



TOKYO DEVICES

IWS520-USB

USB General Purpose Ultrasonic Distance Meter (Distance Sensor)

Revision 1.0



The Tokyo Devices IWS520-USB is an ultrasonic distance sensor that measures the distance to objects in front of it, ranging from approximately 0.3 m to 5 m. With USB connectivity, the sensor's sensitivity can be finely adjusted from a computer, allowing for features such as ignoring reflection noise from small objects nearby. Additionally, free and easy-to-use development software is provided, making it simple to integrate into custom systems and applications.

Applications include stationary observation, security, robotics, welfare and caregiving systems, and marketing measurement systems, making it suitable for a wide range of fields.

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1. Specifications

Item	Value
Power Voltage	5V ± 10% (USB bus-powered)
Current Consumption	20mA typ. (varies with detection interval)
Measurement Method	Ultrasonic Echo
Measurement Frequency	40,000Hz (± 400Hz)
Detection Angle	50 degrees (-10dB)
Measurement Range	0.3 to 5m ¹ Adjustable (ultrasonic emission time and masking distance can be set arbitrarily)
Resolution	Approx. 1cm (25°C)
Measurement Interval	Arbitrarily settable, minimum 0.1 seconds
Control Interface	USB 1.1 HID Device
Supported OS	Windows 7, 8.1, 10 or later (32-bit/64-bit) Linux

1. Applies to objects with hard and smooth surfaces. Performance may vary based on the material or composition of the object.

2. Features

- **Sensitivity Adjustment:** Can flexibly adapt to various environments, such as ignoring obstacles in the foreground.
- **Extensibility:** Free software makes integration into custom applications simple.
- **Standard HID Device:** Powered directly via USB, eliminating the need for batteries or adapters. No driver software required.

3. Tutorial

First, connect the IWS520-USB to your PC's USB port.

The IWS520-USB is controlled by the dedicated software, "iws520ctl."

1. Download "iws520ctl" from Tokyo Devices' website. Search for "IWS520" and access the product page for IWS520-USB. → <https://en.tokyodevices.com/>
2. For Windows, after downloading and extracting the iws520ctl files, place the executable in any location. For Linux, compilation is required. Extract the files, then compile and configure the software according to the README instructions (Tokyo Devices does not provide support for Linux operations or compilation).
3. The "iws520ctl" program operates via the command line. In Windows, launch the Command Prompt. Note that since this program does not have a graphical user interface, double-clicking the iws520ctl icon will not display anything.
4. After launching the Command Prompt, change the current directory to the one containing the iws520ctl command. Then, execute the command as follows:

```
> iws520ctl MEASURE ANY 3 1000 340.29 16 0.3
1.90,318,24
1.90,318,21
1.20,318,23
```

If you see output like above, with three measurements (lines) roughly every second, the program is functioning correctly.

4. Sensitivity Adjustment

In ultrasonic distance measurement applications, sensitivity adjustment is essential. The IWS520-USB is designed with a robust sensitivity adjustment feature, prioritizing versatility to accommodate a wide range of scenarios. Adjusting sensitivity requires an understanding of the principles of ultrasonic distance measurement and sound wave reflection.

4.1. Principles of Ultrasonic Distance Measurement

The IWS520-USB measures the distance to an object by emitting a very short ultrasonic pulse (40 kHz) and timing how long it takes for the reflected sound (echo) to return. Since the speed of sound is constant at approximately 340 meters per second at room temperature, the distance can be calculated once the time taken for the echo to return is known. For example, if the echo is detected 10 milliseconds after emission, the one-way travel time is 5 milliseconds. The distance the sound wave travels in 5 milliseconds is: $340(\text{m/s}) \times 0.005(\text{s}) = 1.7\text{m}$. So, the object is 1.7 meters away.

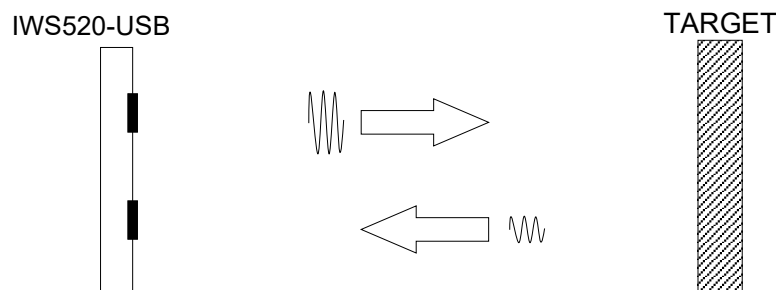


Figure 1 Principle of Ultrasonic Distance Measurement

Figure 2 shows the waveform from the emission of a pulse to the receipt of the reflected signal. The horizontal axis represents 1 millisecond per division. In Figure 2, immediately after the pulse is emitted, significant amplitude due to direct waves and echoes can be observed. This is caused by vibrations within the device itself, which typically last for about 1 millisecond.

