

SC1232AR3: Application Note #6

Application Example

for Human Presence Detection

CMOS 24GHz Radar Sensor
Ver.1.0.0a

Jun. 24th, 2019
Socionext Inc.

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Revision History

Date	Revision	Description
2019.05.20	0.1.0	Initial edition for Evaluation Kit (EVK)
2019.05.31	1.0.0	Edition for EVK ver.1.3 release
2019.06.24	1.0.0a	Some minor editorial corrections

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1. Introduction

1.1. About This Document

This document describes one of the usage examples how Socionext 24GHz Radar Sensor: SC1232AR3 can be applied to the Human Presence Detection application.

In section 2, an overview of the Human Presence Detection application with SC1232AR3 is described.

In section 3, an example usage procedure of the Human Presence Detection is described.

In section 4, recommended sensor setting parameter sets are described.

In section 5, notes and restrictions in use are described.

And, in section 6, some example sensing results are shown.

1.2. Related Documents

- SC1232AR3-B-001: Evaluation Kit Operation Manual
- SC1232AR3-B-001: Evaluation Software Operation Manual
- SC1232AR3: Control API Specifications
- SC1232AR3: Datasheet (Evaluation Kit Edition)
- SC1232AR3: Application Note #2: Sensor Setting Parameter Descriptions
- SC1232AR3: Application Note #3: Sample C Source Code for Entry Motion and Distance Detection

2. Overview of the Human Presence Detection

In Motion Detection mode, comparison of the sensed motion level with the reference value at each FFT index is made within the specified target range, and if higher motion level is detected in any target indexes, it is decided that the motion is detected, and DETOUT pin is set as High.

By adequately configuring the sensing configurations and combining some additional operations, such as calibration if needed, this Detection mode can be applied for Entry Motion Detection application and Human Presence Detection application.

In Entry Motion Detection application, the reference value is calculated by combining the past sensed motion level and the latest one for smoothing, and is dynamically varied according to the surrounding environment. Thus, it is not necessary to apply the calibration in this application. However, once an object, such as a human enters into the detection target area and a higher level motion is detected, calculated reference value also becomes higher. It would require some extra time for the reference value returns to the original level which was in no object environment. Therefore, this application is suitable for detecting only an entry motion into the detection target area.

In Presence Detection application, fixed reference value which is acquired by the calibration executed beforehand is used for motion detection. Since the reference value is fixed, it can keep detecting consecutive motions. Host MCU can decide a presence of the object with motion (such as human) by monitoring a status of DETOUT pins. However, it is necessary to execute the calibration before the actual presence detection. It may also be necessary to execute the calibration again regularly or irregularly in case that the surrounding environment varies. The host MCU should manage operation, control and calculations for the calibration. This detection is suitable for the applications which requires to detect a presence of the human within the specified distance range while a precise distance to the detected object is not necessary.

3. Example Usage Procedure of the Human Presence Detection

In this section, an example way of Calibration and Sensing Operation in the Human Presence Detection application is described.

3.1. Calibration

This application usage requires a calibration before the actual Presence Detection operation in order for acquiring the reference value to be compared with the sensed level.

The calibration should be executed under the environment of no motion objects (i.e. no persons) in the sensing target area. The condition of no motion objects should be kept during the execution of calibration. In the calibration process, a reference value is calculated by averaging the sensed motion level over certain period of the time. This reference value is to be used later for the human presence decision by comparing with the sensed motion level.

As the reference value would vary according to the change of the surrounding environment, calibration should be executed if any surrounding environment is anticipated to be changed. Adequate timing and interval of the calibration should carefully be determined according to the assumed environment and conditions where the sensor is to be installed.

The calibration operation and its related setting items are shown in Figure 3-1.

