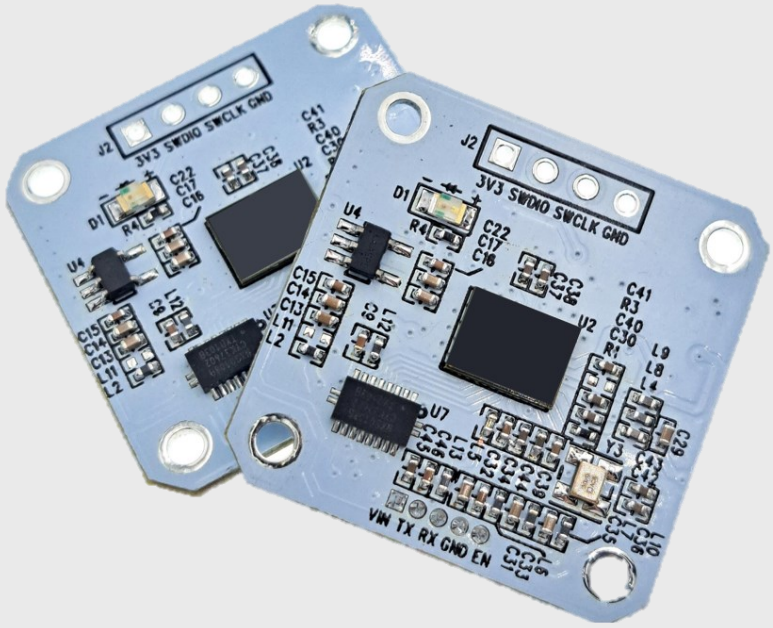


Product Data Sheet

AGIL® Sense

MP555

Digital 3D Millimetre Wave Radar

Product Overview

The MP555 is an ultra small V-band millimeter wave 3D radar with the ability to provide high resolution range, velocity and 2D angle measurements.

The MP555 comes complete with signal processing algorithms for accurate object detection that enables object classification, ranging and counting. Plus, it comes with added algorithms to simultaneously detect occupancy, fall and motion.
Hence, it removes the need for complex radar signal processing for many applications.

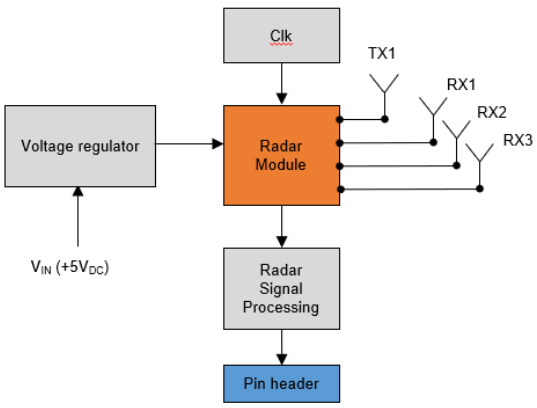
Together with its compact footprint and size, it enables OEMs to create innovative products packed with features. Its integrated architecture optimizes BOM and costs for the end user.

Key Features

- Highly integrate-able through digital interfaces
- Provides radar point cloud in a 3D-space
- Up to 5 cm range resolution and precision
- Provides occupancy, fall detection and motion detect flags simultaneously
- Ultra small and flat profile

Key Applications

- Occupancy and motion detection
- Fall detection
- Gesture recognition & control
- People counting
- Security & surveillance
- Collision avoidance
- Range measurements
- Traffic control and monitoring
- Smart auto door control
- Elevator control



