SakuraTech Human-friendly Sensors Anytime ENABLED BY ANALOG DEVICES

# 76/77 & 77/81GHz Millimeter Wave MIMO FMCW Radar Sensor Platform

**Data Sheet** **miRadar12e B290-111/121 / ADRP1121-01/02**

## 1 GENERAL DESCRIPTION

The miRadar12e family is a small size 76GHz/79GHz millimeter wave FMCW (Frequency Modulated Continuous Wave) radar sensor unit. It integrates an array antenna, mm-wave radar MMIC (Multiple input multiple output) and DSP (Digital Signal Processor). The radar sensor can provide processed data such as range and angle heatmap data, including detected target positions by the onboard embedded radar DSP ). Alternatively, it also provides raw data output as an option for users to develop their own custom signal processing. The miRadar12efeatures a USB-HS+PD (High Speed Power Delivery)/RS485 serial interface. SakuraTech also provides graphical user interface (GUI) application for both Windows and Linux. The GUI helps facilitates easy sensor evaluation for appropriate configurations, capturing data, and signal Additionally, ROS (Robot Operating System) node is available for autonomous robotics applications.

## 2 APPLICATIONS

- Autonomous machines (robot, construction/agricultural machines)
- AGV (Autonomous Guided vehicle)
- AMR (Autonomous Mobile Robots)
- Drone
- UAV (Unmanned Aerial Vehicle)
- UGV (Unmanned Guided Vehicle)


**Figure 1.** ***miRadar12e sensor module***

## 3 FEATURES

- Very small size:(L x W x H) 92 × 55 × 10 mm
- Best-in-class accuracy in ranging, DoA (Direction of Arrival) estimation and doppler measurement.
- RF Frequency: 76-78GHz/77-81GHz
- Tx Power: 10 dBm (ANT input power) + 10 dBi (ANT gain)
- FMCW, TDD-MIMO (Time Division Duplex)
- Tx 3-ch & Rx 4-ch linear array
- Detection Range: 200m (depending on the RCS (Radar Cross Section) dependency)
- FoV (Field of View):
  - ✓ Elevation: ±45 deg.
  - ✓ Azimuth: ±60 deg.
- Resolution:
  - ✓ Range: 0.04 m
  - ✓ Azimuth: 1 deg.
- Embedded DSP capability:
  - ✓ On-board radar DSP mode: heatmap data by range and angle, position data of detected targets (max. eight targets)
  - ✓ Raw data mode: raw ADC data
- System interface:
  - ✓ USB-HS (PD)/RS485
- Evaluation software
  - ✓ Sensor configuration
  - ✓ Range and angle in heatmap view
  - ✓ GUI (Graphic User Interface)
  - ✓ Windows and Linux PC

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## REVISION HISTORY

9/2024 – Rev.3

9/2024 – Rev.2

8/2024 – Rev.1

7/2024 – Rev. 0: Initial Version

## 4 FUNCTION BLOCK DIAGRAM

The miRadar12e integrates a millimeter-wave radar MMIC, radar DSP, three transmitters, four receivers and MIMO (Multiple Input Multiple Output) antenna into compact RF module (92 × 55 × 10 mm). The on-board DSP facilitates embedded radar signal processing for ranging, Direction of Arrival (DoA) estimation, and multiple target detections. Alternative bypass for RAW data output mode is supported too. The host system interface is selectable either USB High-Speed with Power Delivery (USB HS+PD) or RS485 serial interface. Due to its minimal size, the miRadar12e can be embedded compactly into various autonomous machines. The antenna design is optimized for either 76-77GHz or 79-81GHz frequency bands. For specific ordering details, please refer to the ORDER GUIDE section.

