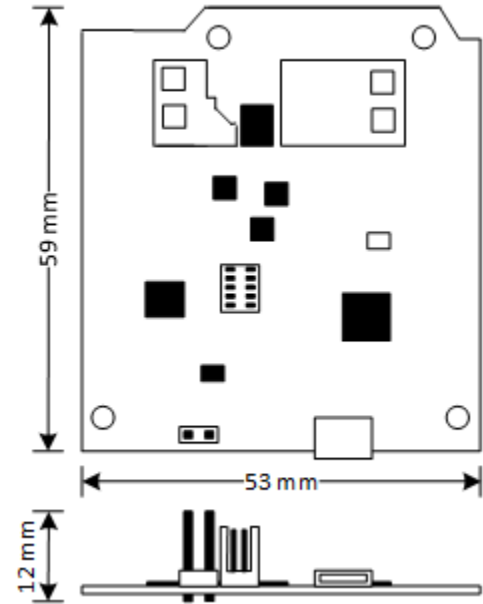


OPS241 Short Range Radar Sensor

Feature Set

- Doppler (OPS241-A) and FMCW (OPS241-B) radar
- 1-30m (3-98') detection range
- Speed reporting up to 222 kph (138mph)
- Speed accurate to within $\pm 0.5\%$
- Direction reporting (Inbound/Outbound)
- Range resolution of 0.075m
- Range reporting accuracy $\leq 10\%$
- Wide 78° beam width (-3 dB)
- USB, UART, and simple Interrupt interface
- Simple API control
- 1.4W Active power, 0.6W Idle power
- Wide temperature operating range, -40°C to $+85^{\circ}\text{C}$
- Small form factor 53 x 59 x 12 mm, 11g



The OPS241 is a small form factor, short range radar (SRR) sensor capable of detecting objects up to 30m away. The sensor can be used in a number of applications including security, traffic monitoring, radar gun, drone collision avoidance, robotics, and as an IoT sensor. All radar signal processing is embedded on the sensor and a simple API is provided to ease system integration. Detected object information is communicated over a USB, UART or a simple interrupt interface. The API provides control over the output format of the data (units, digits, etc.) and operation of the sensor.

There are two versions of the OPS241 radar sensor. The OPS241-A operates as a Doppler radar with CW (constant wave) modulation and reports speed information. The OPS241-B utilizes FMCW (frequency modulated constant wave) modulation to report the range to the objects in the field of view.

The OPS241-A provides data reported over the interface including motion detection, speed, direction (inbound/outbound), and range. Speed data is accurate to within $\pm 0.5\%$ which meets standards for police radar guns. With default settings, objects traveling up to 222 kph (138 mph) can be detected. Range measurements are accurate to within 10% of the actual distance of the object.

The OPS241-B provides range to the objects in its field of view up to 30m. Multiple objects may be reported at the same time. Range resolution is 0.075m while reporting accuracy within 10% of the true distance.

The detection range of the OPS241 covers a wide angle of 78° (3dB point) in both the azimuth and altitude. Typical detection range is 8-10 m (26-32 ft) for a person and 20-25 m (65-82 ft) for large

metal objects such as a car. Large flat surfaces such as the wall of a building can be detected up to 30m (98 ft). The API provides control over the transmit power which enables custom control over the detection range. Control over the transmit duty cycle is also provided enabling lower power operation. At full continuous power the module consumes 1.4W and idle power (RF disabled) is 0.6W. Duty cycling can enable active modes with power consumption in between these values.

Connecting an OPS241 to a PC (Windows or Mac), Android phone/tablet, or Raspberry Pi is easily managed. By default, speed or range data is sent as a number in ASCII characters. All other messages are provided in JSON format for easy parsing and manipulation (speed and range can also be sent by JSON). The JSON output is compatible with emerging IoT standards and technologies such as Node-RED which is standard on Raspberry Pi distributions. This makes the module ready to plug into hybrid solutions that use multiple sensors and inter-operate with IoT cloud-based solutions. See the applicable application note for interfacing to these products.

The module comes in a very small form factor of 53 x 59 x 12 mm. Utilizing the 24GHz millimeter spectrum, the module can easily be placed behind plastic enclosures and still function correctly.

