User's Guide

HDMS – HDMS FMCW RADAR

- User's Guide

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This document contains all the resources needed to set up the HDMS FMCW RADAR for performance evaluation.

Project Manager	----
Technology	----

Date	Description	Name	Note
21.10.01	최초작성 Production	이제우	V1.00
21.11.15	IC, FCC, CE RED_EC 추가	이제우	V1.10
21.12.27	공급업체 관련 코멘트 추가	이제우	V1.20
22.01.03	동작전압, 주파수, RF Power 관련 내용 수정	이제우	V1.30

Revision history

List

1 RADAR (Radio Detection and Ranging)?

- It is a device that measures the distance or shape to an object by radiating strong electromagnetic waves and measuring reflected waves reflected by the object.
- Compared to other sensors, it has higher permeability (lower impact on clouds and weather) and can detect long distances.
- The Frequency Modulated Continuous Wave (FMCW) method is mostly used, the hardware configuration is easier than other modulation methods, and it has high resolution and speed resolution in terms of performance.
- HDMS FMCW RADAR is a RADAR with a 77 ~ 81Ghz frequency band and is installed in heavy equipment with stable and excellent performance and is used to detect people.
- It is installed in heavy equipment and can be expected to reduce injuries and accident rates due to collision prevention and prevention with RADAR and reduce the cost of human and material resources due to accident prevention.
- RADAR data output information is as follows.
  - ✓ Distance(X,Y Coordinates)
  - ✓ Object Signal Power

➢ Construction Equipment Safety Radar

Safety
✔ Avoid collisions, reduce accidents and injuries

Efficiency
✔ Efficient equipment operation

Compatibility
✔ Superior performance at the construction site

Ruggedness
✔ Excellent performance due to moisture, dust, vibration and weather

1.1 Detailed Specifications

Short Range FMCW RADAR

[FMCW RADAR]

Safety
- ✔ Prevent Collision,
- ✔ Decrease Accidents & Injured

Efficiency
- ✔ Efficient Operating Machinery

Compatibility
- ✔ Outstanding Performance

Ruggedness
- ✔ Great Stability in Construction Area Environment

FMCW RADAR	Short Range
Division	Descriptions
Power input	6 ~ 36 Vdc
Operation voltage	24 Vdc
Operating temperature(℃)	-40 ~ 85
Storage temperature(℃)	-40 ~ 85
Current Consumption	〈2W
Water/Dust Proof	IP6K7***
INTERFACE	CAN Protocol Version 2.0 Part A, B and ISO 11898-1, CAN-FD support, Not Termination
Frequency	80 ~ 81 GHz
Modulation	FMCW
Position Accuracy	〈 0.5 m
Update frequency	5 Hz (20 Hz**)
Target separability	〈 0.5 m
Minimum range	〈 0.5 m
Maximum range	10 m
Azimuth angle range	〈 100 ° (±5%)
Vertical FOV	30 ° (±1%)
RF Power	6.76dBm
Latency	First object detection : 200ms → after objects detected 50ms

*Refers to a target with RCS of -10dBsm (Based on ISO 16001).
**Maximum performance, it could be controlled by a user program.
***Waterproof Test(Based on ISO16750-4, DIN 40050-9).

❖ Main Features

- ➢ Compliance with ISO 16001, 3401 standards.
- ➢ Stop Target detect performance and Moving Target detect performance are satisfied.
- ➢ All tests are applied and complied with Construction area environment.
- ➢ Testing detect performance with all environment area.

2.3 Receiver requirements

2.3.1 Receiver spurious emissions

- Definition:
Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode.