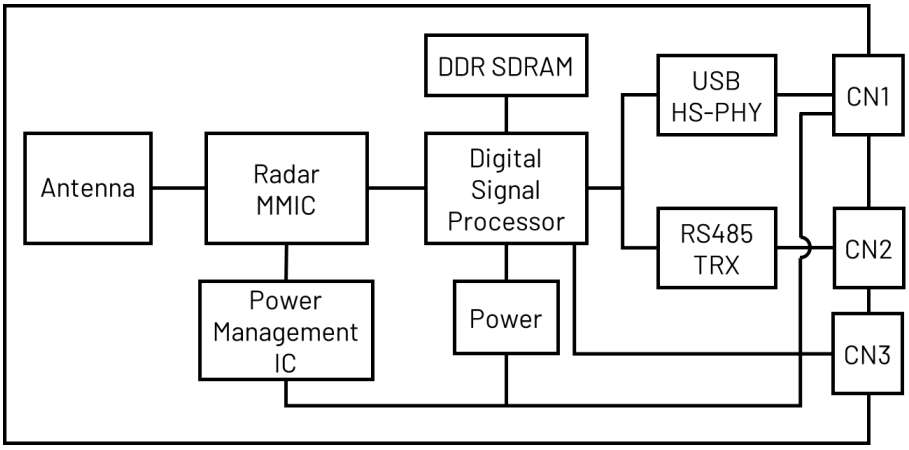


**Figure 2** ***System diagram***

## 5 MECAHANICAL DRAWING

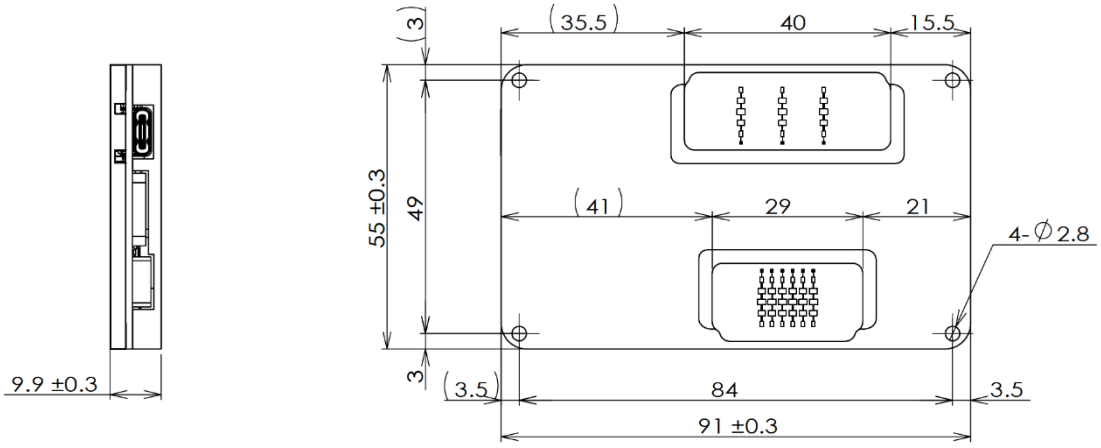


**Figure 3** ***Mechanical drawing***

## 6 PIN DESCRIPTION

The miRadar12e has three connectors as shown in Figure 4 below:

- CN1 (USB-C HS & PD)
- CN2 (RS485)
- CN3 (GPIO)

CN1 supports USB Power Delivery (USB-PD), enabling power supply when connected to a USB-PD enabled computer as well as data transfer. For RS485 connection, CN2 has to be used instead of CN1, and power supply must be supplied via CN2 but not CN1, where USB-PD function is disabled. For GPIO, CN3 can be used, and on-board DSP controls the GPIO pins. For example, miRadar12e has a feature like proximity sensor where on-board DPS controls GPIO when a target comes to specified range (e.g., 1 m).

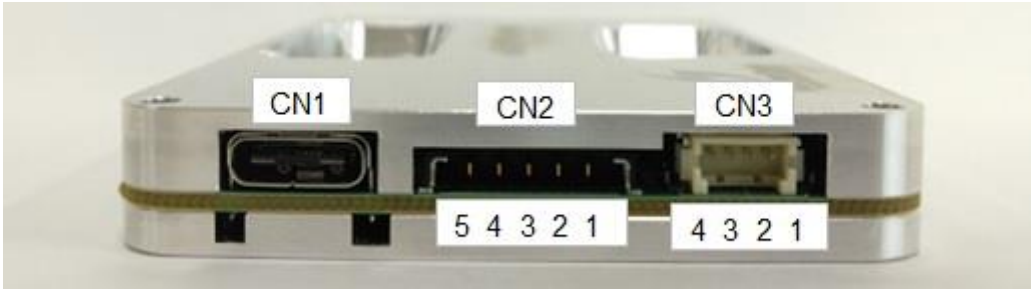


**Figure 4.** ***Connector and pinout***

**Table 1.** ***CN2 (RS485) pin description***

| Pin No. | Name | Type | Description |
|---|---|---|---|
| 1 | SGND | GND | Signal ground |
| 2 | GND | GND | +12 V power supply ground |
| 3 | RS485+ | DIO | RS485 interface D+ |
| 4 | RS485- | DIO | RS485 interface D- |
| 5 | +12V | Power | +12 V power supply input |

Connector models are described as flowing:

- Connector (miRadar12e): Molex 2053380005
- Mating connector: Molex 2053410205 (hosing) and Molex 2053425028 (contact)
- Wire gauge: AWG20 for Pin1 and Pin4, AWG25 for Pin2 and Pin3 and Pin5

**Table 2** ***CN3 (GPIO) pin description***

| Pin No. | Name | Type | Description |
|---|---|---|---|
| 1 | +3.3V out | Power | +3.3 V DC output |
| 2 | GPO1 | DO | Digital output |
| 3 | GPO2 | DO | Digital output |
| 4 | GND | GND | GND |