Block Diagram

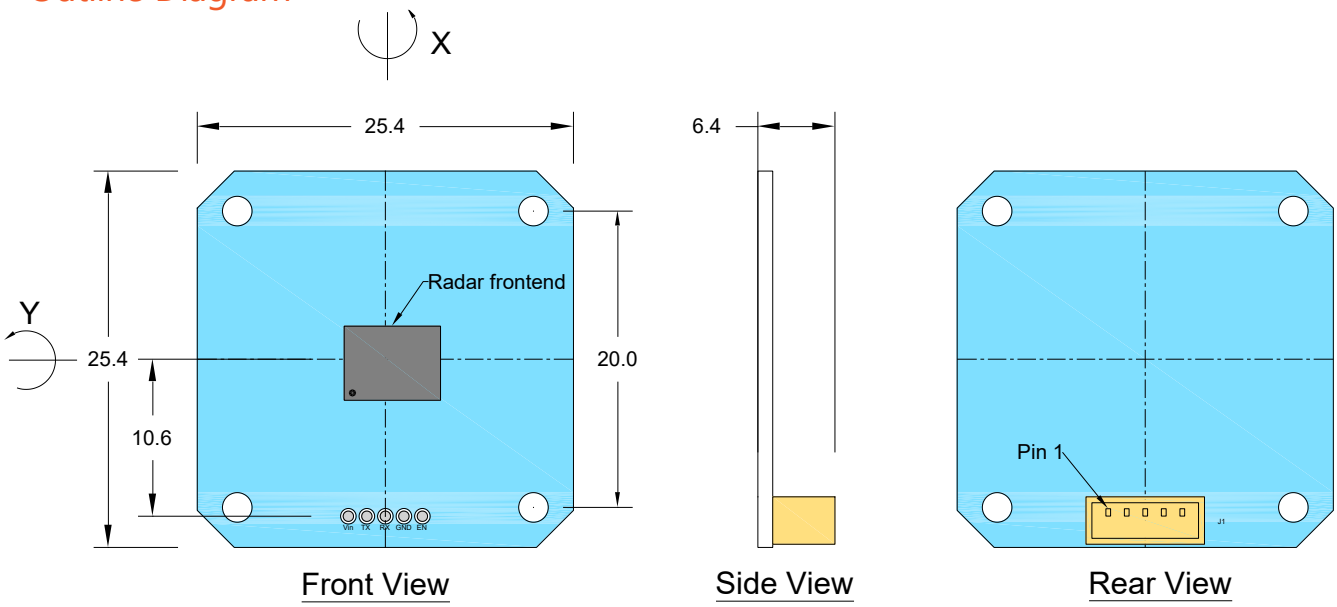
ST Engineering

Technical Specifications

Parameter	Remarks	Min.	Typical	Max.	Unit
Operating Condition					
Supply Voltage, V_{IN}		3.3	5	5.5	V_{DC}
Current Consumption			20		mA
Operating Temperature		-40		80	°C
Transmitter					
Operating Frequency	Band 1 (Default)	59.6		61.4	GHz
	Band 2	61.0		61.5	GHz
	Band 3	60.0		61.0	GHz
	Band 4	60.0		63.0	GHz
	Band 5	59.0		63.5	GHz
Radiated Power, EIRP				10	dBm
Spurious Emission				-30	dBm
Antenna					
Detection Angle, 3 dB – X	TX_1, RX_{1-3}		50		°
Detection Angle, 3 dB – Y	TX_1, RX_{1-3}		60		°
Receiver					
Sensitivity	User configurable Default = 55	35		60	dB
Signal Processing					
No. of FFT points	Fixed		256		pts
Range resolution	Band Dependent	0.06		0.3	m
Range precision	R_{max} Dependent	0.03		0.3	m
No. of points in point cloud				215	points
Device Parameters					
Device ID	User configurable Default = 1	1		255	-
Baud rate	User configurable Default = 230,400	9,600	230,400	460,800	bps
Start-up time	Time to get 1st set of point cloud		250		ms
Update rate	Fixed		10		Hz
Physical Properties					
Dimensions	Incl. connector		25.4 × 25.4 × 6.4		mm
Weight	Incl. connector		2.5		g

Note 1: MP555 is designed to meet the requirements of EN 305 550 and FCC Part 15.255.
Note 2: Built-in voltage regulator ensures the performance of the sensor is independent of voltage supply.
Note 3: CAUTION: ELECTROSTATIC SENSITIVE DEVICE. Observe precautions for handling and storage.

Outline Diagram



All units in millimetres

***** On-board connector is the Molex Picoblade, 53047-0510. Mates with receptacle 51021-0500 or cable assembly 15134-0500.

Pin Description

Pin	Name	Description
1	EN	EN High Pin
2	GND	Ground
3	RXD	UART RXD
4	TXD	UART TXD
5	VIN	+5 V_{DC}

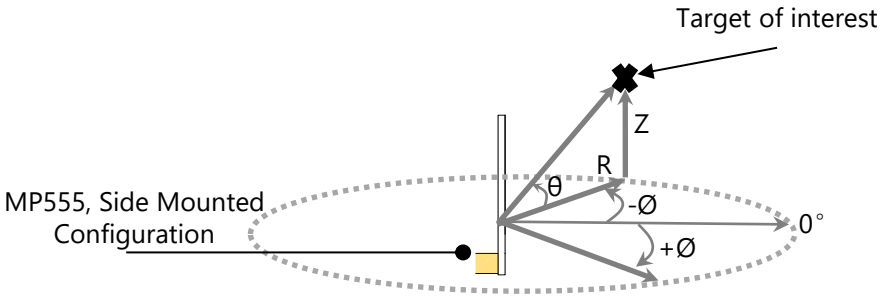
Ordering Information

Order Code	Description
MP555-1	Outputs 3D point cloud.
MP555-2	Outputs occupancy, fall, motion flags.

