

BroadScan D200 Ultrasonic System Guide



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1 Introduction

1.1 BroadScan D200

Designed for ultrasonic scan and structural health monitoring applications, BroadScan D200 is a network device capable of multi-channel ultrasonic scan and sensor data acquisition. It can be connected to a network through the Ethernet interface. It provides an easy-to-use web interface for remote access. Users can access the web interface with any major browsers such as Chrome, Firefox, Edge, Safari, etc. D200 can be operated with external power or internal battery (optional).

Multiple BroadScan D200s can be connected to monitor a large structure. Parallel data acquisition can also be achieved with multiple D200s. Ultrasonic sensors connect to BroadScan D200 with standard industrial plugs, which is easy to use and ideal for industrial applications.



Figure 1. BroadScan D200 back view

1.2 Package contents

BroadScan D200 system consists BroadScan D200 main body, 24V DC input power adapter, RJ45 Ethernet cable, and BroadScan software. An electronic version of this operation manual is also provided by email or web download.



Figure 2. BroadScan D200 front view

BroadScan software is pre-installed inside BroadScan D200. The software can be accessed through web interface with any main web browsers. BroadScan software supports all BroadSens BroadScan devices, including D100, D110C and D200. The device can be selected at the “Device setup” page in the dashboard.

1.3 Interfaces



Figure 3. BroadScan D200 interfaces

The front panel of BroadScan D200 consists of LEDs and power switch. The back panel consists of power plug, Ethernet port, micro USB debug port (factory usage), I2C interface and 16 ultrasonic connections.

① Power switch

Press the power switch to turn on/off the BroadScan D200.

② LEDs

There are five LEDs. The functions of LEDs from left to right are as follows.

Color	Functions
Red	Alarm and maintenance
Blue	Device is communicating
Yellow	Low battery
Red	Charging, or battery not connected
Yellow	Power

③ DCIN (Power plug)

Use provided 110V/220V AC to 24v DC adapter to plug in to D200.

- ④ Ethernet port. Connect D200 to a router or switch for network connection and control of D200.
- ⑤ USB debug interface. This port is reserved for debug purpose. Do not plug in for general applications.
- ⑥ I2C interface. D200 supports BroadSens's standard digital I2C sensors such as temperature sensor, strain sensors, distance sensors and vibration sensors.
- ⑦ 16 ultrasonic ports. Each port can be used as either transmission/actuation or receive functions. The actuation and receive function can be adjusted by software in the fly. The channel number is labeled with signal and ground pair. The left side is the signal I/O, and the right side is ground.

2 Specifications

The specifications of BroadScan D200 are as follows:

- 16 ultrasonic channels with industrial plugs for easy connection. Each channel can be used either as transmission channel or receive channel. Channel configuration is software adjustable in the fly.
- I2C interface that support multiple BroadSens standard I2C sensors.
- 20 dB-80 dB adjustable receive gain
- 14-bit ADC with integrated hardware filter
- 14-bit high resolution arbitrary waveform generator with adjustable frequency from 50kHz up to 5Mhz
- Adjustable sampling rate of ultrasound scan. 80MS/s, 40MS/s, 20MS/s, 10MS/s, 5MS/s, 2.5MS/s and 1.25MS/s sampling rate.
- Adjustable sample points: 2048, 4096, 8192, 16384, 32768
- 64-bit ARM Cortex-A53 microprocessor with 1.2GHz speed
- 1 GB RAM
- 32 GB eMMC Flash
- 10/100 Ethernet port
- 802.11n Wi-Fi (optional)
- Optional backup battery (optional)
- Working temperature: -30 °C- 65 °C (-22 Fahrenheit to 149 Fahrenheit)
- 24V DC input
- Size: 180 × 135 × 40 mm/ (D x W x H)
- Weight: 2 lbs without optional battery
- Integrated high precision hardware clock
- Integrated time series database InfluxDB to store general I2C sensors data and ultrasonic damage indexes
- Software: BroadScan software preinstalled (based on Node-RED)

3 System setup

Attention, please power off the device before connecting cables

3.1 Connect BroadScan device

BroadScan devices should be connected through a secure network. Multiple BroadScan devices can be used at the same time for parallel data acquisition and large-scale machine/structure monitoring.

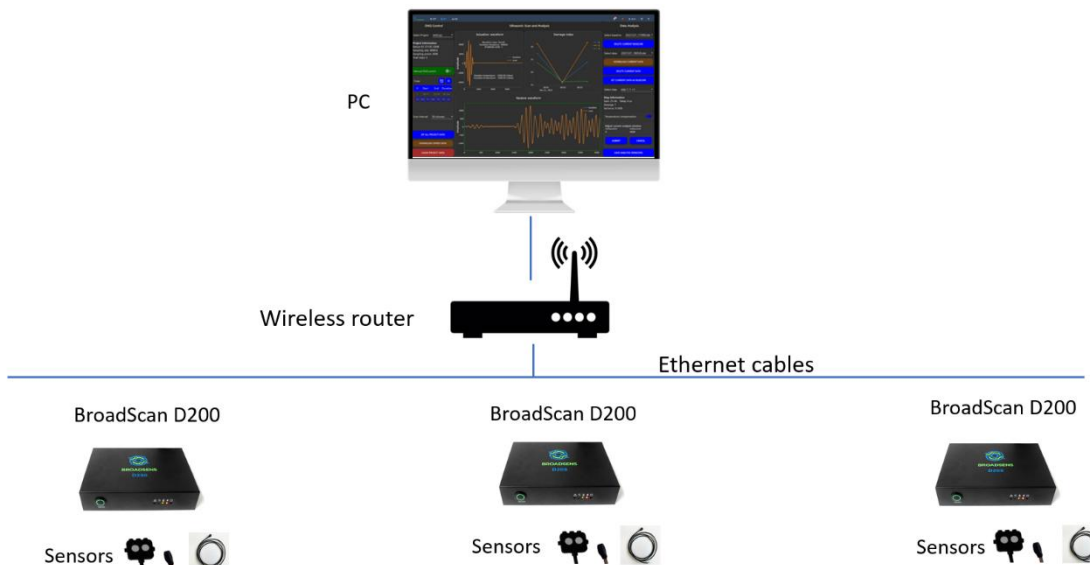


Figure 4 BroadScan D200 connection

Plug in the Ethernet cable to the Ethernet port of D200, and plug the other end to a router or switch. Connect the power cord to the DCIN connector of D200.

3.2 Connect ultrasonic sensors

An ultrasonic sensor can be connected to one of the ultrasonic ports of BroadScan D200. D200 can connect to BroadSens's BHU100 single crystal ultrasonic sensor (Figure 5), or BHU200 double-crystal ultrasonic sensor (Figure 6). If users order ultrasonic sensors

with D200, then the sensors typically come with open wires in the end, so that they can be connected to D200 easily.

The wires of BHU100 and BHU200 are made of flexible coaxial cables. Each ultrasonic port of D200 consists of a signal I/O connector and a ground connector. The left side is signal I/O, and the right side is ground (Figure 7). The signal wire of BHU100/BHU200 should be inserted into the signal I/O connector, and the ground (shielding) wire should be inserted into the ground connector, as shown in Figure 7.

BHU200 has two crystals, so that it has four open wires (two signals and two grounds). The crystal of BHU200 is symmetric, so that either crystal can be used as the transmitter or receiver for the thickness measurement. To reduce the crosstalk between excitation signal and receive signal, it is recommended to avoid using adjacent channel for transmit and receive. For example, in Figure 7, we use channel 1 for transmit and channel 3 for receive.



Figure 5 BHU100 ultrasonic sensor



Figure 6 BHU200 ultrasonic sensor

To connect a sensor, use a flat-head screw driver to turn counter-clock wise to loosen the screws on top of the plug, insert the wires, then tighten the screw in clock wise direction to lock the wire (Figure 7).

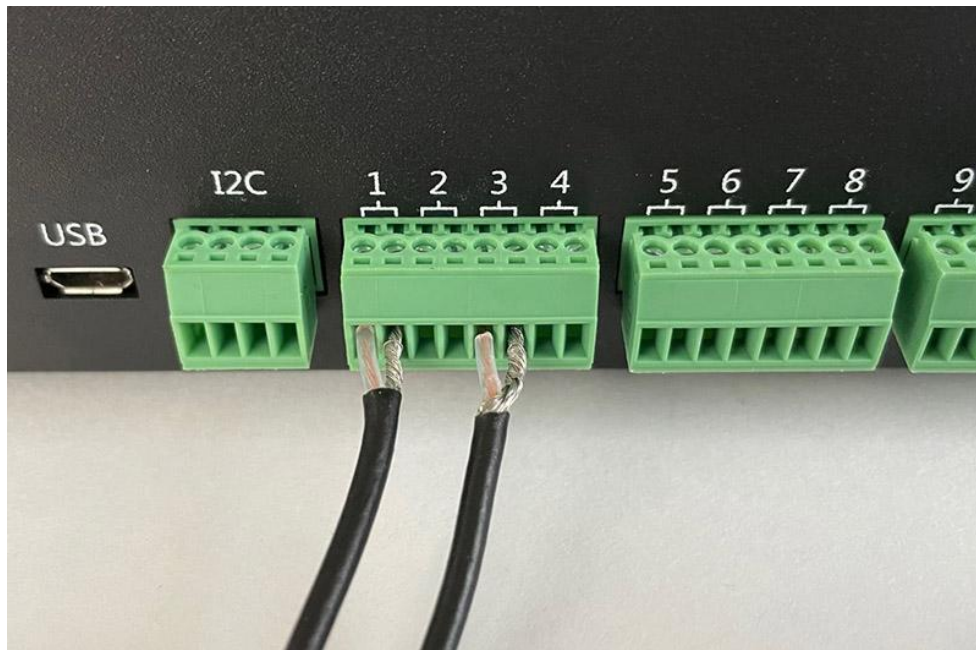


Figure 7 Connect ultrasonic sensor BHU100/BHU200 to D200

Each plug can be removed by pulling it outward. The plug can be pushed back to the connector. Please do not push the plug with brutal force to avoid damaging the PCB of D200.

3.3 Connect digital sensors

If digital sensors are purchased with D200, then you may also plug in the digital sensors. BroadScan D200 can connect to BroadSens's digital sensors via the I2C port. The general I2C sensors include temperature sensor (Figure 8), strain sensor, displacement sensor, vibration sensor, etc. Some of the sensors are industrial grade sensors with waterproof case such as TMP210. Please contact BroadSens for details of customized sensors.



Figure 8 Waterproof temperature sensor TMP210

3.3 Connect to D200 with web browser

Turn on BroadScan D200. In default, D200 uses DHCP service. When D200 connects to a network, it will be assigned an IP by the network automatically.

If you have the management right of the network, then you can find the IP address of D200 from the device management interface of the router. Alternatively, you can use software such as Advanced IP Scanner to find the IP address of the D200 in your network. The software can be downloaded here:

<https://www.advanced-ip-scanner.com/>

Advanced IP scanner has the option of running standalone without installation, which is handy for a company that does not allow software installation. The name of the D200 may appear as the manufacturer of the microcomputer “Raspberry Pi Foundation” instead of “D200” from the result of Advanced IP scanner. In rare cases, the name may be blank.

Assume that the dynamic IP of D200 is 192.168.1.60, then the link for the D200 dashboard web access is:

`http://192.168.1.60:1880/ui`

When a user logs in the for the first time, a pop-up window will appear asking for user name and password (**Error! Reference source not found.**).

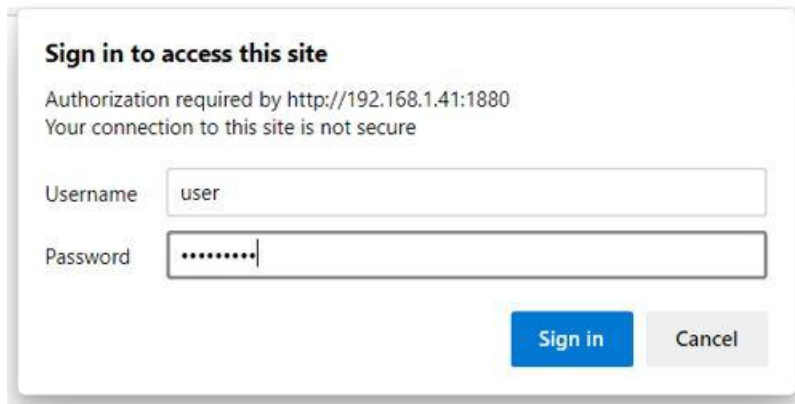
A screenshot of a web browser's security warning dialog box. The title is "Sign in to access this site". Below the title, it says "Authorization required by http://192.168.1.41:1880" and "Your connection to this site is not secure". There are two input fields: "Username" with the text "user" and "Password" with masked characters ".....". At the bottom right, there are two buttons: "Sign in" (blue) and "Cancel" (grey).