- "start wait" represents a wait time until the start of the calibration process. The operator who handles calibration can go away from the sensing target area for stable calibration.
- "wait time 1" represents a wait time until the reference value becomes stable. During this period, although the sensing is executed with the specified sensing parameter set, sensed motion levels are discarded.
- "wait time 2" represents an interval for acquiring the sensed motion level for calculating the reference value. For example, if this parameter is set as 1sec, acquiring for reference value calculation is executed every 1sec, and the sensed motion level except that timing is not used for the reference value calculation..
- "repeat num" represents a number of samples averaged for calculating the reference value
The reference value can be calculated by averaging the sensed motion level over number of "repeat num".
- "alpha" represents a smoothing factor in calculating the reference value. In Human Presence Detection application, as the reference value is calculated in the calibration phase, and then fixed in the actual detection operation, the parameter "alpha" only contributes to the smoothing in calculating the reference value in calibration. In the attached sample source code, alpha=0.9 is used. If alpha is set as more than 0.9 (closer to 1.0), since it would take more time for the reference value to be stable, "wait time 1" should also be set as longer.

Regarding a detail of "alpha", please refer "SC1232AR3: Application Note #2: Sensor Setting Parameter Descriptions".

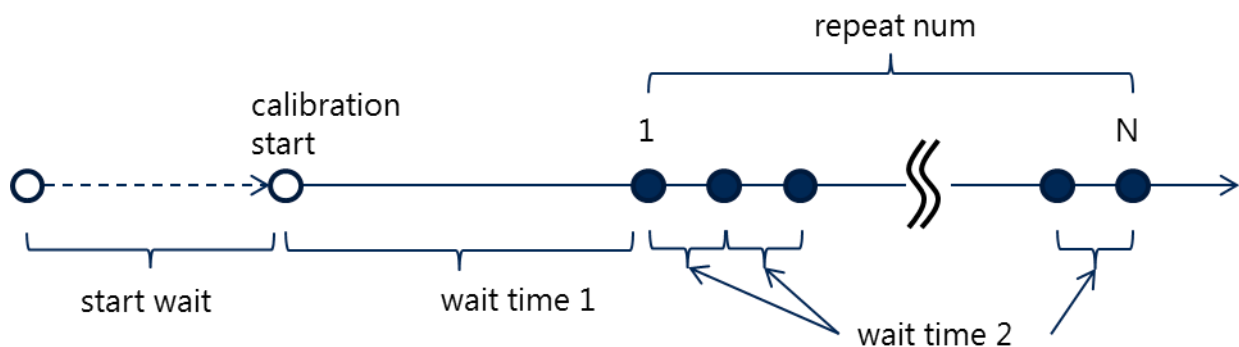


Figure 3-1: Calibration Settings

In the attached sample C source code, as an example, required time for total calibration operation is around 40 seconds.

3.2. Sensing operation for Human Presence Detection application

After the acquired reference value by the calibration is set to the Sensor LSI, sensing for Human Presence Detection can be started. When an objects with motion is detected within the specified detection target range, DETOUT pin is set as High. This detection can match with the application to detect a presence of the human within the specified distance range although the precise distance to the detected object is unknown. In decision of Motion Detection, sensed motion level is compared with the specific value which is the multiplied reference value by the threshold decision coefficient, "motion_threshold", and the decision result is outputted as High/Low at the DETOUT pin.

The parameter, "motion threshold", should be specified so that the DETOUT becomes High while no persons exist in the target detection range. If the motion_threshold is set as higher, false positive detection can be reduced while it tends to become insensitive to detect the human with less motion. In an opposite manner, if the motion_threshold is set as lower, it will become more sensitive to detect the less motion while the false positive error would increase. Thus, "motion threshold" should carefully be specified according to the target environment and use cases to be applied.

By using this detection, host MCU can make decision if any electric appliances should be turned on or be kept on by monitoring if DETOUT becomes high during the certain period.