- Connector (miRadar12e): Hirose DF13-4P-1.25H
- Mating connector: Hirose DF13-4S-1.25 (housing) and Hirose DF13-2630SCF (contact)
- Wire gauge: AWG26 UL1571 for all pins

## 7 ELECTRIC SPECIFICATIONS

**Table 3** ***Electrical specifications***

| Parameter | Min | Typ | Max | Unit | Details |
|---|---|---|---|---|---|
| **Distance** | | | | | |
| Max. distance capability | | | 200 | m | RCS dependency |
| Distance resolution | 0.04 | | | m | OBW dependency |
| **Angle** | | | | | |
| Azimuth angle | | | ±60 | deg. | |
| Angle resolution | 10 | | | deg. | |
| **Velocity** | | | | | |
| Measurable velocity | | | 64 | km/h | TDD by TX*3, 30 μs Ramp Time |
| **RF** *1 | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Frequency | 76 | | 77 | GHz | Model# B290-121 |
| | 77 | | 81 | GHz | Model# B290-111 |
| Ramp time | 8.5 | | 1600 | μs | Decimation# dependency |
| TX power | | | 10 | mW | ANT input power |
| ANT gain | | 10 | | dBi | |
| RX HPF Gain | 6 | 12 | 18 | dB | 6 dB step |
| RX PGA Gain | 0 | 6 | 12 | dB | 6 dB step |
| **GPIO** | | | | | |
| Output voltage low | | | 0.3 | V | Sink current 3 mA (max) |
| Output voltage high | 2.9 | | | V | Source current 3 mA (max) |
| **Power by USB (CN1)** | | | | | |
| Input voltage | | 5 | | V | |
| Current consumption *2 | | 1300 | | mA | |
| I/F speed | | | 12 | Mbps | |
| **Power by RS485 (CN2)** | | | | | |
| Input voltage | 5 | 12 | 24 | V | |
| Current consumption*2 | | 520 | | mA | @12V DC |
| Max I/F speed | 0.1152 | | 0.9216 | Mbps | |

*1) Once radio regulatory is certificated for commercial production, RF specification has to be frozen.
*2) Current consumption by TDD by three TXs, max. TX gain, max. RX gain, Ramp time 28us, Decimation# 96 and using On-board radar DSP.

# 8 ABSOLUTE MAXIMUM RATING

**Table 4** ***Absolute maximum ratings***

| Parameter | Rating |
|---|---|
| +12V (CN2) to GND | -0.3V to +51 V |
| Storage temperature | -40 ˚C to +85 ˚C |
| Operating temperature | -20 ˚C to +70 ˚C |
| ESD Human Body Model (HBM) | 4 kV |
| ESD Field-Included Charged Device Model (FICDM) | 1 kV |

# 9 EVALUATUION SOFTWARE GUI

The miRadar12e supports the following data output modes.

## 9.1 On-board DSP mode:

- Utilizes miRadar12e's embedded DSP for processing RAW data
- Provides range and angle data displayed in a heatmap view
- Detects multiple targets with position data

The on-board DSP of miRadar12e processes whole radar signal processing and the sensor outputs heatmap data in range and angle. In addition, the sensor detects multiple targets up to eight objects, and the position data is provided too.

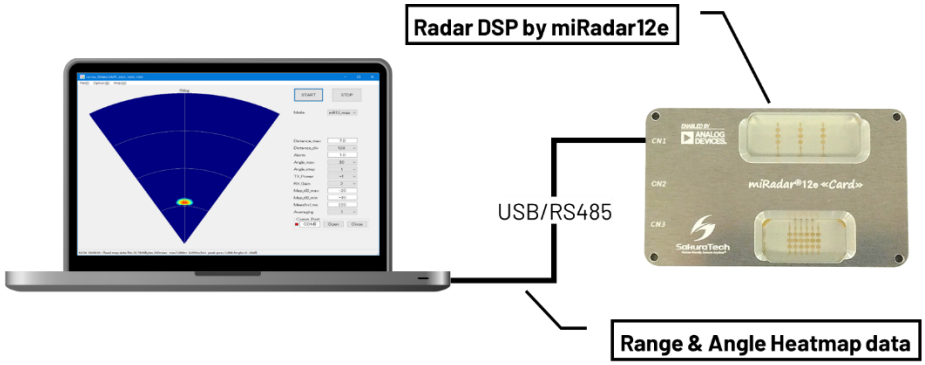


**Figure 5 On-board DSP mode**

## 9.2 Raw data mode:

- Outputs raw data as IF data with real-IF wave signals
- Allows users to develop custom radar signal processing algorithms based on the raw data.

The on-board DSP does not work and just bypasses raw data as FMCW IF waveform signals. You can develop own radar signal processing algorithm on the raw data.