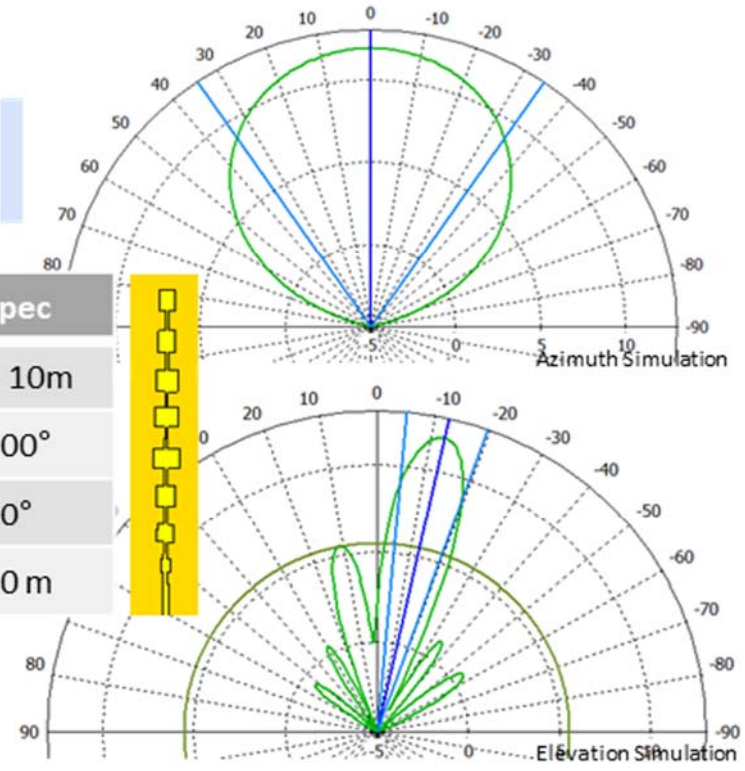
Test method : EN 303 396 V 1.1.1 clause 6.3.11

- Measurement Data: Not Applicable
This EUT is the receiver is co-located with and operates simultaneously with the transmitter.

1.2 About RADAR antennamodule measurement ranges and beam patterns

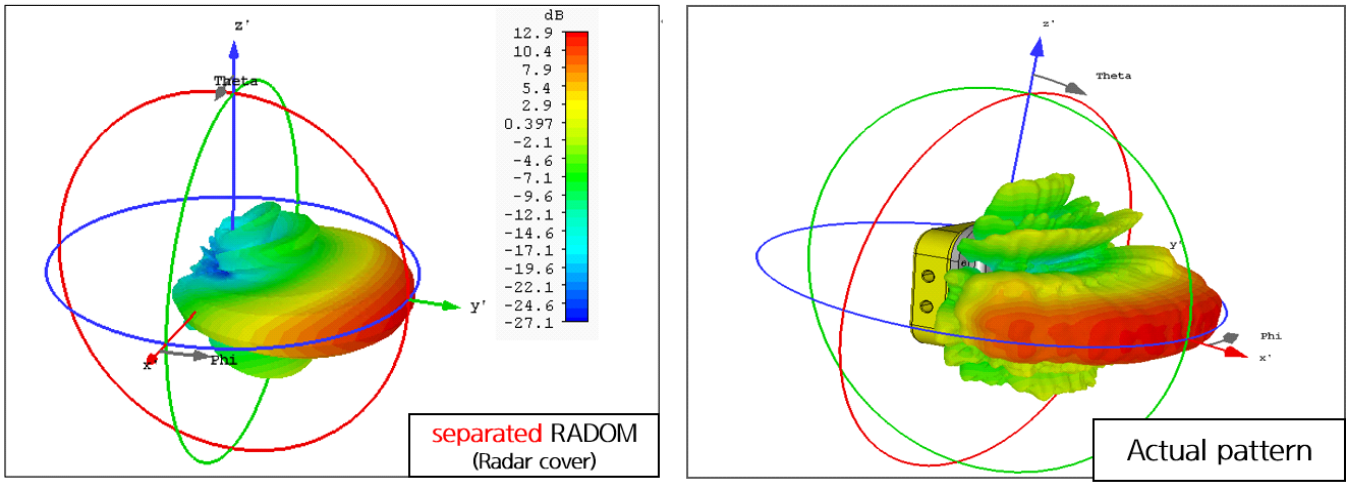
- RADAR's beam pattern computer simulation image is as follows, and RADAR's beam pattern is different depending on the presence or absence of a cover of the case.

Items	Spec
Max Range	> 10m
Azimuth	100°
Elevation	30°
Azimuth Range	10 m



RADAR Antenna Module, Detecting Range, Azimuth Pattern

Radiation Pattern - 3D



RADAR Antenna Module beam radiation pattern

(Left: Top case remove, Right: Top case)

> 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.

> This equipment has been tested and found to comply with the limits for a 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 or more 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.

This device should be installed and operated with minimum 20 cm between the radiator and your body.

