Index

miRadar12e/ADRP1121
Quick Start Guide

1. Hardware setup

The miRadar12e supports two host interfaces: USB (High Speed + Power Delivery) and RS485, with the option to select either interface.

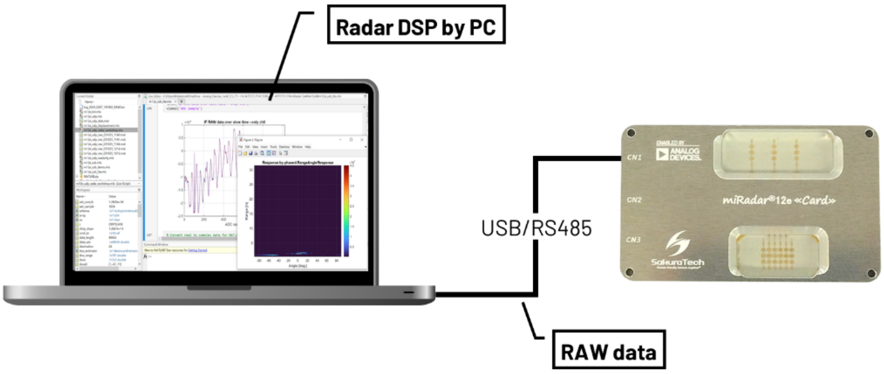


Figure 1. System setup.

1.1. USB interface

The USB interface supports both data communication and power supply via a USB-C connector. If your PC does not support USB-PD, you will need to use a USB-C PD injector to supply power to the miRadar12e.

Figure 2. Connecting miRadar12e by USB-C.

1.2. RS485 interface

For the RS485 interface, you need to prepare a +12V DC power supply and an RS485 cable assembly, as described in Figure 3. Additionally, a USB-to-RS485 converter is required to connect the sensor to a standard PC. You can also refer to the 'miRadar12 Datasheet' for the connector pin descriptions.

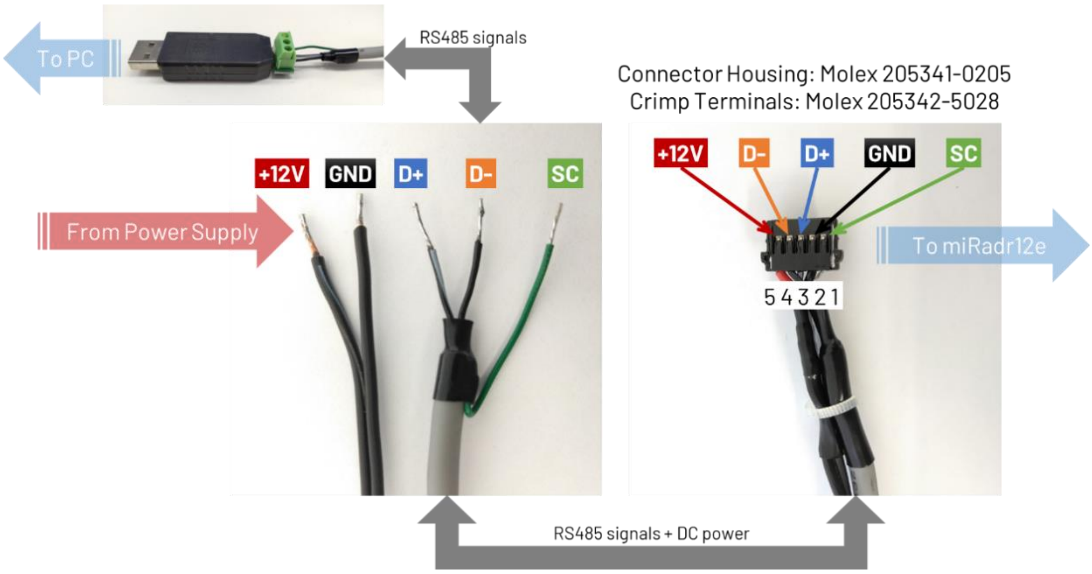


Figure 3. RS485 connections.

Alternatively, SakuraTech may provide an RS485 cable assembly as an optional product (part number: B290-OP05). You can inquire about the cable by contacting SakuraTech at info@sakuratech.jp.

2. Software setup

SakuraTech provides evaluation software with a graphical user interface (GUI) to quickly assess the miRadar12e. This software allows you to flexibly configure sensor parameters, capture sensor data, and visualize data plots, such as PPI scopes.

The GUI supports the following operating systems:

- Microsoft Windows 10 or 11 (both Pro and Home version)
- Ubuntu 20.04LTS or 22.04LTS

3. Installation guide

i. Download software from the link at https://sakuratech.jp/adi/.

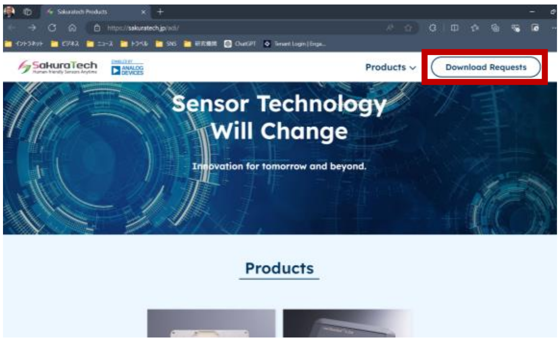


Figure 4. Software download page.

NOTE: The SakuraTech software download page is still under construction. For now, you can request the software from the ADI Japan team (as of September 25th, 2024).

ii. Extract "mr12e_RS485_2023_xxxx_xxxx.zip" file.

iii. Move to the extracted folder to proper directory.

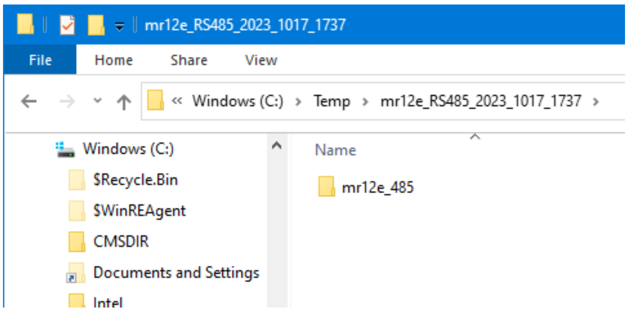


Figure 5. Extract folder.

iv. Run "mr12e.exe" file in the directory for extraction.

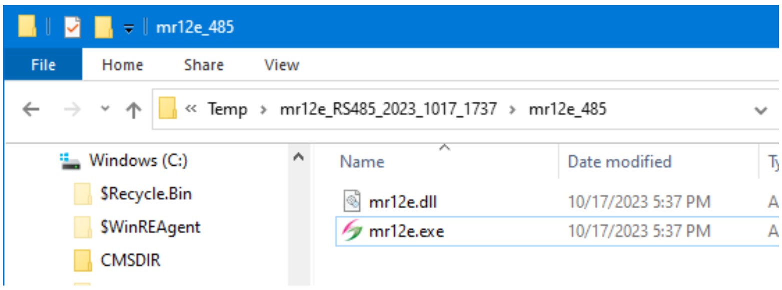


Figure 6. Application software "mr12e.exe" file.

v. Set proper COM port number.

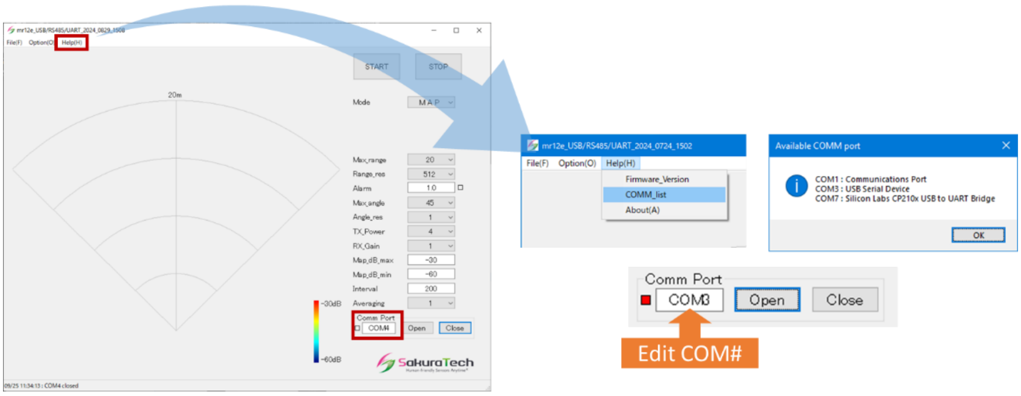


Figure 7. Set COM port.