After this initial period, a reflection from an object directly in front is detected 4 milliseconds after the pulse is emitted. This means the round-trip travel time is 4 milliseconds, so the one-way travel time is 2 milliseconds. Thus, the distance to the object can be calculated as: $340(\text{m/s}) \times 0.002(\text{s}) = 0.68\text{m}$

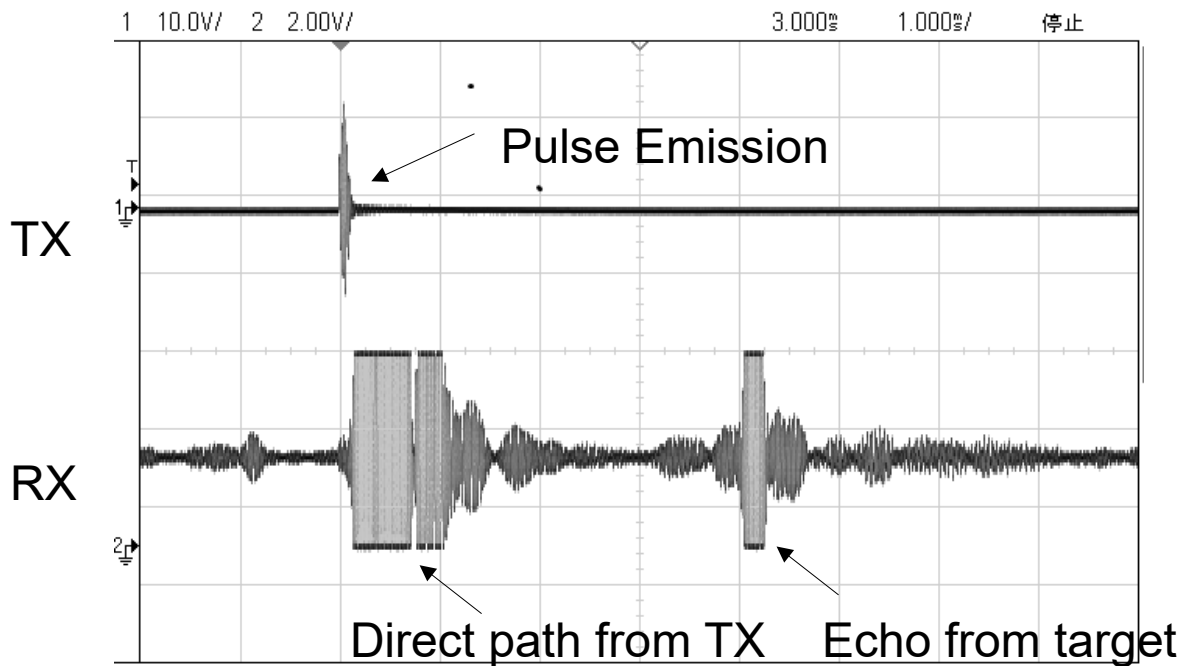
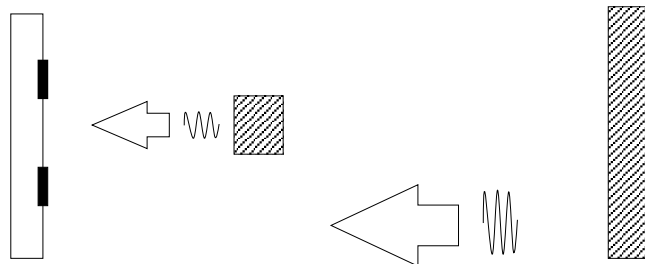


Figure 2 Example of Ultrasonic Pulse and Reflected Wave

4.2. Need for Sensitivity Adjustment

In an open space where only the target object exists, a single, distinct echo is observed for each emission. However, in practice, various surrounding objects reflect sound waves. For instance, suppose a small object is located in front of a wall. In that case, a weak echo will first return from the small object, followed by a stronger echo from the distant wall.