Prohibited applications of RADAR equipment under this service rule include fixed RADAR use outside of airport areas and airborne RADAR operations.

- This device can be operated in at least one Member State without infringing applicable requirements on the use of radio spectrum.

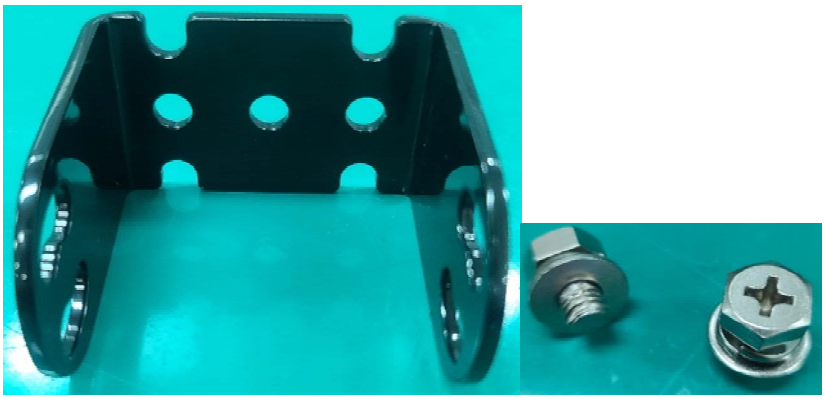
2 Components

2.1 IP6K7 RADAR

- RADAR product is composed in detail as follows.
  - ✓ Top Case, Bottom Case
  - ✓ Connect Cables
  - ✓ Interface board, RADAR Antenna module

IP6K7 RADAR(24RA-20000)

2.2 RADAR Bracket

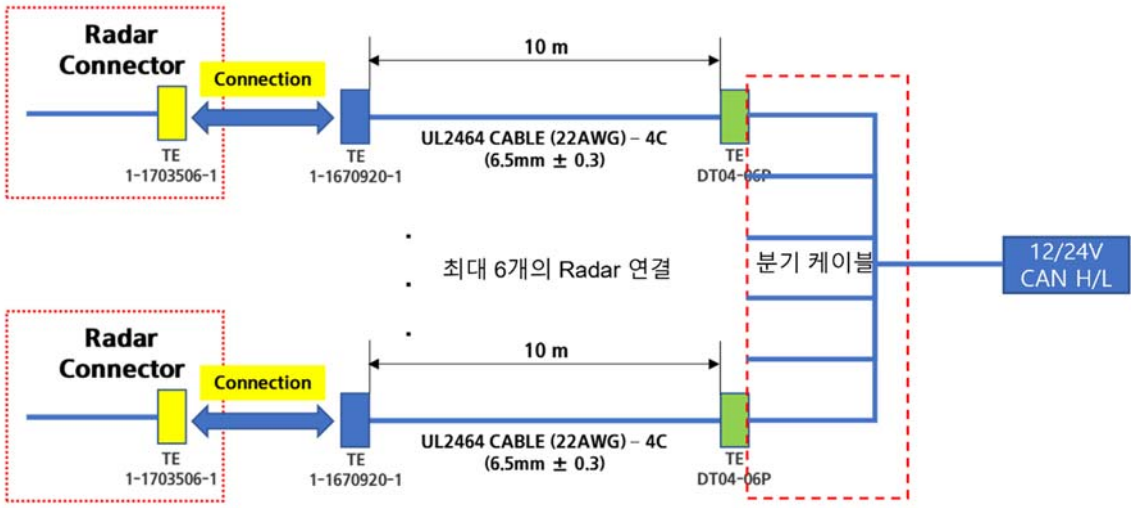


RADAR Bracket, assembly screws

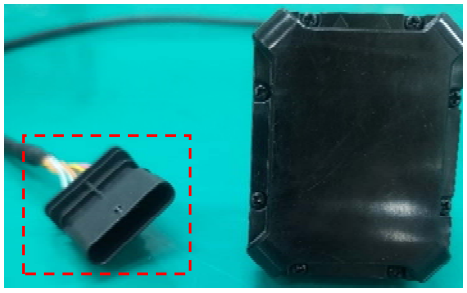
- Bracket is used to fix RADAR in a specific position.
- Four M8 screws are used to fix the bracket and RADAR.

2.3 Connect cable

- The basic configuration for RADAR and the connection cable is as follows.