If you are unsure of the correct serial port number, you can check it in the GUI by selecting the following options:

'Help' > 'Comm_list'

This will allow you to choose the appropriate COM port number. Once all settings are finalized, click the 'Open' button to connect your PC to the miRadar12e. If the connection is successfully established, a confirmation message will appear on the status bar at the bottom of the GUI, displaying the port number and baud rate.

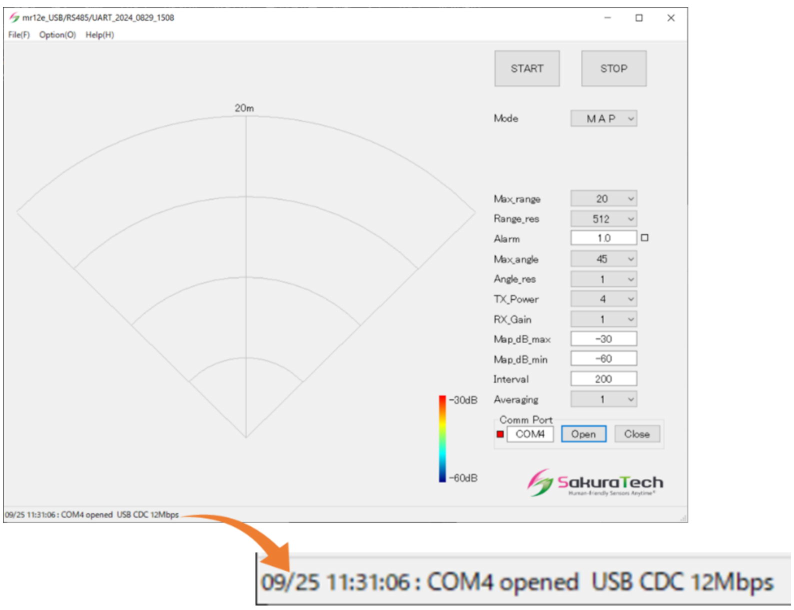


Figure 8. Establish connection.

vi. Push "Start" button for sensor measurement.

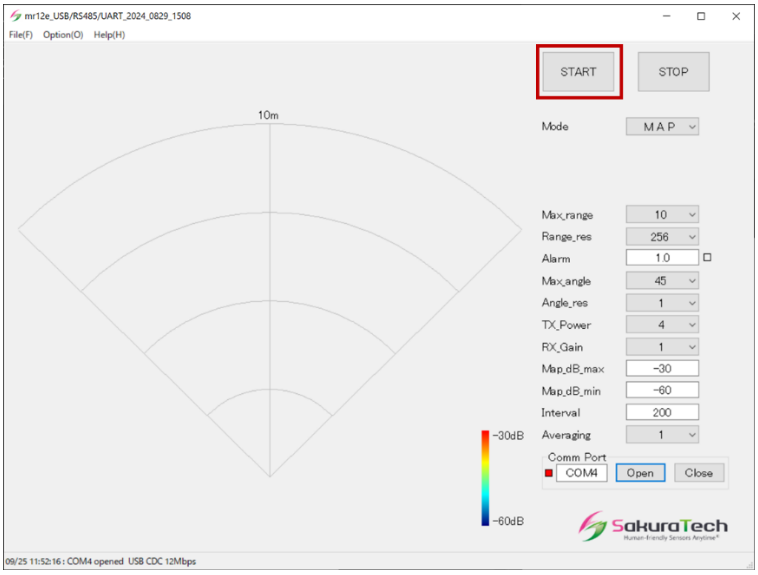


Figure 9. Measurement start.

4. Operation mode

The evaluation software GUI supports two operational modes: MAP mode and PPI mode.

4.1. MAP mode

MAP mode displays signal strength in terms of range and angle using a heatmap view.

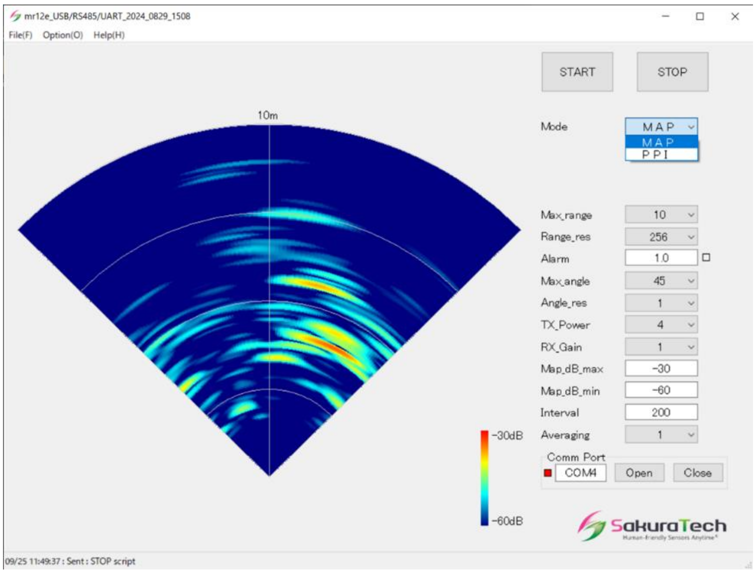


Figure 10. Map mode.

4.2. PPI mode

PPI mode displays the positions of targets detected by the miRadar12e, along with their moving directions: 'approach' (red), 'stillness' (green), and 'separation' (green).

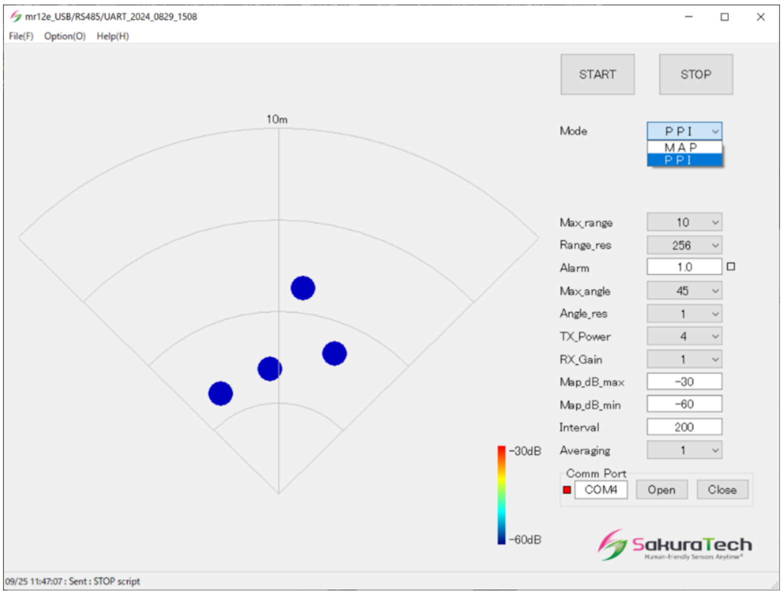


Figure 11. PPI mode.

A maximum of eight targets can be detected simultaneously, and you can select the desired number from the menu in the GUI.