Description

Operating Principle

The OPS241 is a simple, short range radar sensor. The OPS241-A is a Doppler radar which provides motion detection, speed, and direction information. The OPS241-B is an FMCW radar sensor. All radar signal processing is handled by the on-board ARM processor. The basic principle of the OPS241-A sensor is to detect Doppler frequency of a moving object and report its speed and direction. While the OPS241-B use FMCW modulation and time of flight to report the range to objects in its field of view.

On power-up, the embedded firmware initializes the module for the radar signal processing. After initialization is completed, the green LED will start to blink on a 1 second duty cycle. The default operation is for the data to start streaming over the UART interface. If the module is connected to a USB interface, it will complete the enumeration triggered by the host and data on the UART will be turned off. The red LED will be lit until the enumeration is complete. If the USB enumeration has not been successful, the red LED will stay lit. Alternatively, the simple interrupt can be used to monitor motion detection. The API provides for a means of filtering detected speed and signal magnitude for triggering the interrupt or which data is reported over the USB and UART interfaces.

When initialization is complete, the firmware will enable the LDO (low dropout) regulator providing power to the 24GHz RF device. With the RF powered up, the internal VCO (voltage controlled oscillator) will start generating the 24.125GHz signal for the OPS241-A or 24.0 to 25.0GHz ramp signal for the OPS241-B. Internal algorithms in the ARM processor are used to sense the VCO frequency and make adjustments to the VCO Control signal.

After a set time period, the ARM processor will enable the RF device to start transmitting the signal through the on-board transmit patch antennas. For the OPS241-A, if a moving object is detected in the field of view, the transmitted signal will bounce back and be detected by the on-board receive patch antennas. The received signal is mixed with the transmitted signal to down convert to an IF signal which represents the Doppler frequency of the moving object. This signal is filtered and provided to the internal A/D converter of the ARM processor. The radar signal processing converts this signal into speed and direction information which is then output on the UART or USB interface and the LEDs. If the object is moving towards the module, the red LED will light and if away, the blue LED. For the OPS241-B, the frequency delta proportional to the range to the object detected is calculated and the range reported over the UART or USB interface.

A simple API allows control of the module and information that it provides. See [Application Note AN-010 API Interface Specification](#) for full details on using the API. The default settings of the OPS241-A provide speed/direction readings at approximately 6-7Hz. Faster reporting can be achieved by increasing the sample frequency. The OPS241-B report rate is 14 Hz.

Note the speed reported by the OPS241-A is not compensated for the cosine error. See [AN-011 Cosine Error Adjustment](#) to understand how to correct the speed for the angle to the detected object.

Block Diagram

The block diagram of the OPS241 is shown in Figure 1. The key components shown are the RF, IF filtering, ARM processor, and LDO for the RF.

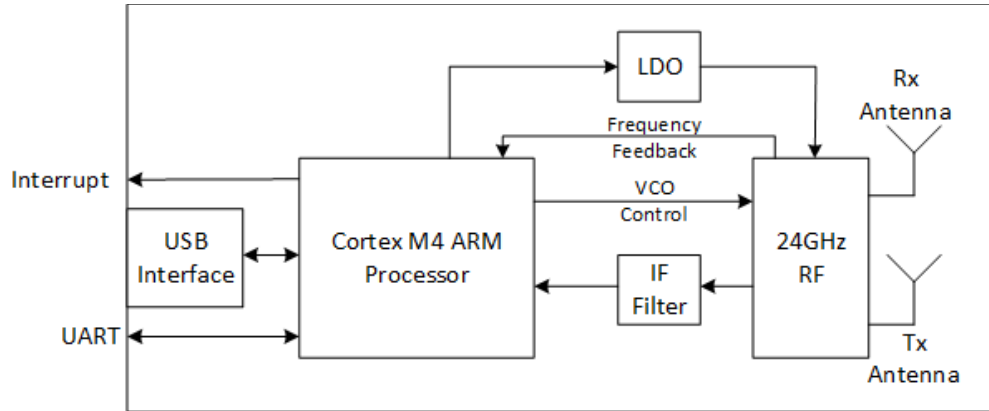


Figure 1. OPS241 Block Diagram

Interface

The OPS241 module provides four interfaces, USB, UART, simple interrupt, and LEDs. USB and UART provide detailed information and control of the module via the API while the simple interrupt and LEDs provide a quick check as to how the sensor is functioning or presence of an object detected.