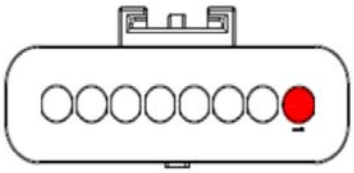


- Refer to the table below and the image for the pin configuration of the connection cable TE 1-1703506-1 of RADAR.



PIN	Pin Description
1	Power(24V)
2	GND
3	CAN HIGH
4	CAN LOW
5	Reserved
6	Digital Input1
7	Digital Input2
8	Digital Input3

[커넥터 전면부]



[커넥터 Pin 번호]

장착 위치	CAN ID	GPIO 입력 값(0:Low, 1:High)		
		PIN 6 (Radar ID 1)	PIN 7 (Radar ID 2)	PIN 8 (Radar ID 3)
Install_Position_0	0x18FF326C	Open/GND	Open/GND	Open/GND
Install_Position_1	0x18FF326A	Open/GND	Open/GND	24v
Install_Position_2	0x18FF3268	Open/GND	24v	Open/GND
Install_Position_3	0x18FF326B	Open/GND	24v	24v
Install_Position_4	0x18FF3269	24v	Open/GND	Open/GND

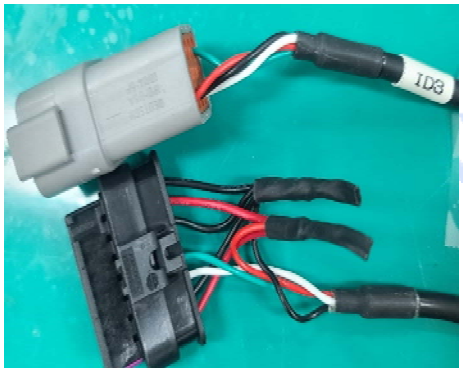
Install_Position_5	0x18FF326D	24v	Open/GND	24v
Install_Position_6	0x18FF32F1	24v	24v	Open/GND
Install_Position_7	0x18FF32F2	24v	24v	24v

- 10m extension cable (ID 1~6): A cable that extends the distance according to the installation location of the RADAR and distinguishes CAN IDs by location