1) Applications

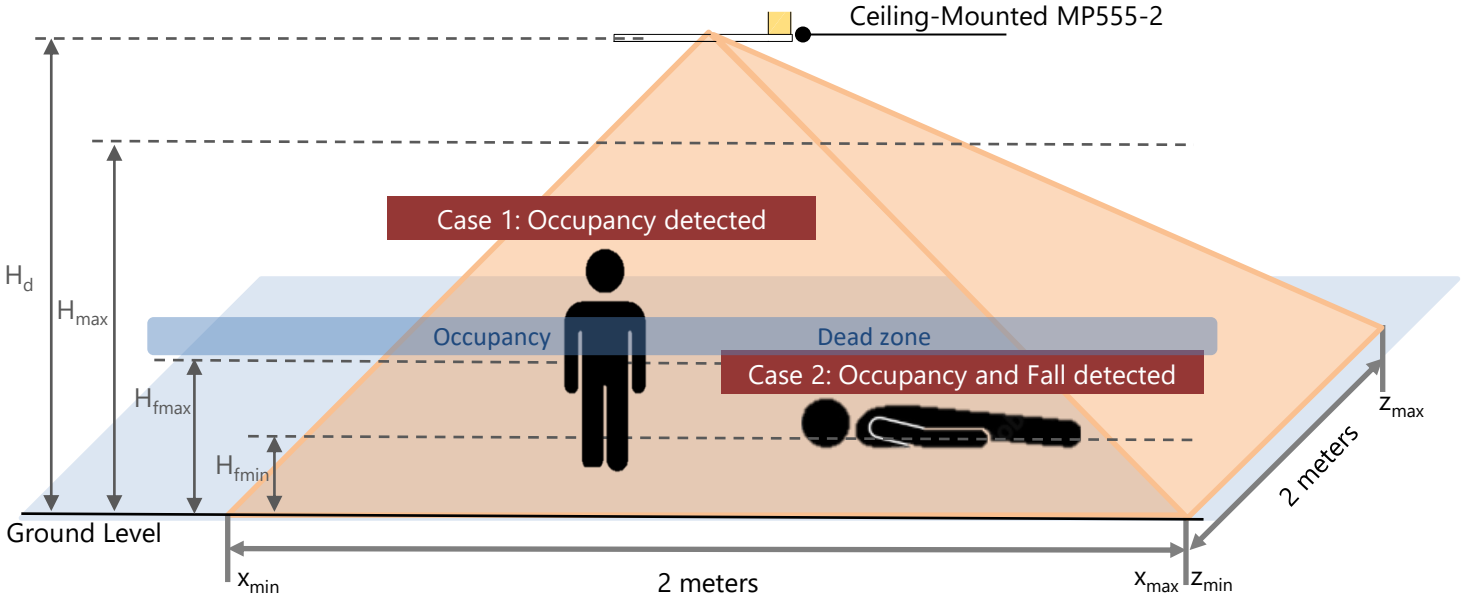
a) MP555-1: Point cloud output

The point cloud output is the most generic output and can be used in most general applications. Depending on the application, the MP555-1 can be deployed on a (i) pole: side-mounted, (ii) corner-tilted or (iii) ceiling-mounted facing the ground, to provide the corresponding point cloud output of desired targets. Through the point cloud, the MP555-1 distinguishes the points, clusters the densest points and outputs this information in cylindrical coordinates (i.e., r, θ, z) defined in the figure below and in section 2, pg 5. This simplifies further point cloud processing and concurrently gives the user the flexibility to analyze targets based on the clusters for their specific application requirements.



b) MP555-2: Simultaneous occupancy, fall and motion detect flags

In using the MP555-2's occupancy, fall and motion detect flags, the MP555-2 should be ceiling-mounted. In this mounting configuration, the MP555-2's detection covers a square area of 2-by-2 meters shown in the figure below. The limits of these flags can be controlled by the parameters defined in section 2, pg 6 and the figure below. 2 example cases of occupancy and fall detection are also illustrated in the figure below.