Figure 9 User name and password window

Please use the provided ID and password to log in to the web management page. BroadScan D200 is designed to work in a secure enterprise network. It is recommended to keep the device inside a secure sub network behind the firewall all the time. For remote access, VPN is recommended. Alternatively, data can be sent to remote server or clouds with MQTT protocol. For MQTT data transfer, please contact BroadSens.

4 Dashboard

The dashboard of BroadScan D200 can be accessed with any major web browsers such as Chrome, Firefox, Edge, Safari etc.

4.1 Homepage

In previous version, the homepage is the “System” page. This page is moved to homepage for easier access to device power down purpose. User can shut down or restart the device, check the device network information, check CPU usage, temperature, memory usage and storage. In this page, user can also change device ID/name, update BroadScan software, and reset the whole database (Figure 10).

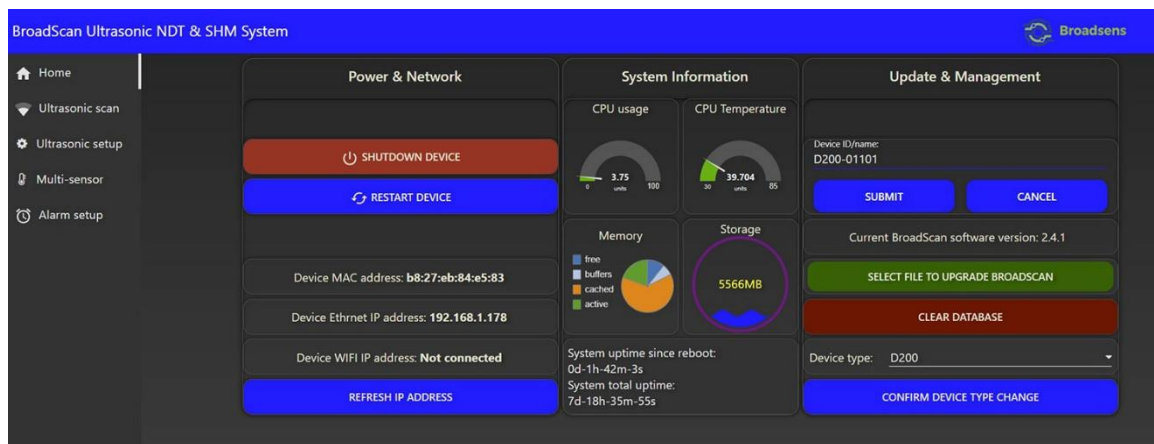


Figure 10 Device setup

Attention:

It is strongly recommended to click on “shutdown device” button first to turn off software operation. After that, user can turn off the power button at the device. This can help prolong the device life. It is normal to have the power light to be on (for optional battery charging purpose).

Current BroadScan software version is displayed (Figure 11). BroadScan software can be upgrade easily by using the provided update file. Click on “Select file to upgrade

BroadScan”, then select the upgrade file to complete the one-click upgrade. The system will ask user to reboot the device to implement the update.

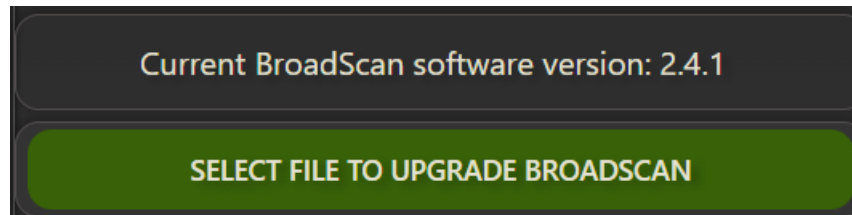


Figure 11 BroadScan software update

At this page, the entire database can be cleaned by clicking on “Clear database” button. The database includes multisensory data and damage index for all the projects. The system will warn user about the operation. Click on “confirm” to clear the database.

Clearing the database will not delete ultrasonic scan files. To delete ultrasonic scan files, you can delete the projects.

BroadScan software supports all BroadScan devices, including D100, D110C and D200.

4.2 *Ultrasonic scan*

Click on “ultrasonic Scan” tab on the left panel to access the “ultrasonic scan” page. Ultrasonic scan and analysis page integrates multiple functions including project selection, manual DAQ, automatic DAQ with timer, project data export, project data clean, actuation waveform view, damage index view, receive waveform review, baseline data setup, scan data selection and individual scan data export, step information and analysis window setup (Figure 12).

User can create multiple ultrasonic scan projects with completely different setups. The project can be selected from the dropdown menu “select project”. When BroadScan D200 boots up, the last selected project will automatically load into the memory for quick operation. Project information section displays device ID (name), sample rate, sample

points and number of scan steps. Each project can have multiple scan steps with different excitation channel, receive channel, excitation signal, receive signal gain and receive delay.

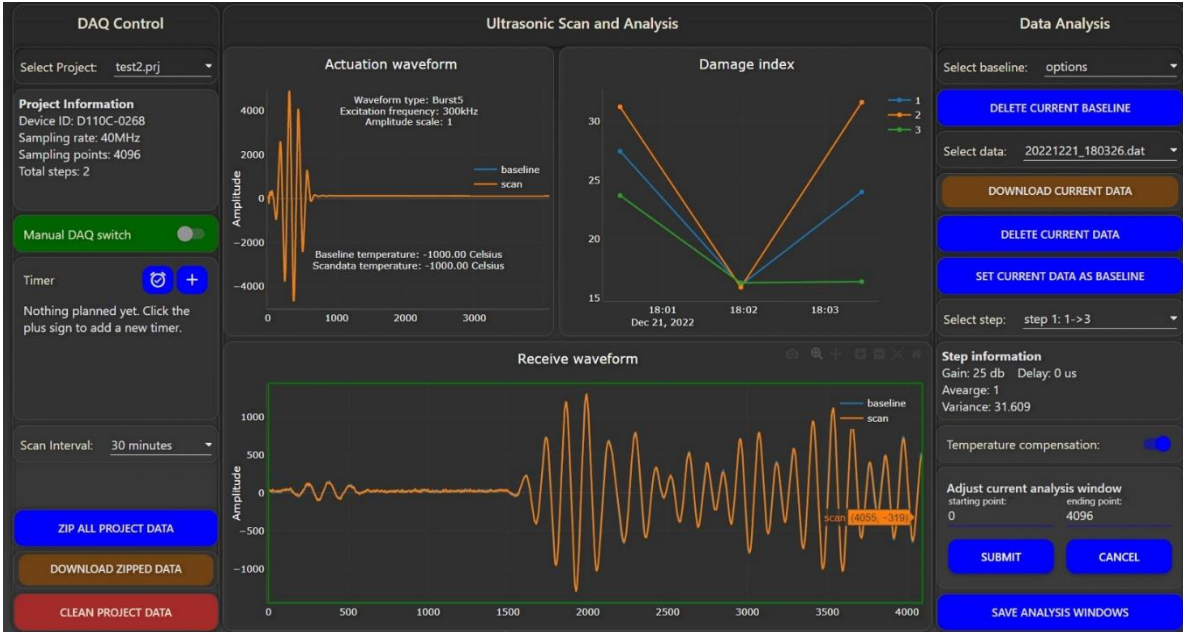


Figure 12 Ultrasonic scan and analysis

4.2.1 Data acquisition

When you log in for the first time, if there is no data in a project, or the project is just created, then the charts areas are empty (Figure 13). Users need to take data to show the charts. This can be done either with manual data acquisition, or set up a timer for repeated scan.

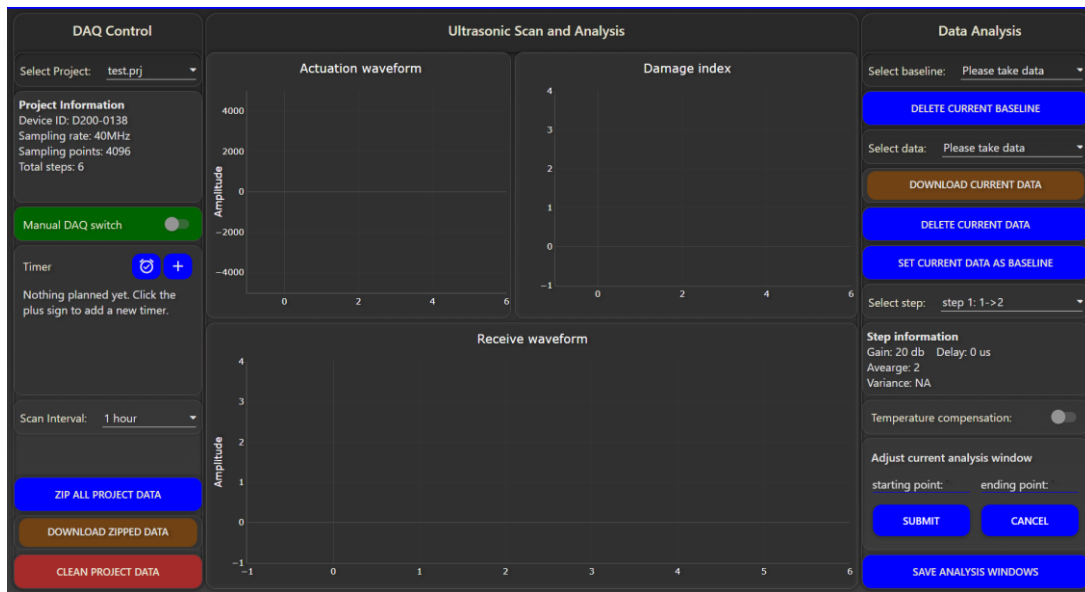


Figure 13 Project with no data

User can select different projects in the project dropdown menu. For a new system, a test project is created with data taken to test the sensors (Figure 14).

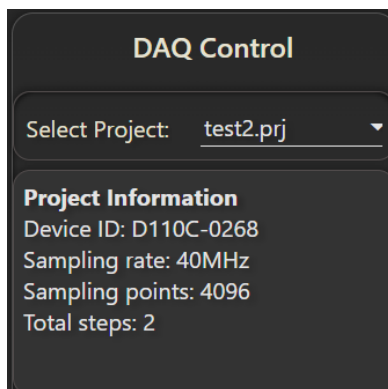


Figure 14 Project selection and information

4.2.1.1 Manual data acquisition

By clicking on “Manual DAQ switch”, user can manually start the ultrasonic scan (Figure 15).

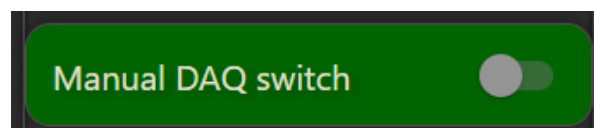
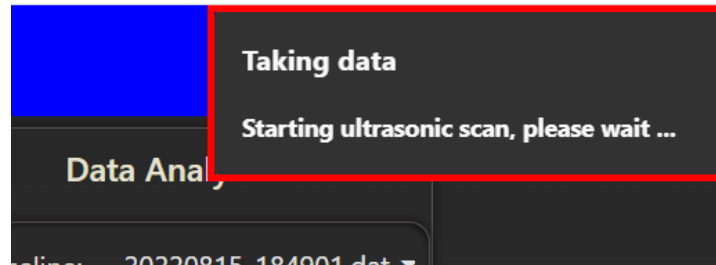


Figure 15 Manual DAQ switch

The switch will turn into red color during DAQ process. There is a popup message in the upper right corner of the browser showing that ultrasonic scan is in progress (Figure 16).

**Figure 16 Popup message of “taking data”**

During DAQ process, please wait until the system finishes taking data. When DAQ is finished, the switch automatically turns off, and the popup message showing that ultrasonic scan is done. Popup messages are used to show different information to the users.

After DAQ is finished, the waveform will automatically show up in the “receive waveform” window. The data files are named based on year-month-date and hour-minute-second format. For example, if the file name is “20220618_153551.dat”, then it means that the ultrasonic scan happens at 15:35:51 on June 18, 2022.

4.2.1.2 Automatic data acquisition (timer)

User can also take data automatically by using the timer. User can specify which dates and what times in a week to take data. Multiple time slots can be added for the automatic data acquisition. If the timer is not setup, then the timer shows that “Nothing planned yet” (Figure 17).

