

SR73 Millimeter Wave Radar

Communication Protocol



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Version History

Date	Version No.	Description
2019-04-01	1.0	the 1 st version of MMV radar 77GHz SR73

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1 CAN Interface Introduction

SR73 radar support CAN interface, the CAN bus communication network conforms to iso11888-2 standard, and the transmission rate is 500K bits/second. MR72 transmits radar signals to surrounding areas, and receives signals through multi-step processing, which can obtain track information of target group.

Through a simple software interface, the sensor is connected to the CAN network to provide radar-based environmental awareness information to one or several evaluation units. Sensors can also be configured through the CAN interface.

The CAN interface of SR73 is used to configure sensors, to output sensor state information, input and output of sensor data. A CAN bus is able to mount up to 8 pieces SR73 sensors. The sensor ID can be configured, and the output Message IDs (Message IDs) can change.

If the sensor ID is 0 ~7, then the message ID can be calculated as follows:

$\text{MsgID} = \text{MsgID_0} + \text{SensorID} * 0x10$

For example, if sensor ID=0, then the configuration message ID is 0x200; If sensorID=1, configuration message 0x210, and so on. When the sensor ID is set, the sensor will only respond to the new configuration message.

Radar Sensor CAN message (SensorID=0)

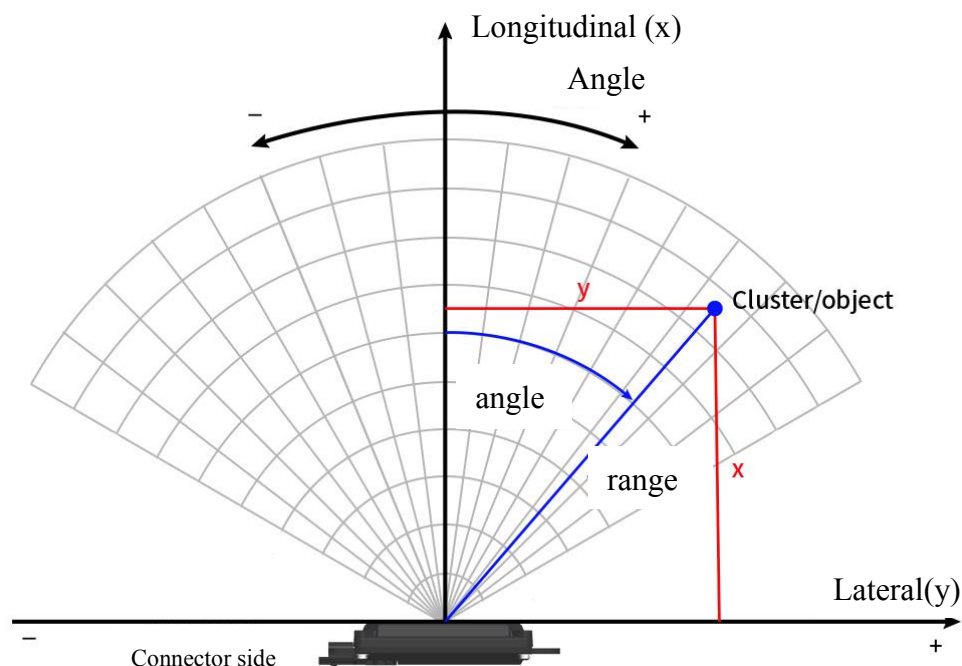
In/Out	ID	Message Name	Content	Section
In	0x200	RadarCfg	Radar sensor configuration	
Out	0x201	RadarState	Radar statue	
In	0x300	SpeedInformation	Speed information	
In	0x301	Yaw rate Information	Yaw rate information	
Out	0x600	Cluster_0_Status	Cluster_Object statue information	
Out	0x701	Cluster_1_General	Cluster_Object general information	
Out	0x702	Cluster_2_Quality	Cluster_Object quality information	
Out	0x60A	Obj_0_Status	Object_Object statue information	
Out	0x60B	Obj_1_General	Object_Object general information	
Out	0x60C	Obj_2_Quality	Object_Object quality information	
Out	0x60D	Obj_3_Extended	Object_Object extended information	
Out	0x700	SoftWareVersion	Software Version	

2 Radar Description

The MR72 USES 77GHz high-frequency electromagnetic waves to analyze the surrounding environment. The reflected signal is output as an object after several steps of processing based in Cluster or Objects. Clusters are information about the target location, speed and signal strength of radar reflection, and they are counted and output periodically.

