V60G-HOME-I Module

User Manual

Revision 1.0.5

Vayyar Imaging Ltd.

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Notice

Revision History

Revision	Date	Author	Description
1.0.1	February 2020		
1.0.2	March 2020		
1.0.3	August 2020		Canada
1.0.4	September 2020		Canada
1.0.5	October 2020		

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Chapter 1
Introduction

This guide provides information on the installation and operation of the **Vayyar V60G-HOME-I modules.**

V60G-HOME-I is a family of multi-antenna millimeter-wave modules operating at 60GHz bands, based on the company's VYYR7201 RF SoC, generating a 3D image of the sensor's vicinity by transmitting and receiving mm-wave signals from multiple antennas (MIMO), used as a fixed field disturbance sensor or a short-range device for interactive motion sensing.

Models pertaining to the V60G-HOME-I family are intended to be integrated with an additional host, either a PC-host operating the device through a USB interface, or a microcontroller-unit (MCU) for integrated and embedded products.

The sensor detects objects in a defined arena and provides 3D-data of the targets to the host, such as: position within the arena, class or posture; a raw 3D image (point-cloud for example).

Typical applications for the device can be touchless input device (e.g. gesture-recognition interface), in-room people detection and monitoring for improving comfort and energy-utilization optimization (e.g. HVAC operation and airflow optimization), detection of abnormal conditions such as fall of elderly people and apnea in adults and babies, and in-cabin monitoring for detection of infants left in car.

The models participating in the V60G-HOME-I family (and certified under modular-approval) include, but not limited to: vStraw_CTPB4_I, vBLU_OK_CTPB4, vBLU_MW_CTPB4.

1.1   Release Information Note

Software capabilities, algorithmic capabilities and different features are under continuous development and improvement.

This document provides basic description of the system and it is operated. For more details – contact Vayyar LTD through – www.vayyar.com.

1.2   Glossary

Table 1: Glossary

Term	Definition
AC	Alternating Current
API	Application Programming Interface
DC	Direct Current
DLL	Dynamic Link Library
EVK	Evaluation Kit
GUI	Graphical User Interface
IP	Internet Protocol. An IP address is a numerical identifier assigned to a computing device or node in a TCP/IP network. The address is used to locate and identify the node in communications with other nodes on the network.
MCU	Micro-Controller Unit
PCB	Printed Circuit Board
RF	Radio Frequency
SoC	System-on-chip

Chapter 2
System Overview

2.1   System Architecture

The V60G-HOME-I system may be operating with a host-PC and dedicated control and imaging SW and GUI (for example an "EVK" architecture), or by running an imaging engine on a dedicated DSP embedded into the proprietary VYYR7201_CTPB4 chips and using a dedicated API to extract the processing outputs ("embedded architecture"), or any combination of the two.