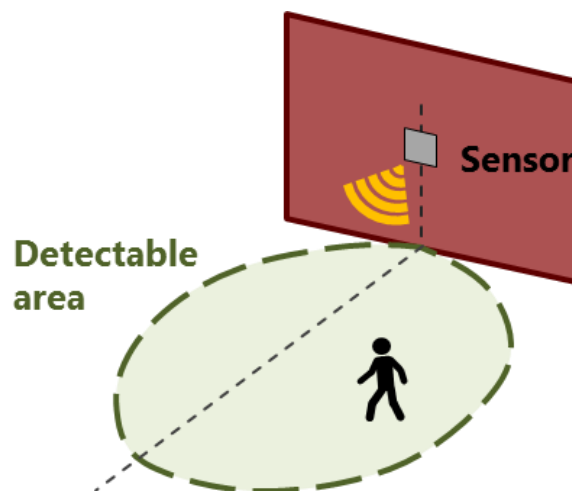


Figure 3-2: Presence Detection

4. Example sensor setting parameter sets

In this section, example sensor setting parameter sets for the Human Presence Detection application are described.

4.1. Example parameter sets in Human Presence Detection

Table 4-1 shows an example parameter sets to be used for Presence Detection application.

Table 4-1: Example parameter sets for Presence Detection mode

Category	Item	Value
1	rx_gain	60 (dB)
1	interval	250 (ms)
1	motion threshold	400
1	startup count	1
1	lower_distance	10 (cm)
1	upper_distance	500 (cm)
1	chirp_time	1100 (us)
1	digital beam shaper	wide
1	high_pass_filter	first order
1	alpha	0.9
2	start wait	5 (s)
2	wait time 1	15 (s)
2	wait time 2	1 (s)
2	repeat num	20

The values shown in Table 4-1 are selected so as to reduce false detections in ordinary environment. But, it is not versatile to any environments. If it is to be applied to the environment where more false detections happens, increase of the "motion_threshold" or narrowing the detection target range by reducing the "upper_distance" would be needed to improve the false detections.

Details of parameters in Category 1 shown in Table 4-1 and their configurable range are described in "SC1232AR3: Application Note #2: Sensor Setting Parameter Descriptions".

Details of parameters in category 2 are described in section 3 of this document. As the values specified in Table 4-1 is an example values chosen under the ordinary environment. Those value should carefully be tuned to the target environment and use cases.

5. Notes and Restrictions to take care in operation

In this section, notes and restrictions to take care in operating this application are described.

- Around 400 would be a reasonable value as the "motion threshold" in ordinary in-room condition without any other jamming moving (including vibrating) objects.
- Higher "alpha" would contribute to reduce false detection by noise but would cause response delay for calibration. So higher "wait time 1" is needed in the calibration process.
- This Presence Detection embedded in SC1232AR3 is designed to intend not to detect static objects.
- Actual detectable range of the target human objects varies according to many factors, such as human's size, posture, moving speed, and environments, such as surrounding objects which causes radio reflection.

For example, if the sensor is located in the room, and the element of the wall, floor or ceiling is made of any metal, those metal objects reflect the sensing radio wave very well, and some unexpected false detection would be happened. Occasionally, those unexpected reflected radio wave would cause cancelling of the wanted original sensing radio wave.

- Experimental verifications and optimization of each parameter under the target environment and usage scenario are strongly recommended.
- When the Human Presence Detection is operated under in-room environment, the parameter to specify upper limit of target detection area, "upper_distance", is recommended to be specified below the distance to the wall in front direction of the sensor face as shown in Figure 5-1 since some architectural components or furniture, such as a wall, a window or a window metal blind might happens to have slight motion from the influence of surrounding environment, such as a mechanical vibration by any motor components.