"Option" >>> "PPI_Num_Plot"

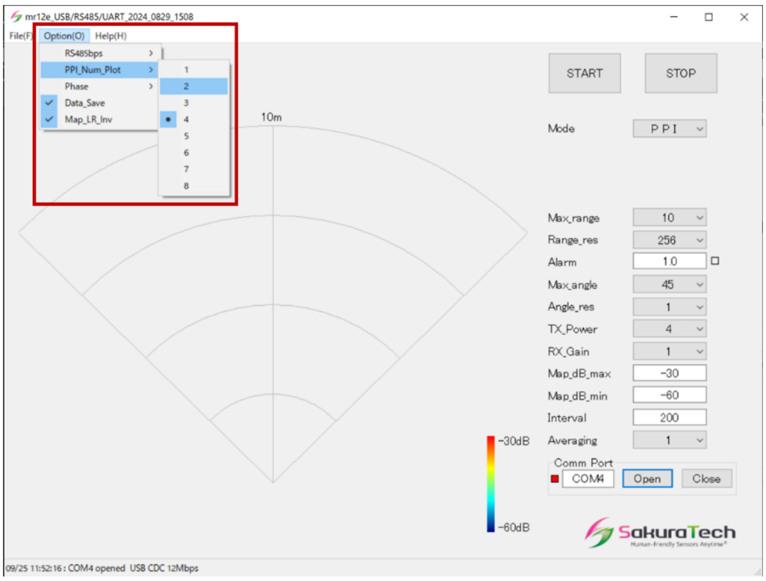


Figure 12. PPI mode – number of target detection.

Note: PPI mode calculates the moving directions (i.e., target velocity) of targets using data from four sequences*, where only phase change data are employed as a simplified method. For accurate velocity measurements, significantly more sequences are required, such as 64 sequences for the Doppler FFT method. Generally, the GUI software is designed for basic evaluation purposes.

*) "Sequence" definition is described in chapter 6.

5. Recommended settings

The miRadar12e supports highly flexible configurations, allowing you to set various radar parameters to your preference, despite their complexity. This section outlines the recommended settings and setup steps for MAP mode. For PPI mode settings, you should first configure the MAP mode parameters, after which you can proceed to set up the PPI mode, which is highly recommended.

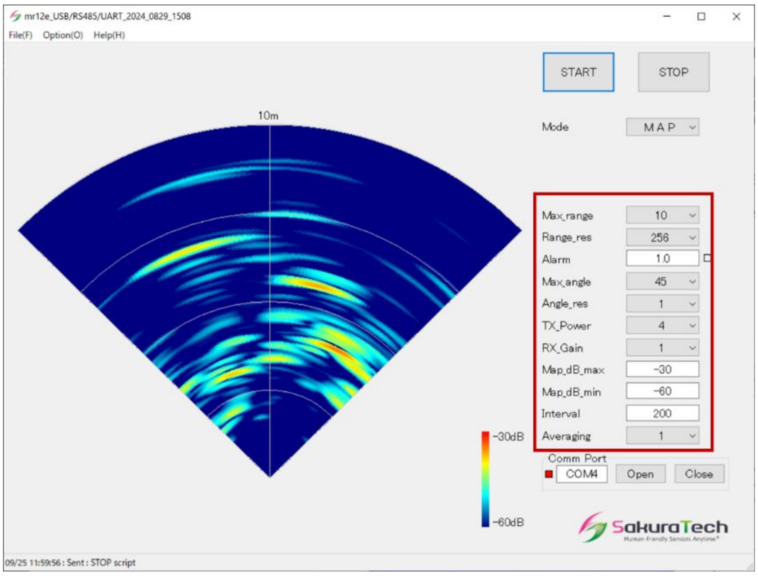


Figure 13. Parameter settings.

5.1. Range and resolution: "Max_range" and "Range_res"

"Max_range [m]" indicates the measurable maximum range (in meters), while "Range_res" refers to range resolution, also known as range bin. The evaluation GUI automatically calculates and sets the appropriate "Max_range" value based on the selected "Range_res." You can choose the "Range_res" value from the drop-down menu.

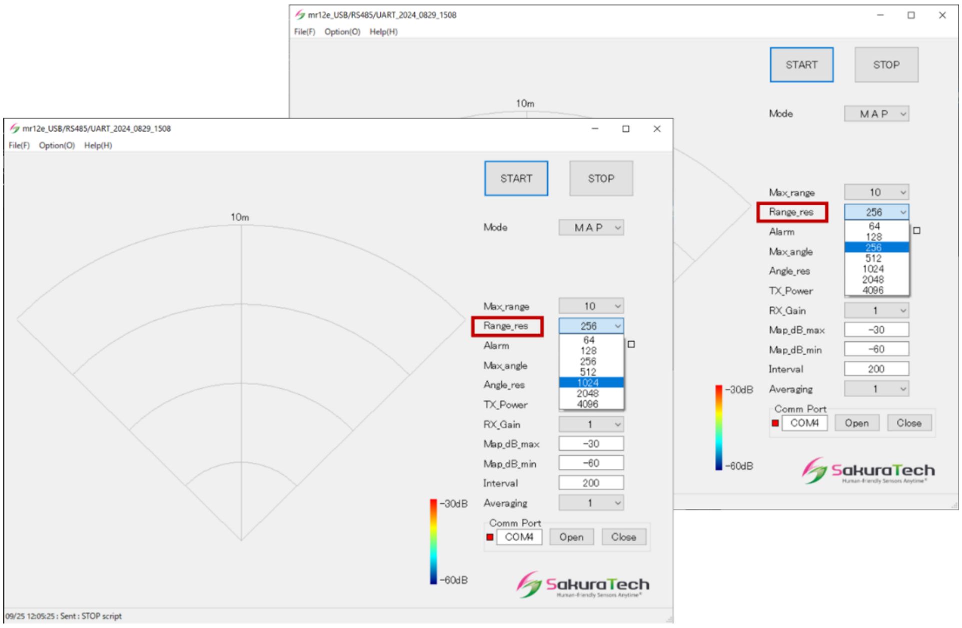


Figure 14. Range resolution settings.

"If you wish to set the "Max_range" manually, you can overwrite the value; however, the "Range_res" value will remain unchanged despite the modification of "Max_range." Please note that the "Range_res" value is generally more dominant than "Max_range" in terms of the settings. The contribution of these parameters can be determined using the following equation, where "c" is the speed of light and "S_{chirp}" is the chirp slope (i.e., Hz/sec). The GUI automatically sets the appropriate chirp slope (i.e., S_{chirp}) value based on the selected "Range_res" and "Max_range.

$$Distance\_max = \frac{Distance\_div \times c}{2 \times S_{chirp}}$$

Table 1 shows the reference combinations of "Range_res" and "Max_range," where the GUI sets the appropriate value when you adjust either the "Range_res" or the "Max_range.

Table 1. Range_res and Max_range.

Range_res		Max_range
76-77GHz	77-81GHz	
2048	4096	200
2048	4096	180
1024	2048	150
1024	2048	120

1024	2048	100
512	2048	80
512	1024	60
256	1024	50
256	1024	40
256	512	30
128	512	20
64	256	10
64	128	5
64	64	3

5.2. DoA (Direction of Arrival) angle

“Max_angle [degrees]” represents the maximum direction of arrival (DoA) angle, and you can set the “Max_angle” value using the drop-down menu.