An "EVK" architecture and connectivity scheme is illustrated in the figure below.
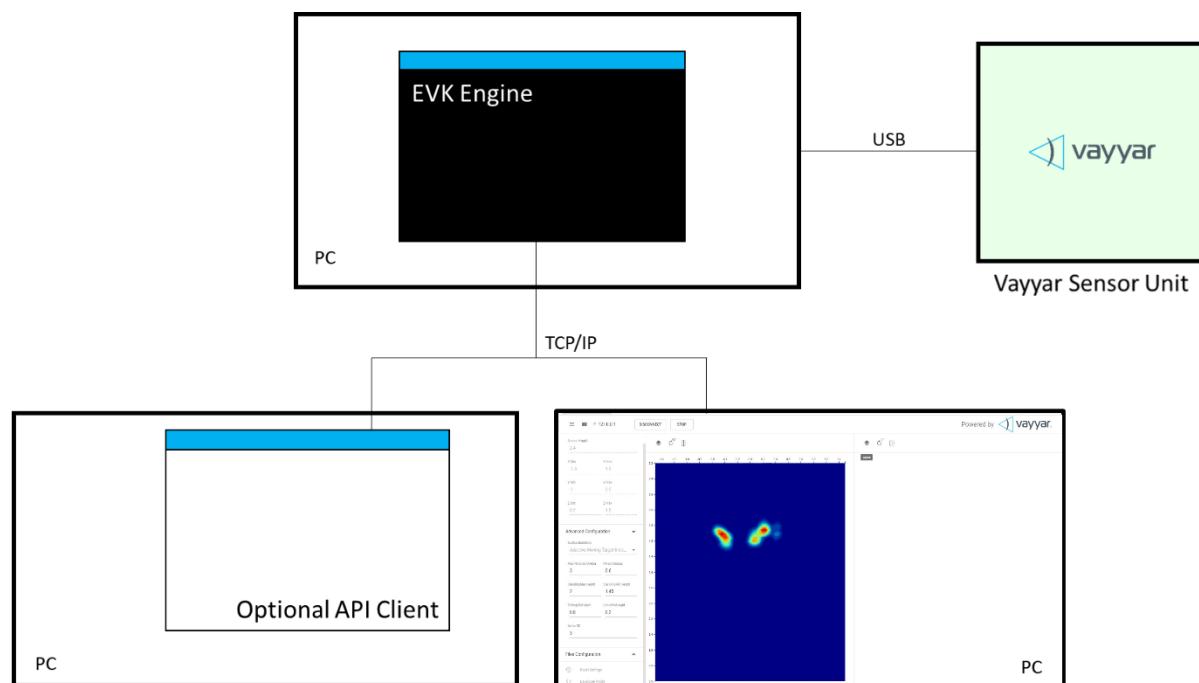
Figure 1: V60G-HOME-I "EVK" System Architecture

The "EVK" V60G-HOME-I system is comprised of the following components:

- **The V60G-HOME-I RF Sensor module.**

- **The EVK Engine.** Host software that performs signal processing functions. The software runs in a command window in a PC, which is connected to the V60G-HOME-I Sensor via a USB cable.

- **Web GUI.** User-interface client software that communicates with the EVK Engine via a TCP/IP connection.

- **API Client.** Optional, customer-developed software that communicates with the EVK Engine via a TCP/IP connection.

A typical "Embedded" architecture is depicted in the following figure:
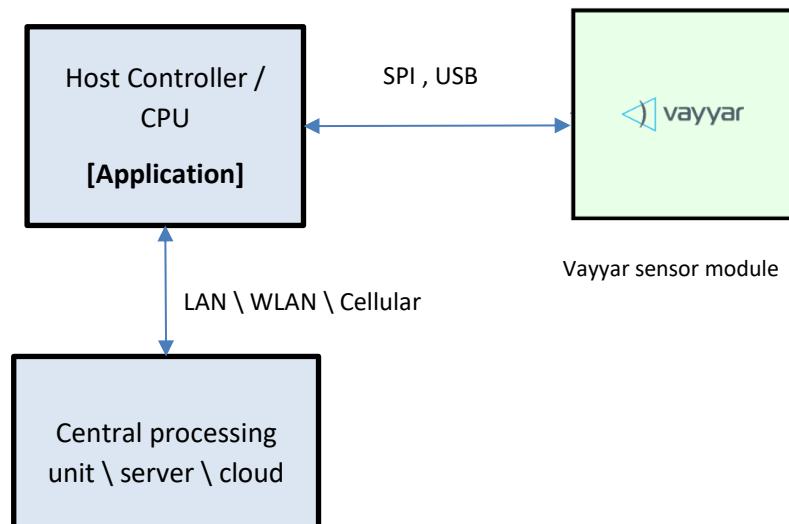
Figure 2: V60G-HOME-I "Embedded" System Architecture

Examples of used controllers may include EPS32, Raspberry-Pi CPU, etc.