USB

The module has a USB 2.0 interface for providing the processed radar information. Control over the sensor configuration is accomplished by using the simple API. A standard micro USB connector is used. The USB interface is also used to power the module. An alternate means of providing 5V power to the module is through header J8.

UART

The sensor has a full-duplex UART interface for providing the processed radar information. Control over the sensor configuration is accomplished by using the simple API. The UART is enabled by default starting with firmware version 1.3.0. The UART interface is disabled if USB is connected and enumerated. The default UART settings are shown in Table 1.

Table 1. UART Specifications

Parameter	Specification
Baud Rate	19,200
Bits	8
Parity	None
Stop Bit	1

Simple Motion Interrupt

A simple interrupt is provided for motion detection. The signal comes out to pin 6 (INT0) on the J5 header and is 5V tolerant (boards with serial number ≥ 1000). It is enabled by the API command "IG". The signal is high when no object is detected and low when an object is detected. See [AN-16 Simple Motion Detection Interrupt](#) for further explanation of the usage of this signal and how to filter speed and magnitude.

Arduino Headers

The OPS241 is designed as an Arduino shield board. The layout is such that with headers installed (sensor provided without headers installed), it can be installed directly into an Arduino. The four headers of interest are J1, J3, J4, and J5. As shipped, there are now headers stuffed on the board. Most signals on these headers are not used. The below tables list the pins for each header.

Table 2. J1 Pinout

Pin	Signal	Name	Note
1	AR_NC	Arduino No Connect	No connect
2	AR_IOREF	Arduino IO Reference	No Connect
3	AR_RESET	Arduino Reset	Reset sensor
4	AR_3V3	Arduino 3.3V Bus	No connect
5	AR_5V0	Arduino 5.0V Bus	5V power for sensor
6	Ground	Ground	
7	Ground	Ground	
8	AR_VIN	Arduino Vin	No connect

Table 3. J3 Pinout

Pin	Signal	Name	Note
1	AR_ADC0	Arduino ADC0	No connect
2	AR_ADC1	Arduino ADC1	No Connect
3	AR_ADC2	Arduino ADC2	No connect
4	AR_ADC3	Arduino ADC3	No connect
5	AR_SDA_ADC4	Arduino ADC4/SDA	I2C not implemented
6	AR_SCL_ADC5	Arduino ADC5/SCL	I2C not implemented

Table 4. J4 Pinout

Pin	Signal	Name	Note
1	AR_SCL	Arduino SCL	I2C not implemented
2	AR_SDA	Arduino SDA	I2C not implemented
3	AR_AREF	Arduino Analog Reference	No connect
4	Ground	Ground	
5	AR_SCK	Arduino SPI Clock	SPI not implemented
6	AR_MISO	Arduino SPI Slave Out	SPI not implemented
7	AR_MOSI	Arduino SPI Slave In	SPI not implemented
8	AR_SS	Arduino SPI Select	SPI not implemented
9	AR_PWM	Arduino PWM	No connect
10	AR_CLK0	Arduino Clock	No connect

Table 5. J5 Pinout

Pin	Signal	Name	Note
1	AR_AIN1	Arduino Analog In	No connect
2	AR_AIN0	Arduino Analog In	No connect
3	AR_T1	Arduino Digital	No connect
4	AR_T0	Arduino Digital	No connect
5	AR_INT1	Arduino Interrupt	No connect
6	AR_INT0	Arduino Interrupt	No connect
7	AR_TXD	UART Transmit	
8	AR_RXD	UART Receive	

LED

LEDs are provided to give a quick understanding of the module operation. There are four LEDs on the module, red, green, orange, and an RGB LED. The LEDs functions are listed in Table 6. Some variations on the LED operation may be made based on the version of code used. Check the API application note AN-10 for the latest descriptions.

Table 6. LED Functions

LED	Function	Reference	Notes
Red	USB enumeration	D3	Turns off when USB enumeration completed
Green	Heartbeat timer	D4	1 second duty cycle
Orange	Not used	D5	
RGB	Red – Inbound direction Blue – Outbound direction Green – Motion detection	D7	Green only used if direction detection turned off via API

Antenna Pattern

The OPS241 provides a very wide coverage with its patch antennas. The beamwidth in the azimuth and altitude is 78° (-3 dB point). Minimal signal is transmitted behind the module due to its construction which helps eliminate false detections. The broad antenna pattern coverage is shown in Figure 2.

