

Flight !

Flight Stand Software User Manual

Plan, control, and manage tests with the Flight Stand software

| Stand Software v1.9.2 | | | |
|-----------------------|-------------------|---|--------------|
| | Automatic Control | 8 | Ø Tare senso |







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1. Download the Software

Download and install the Flight Stand Software on your computer.

Steps:

1. Visit <u>tytorobotics.com/download</u>

2. Locate the "Flight Stand Software" section and click the "download" button.



| Flight Stand software | RCbenchmark software | | | |
|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|--|--|--|
| The official software for the Flight Stand family of products. | The official software for the RCbenchmark Series 1520, Series 1580, Series 1585 and Series 1780 test stands. | | | |
| Version: 2.3.0 Released: February 10th, 2025 | Version: 1.2.1 Released: May 3rd, 2022 | | | |
| Windows installer: download | Windows installer: download | | | |

3. After the download is complete, run the installer.

If you encounter any issues installing the software, try performing the installation in administrator mode.



2. Setup the Simulated Board (optional)

The software includes a simulated board that users can use to simulate a test and explore the software before purchasing a thrust stand. Connecting a simulated board is optional but a great way to become familiar with the platform, no purchase necessary.

The data output from the simulation is based on tests with a real motor, which were used to create a performance model.

Video Tutorial: <u>https://www.youtube.com/watch?v=oszJTbkftbE</u>

Steps:

- 1. Open the Flight Stand Software and navigate to the Hardware tab.
- 2. Click "Connect Simulated Board". In the left panel, simulated data will be displayed.



| Powertrains | | Simulated hardware |
|-------------------------|-------------|------------------------------------------|
| Control | | Status: connected |
| ESC throttle: | off | |
| Inputs | | Identification Firmware Built-in systems |
| Current: | 0.0129 A | |
| Voltage: | 8.085 V | Path: simulated_1 |
| Force Fz (thrust): | -0.0002 kgf | Model number: Sim2000 |
| Torque MZ (torque): | ~0 N·m | Serial number: itSMe7xKDe |
| Rotation speed: | 0 rpm | |
| Derived measurements | | Identify |
| Electrical power: | 0.0758 W | |
| Mechanical power: | 0 W | |
| Motor & ESC efficiency: | 0 % | |
| Propeller efficiency: | 0 gf/W | |
| Powertrain efficiency: | 2.734 gf/W | |

3. To simulate a dual or multi-motor system, return to the Hardware tab and click "Connect Simulated Board" again, adding another simulated powertrain.

Once the simulated board is connected, you can proceed as if it were a real thrust stand and perform the setup, tests, and data visualization described in the next sections.



3. Software Configuration

Configure the software before beginning your tests to ensure optimal performance and safety. Here we will cover the settings in the first four options of the drop-down menu.

| Flight Stand Software v1.9.5 | | | | - 0 X |
|-------------------------------------------------------------------------------------------------------------------------|-----|--------------------------------------------------------------------------------------------------|----|----------------------------------|
| | ¢ | Setup | > | Ø Tare sensors |
| Hardware ✓ Force measurement unit 1 ✓ Electrical measurement unit 1 Powertrains Control | Eng | Setup Hardware Safety limits Powertrain Mappings Manual Control Automatic Control | 5择 | Units of measurement Debug tools |
| ESC throttle: off | | Tests | | |

Video tutorial: <u>https://youtu.be/JUSK1Mns0TA?si=jojtv8rcm57Np1vZ&t=27</u>

Steps:

1. Open the Flight Stand software.

2.Connect your Flight Stand to the USB port of your computer. In the left panel, the

Force Measurement Unit and Electrical Measurement Unit will appear.

- 3. Click on 'Setup': customize your units of measurement.
- 4. Click on 'Hardware': see details about the Flight Stand(s) connected, including serial number, firmware, and which additional systems are active, such as servo controllers and probes.
- 5. Click on 'Safety limits': set safety cut-off values that will limit how high or low your thrust, torque, voltage, current, RPM, and other parameters can go.
- 6.Click on 'Powertrains': map your powertrains by assigning names to your motor, propeller, ESC, and power source. Ensure that the powertrains are associated with the correct force and electrical measurement units.



4. Manual Testing

Perform manual control tests using the ESC throttle slider.

Video tutorial: <u>https://youtu.be/FzfvaZogpwQ?si=6XANU7NCvHQAaHju</u>

Steps:

- 1.Connect and configure your Flight Stand.
- 2.Select 'Manual Control' in the main drop-down menu.
- 3. Name your test.
- 4.Select how you would like to record data: continuously by clicking 'Record' or with snapshots using the 'Take sample' button.
- 5. Activate your ESC by checking the box next to the throttle slider.
- 6. Drag the throttle slider to start the test or enter a throttle value in the text box. The incoming data is visible on the real-time plots.

| Flight Stand Software v1.9.5 | | - D X |
|------------------------------|--------------------|----------------|
| TYTO ROBOTICS | < Manual Control > | Ø Tare sensors |
| Hardware | | |



7. When you are finished, deactivate your ESC by unchecking the box next to the slider.

8. Stop continuous recording by again clicking on the 'Record' button

9. Click 'Save and new' to save your test.

10. View your results in the 'Test' tab where you can also export your data.



5. Automated Testing

Set up and program automated tests using one of several methods:

- a. Values table
- b. CSV Upload/ Flight Replay
- c. Python API
- d. Prepared test scripts

a. Values table

Video tutorial: <u>https://youtu.be/0RqCtd3qnwc?si=l44I6jeJQab18dnr</u>

Steps:

1. In the 'Manual Control' tab, activate the ESC.

2. In the 'Automatic Control' tab, select a type of test (Step or Ramp).



| Simulated hardware | | Choose the type of automatic control to perform: | | | | | |
|----------------------------------------------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
| Powertrains | | | | | | | |
| Control | | Steps | | | | | |
| ESC throttle: | 1335 µs | Generate a sequence of output signal steps, either in a regular, or irregular pattern. Steps can be manually defined, or imported from a spreadsheet. | | | | | |
| Current: | 0.7072 A | Use cases: flight replay, endurance tests, step response, powertrain characterisation, ESC reaction time. | | | | | |
| Voltage: | 8.337 V | | | | | | |
| Force Fz (thrust): | 0.0415 kgf | | | | | | |
| Torque MZ (torque): | 0.0038 N·m | Ramp | | | | | |
| Rotation speed: | 8395 rpm | Perform a smooth ramp pattern while continuously recording data. | | | | | |
| Derived measurements | C (00.11) | Use cases: powertrain characterisation, throttle curve analysis, observe output signal aliasing effects, constant acceleration torque. | | | | | |
| Electrical power: | 6.608 W | | | | | | |
| Motor & ESC efficiency: Propeller efficiency: Powertrain efficiency: | 57.32 % 11.59 gf/W 6.644 gf/W | if (rpm > 100): exit() ADI programming late you control the bardware with any external code | | | | | |
| | | else: startPID() Use cases: CANbus ESCs, advanced control scenarios, factory integration, remote control, interact with other tools. | | | | | |

3. Under 'Controlled outputs' check the box next to the powertrain(s) you'd like to test.

4.Under 'Sequence form', use the 'Add Row' box to enter the time points at which you'd like to make a change in the throttle.

5. In the 'Powertrain throttle' column, add the throttle values you'd like to correspond with the time points in the 'Time' column.



5. Automated Testing

| Flight Stand Software v1.9.5 | | | | | | | | |
|--------------------------------------------------|--------------------------------------------------------------------|---------------------------|---------------|--------------------------|--------------|--|--|--|
| TYT Roboti | | < Auto | matic Control | > | | | | |
| Hardware Simulated hardware | | \leftarrow Back | Steps wiz | zard | | | | |
| Powertrains Control | 1225 | Sequence Controlled ou | e editor | | | | | |
| Inputs Current: | rottie: 1335 μs Controlled Outputs Powertrain 1 ESC throttle —— | | | | | | | |
| Voltage: | 8.211 V | Time (s) | Take San | nple Powertrain 1 ESC th | prottle (us) | | | |
| Torque MZ (torque): Rotation speed: | 0.0038 N⋅m 8224 rpm | 0 | | 1300 | × | | | |
| Derived measurements | | 2 | | 1600 | × | | | |
| Electrical power: Mechanical power: | 5.146 W 2.456 W | 4 | | 1800 | × | | | |
| Motor & ESC efficiency: Propeller efficiency: | 47.74 % 14.39 gf/W | 6 | | | × | | | |
| Powertrain efficiency: | 6.87 gf/W | 8 | | | × | | | |
| | | 10 | N/A | N/A | ~ | | | |

6. Choose how you would like to collect data:

- a.To take a sample at each time point, check the 'Take sample' box in the table.
- b.To continuously record data, scroll down to 'Sequence runner' and toggle on 'Continuous recording".
- 7. Scroll down to the 'Sequence Preview' to see how your test looks.
- 8. To loop your test, enter the number of repeats in the 'Loop sequence' box.
- 9. Name the test in the 'Title' box.
- 10.Click 'Execute sequence' to run the test.
- 11.Once the test is complete, a yellow box will appear in the left panel where you can Save or Discard your data.



5. Automated Testing

b. CSV Upload/ Flight Replay

Video tutorial: <u>https://youtu.be/FroCYgVlPgQ?si=3QrXeoAZ26-I1jBM</u>

Steps:

- 1.After selecting a type of automated test, under 'Sequence editor', click the 'Tools' drop-down and select 'Load demo example'.
- 2.Again under the 'Tools' drop-down, select 'Export sequence from CSV'.
- 3.Use the exported CSV file as a template and add your desired time and throttle points.
- 4.Once your file is ready, return to the 'Tools' drop-down, select 'Import sequence from CSV' and upload the edited CSV file from your computer.

Sequence editor Controlled outputs Powertrain 1 ESC throttle



5.Scroll down to preview and execute the sequence. Once the test is complete, a yellow box will appear in the left panel where you can Save or Discard your data.



5. Automated Testing

c. Python API

Video tutorial: <u>https://youtu.be/Gkf0dAnA1w4?si=nV3WNBGPCv49miR8</u>

Steps:

- 1.Before starting, ensure you have the latest version of the Flight Stand software installed on your computer as well as a text editor with a Python compiler.
- 2.In the 'Hardware' tab of the Flight Stand software, connect your Flight Stand.
- 3. Navigate to the 'Automatic Control' tab and select 'Python API' from the test options.
- 4.Open the repository at: <u>https://gitlab.com/TytoRobotics/flightstand-api</u> and read the 'README' file.

| Project | main x flightstand-ani / README md |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| F Flightstand API | |
| සී Manage > | Updated documentation |
| ë Plan → | Dominic Robillard authored 1 month ago |
| Code | |
| Merge requests 0 | Image: Second secon |
| Repository | |
| Branches | Flight Stand Software API |
| Commits | Introduction |
| Tags | Introduction |
| Repository graph | This project contains the API definition used by the Tyto Robotics Flight Stand Software. |
| Compare revisions | In this project we provide examples and compiled libraries to communicate with the Flight Stand Software using Python, Javascript, and Golang. |
| Snippets | The API uses the gRPC framework. More programming languages are supported by the gRPC framework, such as C++, Java, Ruby, but you will need to compile |
| 2 Build > | the .proto in your target language, which we cannot offer support. |
| ট Deploy > | Getting started |

5. Open your preferred text editor (i.e. PyCharm).

6.In PyCharm you will need to configure a virtual environment.