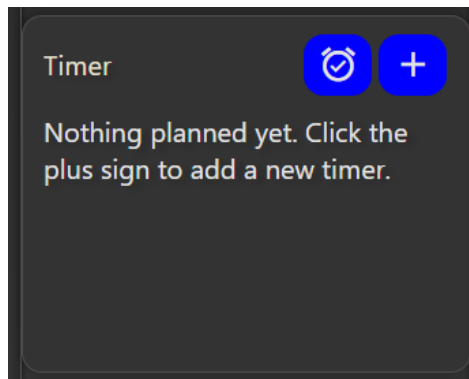


Figure 17 Timer

Click on the “+” sign in Figure 17 to add a schedule (Figure 18).

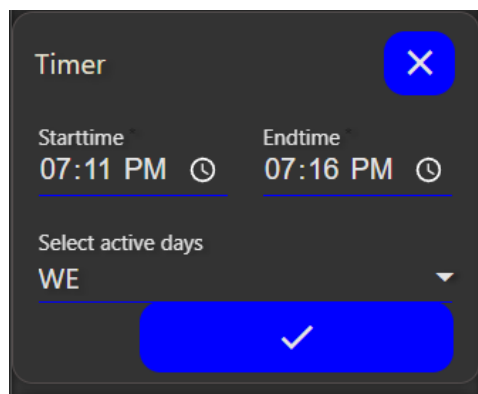


Figure 18 Add a schedule

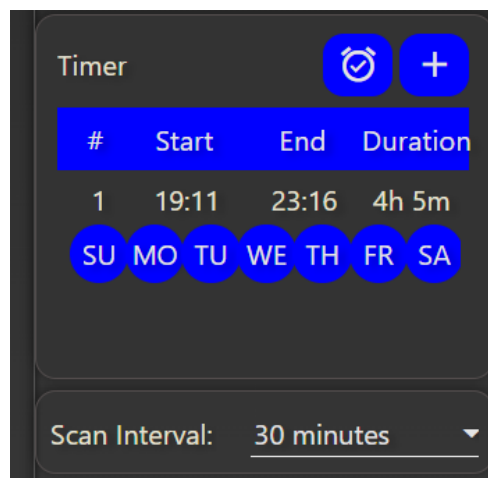
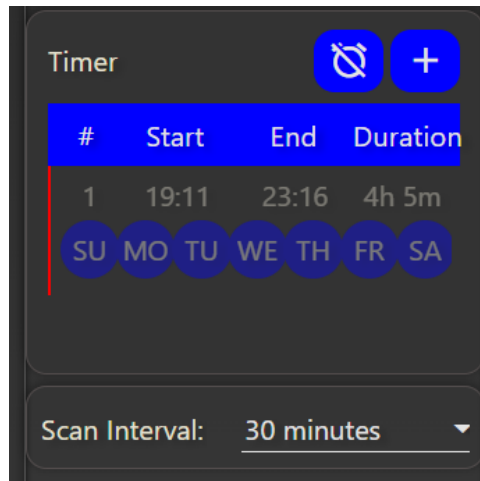


Figure 19 Timer with multiple dates

Timer can be enabled and disabled by clicking on the “clock” sign. When timer is disabled, the schedule is greyed out.



When the timer is enabled, the scan interval is automatically added to the timer. For example, if the timer is specified to start taking data at 8am and finishes at 11am, and the scan interval is 30 minutes, then the DAQ will happen at 8:30am, 9am, 9:30am, 10am, 10:30am and 11am.

[Note]

The timer start time is equal to “Start” time + “Scan interval”.

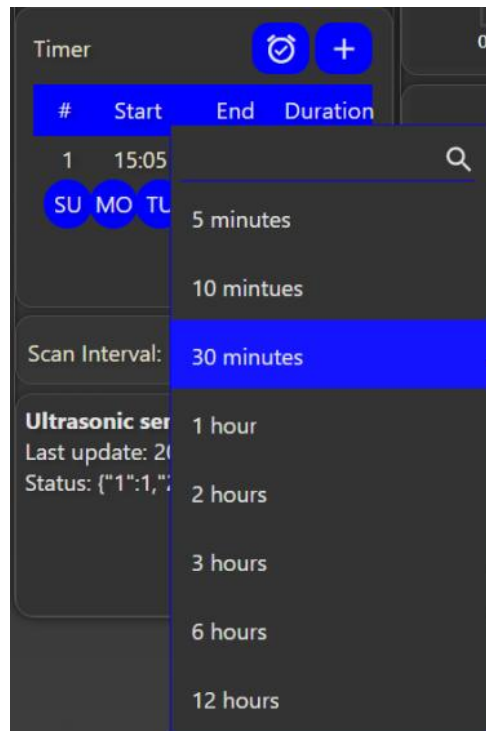


Figure 20 Scan interval

The scan interval can be adjusted using the dropdown menu (Figure 20) as follows: 5 minutes, 10 minutes, 30 minutes, 1 hour, 2 hours, 3 hours, 6 hours and 12 hours. If the scan interval is larger than the timer's duration (end time minus start time), then BroadScan device only takes data once.

4.2.2 Actuation signal

Actuation/excitation waveform chart shows the waveform type used for the ultrasonic scan, the excitation signal frequency and relative amplitude. The amplitude scale is in the range of 0 to 1. A scale value of "0" means there is no actuation signal output, and BroadScan device is used to listen to the machine or structure response passively. This is useful when BroadScan device is used to check high frequency vibration. A scale value of "1" means that BroadScan device uses the maximum excitation voltage (up to 130v peak-peak typically).

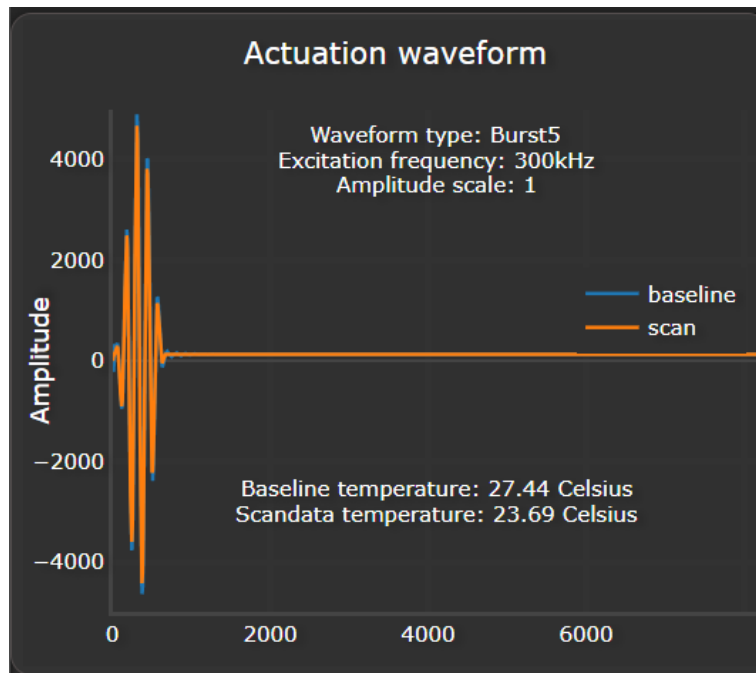


Figure 21 Actuation waveform

The actuation waveform also shows the baseline data temperature and new scan data temperature. If there is no temperature sensor connected, then the system will not show the temperature values.

Waveforms can be zoomed in/zoomed out at each chart easily to see the details. User can save the waveform any time by clicking on “save picture” button (Figure 22).

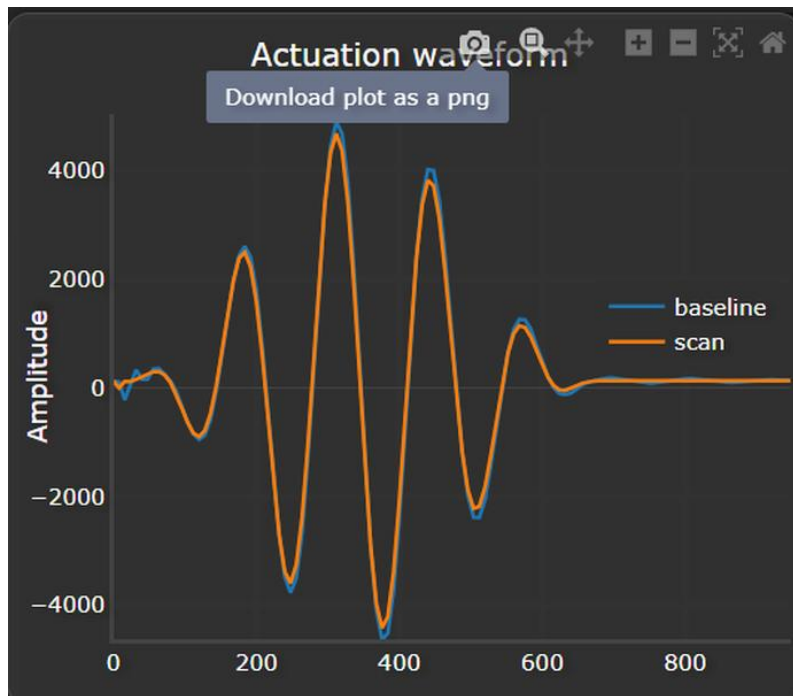


Figure 22 Zoomed in view of actuation signal and picture download

Multiple types of actuation waveforms can be created. User can also create arbitrary excitation waveform. Please refer to the API guide on how to create an arbitrary excitation waveform.

4.2.3 Receive waveform

The receive waveform shows two waveforms in default (the baseline waveform and the new scan). The baseline waveform typically is used as a reference for comparison. It can be set up when the machine or structure is in health condition. Then the new scan waveform is compared against the baseline waveform to detect any anomaly with the machines or structures.

In Figure 23, there is an damage happened in the current scan path, the new scan signal (orange color) shows the clear difference from the original baseline signal (blue color).

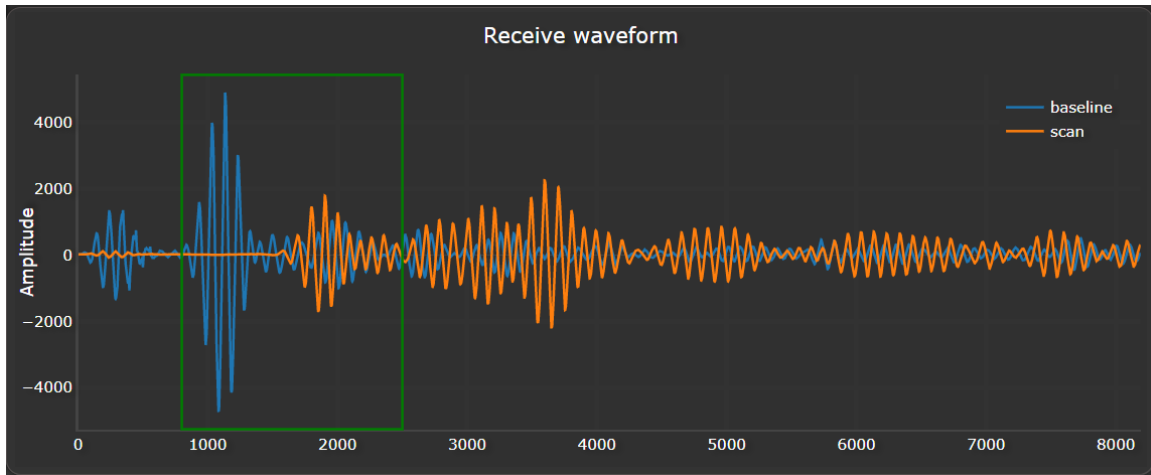


Figure 23 Receive waveform comparison

BroadScan software supports analysis window, in which case the variance and damage index are only calculated inside the analysis window. The analysis window can focus the analysis on the area that users are concerned about. The area can be found out by using the wave velocity in the material being monitored.

4.2.4 Download project data

All project data can be downloaded quickly. To download all the data from the current project, please first click on “Zip all project data” button (Figure 24).

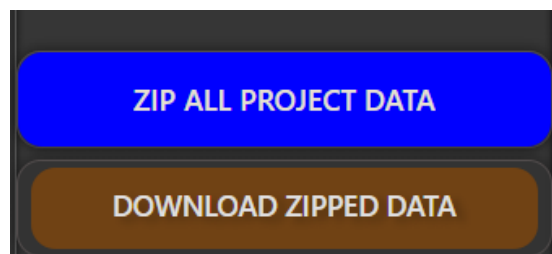


Figure 24 Download project data

When all the data are compressed into a single data file, a popup message will show up in the upper right corner, indicating that the data is ready to download (Figure 25).