If the application requires measuring the nearby object, it's ideal to respond to the close-range echo. Conversely, if the application focuses on the distant wall, it's best to ignore the echo from the nearer object.

The IWS520-USB adjusts sensitivity using two parameters: **emission length** and **masking distance**.

4.3. Emission Length

The emission length refers to the duration of the ultrasonic pulse. A longer emission time provides more acoustic energy to the air (resulting in a louder sound), allowing echoes from more distant objects to be detected. Consequently, the maximum measurable distance increases. However, this also means that larger echoes will be returned from small objects nearby, making the sensor more sensitive to close or surrounding objects.

In contrast, reducing the emission length prevents the sound waves from reaching distant objects, thereby shortening the maximum measurable distance. However, this also reduces sensitivity to surrounding objects.

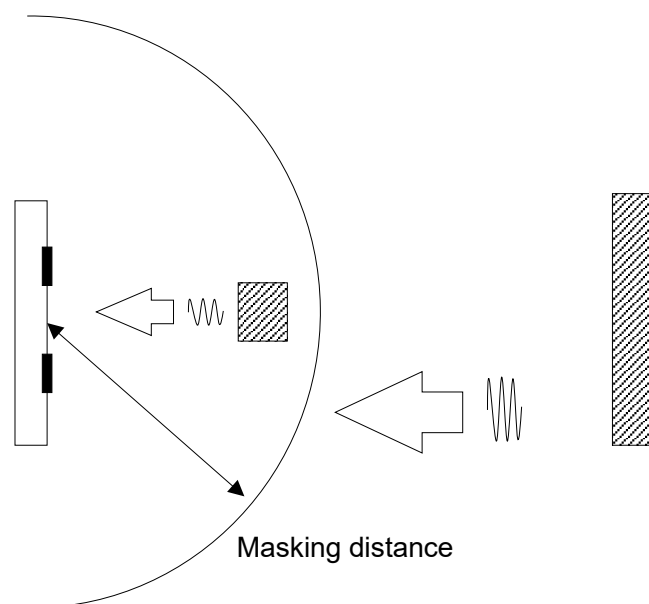
Generally, increasing the emission length is not a problem in environments with little obstruction and clear visibility. For instance, if you aim to measure objects 3-4 meters away in a spacious area, try an emission length of about 30-100 clock cycles. Conversely, in narrower spaces or when only measuring in a range of 0.5-1.5 meters, where detecting farther objects is unnecessary, try an emission length of about 10-20 clock cycles.

If you need to increase the emission length to detect distant objects despite various obstacles near the sensor, you will need to configure the "masking distance," which will be explained in the next section.

4.4. Masking Distance

As previously mentioned, when using a longer emission length for stronger sound waves, echoes will also return from small, nearby objects, making it challenging to measure the distance to distant objects accurately.

By setting the masking distance, the sensor can ignore echoes from objects within a specified range and only measure echoes from objects beyond that range.



For instance, if it's known that the target object is more than 2 meters away from the sensor, setting the masking distance to 2 meters will exclude the influence of smaller objects within 2 meters.

Note that the masking distance should generally be set to at least 0.3 to 0.5 meters. If set too short, the sensor will respond to its own ultrasonic emissions, preventing accurate measurements. The minimum masking distance required depends on the emission length; a longer emission length necessitates a longer minimum masking distance.

5. How to Use the Control Software iws520ctl

The iws520ctl command-line arguments are as follows. All arguments are mandatory and cannot be omitted:

```
iws520ctl MEASURE [serial number] [measurement count] [measurement interval] [speed of sound] [emission length] [masking distance]
```

Table 1 iws520ctl Command Argument Specifications

Option Name	Value	Description
	MEASURE	A fixed string to instruct the command to measure. Must be uppercase and cannot be lowercase.
Serial Number	Serial number or ANY	Specifies the serial number of the target IWS520-USB. When connecting multiple devices, this field is used. If only one device is connected to the computer, you can specify ANY in uppercase to use the device without explicitly providing the serial number.
Measurement Count	Non-negative integer	Specifies the number of measurements to be taken as a positive integer. After the specified count is completed, the command will exit. If 0 is specified, it will continue measuring indefinitely. To stop, kill the process or press Ctrl + C on the command line.
Measurement Interval	Integer ≥ 100	Specifies the waiting time between the completion of one measurement and the start of the next. The unit is milliseconds. If less than 100 is specified, it will function as if 100 were specified.
Speed of Sound	Positive real number	Specifies the speed of sound in m/s (meters per second). For room temperature, set this to 340.29. Adjusting this value according to the temperature can help reduce measurement errors.
Emission Length	Integer (range: 8-188)	Specifies the duration of ultrasonic emission.
Masking Distance	Real number (range: 0.0-5.0)	Specifies the distance to be excluded from measurement in meters. Note that there is a minimum value that must be set. Refer to "Masking Distance" for details.

