 4).
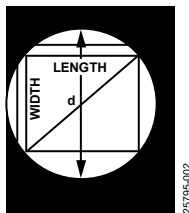

Figure 4. ROI Radius

To convert a room size to an ROI radius, use the following equation:

$$Radius = 1/2 \times (\sqrt{(Length^2 + Width^2)})$$

Using this equation, the ROI radii are computed for commonly used space sizes in an ADI EagleEye™ application (see Table 4).

Table 4. ROI Radii for Commonly Used Space Sizes

ROI Radius (m)	Room Area (m²)	Room Dimension (m)	Room Dimension (ft)
3	18	4.24 × 4.24	14 × 14
3	32	5.65 × 5.65	19 × 19
3	50	7.07 × 7.07	23 × 23
3.29	20.08	5.45 × 3.66	18 × 12

SENSOR COMMISSIONING

Sensor commissioning is required for operation and optimal people counting. The sensor must first be commissioned to assert the relevant ROI. Masks, such as window masks, are used to improve the accuracy of the count (for example, the algorithm does not count people passing by a window). For instance, if more than 60% of a detected person falls inside of an exclusion mask area, the person is not counted.

The optimal operation of the sensor is achieved under the following conditions:

- The sensor is ceiling mounted in the center of the ROI.
- The sensor is mounted with no tilt and is parallel to the floor area.
- The sensor is commissioned using the guidelines detailed in the EVAL-ADSW4000KTZ user guide.
- The sensor is used outside of areas with strong or flickering lights that can compromise the function of the camera module.
- No lights are pointing directly at the camera module.
- People are visible and not occluded by other objects in the FOV, and there is sufficient contrast with the room background.
- There is sufficient space between people to allow proper detection of the individual occupants.

EDGE PROCESSING

ADI EagleEye™ does not transmit any captured images. Edge processing supports a metadata output over the universal asynchronous receiver-transmitter (UART) port of the DSP.

Occupancy metadata is sent over UART in push mode by default under the following conditions:

- Specified rate: user defined, 200 ms minimum
- Data speed: 9600 baud or 115200 baud (default)

The occupancy metadata is sent in JSON format. The following is the JSON metadata packet format (see Table 5 for more details):

'{"PID": 0, "PNO": <Packet number>, "OccStat": <Occupancy state>, "LgtStat": <Light state>, "PplCnt": <People count>, "ZnOccStat": <Zone occupancy state>, "ZnLgtStat": <Zone light state>, "ZnLuxLvl": <Zone lux level>, "ZnPplCnt": <People count at each zone>, "Ppl": <People ID with properties>, "TELEM": <Telemetry data>}\n\r'

Table 5. JSON Metadata Packet Format

Metadata Output	Definition
Packet Number	Number of packets since the initial boot of the sensor
Occupancy State	Flag: shows room occupied (1) or not occupied (0)
Light State	Flag: shows light control output state on (1) or off (0)
People Count	Number of people detected in the ROI
Zone Occupancy State	Flag: shows zone occupied (1) or not occupied (0)
Zone Light State	Flag: shows zone light control output state on (1) or off (0)
Zone Lux Level	Shows the estimated lux level of the specific zone (in lux)
People Count at Each Zone	Number of people detected in the specific zone
People ID with Properties	X and y coordinates for each person detected in the ROI
Telemetry Data	Debug and reserved data

ORDERING GUIDE

Model	Description
ADSW4000-P[1]	PeopleCount perpetual license
EVAL-ADSW4000KTZ	ADI EagleEye™ trial kit

[1] The ADSPBF707BBCZ4-EGE must be used in conjunction with the ADSW4000-P software algorithm.

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