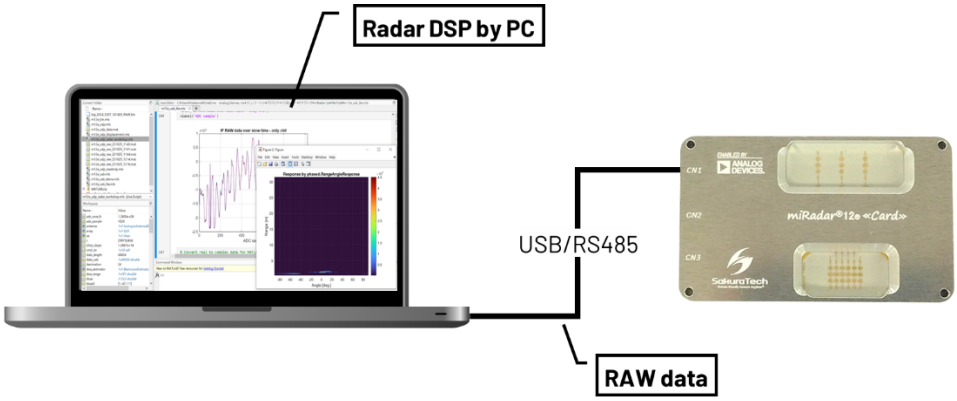


**Figure 6 RAW data mode**

### 9.3 For quick start evaluation:

SakuraTech provides reference application software with Graphical User Interface (GUI), which enables users to evaluate the sensor with various sensor configurations.

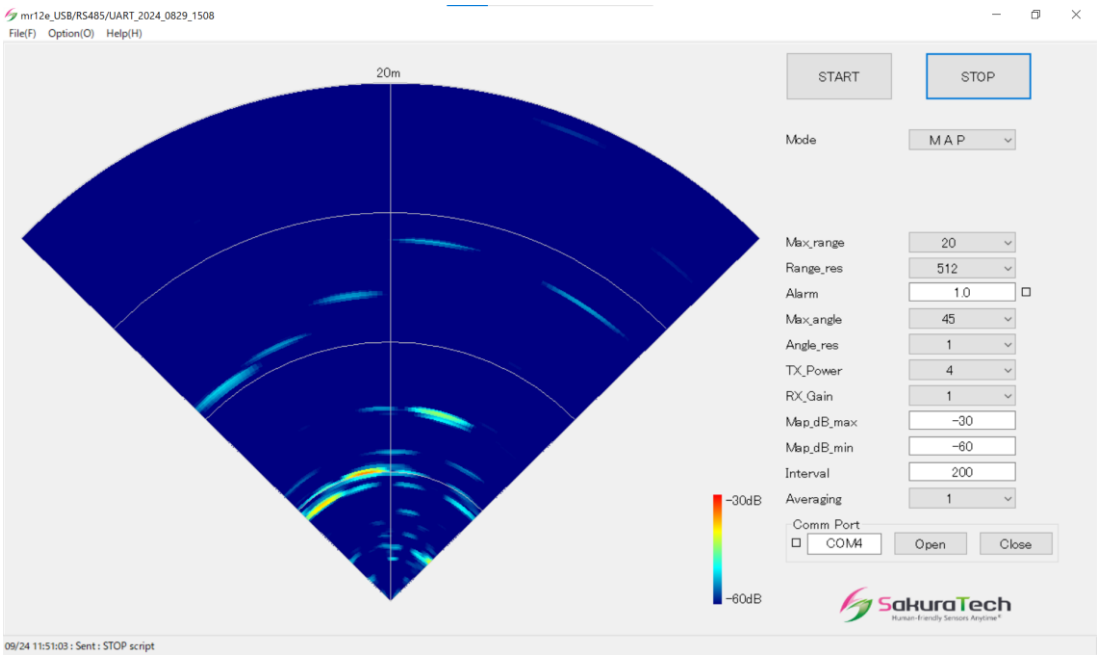


**Figure 7 SakuraTech *evaluation software GUI***

Others reference software is also available, and they can be shared on the request.

DLL (Windows): SakuraTech GUI application software uses the DLL, and you can develop proprietary application software with the DLL, where SakuraTech provides API specification.

MATLAB reference source code (Phase Array System Toolbox is required): MATLAB® is software suites by Mathworks, which is very useful tool for algorithm development.

## 10 ORDERING GUIDE

| Model # | Frequency | Interface | Case | Size (mm) | ADI Part # |
|---|---|---|---|---|---|
| B290-121 | 76-77 GHz | USB/RS485 | RF Shield | 92 x 55 x 10 | ADRP1121-01 |
| B290-111 | 77-81 GHz | USB/RS485 | RF Shield | 92 x 55 x 10 | ADRP1121-02 |