- a.If you are using another text editor such as VS Code you will have to install Python or the Python extension.
- 7.In PyCharm, open the Python folder in the repository.
- 8.Open up a terminal in the folder and run the following command: py -m pip install grpcio grpcio-tools



5. Automated Testing



9.To verify your connection, open the Flight Stand software and make the real-time plots visible. Then in Python, run example.py.

a.In PyCharm, the terminal will output all available boards, automatically connect the simulated board, and list all available inputs and outputs for that board.

| × | 🗮 flightstand-api-main 🗸 Version control 🗸 | | Current File 🗸 🧔 🔅 🔲 🗄 | 24 Q 🕸 | - o | × | | |
|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------|------------|----|--|--|
| | Project ~ | 🕏 example.py 🗵 | | | | Ļ, | | |
| 8. | flightstand-api-main C:\Users\Shijie\Download anguages go js python example2_data_streaming_10hz.py example3_data_polling.py example4_PID_constant_thrust.py example5_external_hardware_interfact flight_stand_api_v1_pb2_py flight_stand_api_v1_pb2_grpc.py M& README.md proto .gitignore README.md fli External Libraries Scratches and Consoles | <pre>143 output_mask = field_mask.FieldMask() 144 output_mask.FromJsonString('outputTarget') 145 UpdateOutputRequest = fs.UpdateOutputRequest(Output=ESC_output, mask=output_mask) 146 ESC_output = stub.UpdateOutput(UpdateOutputRequest) 147 time.sleep(1.0) # Give time for the output change to be applied 148 149 # Print the thrust value 140 ListSamplesResponse = stub.ListSamples(fs.ListSamplesReguest()) 151 for ListedSample in ListSamples(fs.ListSamplesReguest()) 152 if listedSample.signal_name == thrust_signal_name: 153 print("Thrust: " + str(listedSample.filtered_value) + " N") # In Newtons 154 155 # Increase the throttle to 1500 156 print("Setting ESC to 1500") 157 ESC_output = stub.UpdateOutputRequest(output=ESC_output, mask=output_mask) 158 ESC_output = stub.UpdateOutputRequest(output=ESC_output, mask=output_mask) 159 ESC_output = stub.UpdateOutputRequest(output=ESC_output, mask=output_mask) 150 ESC_output = stub.UpdateOutputRequest() 150 ListSamples(fs.ListSamplesReguest()) 151 ESC_output = stub.UpdateOutputRequest(output=ESC_output, mask=output_mask) 152 # Increase the throttle to 1500 153 print("Setting ESC to 1500") 154 # Print("Setting ESC to 1500") 155 ESC_output = stub.UpdateOutputRequest(output=ESC_output, mask=output_mask) 156 ESC_output = stub.UpdateOutputRequest() 157 time.sleep(1.0) # Give time for the output change to be applied 158 159 # Increase = stub.ListSamples(fs.ListSamplesReguest()) 150 ListSamplesResponse = stub.ListSamples(fs.ListSamplesReguest()) 150 ListSamplesResponse = stub.ListSamples(fs.ListSamplesReguest()) 151 time.sleep(1.0) # Give time for the output change to be applied 159 150 ListedSample in ListSamples(fs.ListSamplesReguest()) 150 ListSamplesResponse = stub.ListSamples(fs.ListSamplesReguest()) 151 time.sleep(1.0) # Give time for the output change to be applied 150 151 time.sleep(1.0) # Give time for the output change to be applied 153 154 print the thrust value (it should have increased) 155 ListSamplesResponse = stub.ListSamplesReguest()) 156 ListSamplesResponse = stub.Li</pre> | | | | | | |
| | | 168 # Restore the throttle to 1000 | | | | | | |
| | Run 🗳 example × C 🔲 : | | | | : - | | | |
| 4 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 | Listing available outputs: /boards/simulated_1/outputs/1: type=1 ESC output name: /boards/simulated_1/o Current output target: 1000.0 /boards/simulated_1/outputs/2: type=2 /boards/simulated_1/outputs/3: type=2 /boards/simulated_1/outputs/4: type=2 Activating ESC at 1000 Thrust: 1.6921329006436288-05 N Setting ESC to 1500 | displayName= putputs/1 displayName= displayName= displayName= | | | | | | |
| • filg | ghtstand-api-main > languages > python > 🤣 exam | ple.py | LF | UTF-8 4 spaces | Python 3.9 | đ | | |



5. Automated Testing

d. Prepared test scripts

This Google sheet:

https://docs.google.com/spreadsheets/d/1XvXoo7h2_0t1s1L2px2kDtGj2X2kDnwxDqttWxkE <u>Fus/edit?usp=sharing</u> contains the templates for the Sine wave, Chirp signal, and Sawtooth tests. Add a copy to your Google Drive by clicking 'File' \rightarrow 'Make a copy'.