2) Configuration Parameters

General Radar Operation (MP555-1 and MP555-2)					
Parameter	**Description**	**Register Address**	**Register Value**	**Parameter values**	**Unit**
Baud rate	UART Baud Rate	0×05	1	9600	bps
			2	38400	
			3	115200	
			4	230400 (Default)	
			5	460800	
Operating Frequency	FMCW Frequency Bands	0×0B	1	Band 1 (Default)	-
			2	Band 2	
			3	Band 3	
			4	Band 4	
			5	Band 5	
Sensitivity	Gain of the radar module	0×0C	1	35	dB
			2	40	
			3	45	
			4	50	
			5	55 (Default)	
			6	60	
$CDist_{max}$	Maximum distance between clustered points	0×0D	700	700 (Default)	mm
$CNum_{min}$	Minimum number of points in 1 cluster	0×0E	4	4 (Default)	pts
SF_{env}	Environmental data scaling factor[1]	0×31	12 (Default)		-

Point Cloud Output (MP555-1 Only)						
Parameter	**Description**	**Register Address**	**Register Values**			**Unit**
			Min	**Default**	**Max**	
Z_{min}	Minimum z value	0×0F		-5,000		mm
Z_{max}	Maximum z value	0×10		5,000		mm
R_{min}	Minimum range	0×11		0		mm
R_{max}	Maximum range	0×12	3,840	11,000	38,400	mm
θ_{os}	Elevation[2] offset angle from boresight	0×13	-90	0	90	°
$Ø_{os}$	Azimuth[3] offset angle from boresight	0×14	-90	0	90	°

[1] SF_{env} is the clutter multiplier factor when the clutter suppression function (section 3C) is activated. For example, the default factor of 12 reduces the surrounding environment clutter by 1.2X. The default value is ideal for most enclosed spaces such as rooms.

[2] Elevation refers to Y-axis in outline diagram on pg. 3.

[3] Azimuth refers to X-axis in outline diagram on pg. 3.

2) Configuration Parameters (**MP555-2 Only**)

Occupancy, Fall and Motion Detection (MP555-2 Only)						
Parameter	**Description**	**Register Address**	**Register Values**			**Unit**
			Min	**Default**	**Max**	
x_{min}	Boundary conditions for occupancy, fall and motion detection	0×21	-2000	-1000	X_{max}	mm
x_{max}		0×22	x_{min}	1000	2000	
z_{min}		0×23	-2000	-1000	Z_{max}	
z_{max}		0×24	z_{min}	1000	2000	
H_d	Sensor Deployment height	0×25	H_{max}	2500	4000	mm
Countframes	Number of frames to accumulate clusters	0×27	1	14	20	Frames
CSFrames	Number of frames used for clutter suppression	0×32	1	10	25	Frames
$Tnum_{min\text{-}occupancy}$	Minimum number of pts in a cluster to be considered as a target of interest	0×28	1	100	1,000	Pts
$Tnum_{min\text{-}fall}$		0×2B	1	40	$Tnum_{max\text{-}fall}$	
$Tnum_{max\text{-}fall}$	Maximum number of pts in a cluster to be considered as a target of interest in fall region	0×35	$Tnum_{min\text{-}fall}$	200	1,000	Pts
$MDist_{min}$	Minimum target motion distance between frames to be detected as motion	0×26	50	300	2,000	mm
H_{fmin}	Minimum fall height limit	0×29	0	100	H_{fmax}	mm
H_{fmax}	Maximum fall height limit	0×2A	H_{fmin}	400	H_{max} - Occupancy Deadzone	mm
H_{max}	Maximum height limit	0×2D	H_{fmax} + Occupancy Deadzone	1500	H_d	mm
Occupancy deadzone	Region above the fall region that is not used for occupancy	0×2C	0	300	H_{max} - H_{fmax}	mm
$HoldTime_{occupancy}$	Number of frames the occupancy flag is held if no target is detected in the occupancy region	0×33	1	5	15	Frames
$HoldTime_{fall}$	Number of frames the fall flag is held if no target is detected in the fall region	0×34	1	6	15	Frames

3) UART Interface

i. UART Protocol

The default configuration of the UART interface is as follows:

- Word length = 8 bits
- Baud rate = 230400 bps
- Stop bits = 1
- Parity bits = 0

ii. Message Types

The following operations can be performed on the MP555:

- Read the module's configuration parameter
- Configure module's parameters
- Point-cloud data extraction and reset functions

a) Read MP555's configuration parameters

The command used to read the value of a module parameter is shown below:

The function code used for the read command is 0×03. The parameter address determines which module parameter to read. The reserved bytes are set to 0. The CRC is calculated using the function described in the error handling section.

Device ID (1 byte)	**Function Code** (1 byte)	**Parameter Address** (2 bytes)	**Reserved** (2 bytes)	**CRC** (2 bytes)	
--	0×03	--	0×0000	CRC_{Low}	CRC_{High}

The response from the MP555 module will be as follows:

The device ID, function code and register address will be the same as the command sent to the module. The value of the parameter will be stored in the 2 bytes after the register address.