2.2   Hardware

The figure below presents a high-level block diagram of the PCB that houses the USB-based sensor unit:
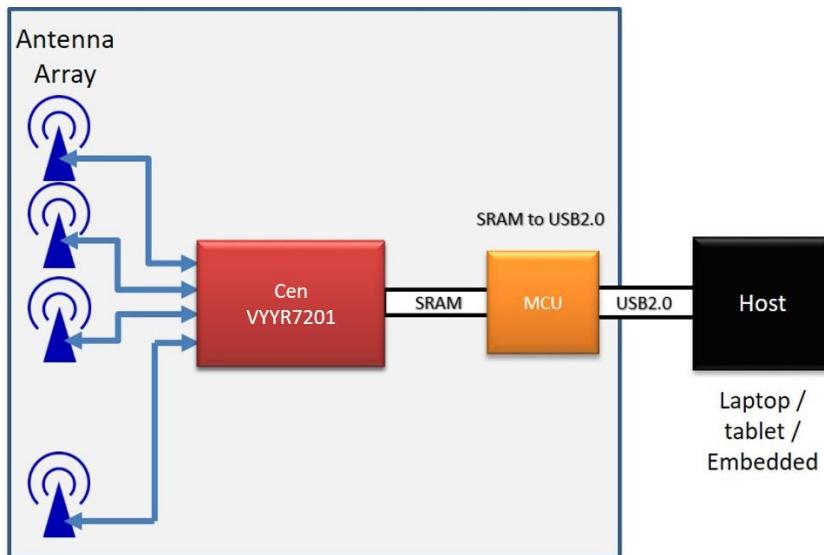
Figure 3: High-Level Block Diagram – USB-based system

An SPI-based module is similar, excluding the USB-related components. The following components are embedded in the sensor unit PCB:

- Vayyar VYYR7201-B4 system-on-chip (SoC).

- 46 embedded Tx/Rx linear polarized PCB embedded, wide-band antennas.

- A Crystal used as a clocking source for the Cypress MCU.

   A TCXO (Temperature Compensated Crystal Oscillator) used as a clocking source for the

   VYYR7201-B4 SoC.

- Power supply system supporting 3.3V, 2.5V, 1.27V and 1.2V DC/DC converters.

- For USB-based models - a digital interface that communicates with a host PC via a USB-2.0 connection. The interface is implemented using on-board Cypress micro-controller unit (MCU).

- For SPI-based models – the interface is communicating directly with VYYR7201- B4 SoC.

2.2.1   Sensor Unit Specification

Table 2: Sensor Unit Specification

Parameter	Specification	Notes
Transceivers	24 Tx, 22 Rx	
Frequency Band	Within 59 - 64 GHz Or 61-61.5GHz	Configured by software.
Field of View (FoV)	Refer to section 2.2.5 Antenna and RF Characteristics	
Range Resolution	$\frac{C}{2BW}$ For example, for BW of 2GHz the range-resolution is 7.5cm	Depends on the configured BW
Range Accuracy	< < Range Resolution	Depends on the target RCS
Angular Resolution	$\Delta\theta \approx \dfrac{\lambda}{D}$ For example, for f = 64 GHz: $\dfrac{3e^8}{64e^9 \cdot 0.046} \approx 0.102 rad \approx 5.9 deg$	λ – Wavelength [@64GHz] D – Length of the effective array [0.046m]
Angular Accuracy	<< Angular Resolution	Depends on the target strength and shape

2.2.2 Digital Interface

The V60G-HOME-I models use either USB 2.0 or SPI as digital-interface, connecting the host module to the sensor module.

The USB interface is implemented on the module using an MCU and a micro-USB connector. The SPI interface is connected directly to the VYYR-7201-B4 chip, through a board-mounted multi-pin connector.

Micro-Controller Unit (MCU)

Cypress's EZ-USB FX3™ MCU integrates the USB 2.0 physical layers (PHYs), and contains a 32-bit ARM926EJ-S microprocessor for building custom USB SuperSpeed applications. The integrated processor contains a unit called General Programmable Interface (GPIF), which provides easy connectivity to popular interfaces.