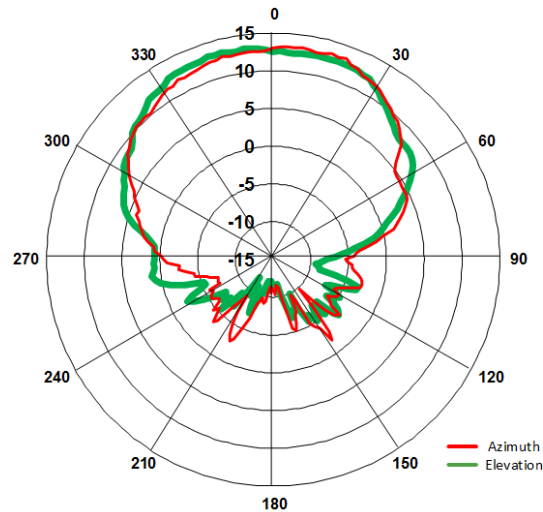


Figure 2. Antenna Pattern

Detection Range

The detection range of the OPS241 is dependent on the object to be detected or its RCS (radar cross section). There is a slight detection range difference between the OPS241-A and OPS241-B radar sensors. These are summarized in Table 8. The detection range is listed for the distance directly in front of the sensor. Objects angled to the side (left/right, up/down) of the sensor will exhibit shorter detection ranges.

The OPS241-A Doppler radar sensor detects human movement 8-10 m out and a large object (higher RCS value) such as a car at 20-25 m. As the object moves more to the right or left of the beamwidth center, the detection range will decrease.

The OPS241-B FMCW radar sensor detects humans 8m out, cars 20m out, and large objects such as the wall of a building up to 30m away.

Table 7. OPS241 Detection Range

Sensor	Target	Detection Range
OPS241-A	Person	8-10m
	Car	20-25m
OPS241-B	Person	8m
	Car	20m
	Building/Wall	30m

Electrical Specifications

Absolute Maximum Ratings

$T_A = -40\text{ }^{\circ}\text{C}$ to $85\text{ }^{\circ}\text{C}$ with all voltages with respect to ground.

Parameter	Symbol	Min	Typ	Max	Units	Notes
Supply Voltage ¹	V_{cc}	4.75		5.25	V	Per USB specification
Power Dissipation	P_{max}			1.56	W	
Operating Temperature	T_a	-40		85	$^{\circ}\text{C}$	
Storage Temperature	T_{stg}	-40		105	$^{\circ}\text{C}$	

1. Power can be supplied through J2 micro USB or J1 pin 5 Arduino header connection (AR_5V0).

Operating

T_A = -40 °C to 85 °C with all voltages with respect to ground.