i. Sine wave

Video tutorial: <u>https://youtu.be/0pu8JYqnV80</u>

Steps:

- 1. Open your copy of the Google sheet and navigate to the 'Sine/Chirp Generation' tab.
- 2.Adjust the # of lines, speedup, frequency, amplitude, and offset values in row 2 to design your sine wave. This will adjust the preview in the 'Throttle vs. Time' graph.
- 3.Copy the 'Time' and 'Throttle Sine' data into the 'Sine Wave Data for Export' tab.
- 4. Download the file as a CSV file (File \rightarrow Download \rightarrow .csv).

| | File Edi | t view insert | Format Data | Tools Extensi | ons Help | | | | | | | | | | | |
|---|----------|---------------|-----------------|------------------|----------|----------|-------|---------------|------------|-------------|----------|----------|---------|--------------|------------|------|
| C | २७२ | 骨 🖥 100% | ▼ \$% | .0 .00 123 | Defaul 🔻 | - 10 | 0 + | вІ | <u>÷ A</u> | è. ⊞ | 돈국 👻 | ≣• ↓ | ד ⊊ ד | - <u>A</u> - | ⊖ | l |
| 8 | • ; | fx | | | | | | | | | | | | | | |
| | A | В | С | D | E | F | | G | F | I | 1 | J | к | | L | |
| | Time (s) | | Throttle - Sine | Throttle - Chirp | | # of Lin | es | Time Interval | Frequenc | y of Sine | Amplitud | e Offset | | | Speedup of | of C |
| 2 | 0 | 0 | 1250 | 1250 | | | 1000 | 1 | | 1 | 5 | 0 1250 | | | | |
| 5 | 1 | 0.01745329252 | 1251 | 1250 | | | | | | | | | | | | |
| | 2 | 0.03490658504 | 1252 | 1250 | | Instruc | tions | Click Me | | | | | | | | |
| 5 | 3 | 0.05235987756 | 1253 | 1250 | | | | | | | | | | | | |
| ; | 4 | 0.06981317008 | 1253 | 1250 | | | | | | | | | | | | |
| 7 | 5 | 0.0872664626 | 1254 | 1251 | | | | | | | | | | | | |
| 3 | 6 | 0.1047197551 | 1255 | 1251 | | | | | | | | | | | | |
| , | 7 | 0.1221730476 | 1256 | 1251 | | | | TL | | /C T:- | | | | | | |
| 0 | 8 | 0.1396263402 | 1257 | 1251 | | | | 11 | irottie | v5. III | ne (s) | | | | | |
| 1 | 9 | 0.1570796327 | 1258 | 1252 | | 2000 | | | | | | | | | | |
| 2 | 10 | 0.1745329252 | 1259 | 1252 | | | | | | | | | | | | |
| 3 | 11 | 0.1919862177 | 1260 | 1253 | | | | | | | | | | | | |
| 4 | 12 | 0.2094395102 | 1260 | 1253 | | 1750 | | | | | | | | | - | |
| 5 | 13 | 0.2268928028 | 1261 | 1253 | | | | | | | | | | | | |
| 6 | 14 | 0.2443460953 | 1262 | 1254 | | | | | | | | | | | | |
| 7 | 15 | 0.2617993878 | 1263 | 1254 | rottl | 1500 | | | | | | | | | _ | |
| 8 | 16 | 0.2792526803 | 1264 | 1255 | Ę | | | | | | | | | | | |
| 9 | 17 | 0.2967059728 | 1265 | 1256 | | | | | | | | | | | | |
| C | 18 | 0.3141592654 | 1265 | 1256 | | 1250 | | | | | | | | | _ | |
| 1 | 19 | 0.3316125579 | 1266 | 1257 | | | | | | | | | | | | |
| 2 | 20 | 0.3490658504 | 1267 | 1257 | | | | | | | | | | | | |
| 3 | 21 | 0.3665191429 | 1268 | 1258 | | 1000 | | 200 | 40 |) | 600 | | 800 | | | |
| 4 | 22 | 0.3839724354 | 1269 | 1259 | | | | | | | | | | | | |
| 5 | 23 | 0.401425728 | 1270 | 1260 | | | | | | Time (| s) | | | | | |
| 6 | 24 | 0.4188790205 | 1270 | 1260 | | | | | | | | | | | | |
| 7 | 25 | 0.436332313 | 1271 | 1261 | | | | | | | | | | | | |

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5. Automated Testing

- 5.Open the Flight Stand software and navigate to the 'Automated Control' tab, click on 'Step test'.
- 6. Under 'Tools', select 'Import sequence from CSV'.
- 7. Select and import the CSV file that you downloaded from the Google sheet.
- 8. The sine wave data points will be displayed in the table and a preview of the wave will be shown in the Sequence preview window.
- 9. Click 'Execute sequence' to run the test.
- 10.Once the test is complete, a yellow box will appear in the left panel where you can Save or Discard your data.

ii. Chirp signal

Video tutorial: <u>https://youtu.be/0pu8JYqnV80?si=GQYjKerpszKwcb5q&t=129</u>

Steps:

1. Open your copy of the Google sheet and navigate to the 'Sine/Chirp Generation' tab.

- 2. Adjust the # of lines, speedup, frequency, amplitude, and offset values in row 2 to design your wave. This will adjust the preview in the 'Throttle vs. Time' graph.
- 3.Adjust the 'Speedup of chirp' value.
- 4.Copy the data from the 'Time' and 'Throttle Chirp' columns into the 'Chirp Data for Export' tab.
- 5.Once you have added the data to the appropriate columns, download the file as a CSV file (File \rightarrow Download \rightarrow .csv).
- 6.Open the Flight Stand software and navigate to the 'Automated Control' tab, click on 'Step test'.
- 7. Under 'Tools', select 'Import sequence from CSV'.
- 8.Select and import the CSV file that you downloaded from the Google sheet.