10m Extension Cable

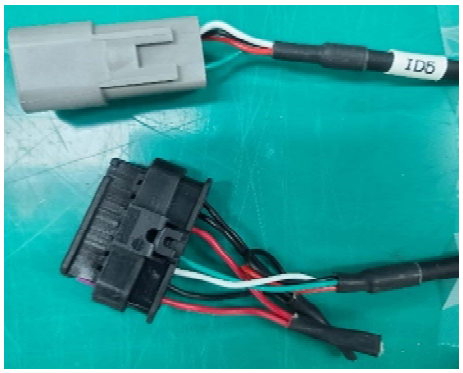
CAN ID 1

CAN ID 2

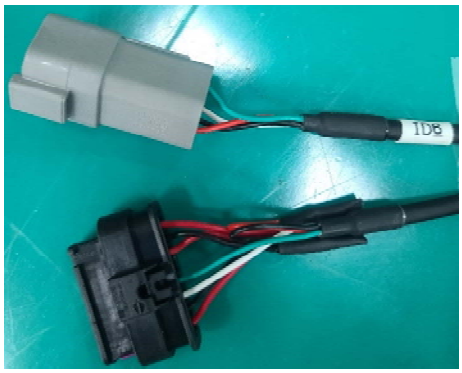


CAN ID 3

CAN ID 4



CAN ID 5



CAN ID 6

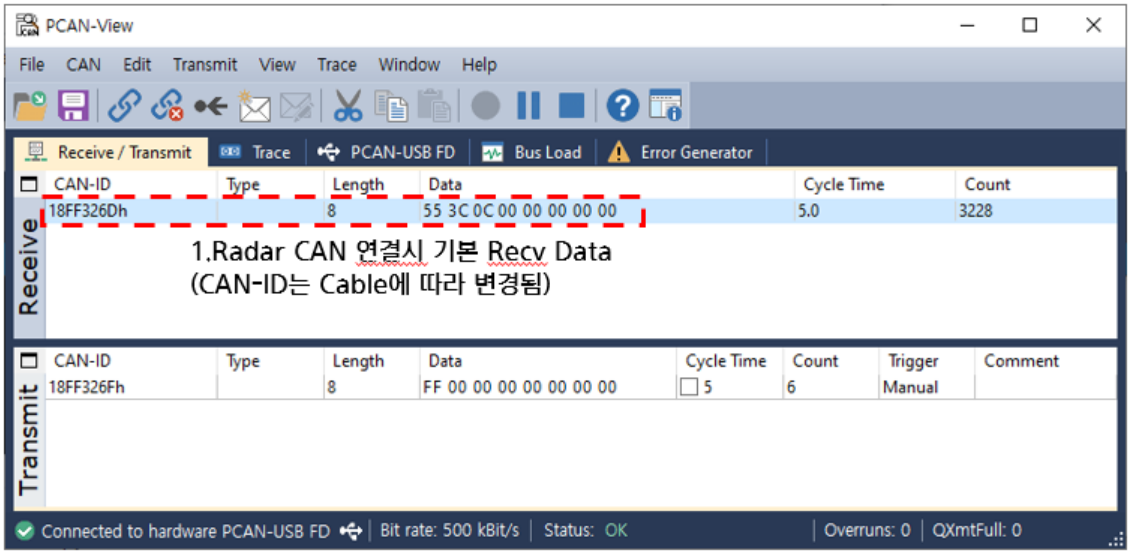
-

- Split cable : Split cables that allow you to connect up to 6 RADARs

- To connect the connecting cable, connect the parts that fit into the grooves as shown in the figure below.

2.4 Power supply and PC connection.

- Apply 12/24V to the connection cable, connect PCAN to USB to CAN H/L, and check information on the object detected from RADAR through PCAN View.



Check packet output status when connecting to PCAN

3 Communication Protocol

- RADAR basic communication uses CAN 2.0B and the communication speed is 500kBit/s.

- Refer to Table 1 below for the packet structure of RADAR. (The CAN ID of RADAR varies depending on the cable being connected.)

Table 1 RADAR CAN Protocol(Total 8Byte)

Start bit	Length	Signal Name	Factor	Offset	Range		Unit	Description
					min	max		
0	4	RADAR Detect Packet Number	1	0	0	15	-	0 : NOT USED / Error 1 ~ 5 : RADAR Packet Number
4	4	Install Position	1	0	0	15	-	0 : RR_BR - Rear RADAR, Backward, Rearward-looking 1 : SR_RR - Side RADAR, Right-hand side, Rearward-looking 2 : SR_LR - Side RADAR, Left-hand side, Rearward-looking 3 : SR_RF - Side RADAR, Right-hand side, Forward-looking 4 : SR_LF - Side RADAR, Left-hand side, Forward-looking
8	2	RADAR Status	1	0	0	3	-	0 : Normal, 1 : Swing, 2 : Moving
10	2	Reserved	1	0	0	3	-	Reserved
12	8	RADAR SW version	1	0	0	255	-	RADAR Software version(ex, 0x10 = ver 1.0)
20	10	n-th Target X data	1	0	0	1023	cm	n : packet number 0 : 0 cm 1~511 : +(X_Distance) cm 512 ~ 1023 : -((1024-X_Distance)) cm
30	10	n-th Target Y data	1	0	0	1023	cm	n : packet number 0 : 0 cm 1~1023 : +(Y_Distance) cm
40	10	n-th Target Power data	1	0	0	1023	dB	n : packet number 0~1023 : Power dBm
50	10	Reserved	1	0	0	1023		Reserved
60	4	Fault Code	1	0	0	15	-	Fault Code 0x0 : Normal 0x1 : RADAR Interface board Error 0x2 : RADAR Module board Error 0x3 : Position Pin Error (Not connect) 0x4 : Position Pin Error (Redundant connect)

4 RADAR Installation and Test Procedure

4.1 RADAR Test Compliance

- The installation location and installation method of RADAR are based on "**Appendix C. Test Procedure for RADAR Sensors in ISO 16001 2017 documents".**

- RADAR's test object should be a human body part protruding to the sensing area. For testing, a real person with the height of an intermediate pilot must use it in accordance with ISO 3411.