Instead, Objects contain historical track and dimensional information, consisting of tracked Clusters of Objects. Where, the velocity of target approaching the radar is negative (-), and the velocity of target away from the radar is positive (+).

The Cartesian coordinates of the radar as below picture:



3 Configuration Message (0x200)

The basic configuration parameters of the radar sensor can be set with message RadarCfg 0x200. It is not necessary to cyclically repeat the configuration message. To store the configuration in the non-volatile memory (NVM) to be automatically set at startup on any subsequent power up, the signal RadarCfg_StoreInNVM has to be set to active (0x1). It is important to note that the number of writes to the NVM should be kept to a minimum as this could reduce the service life of the memory.

0x200 can be modified several or with just one configuration parameter. For each argument, message contains one significant bit. If the valid bit is set to 1, the corresponding change is Valid; otherwise, the corresponding change is invalid.

	7	6	5	4	3	2	1	0
0	Nvm_Valid	Index_Valid	ExtInfo_Valid	Quality_Valid	Type_Valid	Power_Valid	SensorID_Valid	MaxDistance_Valid
1	MaxDistance							
2	MaxDistance		Reserved	Reserved	Reserved	Reserved	Reserved	Built_in_Test_Valid
3								Built_in_Test_Parameter
4			RadarPower		OutputType			SensorID
5	StoreNVM			SortIndex	SendExtInfo	SendQuality	CtrlRelay	CtrlRelay_Valid
6	Reserved	Reserved	Reserved	Reserved			RCS_Threshold	RCS_Threshold_Valid
7	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved

Signal	Start	Len	Min	Max	Res	Unit
RadarCfg_MaxDistance_Valid	0	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_SensorID_Valid	1	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_RadarPower_Valid	2	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_OutputType_Valid	3	1	0	1	1	0x0:Invalid 0x1:Valid

RadarCfg_SendQuality_Valid	4	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_SendExtInfo_Valid	5	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_SortIndex_Valid	6	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_StoreInNvm_Valid	7	1	0	1	1	0x0:Invalid 0x1:Valid
Built_in_Test_Valid	16	1	0	1	1	0x0:Invalid 0x1:Valid
Built_in_Test	24	8	0	255	1	For inner use
RadarCfg_MaxDistance	22	10	0	2048	2	m(40-160m are supported in the standard version)
RadarCfg_SensorID	32	3	0	7	1	ID(0~7) (the default ID is 0)
RadarCfg_OutputType	35	2	0	2	1	0x0:none 0x1:Objects (the default value) 0x2:Clusters
RadarCfg_RadarPower	37	3	0	7	1	0x0:Standard (the default value) 0x1:-3dB Tx gain 0x2: -6dB Tx gain 0x3: -9dB Tx gain
RadarCfg_CtrlRelay_Valid	40	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_CtrlRelay	41	1	0	1	1	0x0:Inactive 0x1: Active
RadarCfg_SendQuality	42	1	0	1	1	0x0:Inactive 0x1: Active
RadarCfg_SendExtInfo	43	1	0	1	1	0x0:Inactive 0x1: Active
RadarCfg_SortIndex	44	3	0	7	1	0x0:No Sorting 0x1: Sorted by range (the default value) 0x2: Sorted by RCS
RadarCfg_StoreNVM	47	1	0	1	1	0x0:Inactive 0x1: Active
RadarCfg_RCS_Threshold_Valid	48	1	0	1	1	0x0:Invalid 0x1:Valid
RadarCfg_RCS_Threshold	49	3	0	7	1	0x0:Standard (the default value) 0x1:High Sensitivity