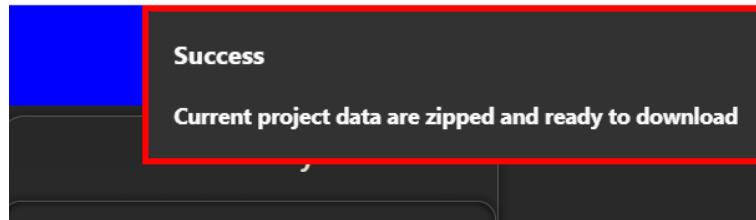


Figure 25 Data ready to download message

Click on “download zipped data” button to download the data file. You can extract the data files with tools such as WinZip.

Current scan data can also be downloaded using the “Download current data” button in the “Data Analysis” panel.

4.2.5 Data file format

The data file is in ASCII format. If there are N steps in the project, then there are $2N+1$ rows in the data file. The first line of the data are the device name and measured temperature. If there is no temperature sensor connected, then -100 degree will be used.

The data are arranged as the following:

Row 1	Device name	Temperature
Row 2	Step 1 excitation data	
Row 3	Step 1 receive data	
Row 4	Step 2 excitation data	
Row 5	Step 2 receive data	
...		
Row $2N$	Step N excitation data	
Row $2N+1$	Step N receive data	

An example of the scan data file is shown in Figure 26.

```

b110c-0268 19.620001
124.000000 124.000000 125.000000 124.000000 125.000000 122.000000 124.000000 118.000000 101.000000 71.000000 31.0000
31.000000 30.000000 27.000000 26.000000 27.000000 23.000000 25.000000 26.000000 15.000000 13.000000 21.000000 28.000
121.000000 123.000000 121.000000 122.000000 122.000000 121.000000 122.000000 122.000000 122.000000 122.000000 121.00
25.000000 27.000000 32.000000 39.000000 39.000000 36.000000 34.000000 29.000000 26.000000 21.000000 15.000000 18.000

```

Figure 26 Data file format

4.2.6 Clean project data

All current project data can be deleted quickly. This can be done by clicking on “Clean project data” button (Figure 27). A popup window will ask user to confirm the action to prevent accidental deleting all data.

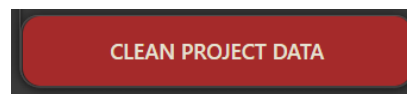


Figure 27 Clean project data

When project data is cleaned, damage index is also cleaned from the database. The concept of damage index is introduced below (section 4.1.6).

4.2.7 Damage index

Damage index is used to show the status of concerned sensors with associated coverage area (Figure 28). Damage index is calculated using the actuation path and receive path of a sensor. Users need to enter sensors and associated channels in the “Ultrasonic Setup” page to generate the damage index value. If there is only one scan path for the actuation sensor and receive sensor, then the damage index is equal to the variance value. When there are multiple paths for an actuation sensor or receive sensor, then the average value is used to calculate the damage index.

Damage index is saved to the time-series database installed inside the BroadScan devices. Each project has a dedicated damage index. When a project is deleted, then the

damage index is deleted automatically. User can also clear a project's damage index by click on "Clean project data" button.

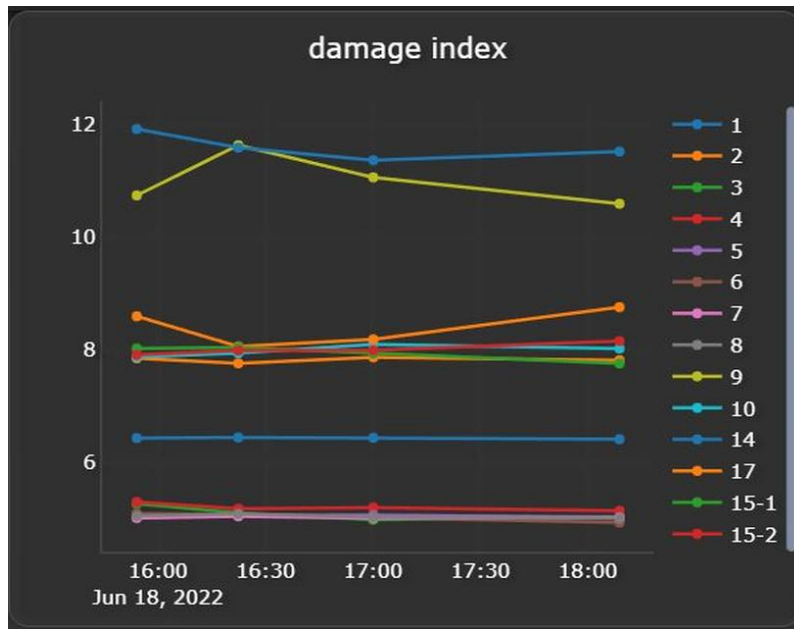


Figure 28 Damage index

4.2.8 Data analysis Panel

At data analysis panel, user can select the baseline data, and scan data to check out the waveform difference (Figure 29). Baseline data is used as the reference. Some basic concepts are introduced in this section.

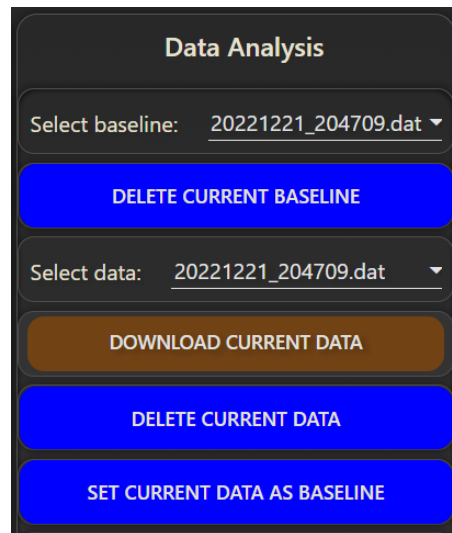


Figure 29 Data analysis panel data selection

[Baseline data]

In Structural Health Monitoring (SHM), the baseline data consists of the data sets when the structure is in healthy condition. New collected data are compared against the baseline data to tell if the structure is in healthy condition. There could be multiple baselines selected. For example, temperature has a big effect on the ultrasonic data. It is desirable to have the baseline data at different temperature values. Baseline data can be added by clicking on “Set current data as baseline” button, and deleted by clicking on “Delete current baseline” button.

Current scan data can be downloaded by clicking on “Download current data” button, and deleted by clicking on “Delete current data” button.

[Scan steps]

Each project can have multiple steps, with each step that defines the excitation channel, receive channel, excitation signal type, excitation signal frequency, excitation signal relative amplitude, receive gain, receive delay and average number. The step can be selected using the “Select step” dropdown menu (Figure 30). Current step information is shown below, including “db” gain, scan delay, average number and variance.

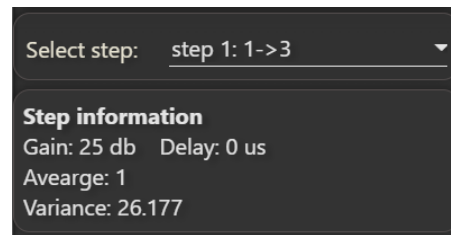


Figure 30 Scan step selection

[Scan delay]

Scan delay is the time difference between the excitation signal starts sending data and the receive channel starts taking data. The minimum value of delay is 0. The maximum value of delay is 16383. The unit of delay is in microseconds (μs).

[Variance]

Variance of each step is calculated using the baseline data and the scan data. Baseline data is required to calculate the variance.

[Temperature compensation]

Because ultrasonic scan signals are affected by temperatures, the BroadScan software can automatically add scan data to the baseline collection. Temperature compensation requires a temperature sensor connected to the BroadScan device. Turn on the “temperature compensation” switch to enable this feature.

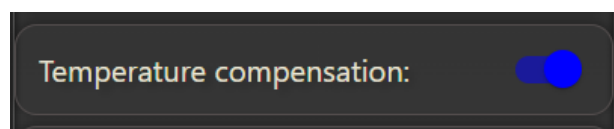


Figure 31 Temperature compensation

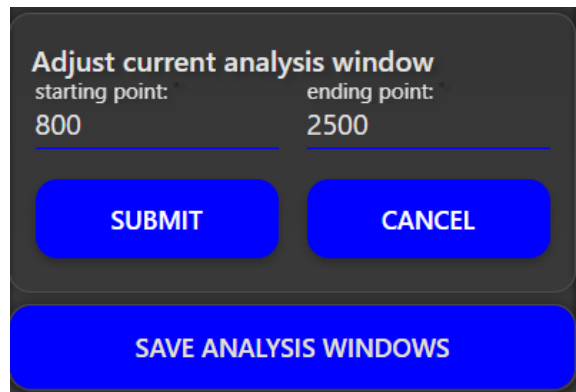
When there are multiple baselines, the software selects the baseline data file that has the closest temperature to the current scan data. If the temperature difference of all baseline data files have more than 1 degree difference from the new scan data, then the system will label the new scan data as a baseline candidate. Later on, when the temperature drops to normal range (the new scan data has temperature difference less than 1 degree from some of the baseline data), then the previous candidate is automatically added to the baseline file

collection. This feature is especially useful for industrial applications, in which case it is either inconvenient or impossible to collect baseline data for all temperature ranges.

[Analysis window]

Analysis window is used to focus the analysis on particular area of the machine/structure (Figure 32). The window can be adjusted by setting the new starting point and ending point. The default analysis is the who signal waveform. The maximum value of the ending point is the signal length. The minimum value of the starting point is 0. Click on “submit” button to adjust the window, and the green frame will be updated based on user’s new analysis window definition.

Analysis window adjustment is saved in the memory. Remember to click on “save analysis window” to save the final result into the project definition file.

A dark-themed dialog box titled "Adjust current analysis window". It contains two input fields: "starting point:" with the value "800" and "ending point:" with the value "2500". Below these fields are two blue buttons labeled "SUBMIT" and "CANCEL". At the bottom of the dialog is a larger blue button labeled "SAVE ANALYSIS WINDOWS".

Adjust current analysis window	
starting point:	ending point:
800	2500
SUBMIT CANCEL	
SAVE ANALYSIS WINDOWS	

Figure 32 Analysis window

4.3 Ultrasonic Setup

Click on “ultrasonic setup” button on the left panel to access this page. In the “ultrasonic setup” page, ultrasonic scan projects can be created, modified and deleted (Figure 33).

Create Project

Project name: test.prj

Sample points: 4096 Sample rate: 40 Mhz

CONFIRM CREATE NEW PROJECT

Transmit channel: 1 Receive channel: 2

Waveform: Burst5 Amplitude: 1

Excitation freq (kHz): 300 Gain (dB): 20

Delay (us): 0 Average number: 2

CONFIRM ADD STEP

Delete step: step 1: 1->2 CONFIRM DELETING SELECTED STEP

Add sensors (optional. Required for damage index computation)

Sensor name/ID:

Sensor type: Select option Channel number: 1

CONFIRM ADD SENSOR

Delete sensor: id: 1 CONFIRM DELETING SENSOR

SAVE PROJECT

Project Information

Project name: test.prj Sample points: 4096 Sample rate: 40 Mhz

Scan steps

Step	Transmit	Receive	Amplitude	Freq.	Gain	Delay	Waveform	Avg.
1	1	2	1	300 kHz	20 dB	0 us	Burst5	2
2	1	3	1	300 kHz	20 dB	0 us	Burst5	2
3	2	3	1	300 kHz	20 dB	0 us	Burst5	2
4	2	4	1	300 kHz	20 dB	0 us	Burst5	1
5	3	4	1	300 kHz	20 dB	0 us	Burst5	1
6	2	5	1	300 kHz	20 dB	0 us	Burst5	1

Sensor table

Sensor name/ID	Sensor type	Channel number
1	Transmit only	1
2	Transmit only	2
3	Transmit only	3
4	Receive only	5

Edit project: test.prj CONFIRM EDIT

Delete project: Select option CONFIRM DELETING PROJECT

Figure 33 Ultrasonic setup

4.3.1 Create a project

To create a project, enter a new project name (Figure 34). Select sampling points from the dropdown menu. Available options of sampling points are:

1,024, 2,048, 4,096, 8, 192, 16,384 and 32,768

The recommended sampling points is typically 4,096 or 8,192. The more sampling points you take, the longer it will the system to process the data. User can always adjust the delay parameter to capture the desired waveform.