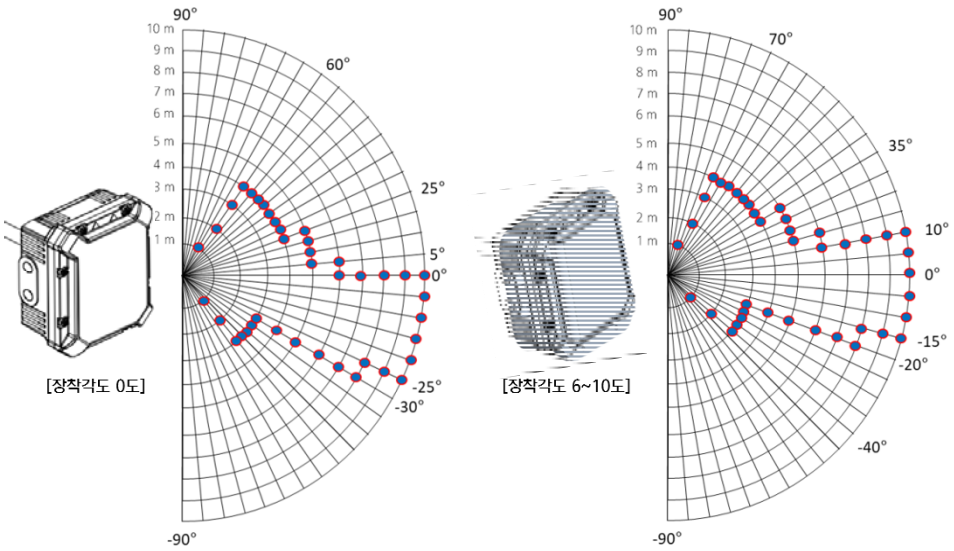
- The surrounding environment for the test should be an open space of flat terrain based on dry sand, dry gravel, or a combination of dry sand and dry gravel. Everyone except the person performing the test should be in an area not detected by RADAR (excerpt from part of the C.3 test area of ISO 16001 2017).

4.2 RADAR Installation Compliance

- This RADAR is permanently attached or fixed to the vehicle. (If the RADAR is shaken by surrounding environment or vibration, the basic sensing performance may be degraded.)

- Using RADAR's bracket or self-made bracket, it can be well fixed to the position where the RADAR is mounted.

- The recommended installation height of RADAR is 1.4-1.6m, and the angle of RADAR can be adjusted according to the installation environment. (As the angle of RADAR faces downward, the detection range decreases, and ground effect may occur due to the ground.)

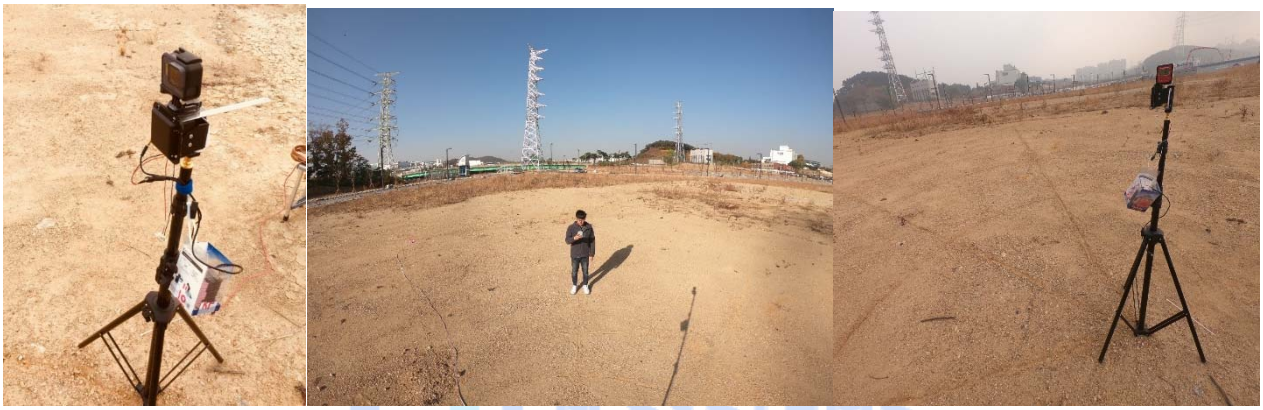


Detection range according to RADAR installation angle

4.3 RADAR Test Method (How to Use a Tripod)

- Fix the RADAR using a tripod, adjust the height of 1.4-1.6m, and adjust the angle of the RADAR according to the environment to check the detection result of humans to adjust the installation height and angle.