Command Example)

```
> iws520ctl MEASURE ANY 3 1000 340.29 16 0.3  
1.90,318,24
```



```
1.90,318,21
```

```
1.20,318,23
```

The command above performs three distance measurements. The interval between measurements is 1 second. The speed of sound used for distance calculation is set to 340.29 m/s. The ultrasonic emission length is set to 16 clock cycles (approximately 85 microseconds), and the masking distance is 0.3 meters.

As a result, the three measurements of 1.90 m, 1.90 m, and 1.20 m are output at roughly 1-second intervals, along with a temperature-related value of 318. The noise level ranges from 21 to 24. Details of the output information are discussed in the following section.

5.1. Output Format

For each measurement, `iws520ctl` outputs one line of text to the standard output. The output format is as follows:

```
(distance),(temperature sensor value),(noise level value)[newline]
```

Example) **1.282,280,25**

Table 2 Output Field Specifications

#	Field Name	Description
1	Distance	The distance in meters.
2	Temperature Sensor Value	The value of the temperature sensor. Refer to the temperature sensor section for details.
3	Noise Level Value	The noise level value. Refer to the noise level section for details.

In case of a communication error, such as when the USB device is removed, the distance field will show "ERR". During such errors, the temperature sensor and noise level fields will be empty.

If the distance is out of the measurement range, the distance field will display "OOR" (Out Of Range). In this case, the temperature sensor and noise level values will still be output.

5.1.1. Temperature Sensor

The IWS520-USB is equipped with an internal temperature sensor. The second element in the `iws520ctl` output is a value related to temperature. By using this value to adjust the speed of sound parameter in `iws520ctl`, the accuracy of distance measurements can be improved. The temperature sensor output reflects readings from a diode whose voltage varies with temperature and is not directly represented in Celsius or Fahrenheit. Table 3 provides approximate representative values. Conversion to temperature should be handled within your application program.

Table 3 Representative Values for the Temperature Sensor

Temperature	-40°C	+25°C	+85°C
Value	230	300	370

Since each temperature sensor has different offsets and gains, an error of $\pm 10^{\circ}\text{C}$ may occur. To enhance accuracy, calibrate the offset and gain using a thermostatic chamber, deriving values from two suitable temperature points.

5.1.2. Noise Level

The noise level is a comprehensive measurement of both electrical and environmental acoustic noise. The IWS520-USB typically measures in the 20-30 range. If the value is abnormally high, accurate distance measurement might not be possible. Sources of noise may include USB port interference, external noise, or surrounding acoustic disturbances. If the noise level is high, consider changing the location of measurement or the computer used.

5.2. Controlling Multiple Units

A single computer can connect to multiple IWS520-USB devices simultaneously. Each IWS520-USB is programmed with a unique serial number at the time of shipping. To retrieve the serial numbers of the connected devices, use the "LIST" option of the `iws520ctl` command. This option outputs one serial number per line for each detected IWS520.

Command Example:

```
> iws520ctl LIST
123456789
234567890
345678901
```

In this example, three IWS520-USB devices are connected to the computer. By specifying a serial number with the serial number option of the `iws520ctl` command, you can selectively retrieve data from any particular device.

5.3. Using IWS520-USB with Custom Programs

To incorporate the functionality of the IWS520-USB into your custom programs, launch `iws520ctl` as an external process and redirect its standard output to the standard input of your program. In your custom program, read each line from the standard input, parse the text string, and handle the data appropriately.

For detailed instructions on launching external processes and redirecting standard input, refer to the manuals or

documentation specific to the programming language you're using.

6. Precautions

- **Environmental Factors:** Ultrasonic distance measurement is susceptible to errors due to variations in temperature, pressure, and humidity. For precise measurements, use calibrated equipment like laser-based systems. Extreme hot or cold temperatures can increase errors, so adjust the speed of sound option in `iws520ctl` accordingly.
- **Power Quality:** IWS520-USB is affected by the power quality of the 5V USB port. Noise or low voltage can cause malfunction. Check the noise level values from IWS520-USB. If high, try another computer.
- **USB Cable:** Inferior USB cables may lead to malfunctions. Always use the supplied USB cable.
- **Obstacles:** Narrow paths and cluttered spaces can produce echo waves, leading to incorrect distance measurements. Use the device in a spacious area.
- **Material Effects:** Reflectivity may be weakened with uneven surfaces or sound-absorbing materials like clothing, fur, or fabric, resulting in reduced measurable distance.