5. Automated Testing

9.The chirp test data points will be displayed in the table and a preview of the wave with increasing frequency will be shown in the Sequence preview window.10.Click 'Execute sequence' to run the test.

11.Once the test is complete, a yellow box will appear in the left panel where you can Save or Discard your data.

| Flight Stand Software v1.9.5 | | | | – 0 × |
|----------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------|--------------------------------------|-------------------------|
| | < Automatic Control > | | | |
| Hardware Simulated hardware | Sequence preview | | | |
| Automatic sequence running 7 minutes, 19.2 seconds Title: Untitled Continuous recording: 4 minutes, 47.75 seconds | 1,300 - 1,200 - | | | |
| Powertrains Control | 1,100 - | | | |
| ESC throttle: 1200 µs Inputs Current: 0.3143 A | 0 100 200 | 0 300 400 500 | 600 700 | - |
| Voltage: 8.327 V Force Fz (thrust): 0.0209 kgf | | Real-time | plots | |
| Torque MZ (torque): 0.0021 N·m Rotation speed: 6126 rpm Derived measurements | Timespan: 1 minute | | Layout Pause Show unfiltered | ed 🕜 🛛 Powertrain 1 ——— |
| Electrical power: 3.635 W Mechanical power: 1.847 W | ESC throttle output | Force Fz (thrust) | Torque MZ (torque) | Voltage |



iii. Sawtooth

Video tutorial: <u>https://youtu.be/0pu8JYqnV80?si=c1WeU3UYjajHE6Bu&t=204</u>

Steps:

1. Open the Flight Stand software and navigate to the 'Automated Control' tab.

2. Click on 'Ramp test'.

3. In the 'Sequence editor' table, enter 2 lines of data for time, throttle and rate of change.4. A preview of a simple up/down pattern (sawtooth) will appear in the 'Sequence preview' window below.



5. Automated Testing



5. Enter the number of repeats you would like in the 'Loop sequence' box and click

- 'Execute sequence'.
- 6.Once the test is complete, a yellow box will appear in the left panel where you can Save or Discard your data.

iv. PID tuning

Note: we highly recommend watching the video tutorial for this section (link on page 15).

A PID controller is a special algorithm that aims to maintain a specific value for a sensor. For propulsion systems, the PID controller achieves this by continuously adjusting the throttle output required to make your propulsion system converge on the desired value.

Before completing this tutorial, you will need to be able to successfully run the first example.py file in the repository. If you have not yet done so, go to section 5c of this user manual to learn how to do so.



5. Automated Testing

Video tutorial: <u>https://youtu.be/8HSNoONR3yg</u>

Steps:

- 1.Assuming you were able to successfully run the example.py file (section 5c), open the Flight Stand software.
- 2.Open your Python compiler and open a console to ensure you have simple-pid installed. You can check by running the command: py -m pip install simple-pid
- 3. Find the number corresponding to the signal of the variable you would like to target by opening the .proto file (we will use thrust as an example), then scroll until you see the list of input signals. Thrust (FZ) corresponds to number 11, note the number.

| PC_ | 🗮 flightstand-api-main ~ Versio | n control 🗸 | Current File 🗸 🕞 🔅 🚦 | 2+ Q 🚳 – 🗉 | × |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------------|---|
| | Project ~ | M# README.md 🚭 example.py 🚭 example_PID_constant_thrust.py M# proto\README.md 🚍 flight_stand_api_v1.proto × 🚭 FlightStand.py | | 1 | Ģ |
| 80 | flightstand-api-main H:\Shared d languages go js python python example_data_polling.py example_data_recording example_stand_api_v1_pb2_ example_flight_stand_api_v1_proto mis README.md exaDME.md gitignore mis README.md exaDME.md exaDME.md | <pre>// 4 bytes of data per parameter. Because if is fixed length it is sent as Uint32. uint32 data = 2; } enum CutoffConditionType { UWKKOWN_CUTOFF_CONDITION_TYPE = 0; NO_CLIENT = 1; // no client is connected MANUAL = 2; // when triggering from a client OUT_OF_RANGE_SIGNAL = 3; HAROWARE_CONNECTED = 4; HAROWARE_CONNECTED = 4; HAROWARE_DISCONNECTED = 5; } // We use S.I. units. enum InputType { UNCALIBRATED_ICAD_CELL = 1; UNCALIBRATED_ICAD_CELL = 1; UNCALIBRATED_ICAD_CELL = 1; UNCALIBRATED_ICAD_CELL = 1; UNCALIBRATED_ICAD_CELL = 1; UNCALIBRATED_TAIL_CURRENT = 3; UNCALIBRATED_FILL CURRENT = 4; UNCALIBRATED_FILL CURRENT = 1; CURCALIBRATED_FILL CURRENT = 1; CURCALIBRATED_FILL CURRENT = 1; CURRENT_HALL_CURRENT = 8; FORCE_FX = 2; CORRENT_HALL_CURRENT = 8; FORCE_FX = 10; CURRENT_HALL_CURRENT = 1; CURRENT_HALL_CURRENT = 8; FORCE_FY = 10; CURRENT_HALL_CURRENT = 1; CURRENT_HALL_CURRENT = 8; FORCE_FY = 10; CURRENT_HALL_CURRENT = 10; CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRENT_HALL_CURRE</pre> | | ± 91 ^ ~ | |
| 4 C I O & O | ghtstand-api-main > proto > ≡ flight s | <pre>815 FORCE_FZ = 11; // Thrust 10 TORQUE_MX = 12; 11 TORQUE_MX = 12; 11 TORQUE_MY = 13; 12 TORQUE_MZ = 14; // Torque 13 ROTATION_SPEED_FREQUENCY = 15; 14 OUTPUT_VALUE_SEC_SIGNAL = 16; 15 OUTPUT_VALUE_SERVO_SIGNAL = 17; 16 ACCELEROMETER_AX = 18; 17 ACCELEROMETER_AX = 18; 18 ACCELEROMETER_AX = 19; 18 ACCELEROMETER_AZ = 20; 18 ACCELEROMETER_AZ = 20; 18 ACCELEROMETER_VIBRATION_LEVEL = 21; 18 TEMPERATURE_IR = 22; 17 EMPERATURE_IR = 22; 18 AIRSPEED_DIFFERENTIAL_PRESSURE = 24; 18 AIRSPEED_DIFFERENTIAL_PRESSURE = 24; 18 AIRSPEED_DIFFERENTIAL_PRESSURE = 24; 19 ADD ADD ADD ADD ADD ADD ADD ADD ADD AD</pre> | 815:1 (26 chars) LE | UTE-8 4 spaces Python 3.11 | f |