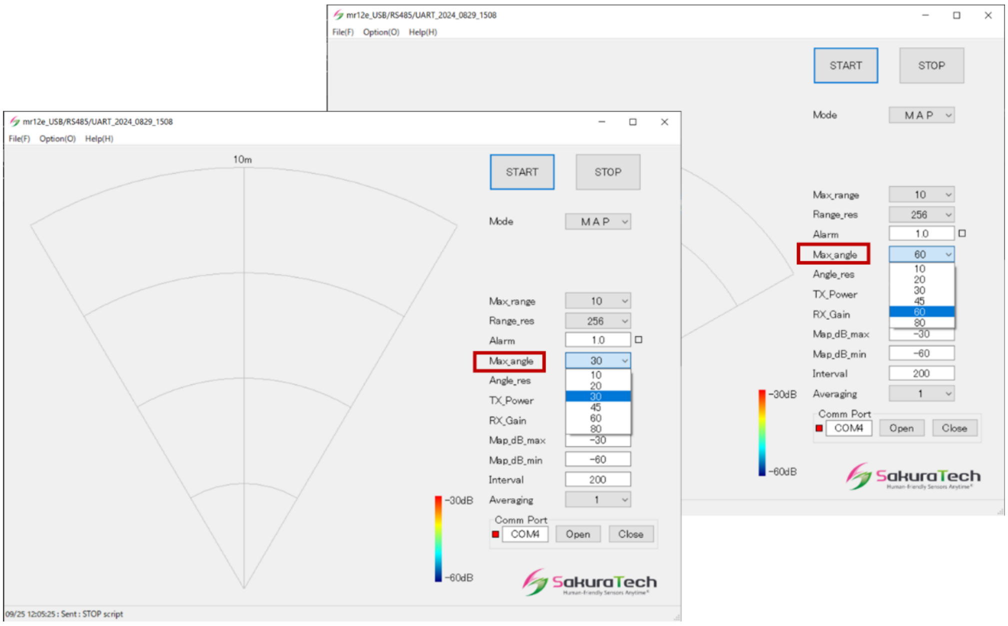


Figure 15. Angle and resolution settings.

"If you set the “Max_angle” to 30 degrees, the direction of arrival (DoA) angle range will be ±30 degrees. The “Angle_res” parameter determines the angle resolution. For example, if you set “Max_angle” to 30 and “Angle_res” to 1, the DoA will be estimated from -30 degrees to +30 degrees (with 0 degrees as the center) at 1-degree resolution. The miRadar12e always estimates the DoA at the center (0 degrees) and other DoA values at ±Angle_res × n (within the Max_angle). For instance, settings of

“Max_angle” = 10 and “Angle_res” = 10 will yield DoA estimates at -10 degrees, 0 degrees, and +10 degrees, resulting in three-point DoA measurements.

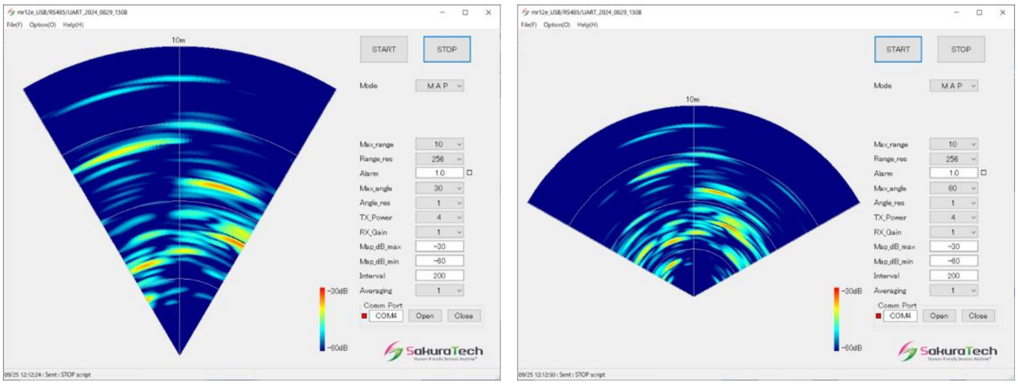


Figure 16. FoV (left ±30 deg.. right ±60 deg.).

Table 2. Angle FoV setting.

Max_angle [deg.]	Angle_res [deg.]	Angle FoV [deg.]
80	1,2,5,10	±80
60	1, 2, 5,10	±60
45	1, 2, 5,10	±45
30	1, 2, 5, 10	±30
20	1, 2, 5, 10	±20
10	1, 2, 5, 10	±10

5.3. Alarm (PPI mode only): Proximity sensor flag

This feature can function as a proximity sensor to detect objects approaching the sensor. The Alarm flag (red ramp in the GUI) will be activated when a detected target is within the alarm distance. You can set this value in meters, ensuring that the set value is less than “Max_range.

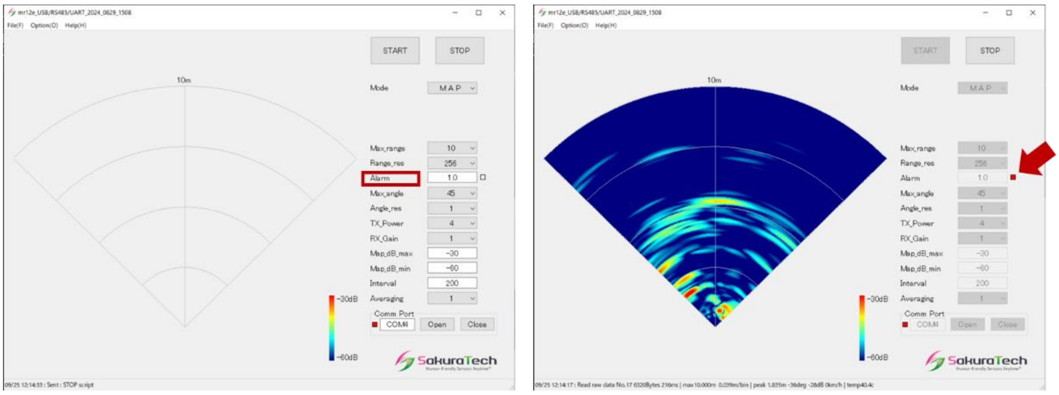


Figure 17. Proximity alarm setting.

5.4. TX_Power: Transmitter power

The value represents the transmit power in five steps, where 0 indicates the weakest power and 4 indicates the strongest power, represented by integer values. For reference, a value of 4 is used for Japanese unlicensed radio regulatory certification.

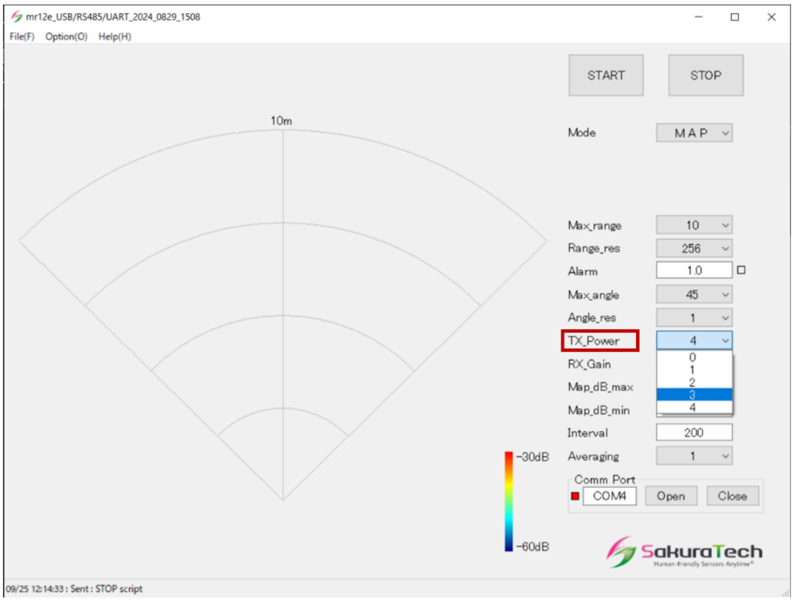


Figure 18. TX power setting.

5.5. RX_ Gain: Receiver gain

The value represents the receive gain in six steps, where 0 indicates the weakest gain and 5 indicates the strongest gain, represented by integer values.