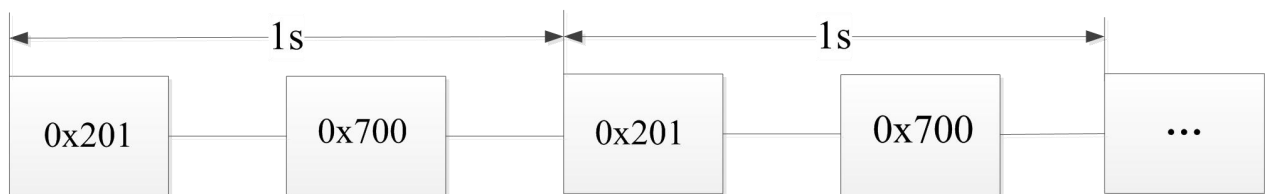
Remarks:

1. In Cluster mode, it must be sorted by distance.
2. In Objects mode, you can select distance, RCS or no sort.

3. Sensitivity can be chosen in cluster mode, but not in Objects mode. The default is standard.
4. After saving parameters, power off and restart the radar, and the saved parameters will take effect.
5. Res stands for resolution. For example, if the maximum distance value is configured as 80 and the resolution is 2, then the maximum distance value is 80 meters.

4 State Output

The sensor is always sending cyclically (once per second) the current configuration and sensor state in message 0x201 and current firmware version in message 0x700.



Overview of state messages that are sent cyclically by the radar

4.1 Radar Statue (0x201)

The message RadarState (0x201) is sent by the sensor in a regular interval (once per second). After configuring a radar configuration parameter, the corresponding signal in message 0x201 can be checked in order to verify that the configuration change has been accepted.

	7	6	5	4	3	2	1	0
0	7 NVMWriteStatus	6 NVMMReadStatus	5 Reserved	4 Reserved	3 Reserved	2 Reserved	1 Reserved	0 Reserved
1	15 MaxDistanceCfg	14	13	12	11	10	9	8
2	23 MaxDistanceCfg	22	21 Reserved	20 Reserved	19 Reserved	18 Reserved	17 Reserved	16 Reserved

3	31 Reserved	30 Reserved	29 Reserved	28 Reserved	27 Reserved	26 Reserved	25	24 RadarPowerCfg
4	39 RadarPowerCfg	38	37 SortIndex	36	35 reserved	34	33	32 SensorID
5	47	46 MotionRxState	45 SendExtInfoCfg	44 SendQualityCfg	43	42 OutputTypeCfg	41 CtrlRelayCfg	40 Reserved
6	55 Built_inTest_Parameter	54	53	52	51	50	49	48
7	63 Reserved	62 Reserved	61 Reserved	60	59	58 RCS_threshold	57 Reserved	56 Reserved

Signal	Start	Len	Min	Max	Res	Uint
RadarState_NVMReadStatus	6	1	0	1	1	0x0:failed 0x1:Successful
RadarState_NVMWriteStatus	7	1	0	1	1	0x0:failed 0x1:Successful
RadarState_MaxDistanceCfg	22	10	0	2046	2	m(40-160m are supported in standard version)
RadarState_SensorID	32	3	0	7	1	Current radar ID(0~7)
RadarState_SortIndex	36	3	0	7	1	0x0:no sorting 0x1:sorted by range 0x2:sorted by RCS
RadarState_RadarPowerCfg	39	3	0	7	1	0x0:Standard 0x1:-3dB Tx Gain 0x2: -6dB Tx Gain 0x3: -9dB Tx Gain
RadarState_CtrlRelayCfg	41	1	0	1	1	0x0:Inactive 0x1: Active
RadarState_OutputTypeCfg	42	2	0	3	1	0x0:none 0x1:Objects 0x2:Clusters
RadarState_SendQualityCfg	44	1	0	1	1	0x0:Inactive 0x1: Active
RadarState_SendExtInfoCfg	45	1	0	1	1	0x0:Inactive