4. Open example 4. Change the input and output signals to match the powertrains in the software. You can find this information in the Flight Stand software's 'Hardware' tab. Click on your powertrain and highlight the first line of text in the 'Identification' tab.



5. Automated Testing

| Flight Stand Software v1.9.2 | |
|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| ROBOTICS | < Hardware → |
| Hardware Solution Flight Stand 15 Standard - Force Measurement Unit Flight Stand 15 Standard - Electrical Measurement Unit | Status: connected Identification Firmware Built-in systems |
| Powertrains | PathCOM3 Model number: FS15S-FMU Serial number: 835034E7 |
| ESC throttle: off Inputs | Identify Disconnect |

- 5. Paste this information into the input/output board information in the Python file.
- 6. Run the Python file. The terminal will output a list of available inputs.
- 7.Find the input corresponding to your target variable's signal number (#11 for thrust) and enter it in example_PID_constant_thrust.py after the target input board.

8.Scroll down to 'Target value' and enter the value you would like to target in SI units (Newtons for thrust).

| K | ≡ flightstand-api-main ∨ Version control ∨ | Current File ✓ ▷ 🎕 🗄 😤 Q | \$ – a > |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| | Project ~ | MI README.md example.py example_PID_constant_thrust.py × MI proto\README.md = flight_stand_api_v1.proto PlightStand.py | i 1 |
| 8 | Flightstand-api-main H:\Shared drives\Marketing\Photos et Vidé languages go js python example.py example_data_polling.py example_data_recording.py example_external_hardware_interface.py example_PID_constant_thrust.py flight_stand_api_v1_pb2.py flight_stand_api_v1_pb2.grpc.py FlightStand.py M* README.md proto flight_stand_api_v1.proto M* README.md gitignore M* README.md gitignore KEADME.md Scratches and Consoles | budget sectings, the output contigeration (war, Using, Fate Caniter, etc.) can impact the contributers. User Application Requirements: Desired control characteristics (fast reaction, no overshoot, etc.) affect the ideal coefficients. Examples of PID Terms: Here are some examples of PID terms used in different scenarios: Simulated Hardware (Constant Thrust): 2000, 1500, 0 Simulated Hardware (Constant Thrust with Output Rate Limit of 200): 2000, 500, 0 Simulated Hardware (Constant Thrust with Output Rate Limit of 200): 2000, 500, 0 Simulated Hardware (Constant Thrust with Output Rate Limit of 200): 2000, 500, 0 Simulated Hardware (Mejzlik 48 x 16,4 Propeller, Xoar 180-35 34kV Motor, Xoar Pulse P200 ESC) Constant Thrust with Rate Limiter of 200us/s at 80V: 2, 5, 0.5 Constant Station Speedi 2, 2, 5, 0.5 Constant Rotation Speedi 2, 5, 0.5 Constant Rotation Speed with Rate Limiter of 200us/s at 80V: 2, 5, 0.3 *** K a = 0 # Derivative term K a = 0 # Derivative term this example performs a square wave pattern alternating between 50% of the target_value and 100% of the target_value. # You can set the period for this pattern in seconds. pattern_period = 10 target_value = 2.1 # The value the input signal should reach *** ScRIPT *** print(" **** Running example PID script in Python **** ") cone = Fs.FilipitStand() | ∞ 5 ^ ~ |
| | Run 🚽 example_PID_constant_thrust × | | |
| a | ₲ ■ : | | |

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5. Automated Testing

- 9. Check your settings for the length of the period, and set starting values for your PID parameters, Ki, Kd, and Kp.
 - a.The Ki term (integral term) is a constant that is multiplied by the integral of the error. The product is then added to offset the error.
 - b.The Kd term (derivative term) is a constant that is multiplied by the derivative of the error.
 - c.The Kp term (proportional term) is similar to the integral and derivative terms but it's the product of the error and the constant.
- 10. Run the script and observe the Flight Stand react accordingly.
- 11.Adjust your Ki, Kd and Kp values as needed until you have a PID response that you are satisfied with.