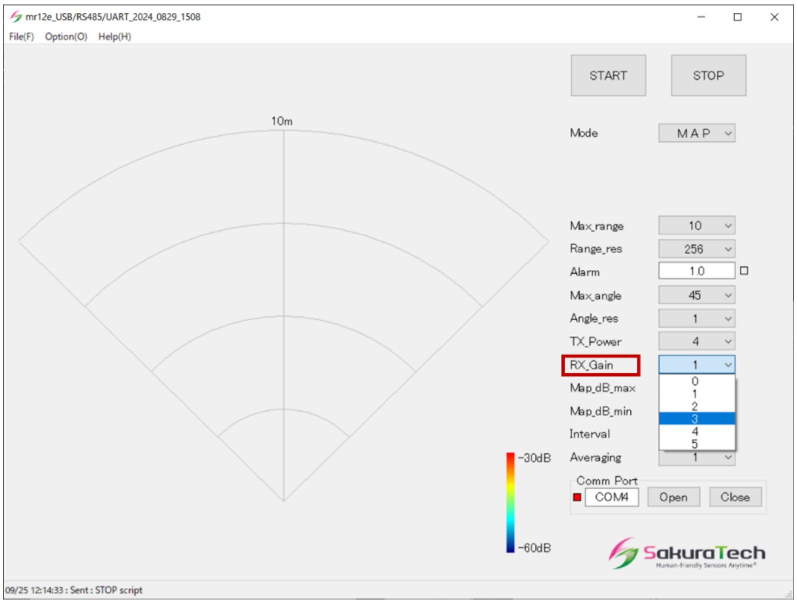


Figure 19. RX gain setting.

5.6. Measurement interval time

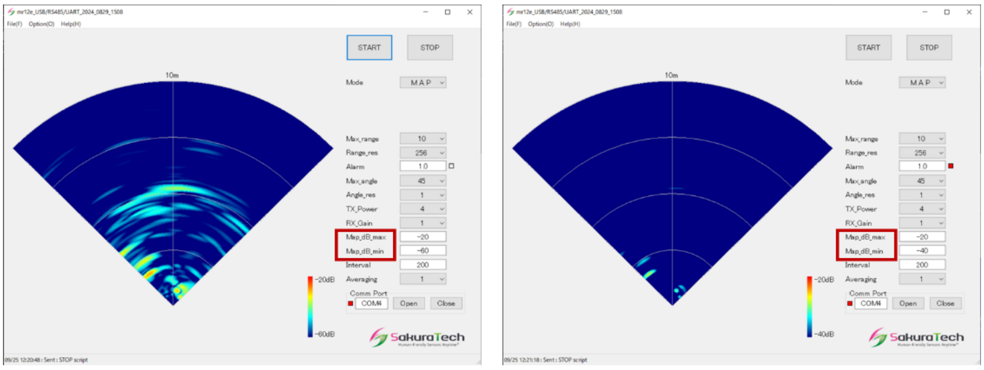
"MeasItvl_ms [msec]" represents the measurement interval time (in milliseconds) during the burst-to-burst period. The "MeasItvl_ms" is dependent on the settings for "Range_res" and "Angle_res," which is a trade-off as described in Table 3.

Table 3. Trade-off for measurement interval time.

	Range resolution	**Angle resolution**	**Measurement Interval Time**
Range_res	Larger "Range_res" makes higher resolution	N/A	Larger "Range_res" needs more interval times
Angle_res	N/A	Smaller "Angle_res" makes higher resolution	Smaller "Angle_res" needs more interval times

5.7. Heatmap threshold

The 'dB_Max' and 'dB_Min' represent the maximum and minimum heatmap thresholds used to create an accurate radar image with 256 resolutions. The full scale, ranging from 'dB_Max' to 'dB_Min,' must be within a 64 dB range.



Range: -60dB to -20dB Range: -40dB to -20dB

Figure 20. Heatmap threshold settings.

5.8. Averaging: Data averaging over time

The miRadar12e features an averaging function over the sample period to reduce unexpected noise, similar to low-pass filtering. A larger averaging number results in less noise and a more stable output; however, the response time will be slower due to the averaging process. The averaging number can be set from 1 to 8 using integer values.

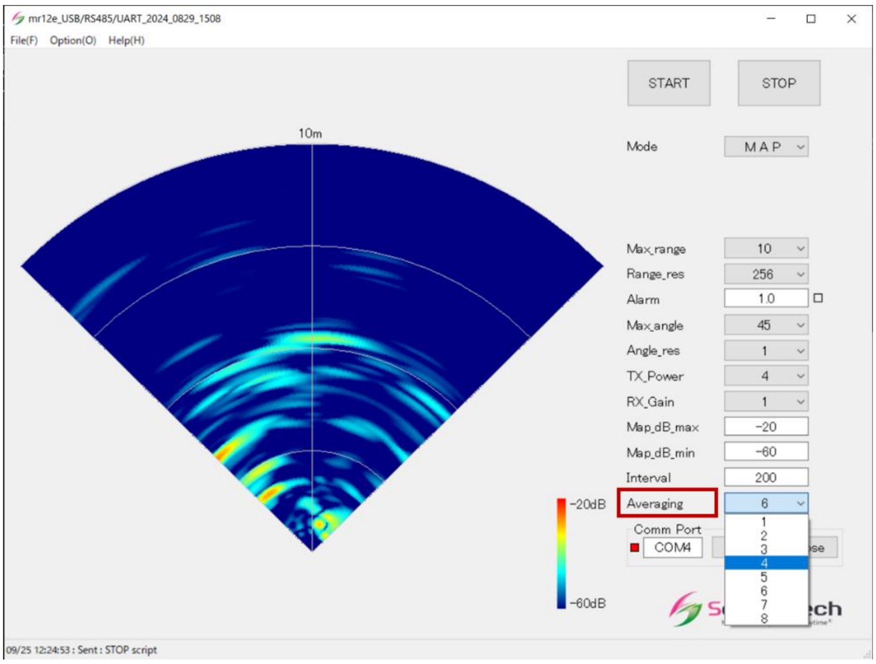


Figure 21. Data averaging setting.

6. Data throughput consideration

6.1. USB

The on-board radar DSP requires processing time to convert the raw data received into digital data output for the interface buffer.

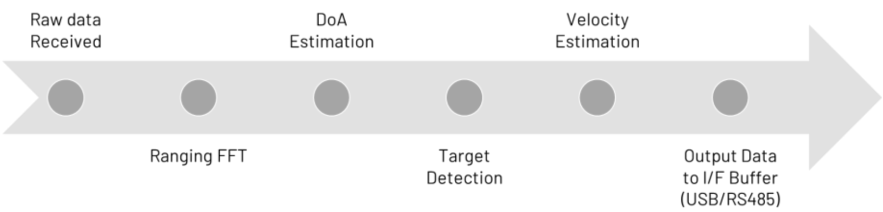


Figure 22. Processing steps by on-board radar DSP.

The process runs for each sequence, which consists of three TX and four RX data points, resulting in a total of twelve datasets for every sequence.

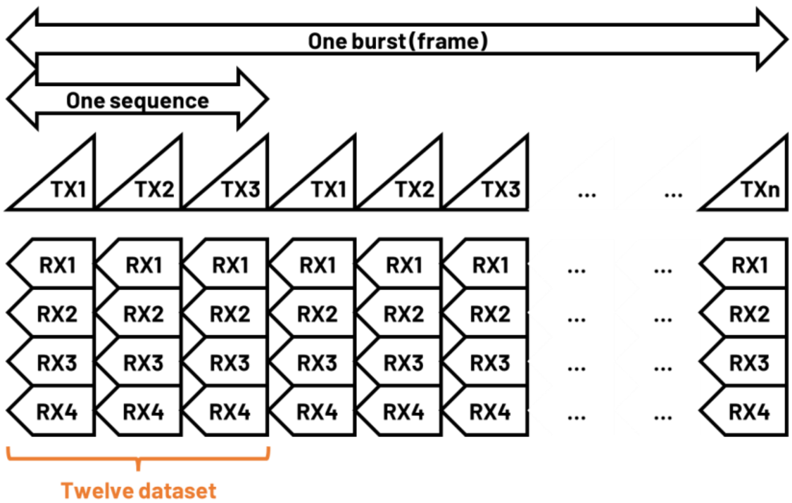


Figure 23. Sequence definition.

Reference processing times are detailed in the following tables, and you must set the 'MeasItvl_ms' value to be greater than the reference processing times. These processing times also depend on the specifications of the host PC, so you should adjust the value according to your system's performance.

Table 4. One-burst processing time [ms] - USB, on-board radar DSP, MAP mode.