USB Connector

The onboard micro-USB-B 2.0 connector is used for power supply and for data transfer between the sensor unit and the host PC. The connector supports the USB 2.0 protocol in High-Speed Mode (480 Mbps).

Figure 4: vStraw_CTPB4_I Connectivity

SPI Interface

Modules which are using SPI interface, the digital-interfaces and power supply are fed through a dedicated connector. The exact connector used changes per specific model, for example VBLUOK_CTPB4 uses OK-06F030-04.
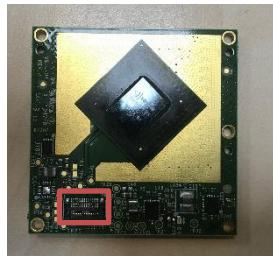
Figure 5: vBLU_OK _CTPB4 connector

The exact pinout is provided with the module itself and a reference design.

2.2.3   RF Interface - Antennas

The array of 46 antennas serves to connect the sensor unit with the environment. The antennas are embedded in the PCB, as depicted in the figure below.
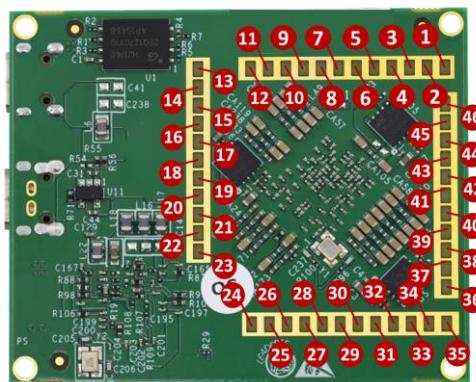
Figure 6: Antenna Positions and Numbering

For each transmitting (TX) antenna, there are multiple receiving (RX) antennas for collecting and recording the received RF signals. Each RX antenna and its associated TX antenna serve as an *antenna pair*.

All 46 antennas are from the same antenna type, which is linear polarized PCB embedded, wide-band antennas.

2.2.4   Electrical Specifications

The following electrical specifications are for the sensor unit. The current consumption specifications are based on lab measurements performed by Vayyar.

Table 3: Sensor Unit Electrical Specification

Parameter	Value
Vcc supply voltage	5 VDC
Max current consumption	~1.6 A
Average current consumption	~0.75 A

2.2.5   Antenna and RF Characteristics

The following are antenna and RF characteristics, based on the simulation of a single antenna over an infinite ground plane:

Table 4: Antenna and RF Characteristics

Parameter	Value	Comment
Gain	~ 5 dBi @62 GHz	At 0˚ Elevation, 0˚ Azimuth
Antenna -5dB beamwidth	160 deg. @64 GHz (E-plane) 80 deg. @64 GHz (H-plane)	
Polarization	Linear	
Max Tx Power	8 dBm	On chip output. Configurable (typically lower to meet FCC requirements)

The figure below depicts an antenna and its E and H planes:

- E-plane – plane XZ (green)

- H-plane – plane YZ (red)
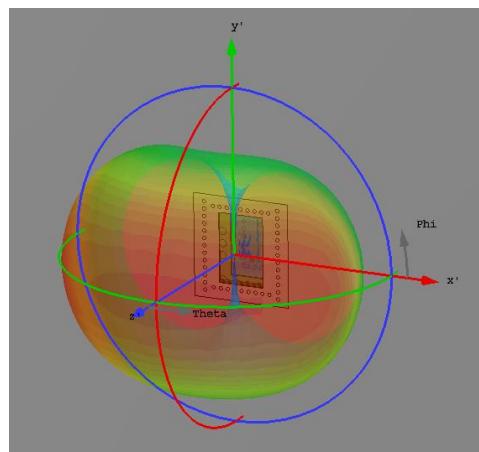
Figure 7: V60G-HOME-I Antenna Pattern

2.3   Software

The V60G-HOME-I system software performs signal processing and generation of the arena image, either on a host-device, or on an embedded DSP processor.