Device ID (1 byte)	**Function Code** (1 byte)	**Parameter Address** (2 bytes)	**Parameter Value** (2 bytes)	**CRC** (2 bytes)	
--	0×03	--	--	CRC_{Low}	CRC_{High}

b) Configure MP555's parameters

The command to modify the value of a module parameter is shown below:

The function code used to modify the value of a parameter is 0×06. The parameter address determines the parameter to modify. The parameter value is the new value of the modified parameter.

Upon successful modification, the module will reply with the same command sent.

The list of configuration parameters is shown in pages 5 and 6.

Device ID (1 byte)	**Function Code** (1 byte)	**Parameter Address** (2 bytes)	**Parameter Value** (2 bytes)	**CRC** (2 bytes)	
--	0×06	--	--	CRC_{Low}	CRC_{High}

c) Execute MP555 functions

The format of the commands to execute the corresponding functions is shown below:

Device ID (1 byte)	**Function Address** (3 bytes)	**Value** (2 bytes)	**CRC** (2 bytes)
--	--	--	--

The MP555 module can perform the following functions:

Function	Function Address	Value		Description
Point cloud output[4]	0×030018	0×00	0×00	Outputs the point cloud data from the sensor.
Data flag output[5]	0×03001C	0×00	0×00	Outputs the data flags.
Clutter Suppression[6]	0×060030	0×00	0×01	Suppresses environment clutter.
Clear Clutter Suppression[7]	0×060030	0×00	0×00	Undo clutter suppression and removes suppression data.
Soft reset	0×03001A	0×00	0×00	Restarts the MP555 module.
Hard reset	0×03001D	0×00	0×00	Restores the parameters of the MP555 to default parameters.

[4] Point cloud output is for MP555-1 only.

[5] Data flag output is for MP555-2 only.

[6] Before performing a second clutter suppression, the Clear Clutter Suppression should be executed. After the device soft resets, the Clutter Suppression function can be run again to adapt the sensor to the new environment.

[7] Clearing clutter suppression will cause the MP555 module to soft reset. This is needed before any clutter suppression.

For example, the clutter suppression function can be activated for a sensor with device ID=1 as shown below:

Device ID	**Function Address**			**Value**		**CRC**
0×01	0×06	0×00	0×30	0×00	0×01	0×4805

After the clutter suppression function has been successfully executed, the module will send the same input command back to the user. However, there will not be any response from the module for clear clutter suppression, soft reset and hard reset functions.

To disable the clutter suppression function, the following command can be sent to the module.

Device ID	**Function Address**			**Value**		**CRC**
0×01	0×06	0×00	0×30	0×00	0×00	0×89C5

Upon disabling the clutter suppression function, there will not be any response from the module, and the module will reset itself.

After receiving the commands above, the MP555 outputs data based on the following formats.

Point cloud output format (MP555-1) is as follows:

Device ID (1 byte)	**Function Address** (3 bytes)	**Num Pts** (2 bytes)	**Pt cloud data** (Num Pts * 8 bytes)	**CRC** (2 bytes)	
--	0×030018	--	--	CRC_{Low}	CRC_{High}

Cluster Number	**r**	**theta**	**z**
(2 bytes)	(2 bytes)	(2 bytes)	(2 bytes)

The data output flag format (MP555-2) is as follows:

Device ID (1 byte)	**Function Address** (3 bytes)	**Flags** (2 bytes)	**CRC** (2 bytes)
--	0×03001C	--	--

Bit	Parameter
0	Occupancy flag (0 – vacant, 1 – occupied)
1	Fall detection flag (0 – no fall, 1 – fall detected)
2	Motion flag (0 – no motion, 1 – motion detected)

d) Error Handling

Communication errors are detected through CRC function computation. It consists of 2 bytes of data. The CRC is calculated using the function described below.

```
uint16_t CRC_16(uint8_t *vptr, int8_t len)
{
   uint16_t MODBUSCRC = 0xffff;
   uint16_t POLYNOMIAL = 0xa001;
   uint8_t i, j;

   for (i = 0; i < len; i++)
   {
      MODBUSCRC ^= vptr[i] ;
      for (j = 0; j < 8; j++)
      {
         if ((MODBUSCRC & 0x0001) != 0)
         {
            MODBUSCRC >>= 1;
            MODBUSCRC ^= POLYNOMIAL;
         }
         else
         {
            MODBUSCRC >>= 1;
         }
      }
}
   return MODBUSCRC;
}
```