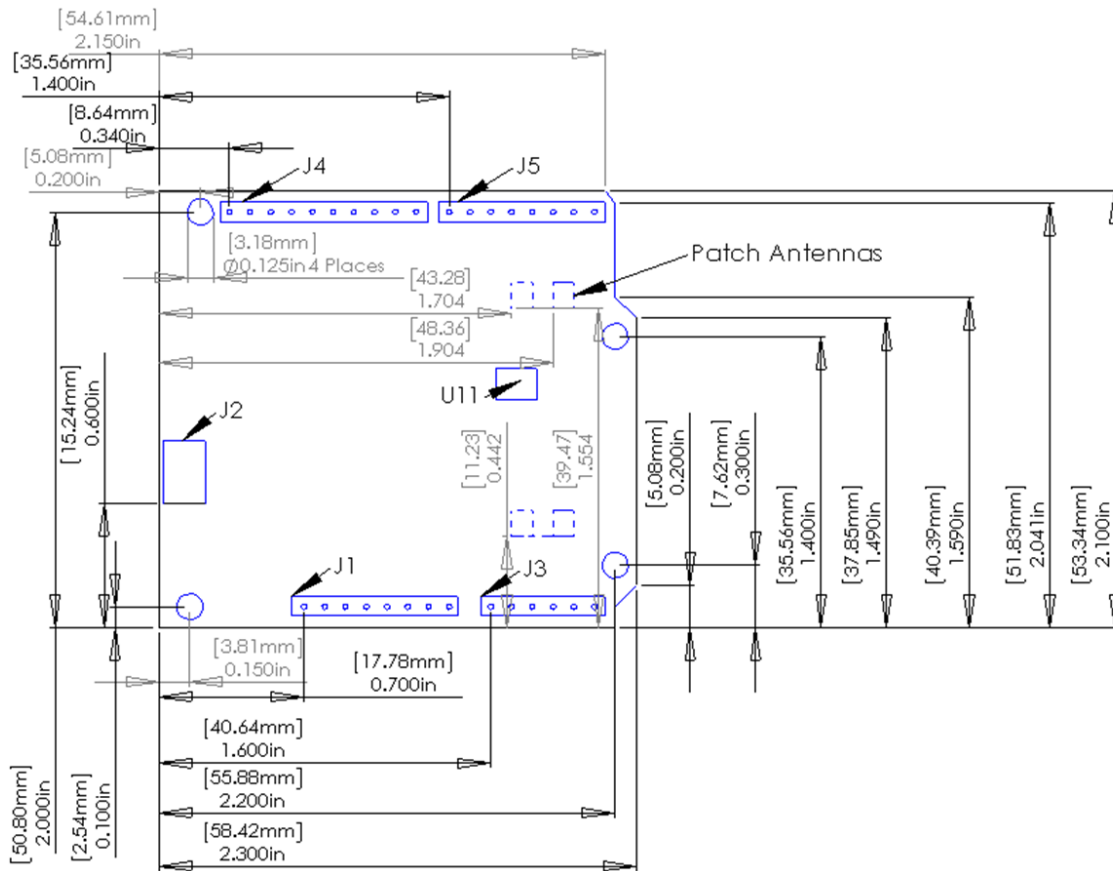
Parameter	Symbol	Min	Typ	Max	Units	Notes
Transmit Frequency ¹	F _{txcw}	24	24.125	24.25	GHz	CW modulation
Transmit Frequency	F _{txfm}	24		25.0	GHz	FMCW modulation
Transmit Power	P _{tx}	6	11	15	dBm	24GHz ≤ f ≤ 25.0 GHz
Transmit Power Adjustment	P _{txadj}	3	9		dB	Adjustable via API
Idle Transmit Power	P _{txadj}			-30	dBm	Not transmitting
Antenna Gain	G _{ant}		7		dBi	
Receive Antenna Azimuth	RA _{azi}		78		°	-3 dB beamwidth
Receive Antenna Altitude	RA _{alt}		78		°	-3 dB beamwidth
Active Current Consumption	I _{cc}		276	290	mA	Actively transmitting
Idle Current Consumption	I _{idl}		130	150	mA	Not transmitting

¹ Configurable using API.

Mechanical Specifications

The mechanical outline drawing for the OPS241 is shown in Figure 1. All units are in inches.

Figure 3. Mechanical Outline



Ordering Information

The full ordering part numbers for the OPS241 sensors are as listed in Table 8. Please use this part number when submitting orders.

Table 8. Ordering Information

Function	Motion	Speed	Direction	Signal Magnitude	Range	Part Number
Doppler Radar	Yes	Yes	Yes	Yes		OPS241-A-CW-RP
FMCW Radar				Yes	Yes	OPS241-B-FM-RP

FCC Notice and Liability Disclaimer

The OPS241 module is not FCC approved. They are designed to comply with FCC Part 15 Rules and Regulations. They are not in a finished product form. They are strictly intended for experimental purposes only. If you wish to use these modules in an actual product (a non-experimental capacity), the module must first be designed into the product then the whole product must be approved by the FCC. OmniPreSense Corporation is not responsible for special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, and any costs of recovering, reprogramming, or reproducing any data stored in or used with OmniPreSense products.

If you need a module that does carry FCC/CE modular approval, please use the [OPS242-A](#).

Revision History

Version	Date	Notes
A	May 26, 2017	Initial release
B	September 5, 2017	Added FCC notice
C	December 26, 2017	Updated range detection information
D	April 10, 2018	Correct mechanical design measurements in inches, added measurements in mm.
E	November 14, 2018	Added UART and simple interrupt interface information.
F	February 26, 2019	Added pin information for J1, J3, J4, and J5.
G	April 16, 2019	Added OPS241-B information and descriptions for range reporting.