| ··· > 🗅 go | |
|------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| > 🗅 js | 47 - Examples of PID Terms: |
| v D python | 48 Here are some examples of PID terms used in different scenarios: |
| 🔿 example.py | 49 - Simulated Hardware (Constant Thrust): 2000, 1500, 0 |
| 🔿 example_data_polling.py | 50 - Simulated Hardware (Constant Thrust with Output Rate Limit of 200): 2000, 500, 0 |
| 🔿 example_data_recording.py | 51 - Simulated Hardware (Constant Rotation Speed): 2, 5, 0 |
| ᇢ example_external_hardware_interface.py | 52 - Real Hardware (<u>Mejzlik</u> 48 x 16,4 Propeller, <u>Xoar</u> 180-35 34kv Motor, <u>Xoar</u> Pulse P |
| example_PID_constant_thrust.py | 53 - Constant Inrust with Rate Limiter of 2000s/s at 80V: 6, 5.5, 0.5 |
| flight_stand_api_v1_pb2.py | 54 - Constant Rotation Speed with Rate Limiter of 2000s/s at 80v: 2, 5, 0.5 |
| night_stand_api_v1_pb2_grpc.py | 55 Kn = 80 # Proportional terms |
| PlightStand.py | 57 Ki = $\mathbf{I}0$ # Integral term |
| M4 README.md | 58 Kd = 5 # Derivative term |
| M+ README.md | 59 |
| v D proto | 60 # This example performs a square wave pattern alternating between 50% of the target_ |
| ≡ flight_stand_api_v1.proto | 61 # You can set the period for this pattern in seconds. |
| M+ README.md | 62 pattern_period = 10 |
| Ø.gitignore | 63 target_value = 2.5 # The value the input signal should reach |
| M+ README.md | 64 |
| > 🗈 External Libraries | 65 SCRIPT |
| Scratches and Consoles | 00 |
| | 67 print(**** Romining example Pib Script in Python ****) |
| | |
| | |
| Run 🗼 example_PID_constant_thrust × | |
| | |

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6. Test Settings and Data Handling

a. Motor rate limiter

Video tutorial: <u>https://youtu.be/JRjxpPYXfaA?si=o8jKjLdUQG9nKL5b</u>

Control the acceleration rate to protect your motor from torque or current overloading.

Steps (manual test):

- 1. Before activating your ESC, click the gear icon to the left of the throttle slider.
- 2. In the 'Rate limiter' text box, enter a maximum acceleration value in μ s/s.
 - a.For example, with a rate of 500 $\mu s/s$ it will take 2 seconds to reach the maximum throttle of 2000 $\mu s.$
- 3.Activate the ESC and increase your throttle. An orange bar will show you the status of the throttle with the rate limiter applied.

| Data re | corder | | | | |
|---------|------------------|----------|-------------|--------------|-------|
| Title: | Manual Control 1 | • Record | Take sample | Save and new | Clear |
| Output | control | | | | |



Steps (automated test):

- 1.If you leave the rate limiter on in the manual control tab, it will apply the limit to automated control tests as well. This is the best option if you would like to apply the same rate limit to the entire test.
- 2.You can also configure unique rate limits to different stages of the test within the automated control tab. Navigate to the 'Automated Control' tab to start.
- 3.Select a type of test and input your sequence steps in the 'Sequence form' table.
- 4. The fourth column is the rate limiter. Enter your desired limit for each step.
- 5. Scroll down to the Sequence preview to see how this will look when the test is run.
- 6. Click 'Execute sequence' to run the test with the rate limiter.



6. Test Settings and Data Handling

b. Customize live data plots

Video tutorial: <u>https://youtu.be/apKQZ2ikbIA?si=jY44hL1aK1W8Zo3a</u>

Customize how data is displayed in the real-time plots during your test.

Steps:

 Enlarge the real-time data plots window by using the drag feature to pull them up or use the arrows on the right side of the 'Real-time plots' window to have them pop-up.
 If you have multiple powertrains, you can select which one(s) you want to display in

the plots by checking the box next to each powertrain in the top right corner.

| | ✓ Manual Control → Ø Tare sensors |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hardware Simulated hardware (45nwKOB1r0) Simulated hardware (QsCHzV5NVj) | Data recorder Title: Manual Control 1 |
| Powertrains 1 Control | 2 Output control Danger! Activating outputs may cause the motor to spin. Experiment without a propeller installed to get familiar with the operation. Never approach energized equipment while in software cutoff mode. Read the product user manual for more safety directives. |



3. Next, use the Timespan slider in the middle to control how much time is displayed on the x-axis. The default is 30 seconds but you can view more or less time as desired.
4. The 'Layout' button to the right of the slider opens a window with options to configure the plot display. The order and size of plots can be adjusted, as well as the number of columns displayed.



6. Test Settings and Data Handling

| | | Real-time plots | | Ţ |
|----------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------|
| Timespan: 30 seconds | | | | × Powertrain 2 —— |
| ESC thr | | Default Number of columns : 3 Drag lines to change the plots orde | ar | rque) |
| | \equiv ESC throttle output C | ≣ Force Fz (thrust) | ≣ Torque MZ (torque) C | 0.015 |
| :40 :45 :50 | $\equiv Voltage \qquad \bigcirc$ $\equiv Electrical power \qquad \bigcirc$ | ■ Current ■ Mechanical power | \blacksquare Rotation speed \bigcirc \equiv Motor & ESC efficiency \bigcirc | 0.000 03:43 :05 |
| 1365 µs | \equiv Propeller efficiency 🜔 | ■ Powertrain efficiency | | 0078 N⋅m |
| Voltage | | Current | Rota | tion speed |

- 5. The 'Pause' toggle switch freezes the data display at a specific time snapshot. When it is toggled off, the charts will return to displaying live data.
- 6. The 'Show unfiltered' toggle switch controls whether displayed data is filtered or unfiltered. By default, a 1 Hz low pass filter is applied to smooth out readings.

c. Noise removal

Video tutorial: <u>https://youtu.be/avy0mIs2qX0?si=DM2XTDYIilkrDlHh</u>

Control the noise filter that is applied to your data. To control the noise filter on the realtime data plots, see point 6 in the previous section.