Select sampling rate from the dropdown menu. The optional sampling rates are:

80Mhz, 40MHz, 20MHz, 10MHz, 5Mhz, 2.5Mhz and 1.25Mhz

It is recommended to sample at the rate of at least 8 times of the excitation signal frequency for a smooth signal. For example, if the excitation signal frequency signal is 500kHz, then the recommended sampling rate is 5MHz and above.

After selecting all the options, then press “confirm create new project” button to create a new project. The “Project information” panel on the right side will show the corresponding information. If a project with the same name already exists, then the system will warn user that the project already exists. User can either overwrite the project, or use “edit project” option to modify the project.

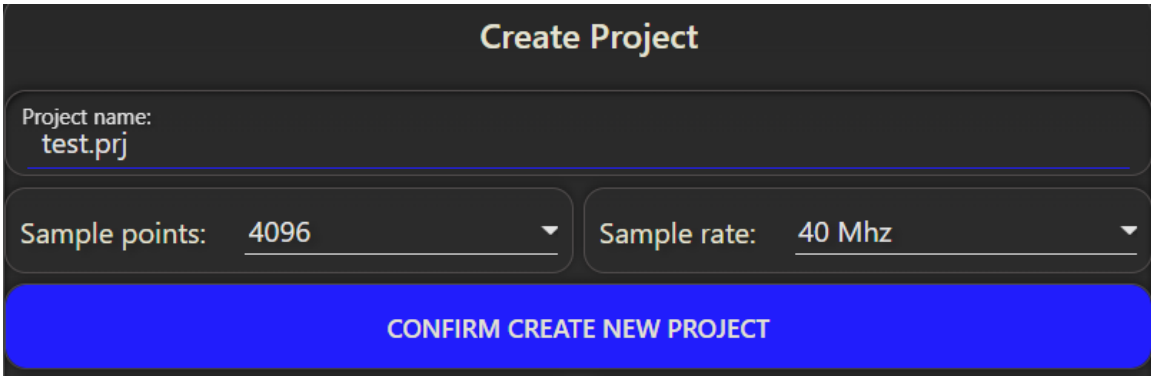


Figure 34 Create a new project

After setting up the basic project information, user can add scan steps. Each project can consist of multiple scan steps. For each step, user need to select transmit channel, receive channel, amplitude scale (0-1), excitation signal frequency, receive signal gain, receive delay, excitation signal waveform, and number of averages (Figure 35). Increasing the number of averages can improve the signal to noise ratio. Added steps will show up on the right side of “Project information”.

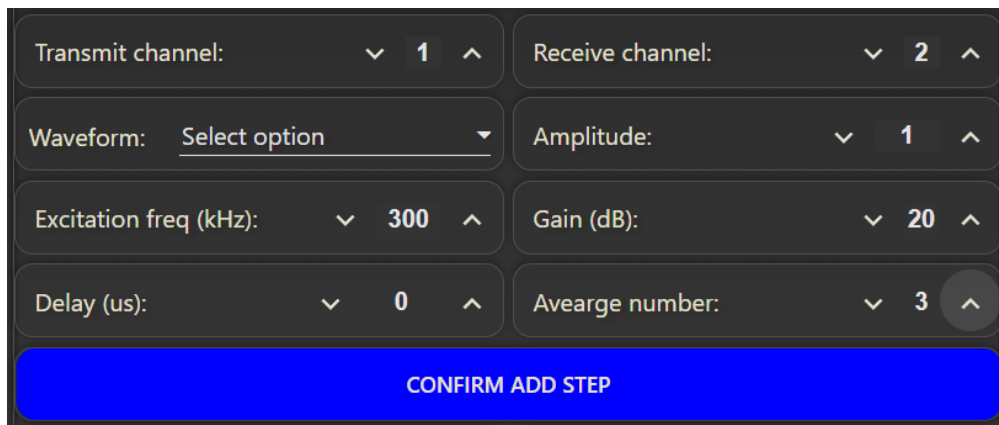


Figure 35 Add ultrasonic scan step

User can also delete scan steps by selecting a step and click on “confirm deleting selected step” button (Figure 36).

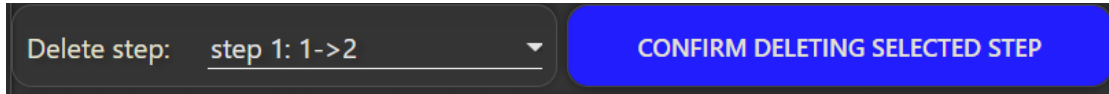


Figure 36 Delete a scan step

User can add sensor information to a project (Figure 37). To display damage index, sensor information is required. Each sensor should map to a unique channel of BroadScan device. Sensor type has options of “transmit only”, “receive only”, “transmit and receive”.

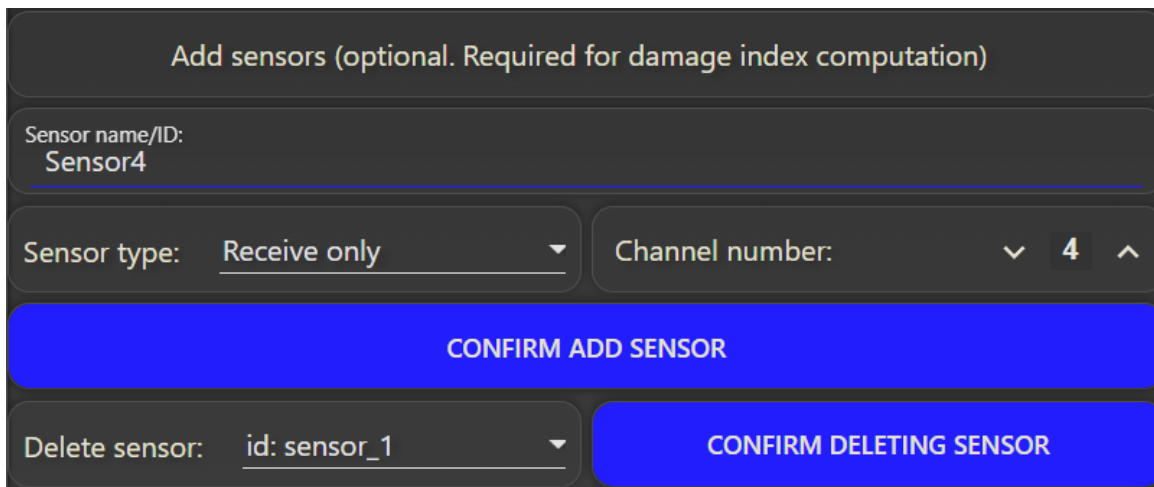


Figure 37 Add or delete a sensor

4.3.2 Edit project

User can edit an existing project by using the “Edit project” dropdown menu and select the project that you want to edit (Figure 38). Because the system compares the new scan file with the baseline file, it is important not to add/delete scan steps, or change sample points when you edit a project. Otherwise, all the baseline files, scan data and damage index will be invalid. A popup window will ask to confirm the editing action. You can clean the project data if you decide to add/remove scan steps or change sample points.



Figure 38 Edit project

4.3.3 Delete project

To delete a project, from the “Delete project” dropdown menu, select the project to be removed, and click on “Confirm deleting project” button (Figure 39). A popup window will ask user to confirm the action. Clicking on “OK” to delete the project.



Figure 39 Delete a project

When a project is deleted, all ultrasonic data and damage index associated with this project are deleted from the data storage.

4.4 *Multi-sensor page*

If BroadSens digital sensors such as temperature sensor are purchased and connected, then the multi-sensor page will show the multi-sensor data automatically. The multi-sensor charts will be blank if there are no digital sensors connected to the BroadScan device.

On the “multi-sensor display” panel, user can select live data view, 1 day, 1 week, 1 month, 1 quarter and 1 year data review. At live data view, the plots are updated every 2s (Figure 40).



Figure 40 Multi-sensor page

By selecting longer period such as 1 day, user can check the system status in the past 24 hours quickly (Figure 41).

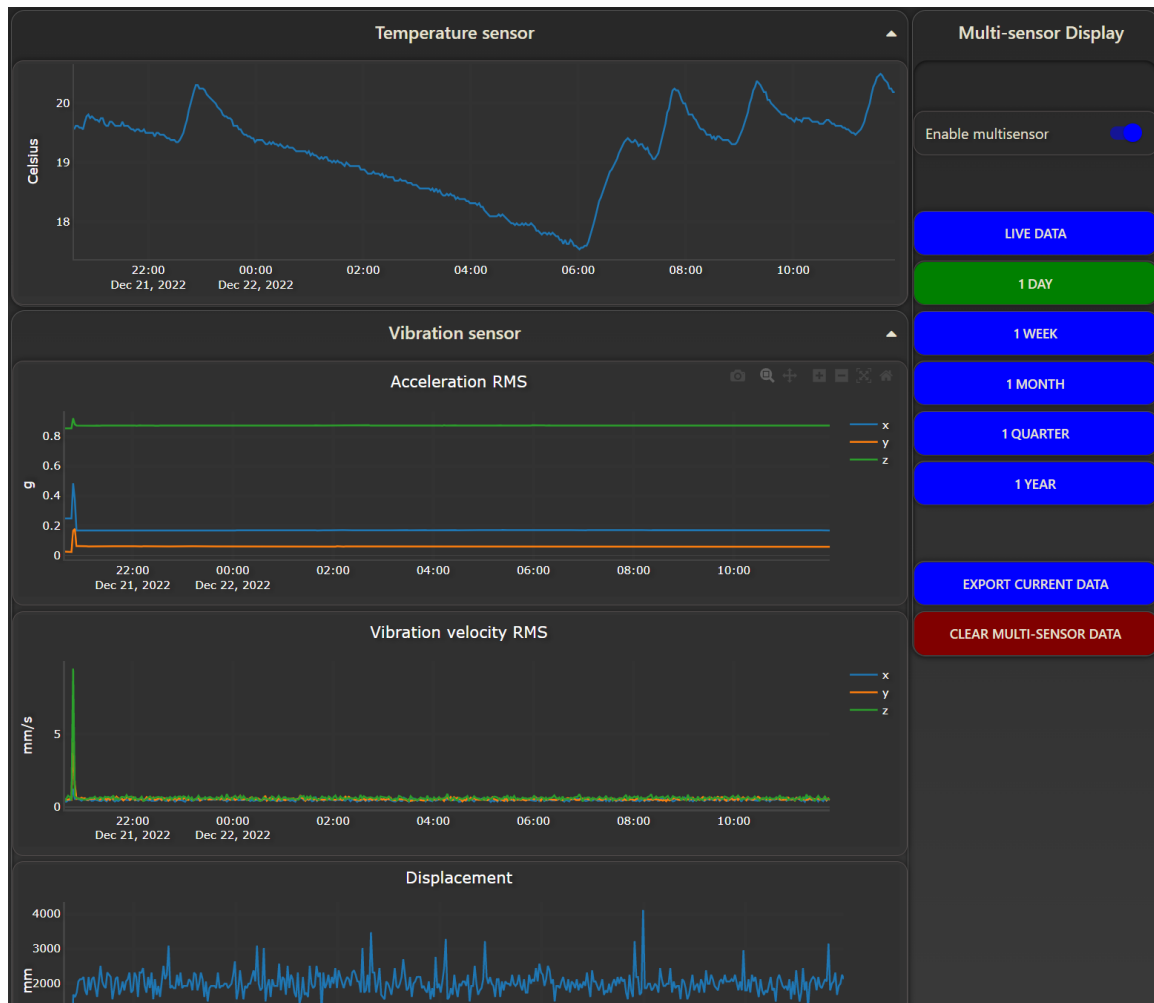


Figure 41 One day data review

For long-term data review from 1 day up to 1 year, the acceleration and vibration velocity RMS value are calculated using the maximum value to capture the maximum vibration level; the temperature, strain and distance are calculated using the average value. It is recommended to use 1-day view in default, since live data view constantly queries the integrated database and plots the charts, which consume higher system resource (CPU & RAM).

If a multi-sensor is not connected, its data can be hidden by clicking on the chart hiding arrow in the red rectangular frames. For example, in Figure 42, vibration sensor's data is hidden by clicking on the hiding arrow.