AngleMax deg	AngleStep deg	Range_res						
		4096	2048	1024	512	256	128	64
80	1	11100	5550	2780	1390	720	360	180
80	2	5640	2820	1410	710	370	190	100
80	5	2420	1210	600	300	160	80	80
80	10	1350	680	340	170	90	80	80
60	1	8360	4180	2080	1040	540	270	140
60	2	4270	2140	1070	540	280	140	80
60	5	2000	1000	470	240	120	80	80
60	10	1080	540	260	130	80	80	80
45	1	6280	3140	1570	790	410	210	110
44	2	3400	1680	840	420	210	110	80
45	5	1500	750	370	190	100	80	80
50	10	940	470	230	120	80	80	80
30	1	4260	2130	1060	530	280	140	80
30	2	2260	1130	560	280	150	80	80
30	5	1070	540	270	140	80	80	80
30	10	680	340	170	90	80	80	80
20	1	2920	1460	720	360	190	100	80
20	2	1600	800	400	200	110	80	80
20	5	800	400	200	100	80	80	80
20	10	540	270	130	80	80	80	80
10	1	1590	800	390	200	100	80	80
10	2	930	470	230	120	80	80	80
10	5	550	280	140	80	80	80	80
10	10	410	210	110	80	80	80	80

Table 5. One-burst processing time [ms] - USB, on-board radar DSP, PPI mode.

AngleMax deg	AngleStep deg	Range_res						
		4096	2048	1024	512	256	128	64
80	1	11450	5730	2850	1430	730	370	190

80	2	6000	3000	1500	750	380	190	100
80	5	2900	1450	700	350	180	90	80
80	10	1800	900	440	220	120	80	80
60	1	8700	4350	2170	1090	550	280	140
60	2	4700	2350	1170	590	300	150	80
60	5	2350	1180	570	290	150	80	80
60	10	1600	800	370	190	110	80	80
45	1	6750	3380	1650	830	420	210	110
44	2	3600	1800	900	450	230	120	80
45	5	1950	980	470	240	130	80	80
50	10	1450	730	340	170	100	80	80
30	1	4700	2350	1150	580	290	150	80
30	2	2750	1380	660	330	170	90	80
30	5	1550	780	370	190	110	80	80
30	10	1150	580	280	140	80	80	80
20	1	3450	1730	820	410	210	110	80
20	2	2100	1050	500	250	130	80	80
20	5	1300	650	310	160	80	80	80
20	10	1020	510	240	120	80	80	80
10	1	2050	1030	500	250	130	80	80
10	2	1400	700	340	170	90	80	80
10	5	1000	500	270	140	80	80	80
10	10	890	450	210	110	80	80	80

In the case of RAW data mode, the on-board DSP simply bypasses data into the interface buffer without performing any radar signal processing.

Table 6. One-burst processing time [ms] - USB, raw data, MAP mode.

Range_res	4096	2048	1024	512	256	128	64
millisec	150	100	80	80	80	80	80

Table 7. One-burst processing time [μs] - USB, raw data, PPI mode.

Range_res	4096	2048	1024	512	256	128	64

ms	490	280	150	100	80	80	80

6.2. RS485

The RS485 data rate is lower than that of USB, resulting in increased processing times. The following examples are based on a baud rate of 921600 bps.

Table 8. One-burst processing time [ms] – RS485, on-board radar DSP, MAP mode.

AngleMax deg	AngleStep deg	Range_res						
		4096	2048	1024	512	256	128	64
80	1	18450	9230	4580	2290	1150	580	290
80	2	9340	4670	2310	1160	580	300	150
80	5	3870	1940	960	480	240	130	80
80	10	2050	1030	510	260	130	80	80
60	1	13840	6920	3440	1720	870	440	220
60	2	7030	3520	1750	880	440	220	110
60	5	2950	1480	730	370	190	100	80
60	10	1590	800	390	200	100	80	80
45	1	10500	5200	2600	1300	650	330	170
44	2	5200	2600	1350	700	350	180	100
45	5	2250	1120	570	280	150	80	80
50	10	1350	700	350	180	90	80	80
30	1	7000	3500	1750	870	440	220	120
30	2	3600	1800	900	450	250	120	80
30	5	1600	800	400	200	120	80	80
30	10	900	450	230	120	80	80	80
20	1	4680	2320	1160	580	290	150	80
20	2	2460	1220	610	300	160	80	80
20	5	1150	550	270	140	80	80	80
20	10	670	320	160	80	80	80	80
10	1	2440	1200	600	300	150	80	80
10	2	1330	660	330	170	90	80	80
10	5	670	320	160	80	80	80	80
10	10	440	210	110	80	80	80	80

Table 9. One-burst processing time [μs] – RS485, on-board radar DSP, PPI mode.

AngleMax deg	AngleStep deg	Range_res						
		4096	2048	1024	512	256	128	64
80	1	11450	5730	2850	1430	730	370	190
80	2	6000	3000	1500	750	380	190	100
80	5	2900	1450	700	350	180	90	80
80	10	1800	900	440	220	120	80	80
60	1	8700	4350	2170	1090	550	280	140
60	2	4700	2350	1170	590	300	150	80
60	5	2350	1180	570	290	150	80	80
60	10	1600	800	370	190	110	80	80
45	1	6750	3380	1650	830	420	210	110
44	2	3600	1800	900	450	230	120	80
45	5	1950	980	470	240	130	80	80
50	10	1450	730	340	170	100	80	80
30	1	4700	2350	1150	580	290	150	80
30	2	2750	1380	660	330	170	90	80
30	5	1550	780	370	190	110	80	80
30	10	1150	580	280	140	80	80	80
20	1	3450	1730	820	410	210	110	80
20	2	2100	1050	500	250	130	80	80
20	5	1300	650	310	160	80	80	80
20	10	1020	510	240	120	80	80	80
10	1	2050	1030	500	250	130	80	80
10	2	1400	700	340	170	90	80	80
10	5	1000	500	270	140	80	80	80
10	10	890	450	210	110	80	80	80

In RAW data mode, the on-board DSP simply bypasses data into the interface buffer without performing any radar signal processing.

Table 10. One-burst processing time [μs] – RS485, raw data, MAP mode.

Range_res	4096	2048	1024	512	256	128	64

ms	1200	600	350	250	200	200	200

Table 11. One-burst processing time [μs] – RS485, raw data, PPI mode RS485 Raw data.

Range_res	4096	2048	1024	512	256	128	64
ms	4400	2200	1200	600	380	380	380

7. Antenna definition

7.1. Spacing channel data and array position

The antenna coordinates on the sensor are specified in the following image.

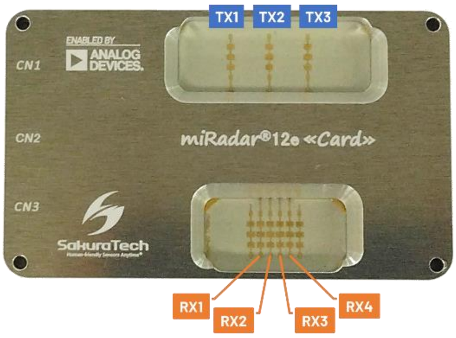


Figure 24. Physical antenna channel specification.

The miRadar12e features three transmitters and four receivers, resulting in a 12-element virtual array of channels.