						0x1: Active
RadarState_MotionRxState	46	2	0	3	1	0x0:input ok 0x1:speed missing 0x2:yaw rate missing 0x3:speed and yaw rate missing
Built_in Test_Parameter	55	8	0	255	1	Internal use, closed to customers
RadarState_RCS_threshold	58	3	0	7	1	0x0:Standard 0x1:high sensitivity

4.2 Version Information(0x700)

	7	6	5	4	3	2	1	0
0	7 Soft_MajorRelease	6	5	4	3	2	1	0
1	15 Soft_MinorRelease	14	13	12	11	10	9	8
2	23 Soft_PatchLevel	22	21	20	19	18	17	16

Signal	Start	Len	Min	Max	Res	Description
Soft_MajorRelease	0	8	0	255	1	Software major release
Soft_MinorRelease	8	8	0	255	1	Software minor release
Soft_PatchLevel	16	8	0	255	1	Software patch level

5 Clusters List Output

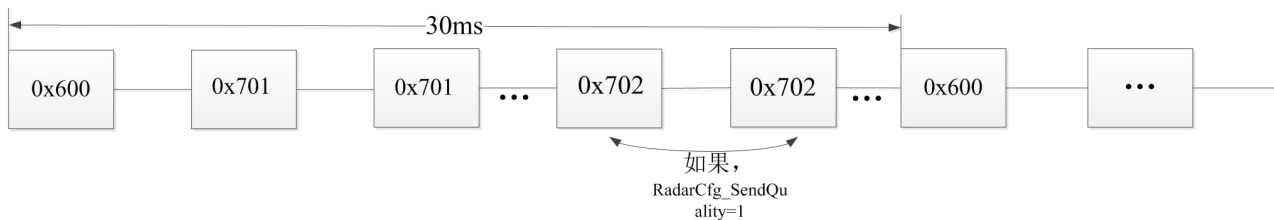
If the target output type is selected in the configuration instruction to be sent as Cluster, the target list message is sent periodically (about 60ms), containing two messages, 0x600, 0x701.

1. Cluster_Status (0x600) Cluster list-- The first message. This message contains the Cluster list header information and is sent as first message of the cluster list output, such

as the number of Clusters in the near and distant modes to be sent later.

2. Cluster_General (0x701) Cluster list-- The second message. This message contains the position and velocity of the clusters and is sent repeatedly for all the detected clusters (first near scan, then far scan). Each of the two cluster lists is range sorted. If there are more than 250 clusters, only the first 250 clusters are sent.

3. Cluster_Quality (0x702). This message contains the quality information of the clusters and is only sent if it was activated in signal RadarCfg_SendQuality (0x200). It is sent repeatedly for all clusters in the same way as message Cluster_1_General (0x701). The message is not yet available.



Overview of radar Clusters target delivery cycle

5.1 Cluster_Status(0x600)

	7	6	5	4	3	2	1	0
0	7 Target_NofTargesNear	6	5	4	3	2	1	0
1	15 Target_NofTargesFar	14	13	12	11	10	9	8
2	23 Target_MeasCount	22	21	20	19	18	17	16
3	31 Target_MeasCount	30	29	28	27	26	25	24
4	39 Target_InterfaceVersion	38	37	36	35 reserved	34 reserved	33 reserved	32 reserved

Signal	Start	Len	Min	Max	Res	Description
Target_NofTargesNear	0	8	0	255	1	Number of detected clusters in the near range scan
Target_NofTargesFar	8	8	0	255	1	Number of detected clusters in the far

						range scan
Target_MeasCount	16	16	0	65535	1	Measurement cycle counter (counting up since startup of sensor and restarting at 0 when > 65535)
Target_InterfaceVersion	36	4	0	15	1	Cluster list CAN interface version

5.2 Cluster_General_Information(0x701)

0x701 message contains the position and velocity of the clusters and is sent repeatedly for all the detected clusters (first near scan, then far scan). Each of the two cluster lists is range sorted. If there are more than 250 clusters, only the first 250 clusters are sent.