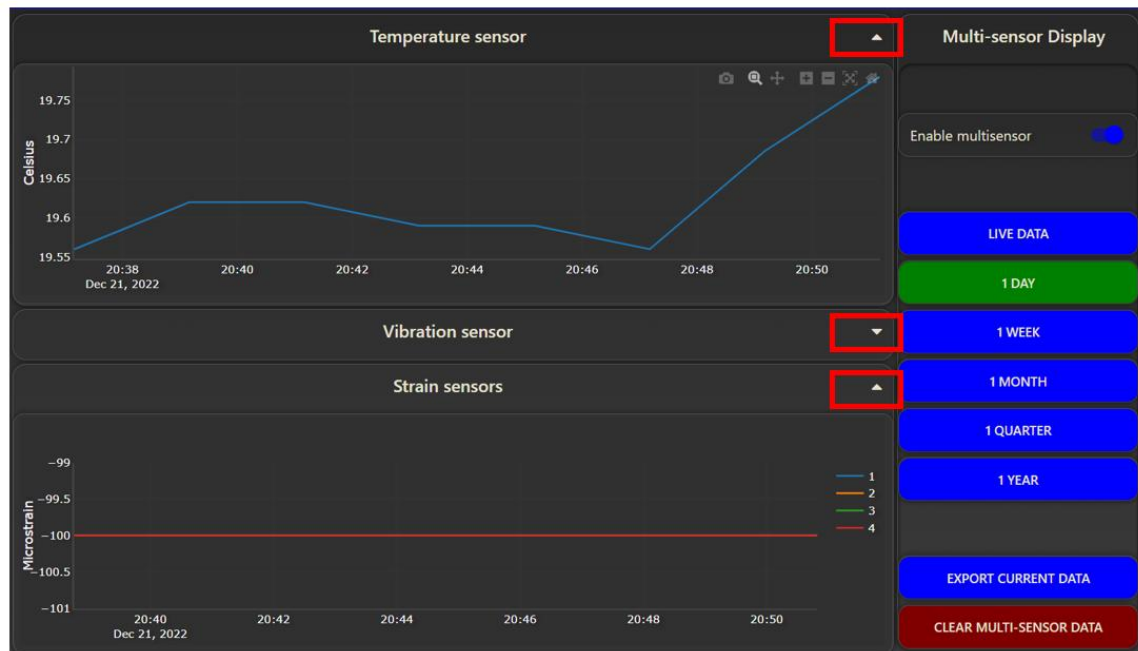


Figure 42 Hide a sensor's data

Multi-sensor data can be downloaded by clicking on “export current data” button. The data will be exported in CSV format.

Multi-sensor data can be removed by clicking on “Clear multi-sensor” data button. A popup window will show up asking user to confirm the action. Press “OK” to delete all multi-sensor data.

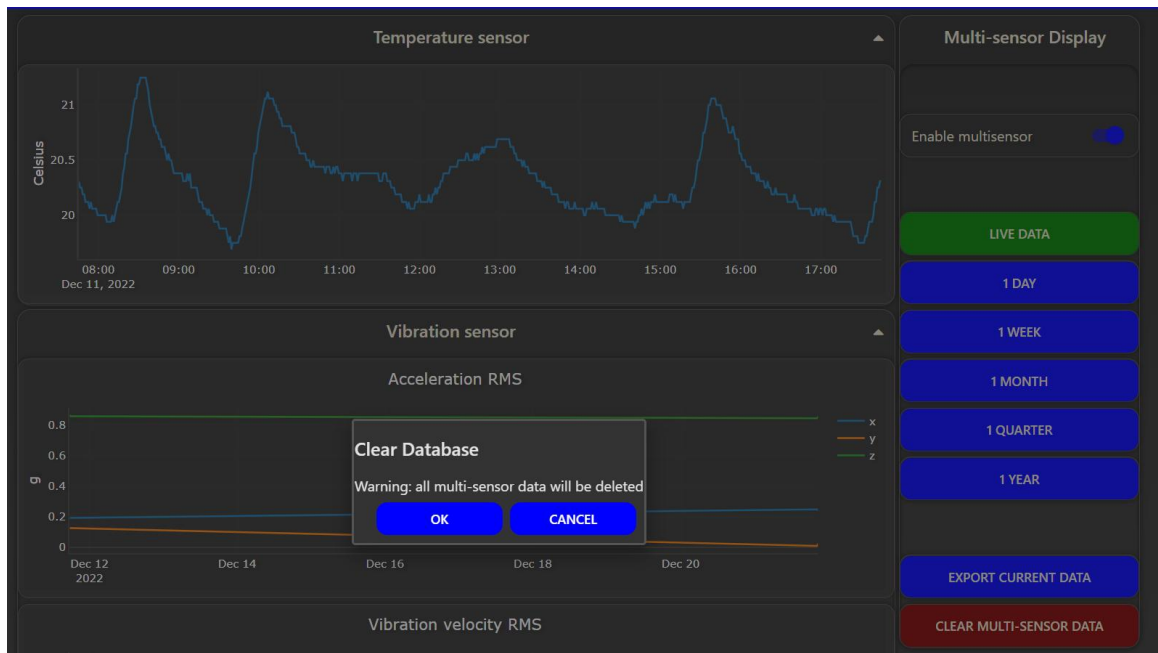


Figure 43 Delete all multi-sensor data

4.5 Alarms setup

In the “alarms setup” page, alarm thresholds can be set up for damage index and multi sensors. Alarms can be emailed to multiple email address (Figure 44). User can set up damage index, vibration velocity RMS for x, y and z axes, acceleration RMS for x, y and z axes, high temperature and low temperature alarm.

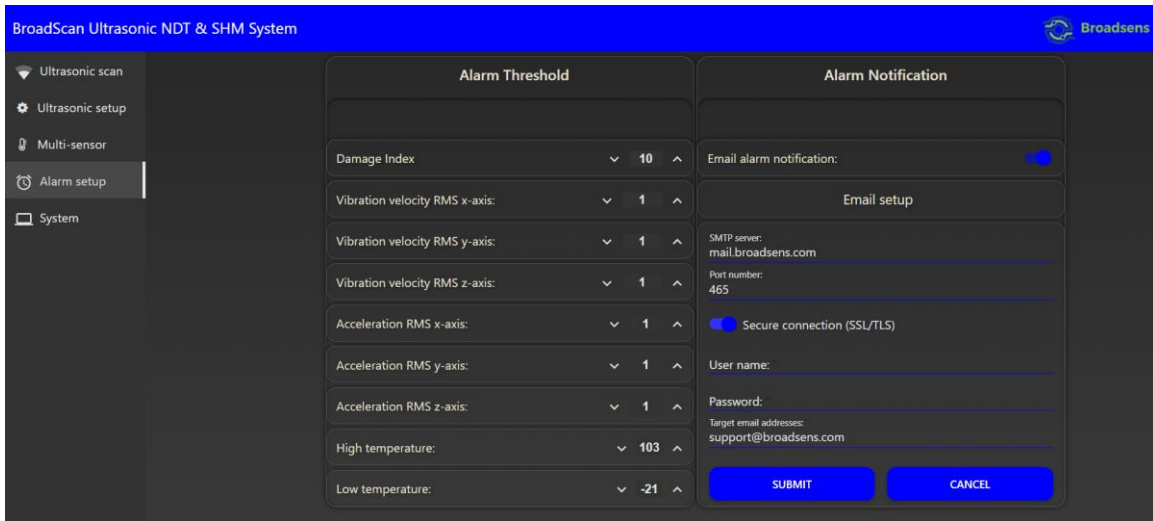


Figure 44 Alarms setup

Figure 45 shows an example on how to set up the alarm email notification. To enable this function, please follow steps below:

- Push the switch of “Email alarm notification” to the right to enable the feature.
- Enter the SMTP server address of your current email provider.
- Please also provide a port number for the SMTP server. If the port number uses secure connection mode, then please turn it on (switch to the right). Typical SMTP secure ports are 465 and 587.
- Enter user name and password to log in to the SMTP server. User name and password will be changed into “.....” characters and encrypted with AES-128 bit algorithm.
- Enter the target email address where the alarm will be sent to. For multiple target email address, one should separate them with “,” sign.
- Click on “Submit” button to apply the change, or click on the “cancel” button to cancel the setup.

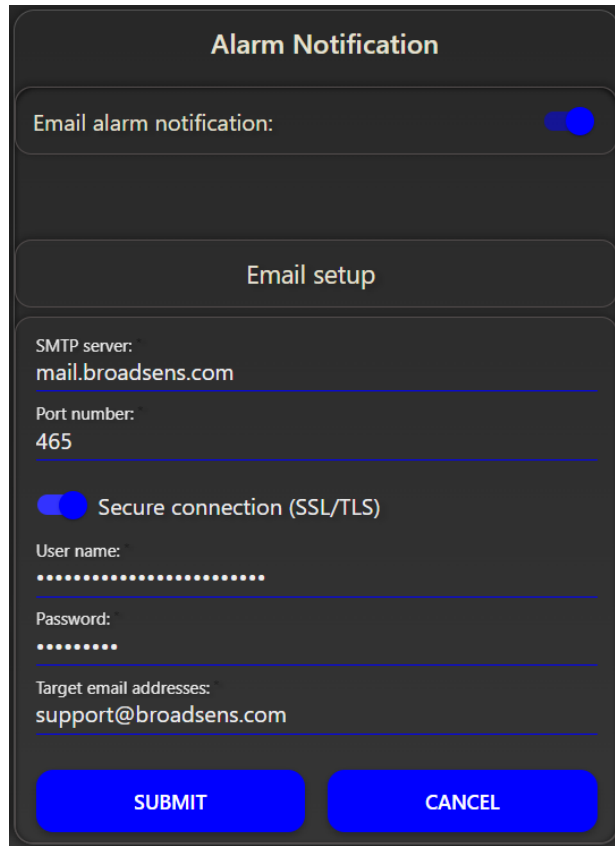


Figure 45 Email setup for alarm notification

5 API development

API library and example are provided to help user to write their own applications. They are located under /home/pi/examples directory.

5.1 *API functions*

DAQ programs need to use corresponding device's library. For example, D100 library file "libD100.a". The library is located in the example folder. User needs to include D100.h to call D100 library.

The API functions available are explained in the following.

```
int Initialize_D100();  
int Initialize_D110C();
```

```
int Initialize_D200();
```

// Hardware initialization of BroadScan devices. This function also initialized GPIO used by the micro-computer (Raspberry pi) to interact with the FPGA. Returns “0” if initialized successfully.

```
int Uninitialize_D100();
int Uninitialize_D110C();
int Uninitialize_D200();
```

// Uninitialize BroadScan devices. This function also releases the GPIO ports used by the library. Returns “0” if uninitialized successfully

```
int SetupDAQ(int iSamplingrate, int iSamplepoints);
// Set up sampling rate and sample points. The available sampling rates and
corresponding value assignment are listed in the following table.
```

Value	0x00	0x01	0x02	0x04	0x08	0x10	0x20
Sampling rate (MS/s)	80	40	20	10	5	2.5	1.25

If the sampling rate and sample points are the same, it is recommended to put the setup function outside the scan loop to save setup time.

```
int BITest();
// Built in self-test function of the FPGA. It return value “0” if there is no problem
found on the digital circuit
```

```
int StartDAQ(int iWaveform, int iFreq, float fAmplitude, char Wavefile[], int iVGC,
int iAverage, int iSamplepoints, float *fAct, float *fRece, int iDelay);
// iWaveform: waveform type: 1: Burst5; 2: Burst3; 3: Sine 9: user defined. Burst5
and burst 3 are popular waveforms used in structural health monitoring to
generate lamb waves. Choose value 9 for user-defined waveform
// iFreq: excitation signal frequency. Unit is in kHz. Supported frequency is from 50
kHz up to 5MHz.
// iAmplitude: value is from 0 to 1. 0 is the lowest and 1 is the highest (up to 130v
pk-pk)
```

```
// Wavefile[]: user-defined wavefile name. default value is "Userwave.dat".
// iVGC: gain in the receive path. The gain is in dB and available range is from 20-
100dB. Please note that a gain of 100dB could cause saturation and produce huge
noise. The recommended gain range is typically from 20-50dB for good signal
to noise ratio.
// iAverage: number of averages. Choose average number "1" for fast scan. Choose
3 averages or more for better signal to noise ratio.
// iSamplepoints: number of sample points. The sampling point definition is as
follows:
```

Value	0x00	0x01	0x02	0x04	0x08	0x10
Sampling points	1024	2048	4096	8192	16384	32768

```
// fAct: pointer to the actuation signal data set
// fRece: pointer to receive signal data set
// iDelay: delay of taking measurements after the excitation signal is sent out.
Default value is 0 us. This feature is very useful for long distance scan. When the
transmitter and receiver are far away, one may need to increase the number of sample
points to capture the response waveform. The delay feature allows users to ignore the
starting period and take less number of sample points. This can reduce the DAQ time and
memory usage.
```

Each time, StartDAQ function will check if the setup has any changes. If all the setup parameters are the same, then StartDAQ function will avoid re-setting up the parameters such as excitation waveform, switch, VGC and delay. This can speed up the DAQ process.

```
int StartADC();
// Start ADC immediately. One may ignore this function, since the StartDAQ function
will start the ADC after setting up all the parameters, and avoid re-setting up the
parameters if they are the same.
int SetWaveform(int iWaveform, float fAmplitude, int iFreq, char Wavefile[]);
// Define excitation waveform. Waveform type: 1: Burst5; 2: Burst3; 3: Sine 9: user
defined.
```

```
int SetSwitch(uint8_t iAct, uint8_t iRece);
// Set actuation switch and receive switch. It is recommended to set up 2 ms delay
after setting the switch for the high voltage switch inside D100 to settle down.
```

```
int SetVGC(int iVGC);  
// Adjust VGC level. The VGC level range is from 20-100dB.  
  
int SetDelay(int iDelay);  
Delay of taking measurements after the excitation signal is sent out. Default value is 0  
us.  
void Sleep(int i);  
// Sleep function in nano level accuracy  
  
int SetLED(int LED, int Value);  
// Turn on/off D100 LEDs. Two LEDs 1 or 2 can be controlled by this function;  
Value: 0: Off; 1:On
```

5.2 Examples

The following example programs are provided. They are written in C.