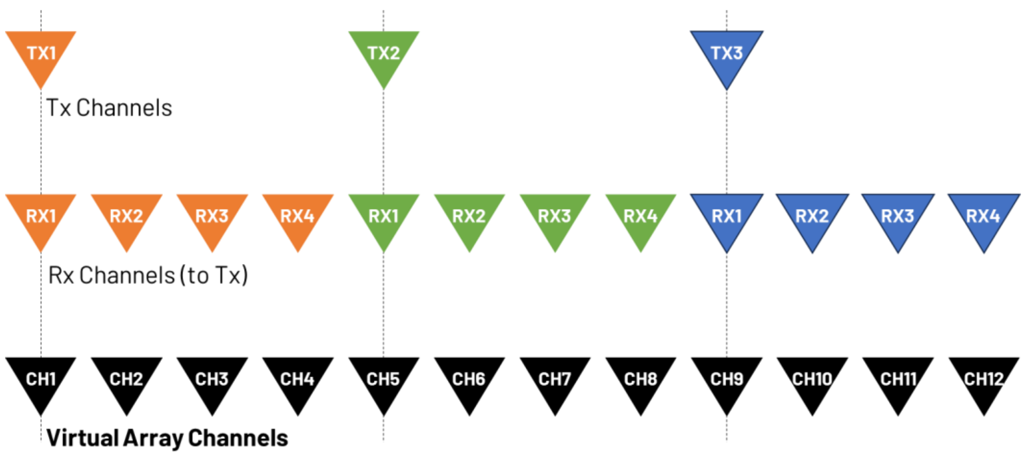


Figure 25. Virtual array specification.

7.2. Antenna specification

The specifications for a single antenna element are described in the following plots, which are based on simulated results.

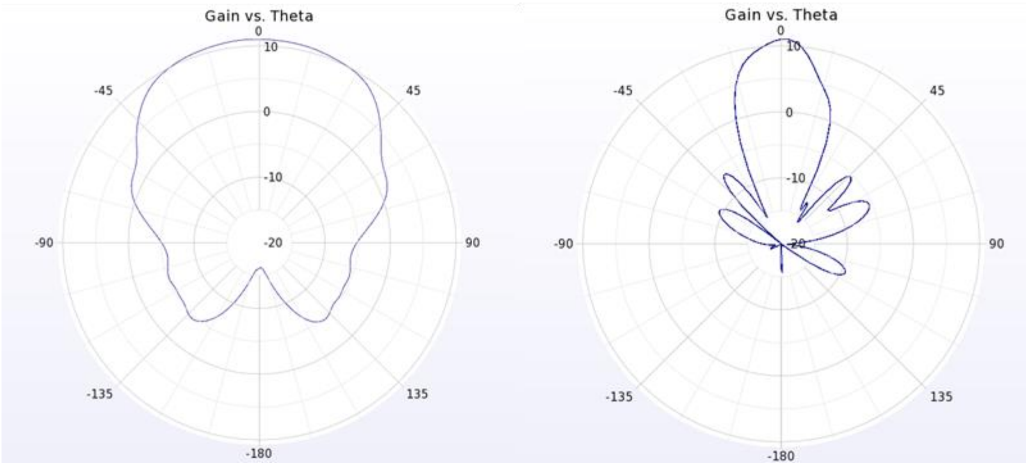


Figure 26. Azimuth (left) and Elevation (right).

8. Saved data

"The GUI saves sensor data in either CSV or BIN (binary) format for user data analysis. If the on-board DSP mode is used, the data is saved in either MAP CSV or PPI CSV format, which have different data structures. Only when you set the raw data mode is the data saved in BIN format. The binary data consists of raw ADC data for twelve channels, allowing you to develop signal processing software for further data processing.

You can enable or disable this feature via the GUI menu using the following options:

"Option" >>> "Data_Save"

Then, you can select either CSV or BIN format using the following options:

"Help" >>> "RAW" >>> "CSV_Save.

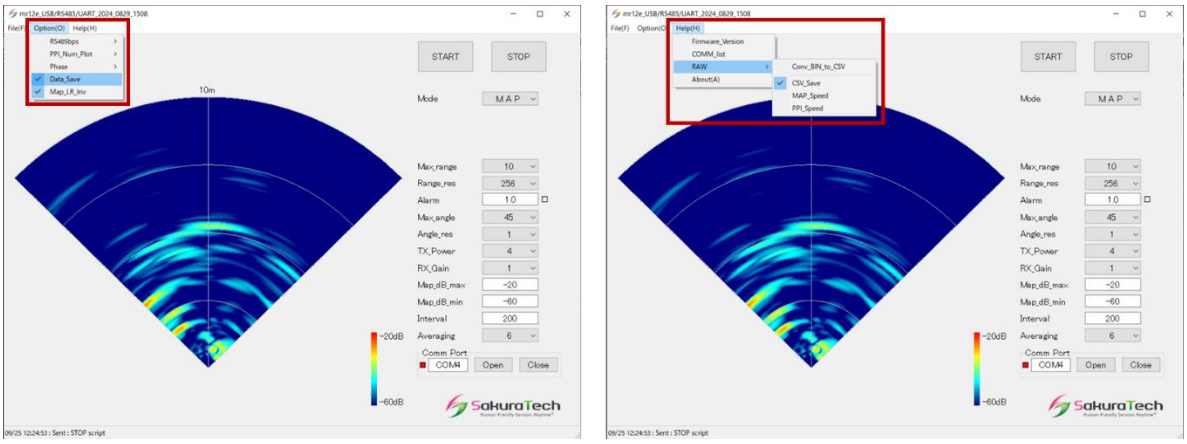


Figure 27. Save sensor data.

The miRadar12 GUI allows sensor data to be saved in either BIN (binary) or CSV format. By default, the BIN format is selected when using RAW data mode. Saving sensor data in CSV format can place a significant load on your PC, which may vary depending on your system specifications. Therefore, it is recommended to use the BIN format, which is the default setting. Additionally, the GUI software includes a format converter that allows you to convert BIN files to CSV.

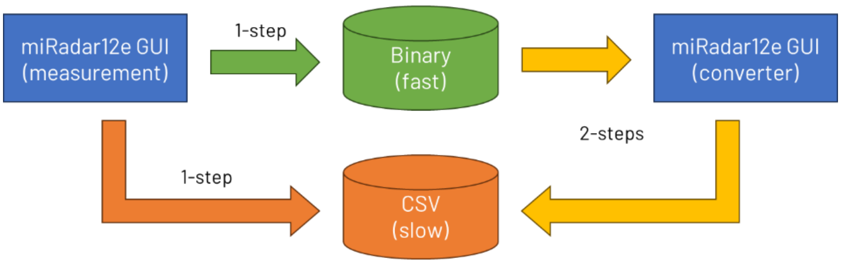


Figure 28. Saving sensor data by GUI.

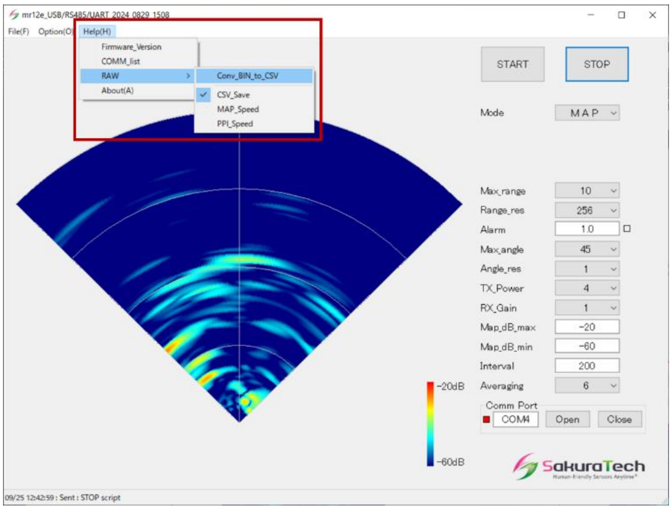


Figure 29. Converting BIN data to CSV format

8.1. Map CSV file

MAP mode generates a CSV data file in the format described by Figure 30. The first row contains header data, which includes sensor parameters. The subsequent rows consist of echo power data organized by angle and range, resembling point cloud data. Within each data block, the number of rows corresponds to the "Angle_div," and the number of columns corresponds to the "Distance_div." Following each data block, there are three rows of blank data before the next data block begins.