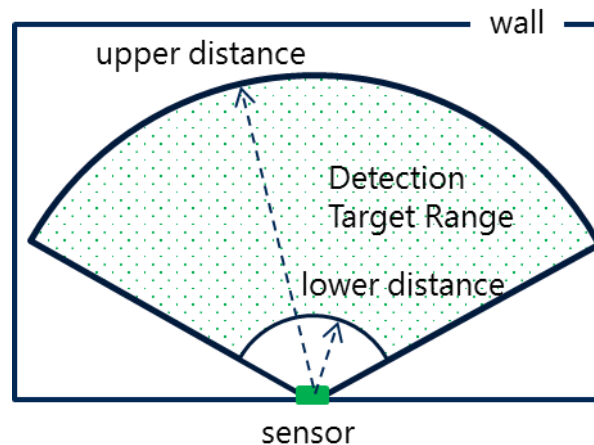


Figure 5-1: Sensing Area

- When the Detection is operated under outdoor environment, it is recommended to be applied where less natural plants, such as tree or tussock which is likely swung exists as much as possible.

6. Example sensing results

In this section, some examples of the actual measurement results under the certain environment are shown. Please note that those results are not universal, and may vary according to the environments to be applied. Careful verifications under the practical or similar environment and condition to be applied are strongly recommended.

6.1. Human walking around in a room by Presence Detection mode

Figure 6-1 shows an example of the actual sensing result when the target human object is walking around in a room.

The human as a target object keeps walking around the point in front of the sensor at 3m distance.

In contrast to the Entry Motion Detection application, it is observed that the object with consecutive motion can be detected.

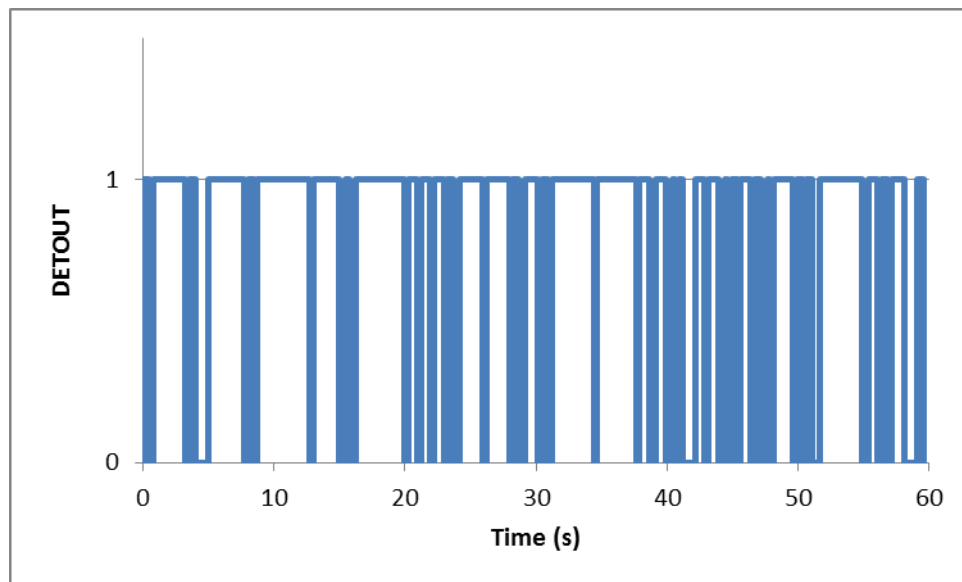


Figure 6-1: Example plot of Presence Detection for walking human detection

6.2. Human sitting on a chair by Presence Detection mode

Figure 6-2 shows an example of the actual sensing result when the target human object is sitting on a chair in a room.

The human as a target object sits and facing in front of the sensor face at 2m distance.

Under this condition, as a motion of the target human is a little, no Presence Detection result would frequently happened for a while. But, by observing the status of DETOUT for a sort of long period, at least one High trigger of DETOUT can be observed. For example, if the criteria to decide a presence of the human is defined as at least one DETOUT=high occurrence per 30 seconds, it is observed that a presence of the human in the room can be detected even if the human is sitting.