- singledaq
- multidaq
- trigger
- userwave
- encoderdaq
- readdata

All the details of the programs are explained in the source codes, including how to compile them in the header area.

Appendix 1. Static IP Allocation

It is possible to set up a static IP for BroadScan D200. **The easiest way to set up the static IP for the D200 is to use the router management page.** Different router has different management page and method. The following shows the management page for ASUS router (Figure 46). At the menu, select “LAN” in the advanced setting, then click on the “DHCP” server tab. At the “manually assign IP” section select the BroadScan D200, click on “+” sign to add the D200 as the static IP.

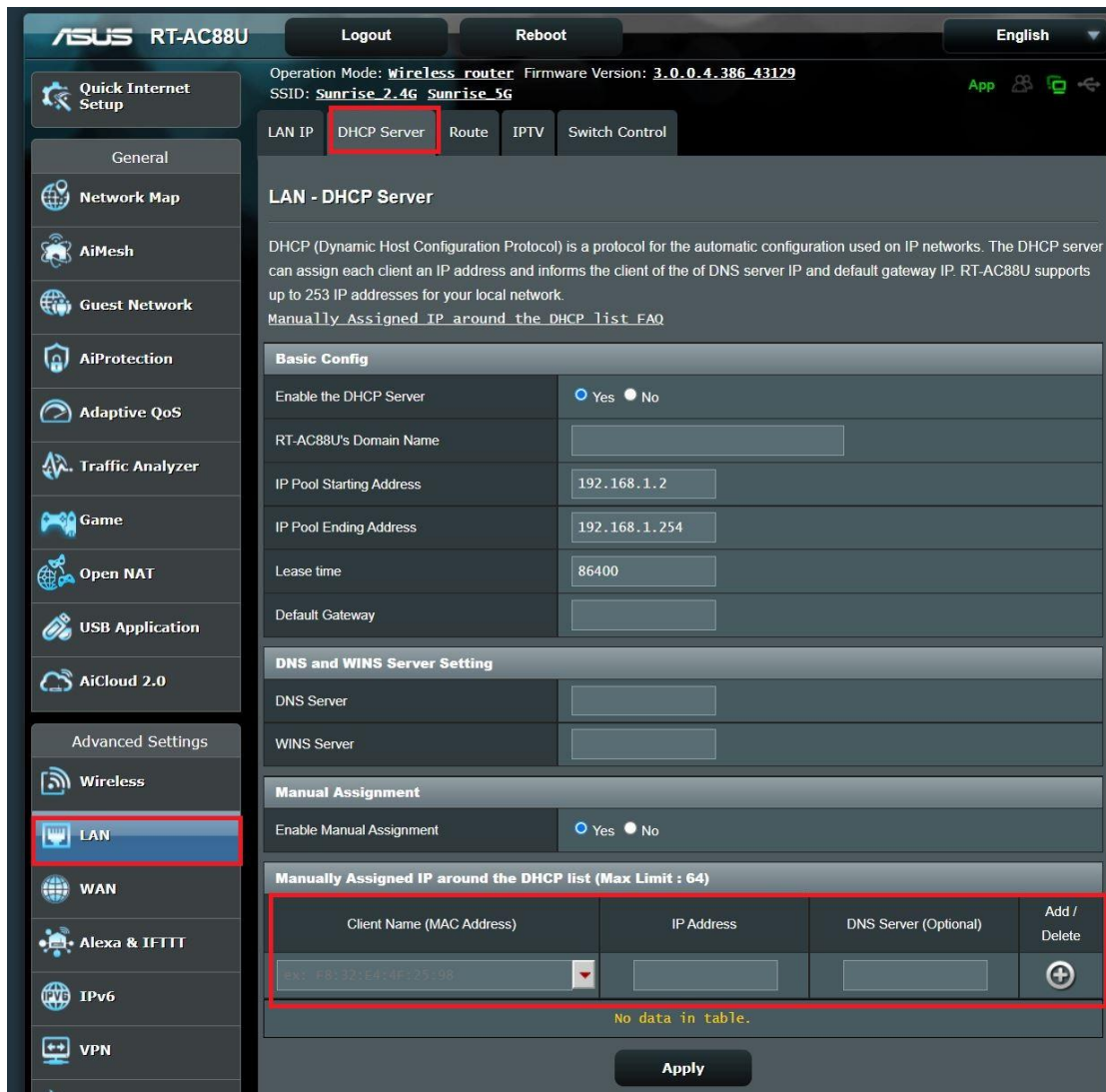


Figure 46 Set static IP at ASUS router

This method allows D200 to change to a different router easily without modifying the network setup inside D200.

Alternatively, you can log in to D200 and assign a static IP inside D200 (**This method is not recommended for beginners, since if you change network IP manually and there is an IP conflict, then you may lose access to D200**). SSH software is needed to log in to D200. The recommended software is Putty and it can be downloaded from the official website:

<https://www.putty.org/>.

Open Putty, enter the IP address of the D200 to access, choose “SSH” option, click on “Open” (Figure 47). Then a terminal window will pop up. Enter the provided SSH username and password to log in D200.

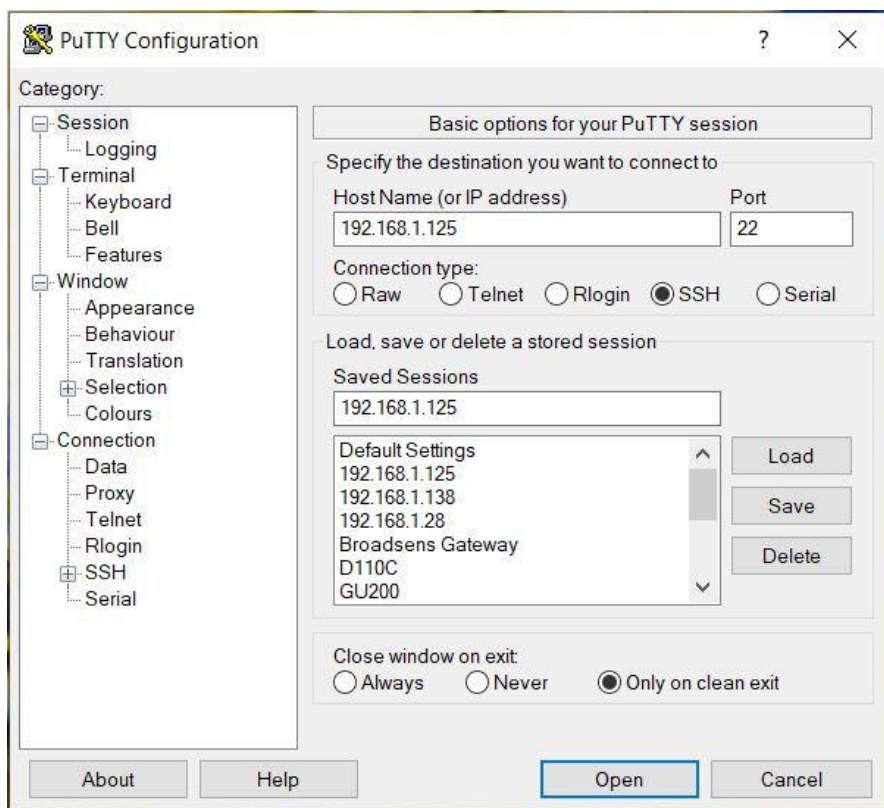


Figure 47 Putty window

Enter the following command to edit the “dhcpcd.conf” file:

```
sudo nano /etc/dhcpcd.conf
```

Assume that we want to use static ip “192.168.1.128” for the wired connection, then add the following lines to the end of “dhcpcd.conf” file:

```
interface eth0
```

```
static ip_address=192.168.1.128/24
```

```
static routers=192.168.1.1
```

```
static domain_name_servers=192.168.1.1
```

Please double-check and make sure that you enter the correct IP address. Please write down the static IP address you entered. You may need it to recover from an incorrect entry.

Enter the following command to reboot the D200:

```
sudo reboot
```

Then the static IP for Ethernet is ready to use.

Attention: Don't use static IP for wired connection and wireless connection at the same time. It is recommended to use wired Ethernet connection for D200. Only use WIFI for backup usage when a wired connection is not possible.

[Recover from an incorrect static IP entry]

In case that an incorrect IP address is entered and you can't access D200 via the network connection. Then please contact BroadSens for tech support.

Appendix 2. Connect PC directly to the BroadScan device

Sometimes, it is desirable to connect a laptop directly to the BroadScan device. There are multiple ways to implement this function. BroadSens recommends to use the following method, which is easy to use and the BroadScan device can be connected to any network without modification easily. Please note that the BroadScan device should not be assigned a static IP from the "dhcpd.conf" file. The following method assumes that you assign the BroadScan device static IP from the router.

Step 1. Install tftpd software. First download the DHCP server software “tftpd64.exe” (use “tftpd32.exe if you use 32-bit OS) from the following link:

<https://pjo2.github.io/tftpd64/>

In the download page, choose “Tftpd64-4.64-setup.exe” or the latest version, as shown in the following picture. Then download and install the software.

Philippe Jounin / Untitled project / tftpd64

Downloads

For large uploads, we recommend using the API. Get instructions

Downloads Tags Branches

Name	Size	Uploaded by	Downloads	Date
Download repository	94.4 MB			
tftpd64-service-edition.464.zip	660.0 KB	Philippe Jounin	46107	2019-02-27
Tftpd64-4.64-setup.exe	633.2 KB	Philippe Jounin	1026616	2019-02-27
Tftpd64_SE-4.64-setup.exe	735.4 KB	Philippe Jounin	129982	2019-02-27
tftpd64.464.zip	557.4 KB	Philippe Jounin	573998	2019-02-27
tftpd32-service-edition.464.zip	628.7 KB	Philippe Jounin	18509	2019-02-27
Tftpd32-4.64-setup.exe	609.5 KB	Philippe Jounin	52980	2019-02-27
Tftpd32_SE-4.64-setup.exe	704.2 KB	Philippe Jounin	8939	2019-02-27
tftpd32.464.zip	534.2 KB	Philippe Jounin	30251	2019-02-27
Tftpd64-4.62-setup.exe	563.2 KB	Philippe Jounin	461956	2018-05-05
Tftpd64_SE-4.62-setup.exe	621.9 KB	Philippe Jounin	117681	2018-05-05
tftpd64.462.zip	488.2 KB	Philippe Jounin	295207	2018-05-05

Figure 48 Download tftpd64

During the software installation, or when the software opens for the first time, if Windows firewall asks for the permission for the “tftpd64” software, then please allow the software to work for both private and public networks.

Step 2. Set up static IP for the Ethernet adapter of the laptop. In the Windows search function, search for “network connections”, or use “control panel->Network and Internet->Network connections” to find Ethernet adapter.