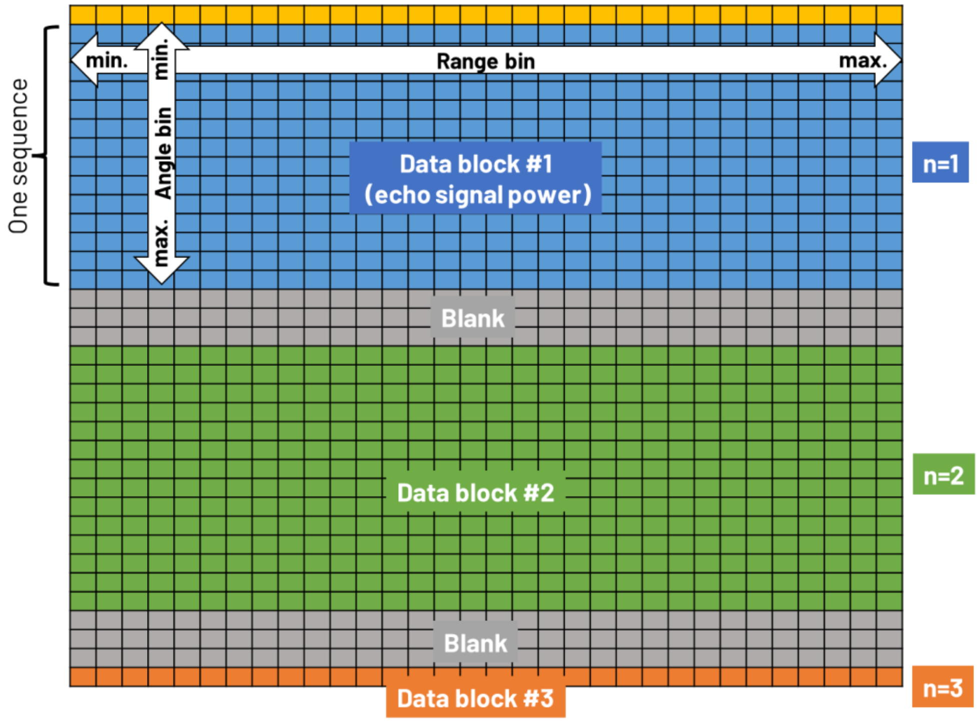


Figure 30. CSV data format by MAP mode.

The header data in the first row consists of the setting parameters. The GUI outputs only one position data point with the strongest echo signal, which is located in the first three columns (i.e., R1C1 to R1C3).

Table 12. Header format at MAP Mode.

ROW#COL#	Example value	Example data
R1C1	Distance for strongest target [mm]	3515
R1C2	Angle for strongest target [deg.]	19
R1C3	Echo power for strongest target [dB]	-34
R1C4	ID (fixed string)	MAP
R1C5	N/A (internal parameter)	2
R1C6	Max_range [mm]	5000
R1C7	Distance_min [mm]	100
R1C8	Alarm distance [mm]	1000
R1C9	Range_res	128
R1C10	Max_angle [deg.]	45
R1C11	Angle_div	1

R1C12	TX_Power	2
R1C13	RX_Gain	2
R1C14	Map_dB_min	-60
R1C15	MeasItvl_ms	200
R1C16	Year	2024
R1C17	Month	8
R1C18	Day	7
R1C19	Hour	12
R1C20	Minute	48
R1C21	Second	54

If you enable the color heatmap for the data block in the CSV file, you can obtain an image similar to the GUI MAP plot. Figure 30 shows a heatmap example generated from the MAP CSV file using Microsoft Excel.

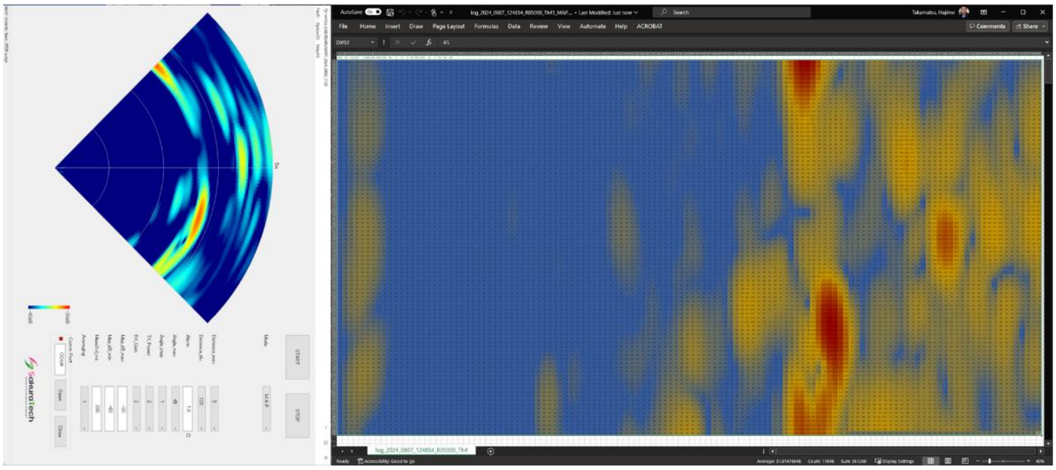


Figure 31. Heatmap example with MAP CSV file.

8.2. PPI CSV file

PPI mode generates a CSV data file in the format described by Figure 32. The first row contains header data, which includes sensor parameters, similar to MAP mode. The subsequent rows consist of individual target position data organized into four columns: distance [m], angle [deg.], speed [km/h], and received echo power [dB]. If a target is moving towards the sensor, the speed will be represented as a negative value. The GUI can detect a maximum of eight targets in parallel, and each row of data may contain up to eight datasets

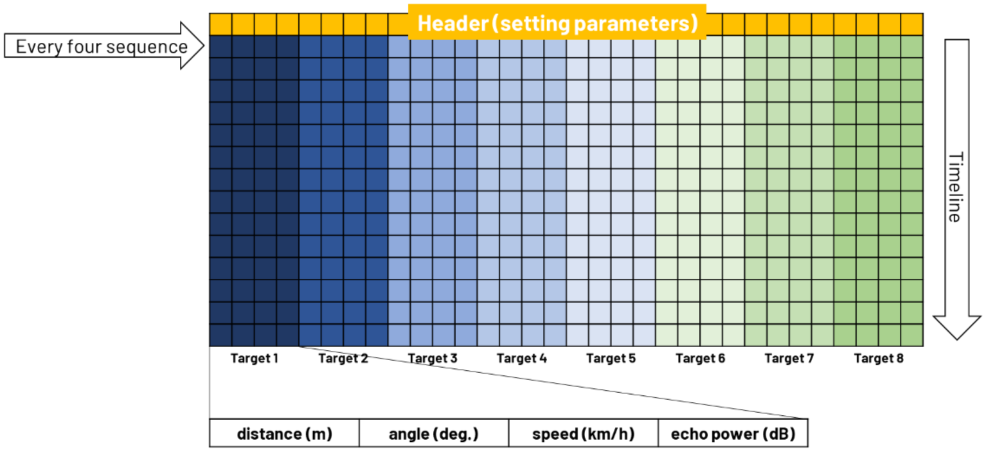


Figure 32. CSV data format by PPI mode.

The header data in the first row contains the setting parameters.

Table 13. Header format at MAP Mode.

ROW#COL#	Example value	Example data
R1C1	File ID (fixed string)	PPI
R1C2	N/A (internal parameter)	2
R1C3	Max_range [mm]	20000
R1C4	Distance_min [mm]	100
R1C5	Alarm distance [mm]	1000
R1C6	Range_res	512
R1C7	Max_angle [deg.]	60
R1C8	Angle_div	2
R1C9	TX_Power	2
R1C10	RX_Gain	2
R1C11	Map_dB_min	-60
R1C12	MeasItvl_ms	200
R1C13	Year	2024
R1C14	Month	8
R1C15	Day	7
R1C16	Hour	10
R1C17	Minute	47
R1C18	Second	14

8.3. Binary file

The evaluation software GUI allows you to save RAW data in a binary format file. You will need your own radar algorithm software to process this RAW data. This document does not cover this topic; for assistance with handling binary format, please contact the product support team. To work with binary data, you should prepare the following items:

- Radar signal processing software (e.g., Python, MATLAB, etc.)
- The command user guide for the miRadar12e