	7	6	5	4	3	2	1	0
0	7 Target_ID	6	5	4	3	2	1	0
1	15 Target_DistLong	14	13	12	11	10	9	8
2	23 Target_DistLong	22	21	20	19	18 reserved	17	16 Target_DistLat
3	31 Target_DistLat	30	29	28	27	26	25	24
4	39 Target_VrelLong	38	37	36	35	34	33	32
5	47 Target_VrelLong	46	45 Target_VrelLat	44	43	42	41	40
6	55 Target_VrelLat	54	53	52 reserved	51 reserved	50 Target_DynProp	49	48

7	63 Target_RCS	62	61	60	59	58	57	56
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Signal	Start	Len	Min	Max	Res	Description
Target_ID	0	8	0	255	1	
Target_DistLong	19	13	-500	1138.2	0.2	m
Target_Distlat	24	10	-102.3	+102.3	0.2	m
Target_VrelLong	46	10	-128.00	127.75	0.25	m/s
Target_DynProp	48	3	0	7	1	0x0:moving 0x1:stationary 0x2:oncoming 0x3:stationary candidate 0x4:unknown 0x5:crossing stationary 0x6:crossing moving 0x7:stopped
Target_VrelLat	53	9	-64	63.75	0.25	m/s
Cluster_RCS	56	8	-64	63.5	0.5	dBm2

5.3 Clusters Quality Information(0x702)

Not available yet.

0x702 message contains the quality information of the clusters and is only sent if it was activated in signal RadarCfg_SendQuality (0x200). It is sent repeatedly for all clusters in the same way as message Cluster_1_General (0x701).

	7	6	5	4	3	2	1	0
0	7 Target_ID	6	5	4	3	2	1	0
1	15 Target_DistLong_rms	14	13	12	11	10 Target_Distlat_rms	9	8
2	23 Target_Distlat_rms	22	21 Target_VrelLong_rms	20	19	18	17	16 Target_VrelLat_rms
3	31 Target_MeasCount	30	29	28	27	26 Target_Pdh0	25	24

4	39 Target_InvalidState	38	37	36	35	34 Target_AmbigState	33	32
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Signal	Start	Len	Min	Max	Res	Description
Cluster_ID	0	8	0	255	1	
Cluster_ _DistLong_rms	11	5	0	31	1	
Cluster_ _VrelLong_rms	17	5	0	31	1	
Cluster_ _DistLat_rms	22	5	0	32	1	
Cluster_Pdh0	24	3	0	7	1	0x0:Invalid 0x1:25% 0x2:50% 0x3:75% 0x4: 90% 0x5:99% 0x6:99.9% 0x7:<=100%
Cluster_VrelLat_rms	28	5	0	31	1	
Target_AmbigState	32	3	0	7	1	0x0:invalid 0x1:ambiguous 0x2:staggerd ramp 0x3: umambiguous 0x4:stationary candidates
Target_InvalidState	35	5	0	31	1	0x00: invalid 0x01:invalid due to low RCS 0x02: invalid due to near field artefact 0x03:invalid far range cluster because not confirmed in near range 0x04: valid cluster with low RCS 0x05:resvered 0x06: invalid cluster due to high mirror probability 0x07:invalid cluster because outside sensor filed of view 0x08:valid cluster with azimuth correction due

						to elevation 0x09:valid cluster with high child probability 0x0A: valid cluster with high probability of being a 50 deg artefact 0x0B: valid cluster but no local maximum 0x0C: valid cluster with high artefact probability 0x0D: reserved 0x0E:invalid cluster because it is a harmonics 0x0F:valid cluster above 95m in near range 0x10:valid cluster with high multi-target probability 0x11:valid cluster with suspicious angle
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6 Object list