7. Sensitivity Characteristic

The actual sensitivity varies based on the reflective material, surrounding objects causing noise, and the environment. The provided diagram should be considered as a reference, and it's recommended to verify specific measurements through experimentation.

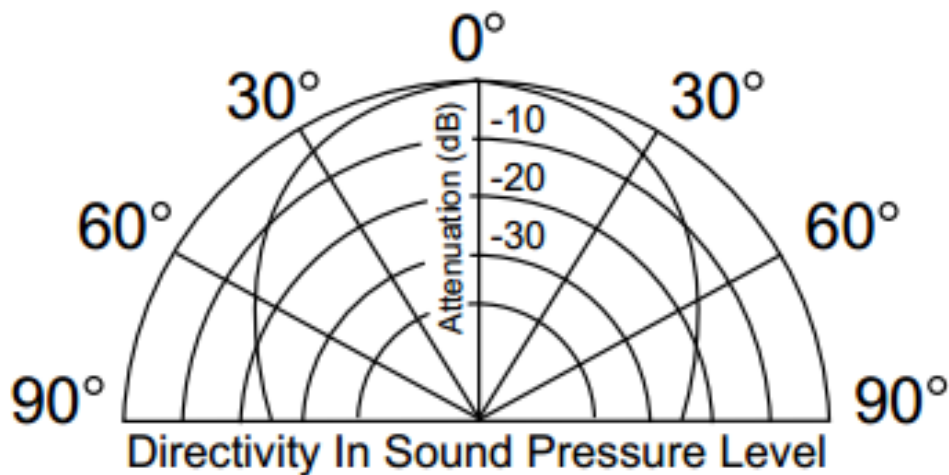
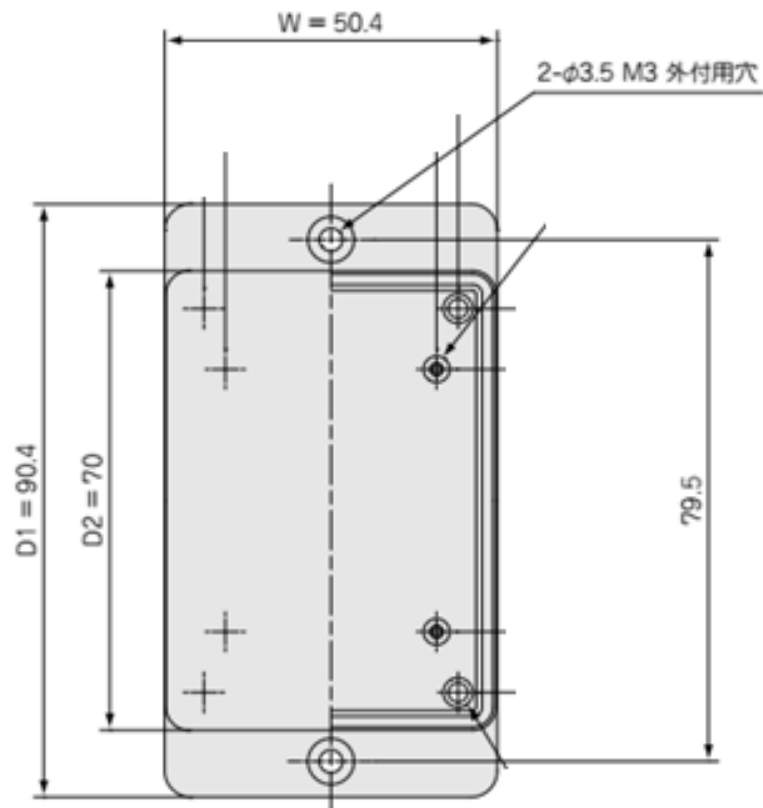


Figure 3 IWS520-USB Ultrasonic Sensor Characteristics

8. Case Dimensions



9. Product Customization Services

Tokyo Devices offers customization of circuit board exteriors, functionalities, and performance based on customer needs. For more details, please check the "Customization" on the Tokyo Devices website.

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