The software generates a 3D image and a point-cloud corresponding to the detected objects in the arena, and may extract further details through more advanced algorithms (for example – fall-detection, breathing waveform monitoring etc). The data can be obtained either using a dedicated API (see detailed module SW manual), or a Graphical User Interface (GUI).

The following diagram describes a typical processing flow of the software.
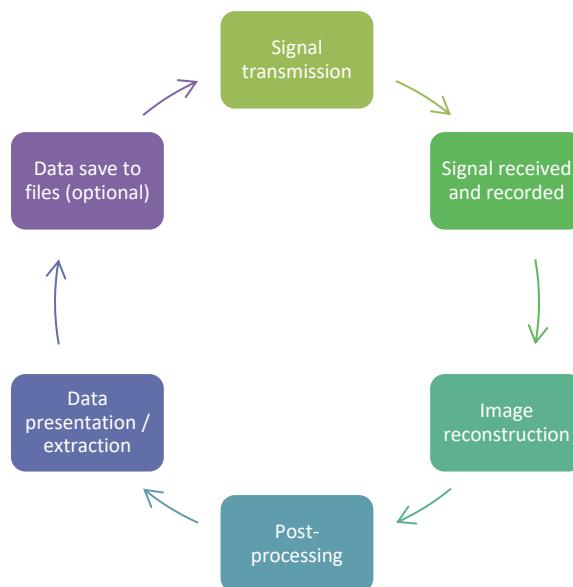

Figure 8: Processing Flow

Chapter 3
Regulatory section

3.1   Compliance

3.1.1   FCC

The device is certified under FCC part 15 section 15.255, as - FCC-ID : 2AHIS-V60G-HOME-I.

This V60G-HOME-I device has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The device shall not be used on an airplane while airborne.

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) This device must accept any interference received, including interference that may cause undesired operation.

3.1.2   IC

Industry Canada ICES-003 Compliance: CAN ICES-3 (B)/NMB-3(B)

IC Caution: RSS-Gen Issue 4 December 2014"&"CNR-Gen 4e Décembre 2014:

- English:

This device complies with Industry Canada licence-exempt RSS standard(s).

Operation is subject to the following two conditions: (1) This device may not cause

interference, and (2) This device must accept any interference, including interference

that may cause undesired operation of the device.

- French:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux

appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions

suivantes:

(1) l'appareil ne doit pas produire de brouillage, et;

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même

si le brouillage est susceptible d'encompromettre le fonctionnement.

IC: 21498-V60GHOMEI.

3.2   Instructions for the Integrator

The OEM integrator is responsible for ensuring that the end-user has no manual instructions to remove or install module.

3.2.1   OEM Integrators Notices

This device is intended only for OEM integrators under the following conditions:

The transmitter module may not be co-located with any other transmitter or antenna. As long as this condition above is met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

IMPORTANT NOTE: In the event that this condition cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC/ISED authorization is no longer considered valid and the FCC ID/IC number cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC/ISED authorization.

3.2.2   End Product Labeling

Visible area with the following: "Contains FCC ID: 2AHIS-V60G-HOME-I" and "Contains IC ID: 21498-V60GHOMEI" (either in user-manual, on the package or the product case).

When the hosting device uses an electric-display in a product, it should be possible to display electronically the FCC-ID.

3.2.3   OEM Manual Information that Must be Included

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user manual of the end product which integrates this module.

The user manual for OEM integrators must include the following information in a prominent location:

IMPORTANT NOTE: To comply with FCC/ISED RF exposure requirements, this device and its antennas must not be co-located or used in conjunction with any other antenna or transmitter except under the conditions shown in the FCC/ISED filing and/or in accordance with FCC/ISED multi-transmitter product guidelines.

3.2.4   RF Exposure Guidance

In order to comply with FCC / ISED RF Exposure requirements, this device must be installed to provide at least 20 cm separation from the human body at all times.

"Afin de se conformer aux exigences d'exposition RF FCC / ISED, cet appareil doit être installé pour fournir au moins 20 cm de séparation du corps humain en tout temps."

END OF DOCUMENT