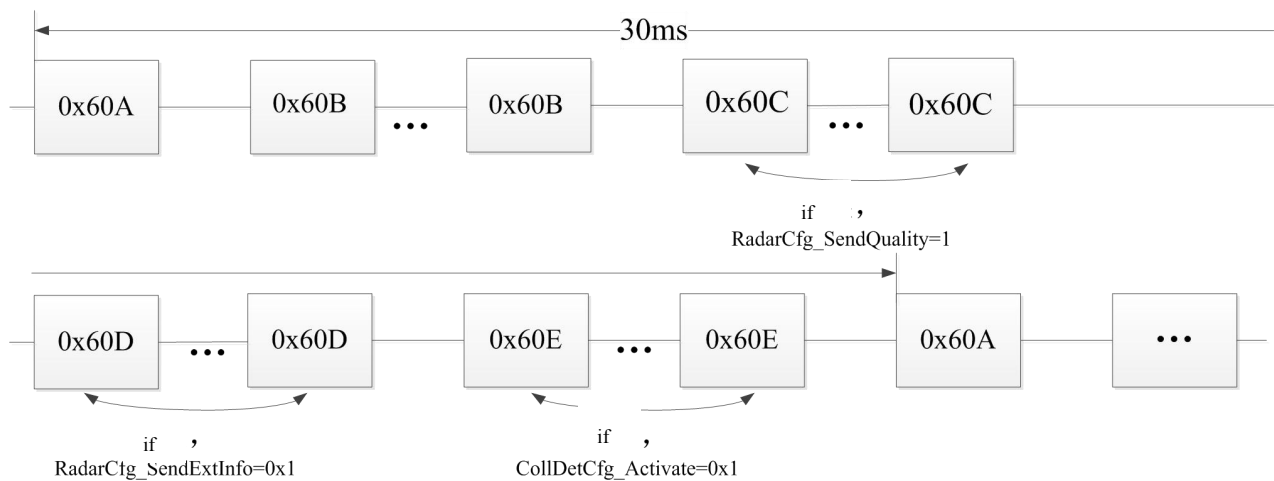
The object list output consists of up to five message definitions that are sent in a regular interval if objects are selected in signal RadarCfg_OutputType (0x200). 0x60C, 0x60D, 0x60E not open yet.

- 1、 Object_0_Status(0x60A)-- The first message contains list header information, i.e. the number of objects that are sent afterwards.
- 2、 Object_1_General (0x60B)-- This message contains the position and velocity of the objects and is sent repeatedly for all the tracked objects.
- 3、 Object_2_Quality(0x60C)-- This message contains the quality information of the objects and is only sent if it was activated in signal RadarCfg_SendQuality (0x200). It is sent repeatedly for all objects in the same way as message Object_1_General (0x60B)
- 4、 Object_3_Extended(0x60D)-- This message contains additional object properties and is only sent if it was activated in signal RadarCfg_SendExtInfo (0x200). It is sent repeatedly for all objects in the same way as message Object_1_General

(0x60B)

- 5、 Object_4_Warning(0x60E)-- This message contains the collision detection warning state and is only sent if collision detection was activated in message CollDetCfg (0x400). It is sent repeatedly for all objects in the same way as message Object_1_General (0x60B).

If the quality information, extended information and/or warning state is sent, first all messages of type Object_1_General (0x60B) are sent and afterwards all messages of type Object_2_Quality (0x60C), afterwards of type Object_3_Extended (0x60D) and/or afterwards of type Object_4_Warning (0x60E).



6.1 Object List Status(0x60A)

Object List Status(0x60A) is contains the target list header message, first sending 0x60A message during each measurement cycle.

	7	6	5	4	3	2	1	0
0	7 Objects_NofObjects	6	5	4	3	2	1	0
1	15 Objects_MeasCount	14	13	12	11	10	9	8
2	23 Objects_MeasCount	22	21	20	19	18	17	16
3	31 Objects_InterfaceVersion	30	29	28	27	26	25	24

Signal	Start	Len	Min	Max	Res	Description
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Objects_NofObjects	0	8	0	255	1	
Objects_MeasCount	8	16	0	65535	1	Cycle count
Objects_InterfaceVersion	28	4	0	15	1	Target list CAN interface version

6.2 Objects General Information(0x60B)

This message contains the location and speed of the target, periodically sending all tracking target information.