- If the environment is complex, there is a possibility of misunderstanding. Therefore, it is recommended to perform the RADAR test in an open space with a left and right width of 10 meters or more.



4.4 RADAR Test Method (How to Use in Vehicle)

- In the picture below, the test was conducted by mounting it on the actual excavator equipment, and the test was conducted by mounting it using a bracket at a height of 1.5m for each equipment. The test was conducted by mounting a RADAR at a location of 1.5 meters for each equipment.

Mount on an excavator(For Example)

5. Appendix

Interference Mitigation For IWR1443 RADAR Device

- References : swra662_Interference Mitigation For AWRIWR Devices
  http://www.ti.com/lit/an/swra662/swra662.pdf

1 Types of Interference in FMCW RADAR

- Crossing Interference
- Parallel Interference
- Between Crossing and Parallel Interference

2 Interference Avoidance

NO	Technique	Method	Implementable in TI device.	Usefulness and simplicity
1	CFAR –based mitigation	Increase the CFAR thresholds accounting for the interference. This decreases the detection sensitivity but avoids spurious sidelobes.	Yes. The detection threshold is user programmable.	Debatable usefulness. Very simple to implement.
2	Dithering in time domain.	Dithering the idle time (time between chirps) or the interframe time (time between frames). Since this dither is different for the	Yes. A near infinite variation is possible on the 'idle time'. Frames can be generated with	Very Useful. specially in a parallel interferer scenario. Simple to implement

		Aggressor and the Victim, the probability of interference on more than one chirp is reduced.	dithering as well (software control).	
3	Direction specific predefined frequency band separation.	Use a separate RF bandwidth for long range RADAR, and short-range RADAR. Use a different RF Bandwidth for front facing RADAR, and another band for rear facing RADAR.	Yes.	Debatable usefulness Very simple to implement and process.
4	Detect interference and repair Rx results	The region of the ADC affected by interference is deduced, and 'repaired'. Detection is performed using statistical information of the ADC data. Repairing involves – interpolation (for short sections) or 'signal healing'..	Yes. IWR1443 devices provide side channel information (called chirp quality) to aid in narrowing down the region of interference.	Very Useful.

5	Dithering the phase of each chirp	Randomize the transmitted phase of each chirp. Since the aggressor would have no notion of this randomized phase, the phase of the interference event would be randomized spreading the interference across chirps	Yes.	Extremely Useful. Especially in a parallel interferer scenario. The reduction in the interference level is a function of the number of chirps.
6	Digital Beam Forming	Place a notch at the direction of the interferer 'adaptively'. This is done by applying a notch filter to the receiver array before processing.	Yes.	May not work well if there are only a limited number of receivers. Also, the DoA of the aggressor needs to be estimated a priori.
7	Detect interference and change timing of transmit chirp or frames	If an interferer is detected, avoid it, either in frequency or in time. Essentially – frequency/time hopping.	Yes.	Possibly the most useful technique. Reasonably simple to implement.
8	Specific polarization of the antennas	Use horizontal polarization for a certain set of antennas, and vertical polarization for another	Needs antenna designers	Useful – but only two different options are available. Also, increased complexity

		set.		in antenna design.

FCC Instructions

FCC Compliance Statement(Part 15.19 (3))

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.

FCC Interference Statement(Part 15.105)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

• 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 which the receiver is connected. • Consult the dealer or an experienced radio/TV technician for help.

FCC Caution

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

FCC Radiation Exposure Statement (Part 2.1091)

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. **This equipment should be installed and operated with minimum distance 20 cm between the radiator and your body.** This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

'SDoC form will be attached to the manual when placing to the market.'

IC

Industry Canada Statement

This device complies with RSS-251 of the Industry Canada 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. Ce dispositif est conforme à la norme CNR-251 d'Industrie Canada applicable aux appareils radio exempts de licence. Son fonctionnement est sujet aux deux conditions suivantes: (1) le dispositif ne doit pas produire de brouillage préjudiciable, et (2) ce dispositif doit accepter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

Industry Canada Radiation Exposure Statement

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

Déclaration d'exposition aux radiations

Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non con trôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

CE RED_EU declaration

(This product can be used in which EU members, in accordance with Article 10(10) **or** this product can be used in at least one EU country, in accordance with Article 10(2))