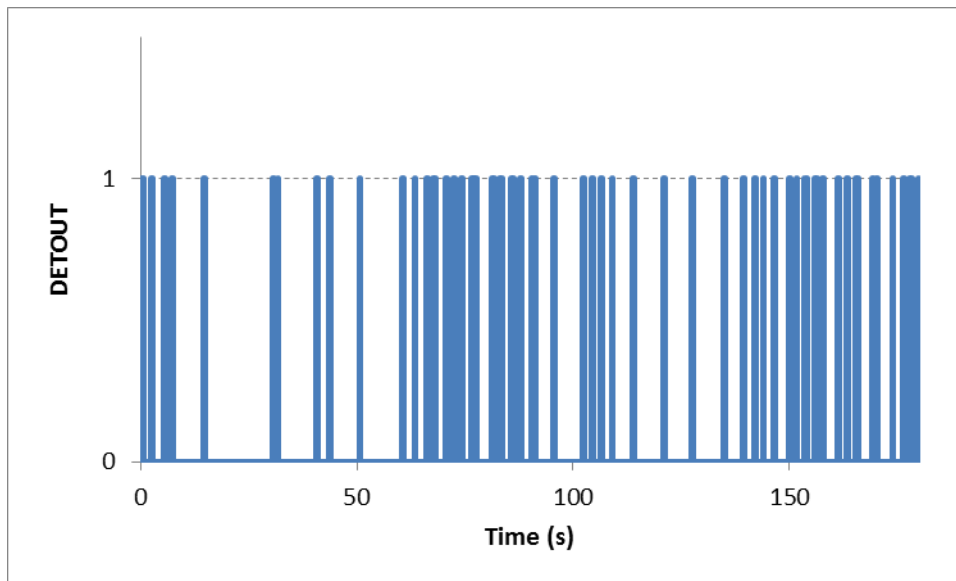


Figure 6-2: Example plot of Presence Detection for sitting human detection

6.3. Sensing result in an office all over night

Figure 6-3 shows an example of the actual sensing result in an office all over night. No signal in mid night can be observed.

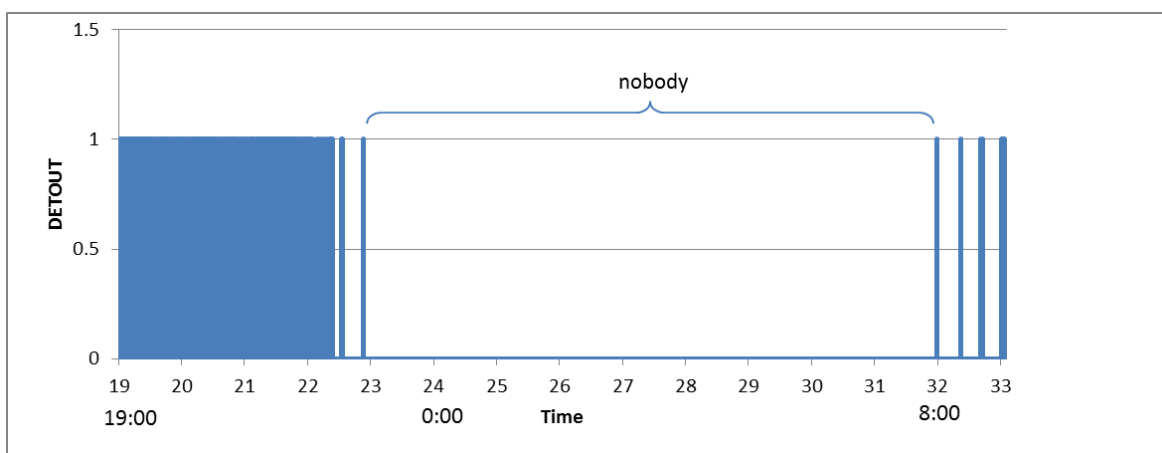


Figure 6-3: Example plot of Presence Detection in an office all over night