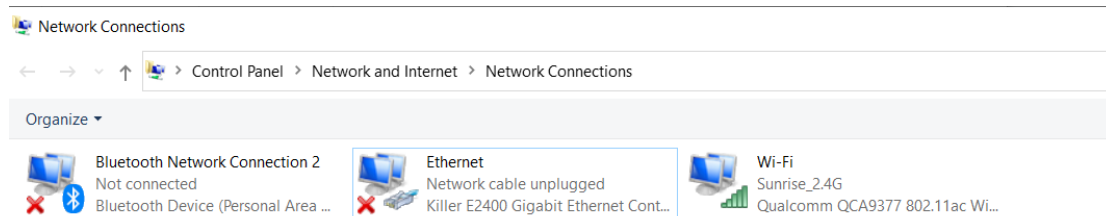
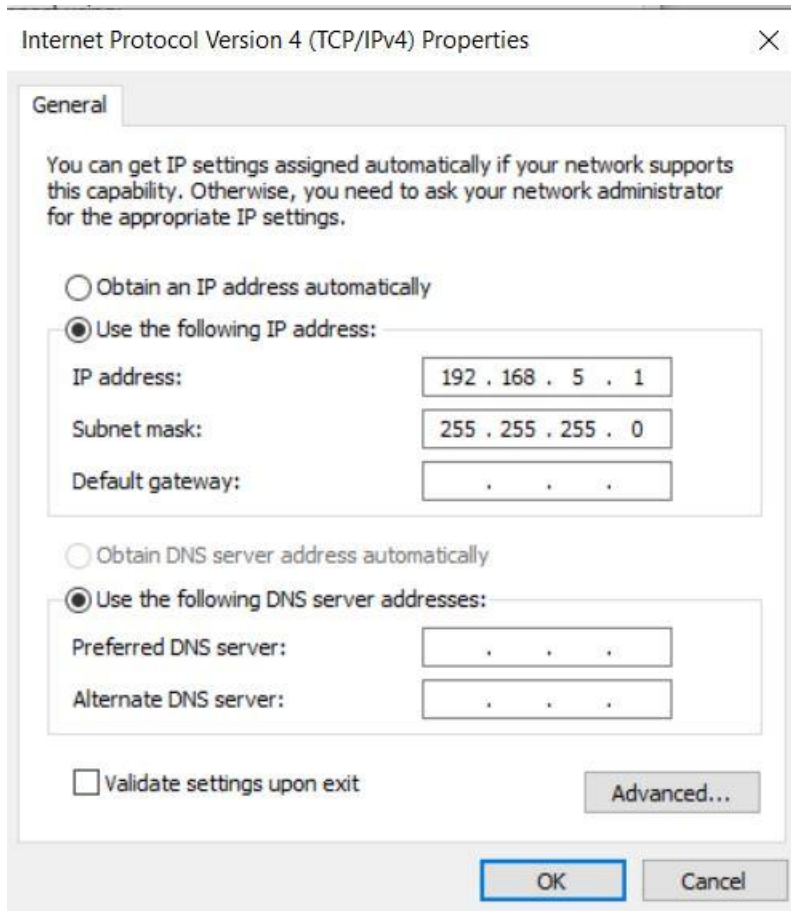


Figure 49 Ethernet adapter

Right click on the “Ethernet” icon, enter a static IP address for the Ethernet adapter of the laptop. Here we use “192.168.5.1”. You may use other available Ips too.

**Figure 50 Static IP for Ethernet adapter**

Step 3. Set up DHCP server for the Ethernet adapter of the laptop. Open tftpd, click on “settings” in the bottom of the software.

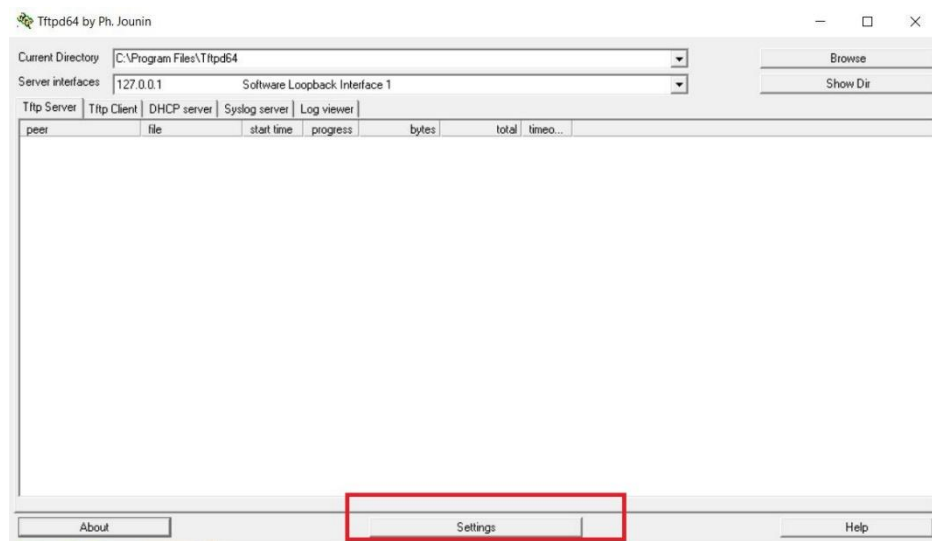


Figure 51 tftpd settings

Follow Figure 52 to enter the corresponding set up information. Please note that the router IP should be the static IP of the Ethernet adapter in Step 2. The “IP pool start” address should start from “xxx.xxx.xxx.10” to avoid conflict.

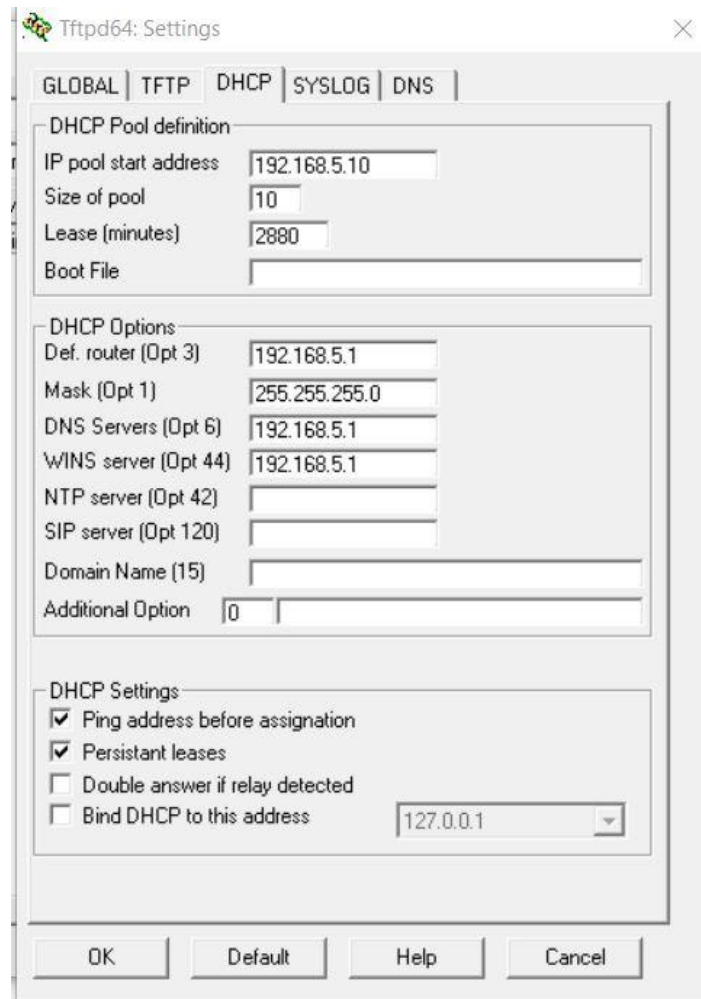


Figure 52 Set up DHCP for Ethernet adapter

Step 4. Connect the BroadScan device to the laptop and enjoy the direct connection. Power up BroadScan device, connect Ethernet cable from the BroadScan device to the Ethernet port of the laptop. Click on the “DHCP server” tab, BroadScan device IP should appear in the DHCP panel. In the following example, the new IP is “192.168.5.10”.

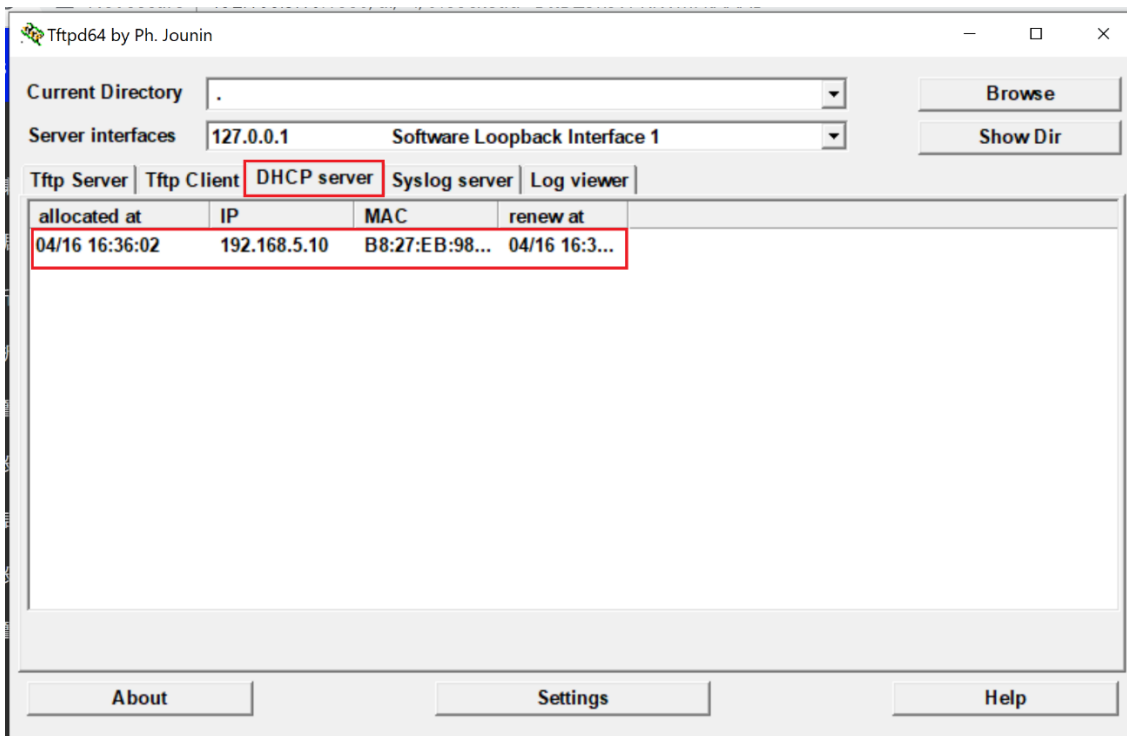


Figure 53 Find new IP for BroadScan device

Now the BroadScan device can be accessed from the new IP address given by step 3. In this example, the new IP address is 192.168.5.10. From the laptop browser, enter the following link to access the BroadScan device dashboard “192.168.5.10:1880/ui”.

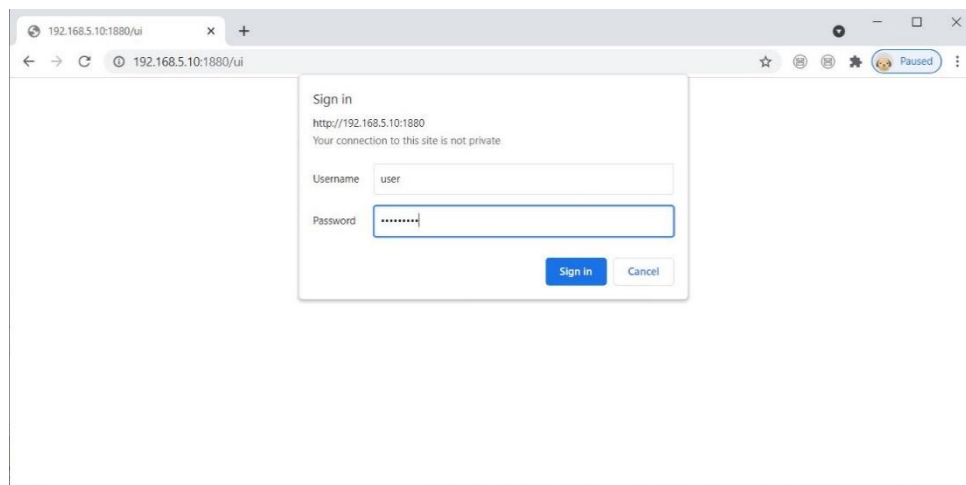


Figure 54 Access the BroadScan device from a web browser