	7	6	5	4	3	2	1	0
0	7 Objects_ID	6	5	4	3	2	1	0
1	15 Objects_DistLong	14	13	12	11	10	9	8
2	23	22	21	20	19	18	17	16 Objects_Distlat
3	31 Objects_Distlat	30	29	28	27	26	25	24
4	39 Objects_VrelLong	38	37	36	35	34	33	32
5	47 Objects_VrelLong	46	45 Objects_VrelLat	44	43	42	41	40
6	55 Objects_VrelLat	54	53	52 reserved	51 reserved	50 Objects_DynProp	49	48
7	63 Objects_RCS	62	61	60	59	58	57	56

Signal	Start	Len	Min	Max	Res	Description
Objects_ID	0	8	0	255	1	
Objects_DistLong	19	13	-500	1138.2	0.2	m
Objects_Distlat	24	11	-204.2	+204.8	0.2	m
Objects_VrelLong	46	10	-128.00	127.75	0.25	m/s
Objects_DynProp	48	3	0	7	1	0x0:moving 0x1:stationary 0x2:oncoming 0x3:stationary candidate

						0x4:unknown 0x5:crossing stationary 0x6:crossing moving 0x7:stopped
Objects _VrelLat	53	9	-64	63.75	0.25	m/s
Objects _RCS	56	8	-64	63.5	0.5	dBm2

7 Motion Information Input

The sensor receives input messages 0x300 and 0x301, but works without input. After 500ms, the sensor defaults to the following state:

1. speed 0m/s Standing
2. Yaw rate 1deg/s

Each message is monitored independently for timeouts. The timeout state is reflected in the 0x201 message RadarState_MotionRxState bit.

7.1 Speed Information(0x300)

	7	6	5	4	3	2	1	0
0	7 Radardevice _speedDirec tion	6	5 reserved	4 RadarDevic e_Speed	3	2	1	0
1	15 RadarDevice _Speed	14	13	12	11	10	9	8 lsb

Signal	Start	Len	Min	Max	Res	Description
Radardevice_speedDirection	6	2	0	2	1	0x0:standing 0x0:forward 0x0:rear
RadarDevice_Speed	8	13	0	163.8	0.02	m/s

7.2 Yaw Rate Information(0x301)

	7	6	5	4	3	2	1	0
0	7 RadarDevice _YawRate msb	6	5	4	3	2	1	0
1	15	14	13	12	11	10	9	8

	RadarDevice_YawRate							lsb
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Signal	Start	Len	Min	Max	Res	Description
Radardevice_speedDirection	8	16	-327.68	327.68	0.01	deg/s

8 Example for CAN protocol parsing

8.1 Configuration message example

The default program type of “radar_outputType” is “Objects”, it will be revised and saved to “NVM”;

“radar_power” is “standard”;

SortIndex is classified as distance (range);

RCS_Threshold is “standard”;

SensorID is “0”;

MaxDistance is 160 meters.

Example: if ID is 0*200, then the message content is 0xFF 0x14 0x00 0x00 0x09 0x90 0x00 0x00

If this message modify the radar ID to 1, and save the modified parameters to “NVM”.

The next time the radar is powered on, ID is 1. The max distance is 160 meters, that is $(0x14 \times 4 + 0x00 \gg 6) \times 2$; the value resolution is 2, so $0x50 = 80$, 80 times 2, then the max distance is 160meters.

When configure the bit, bit 0 needs to enable byte 0, and enable maxdistance_valid to 1; If bit 0 maxdistance_valid of byte 0 is “0”, then the configuration is invalid.

When the change is started, the valid bit must be valid for the configuration to take effect, otherwise the configuration doesn't take effect.

8.2 Heartbeat Signal (0x700)

The first three bytes of the message represent the software version number. If the return message is 0x700, which means the current radar ID is 0; If returns 0x710, means the current radar ID is 1.

Example: the return message is 0x01 0x00 0x15 0x00 0x00 0x00 0x00 0x00

The the radar version is V 1.0.21.