Note: data is recorded without a noise filter. This feature implements a post-test low pass filter with a selectable cutoff frequency.

Steps:

1. Navigate to the 'Tests' tab and open the test you would like to adjust.

2.Go to the 'Plots' tab and use the 'Noise filter' slider to adjust the level of noise removal.

a.A 1 Hz filter is automatically applied, but you can turn that off or apply a higher or lower filter.





6. Test Settings and Data Handling



d. Resample data

Video tutorial: <u>https://youtu.be/Mc9S9Y9fUxo?si=bzWJC6vo5SsKjMGk</u>

Export your data at a custom sampling rate after your test.

Steps:

1. After completing your test, go to the 'Tests' tab and click on your test.

2.Go to the export tab, where you'll see a table with all your data points.



6. Test Settings and Data Handling

- 3. Under 'Time resolution', check the option next to 'Resample' and type in your desired resolution in the text box that appears. The number you enter is how often you'd like a sample to be given in seconds.
 - a. The default resampling rate is 0.1 seconds or 10 samples per second.
 - b.The only limitation is that you cannot increase the sampling rate above the limits of your thrust stand (100 samples/ second for Standard Flight Stands and 1000 samples/ second for Pro).



| 0.15 | 8.179 | 0.013 | -0.0002 | ~0 | ~0 | 0.1063 | ~0 |
|------|-------|--------|---------|----|----|--------|----|
| 0.2 | 8.082 | 0.0129 | -0.0002 | ~0 | ~0 | 0.1039 | ~0 |
| 0.25 | 8.201 | 0.0131 | -0.0002 | ~0 | ~0 | 0.107 | ~0 |
| 0.3 | 8.221 | 0.0131 | -0.0002 | ~0 | ~0 | 0.1076 | ~0 |
| 0.35 | 8.154 | 0.013 | -0.0002 | ~0 | ~0 | 0.1059 | ~0 |
| 0.4 | 8.23 | 0.0131 | -0.0002 | ~0 | ~0 | 0.1079 | ~0 |
| 0.45 | 8.17 | 0.013 | -0.0002 | ~0 | ~0 | 0.1064 | ~0 |
| 4 | | | | | | | |

4. Click 'Export to CSV' to save the test to your computer at the desired sampling rate.

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7. Connect a CAN ESC

Our Flight Stands support most ESC protocols. These additional steps are required for CAN ESC protocols.

In our example, we are using the Yukon software which works specifically with Zubax devices. Other CAN products may use other third-party software.

Video tutorial: <u>https://youtu.be/BiZuCrVQNnU?si=V2gVWdD7fGlJeMeZ</u>

Steps:

- 1. Download and open the Flight Stand software.
- 2. Download the repository at https://gitlab.com/TytoRobotics/flightstand-api and extract the repository on your computer.
- 3. Download the latest version of Python as well as PyCharm Community edition.
- 4. Open Pycharm and open the downloaded repository.
- 5. In the downloaded folder, go to 'languages' \rightarrow 'python' \rightarrow 'examples' \rightarrow 'canbus-cyphal'
 - a. This is where you'll find the examples that we will be running.





7. Connect a CAN ESC

- 6.Configure your Python interpreter by going to 'File' \rightarrow 'Settings' \rightarrow 'Project' \rightarrow 'Python interpreter' and in the pop-up click 'Add interpreter' \rightarrow 'Add local interpreter'.
- 7. Click 'Apply' and Pycharm will automatically set up the virtual environment.
 - a.To confirm that you have the virtual environment set up correctly, you can either find it in the virtual environment path or open the terminal where you will see the virtual environment before the command line.
- 8. Open the 'README' file under 'examples'.
- 9. Run the three commands listed in the README file, which will install the proper packages in order for you to run the Python API.
 - a.To verify that the connection is working, open the Flight Stand software. Confirm that a simulated board has been connected under "Hardware" and that it has an ESC throttle input.



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7. Connect a CAN ESC

10.Under 'examples', open the canvas.cyphal folder and open example_1_main.11.Copy and paste the command in line 15 from the code to the console and hit Enter to install an additional package.



12. Highlight the environment variables from lines 20 - 24, right click, and select 'Modify Run Configuration'.

13.In the environment variables line, hit Ctrl A then Ctrl V to replace the variables.

| | E flightstand-api-main 🗸 Version control 🗸 | | | | Current File 🗸 | ⊳a≎∶ | 24 | Q | ¢ – | ō | |
|--------|------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------|------------------------------------------------------|------------------------------------------|-----------------------------------|-------------------------|-----------------|------------------------------|-------------------------|---|
| | Project ~ | M4 README.m | d 🥏 example_1_main.py | × | | | | | | : | Ļ |
| 80 | C:\Users\Tutorials\Desktop\flightstand-a Ianguages Go So in | 7 8 The 9 a 1 10 Soj | e example consists of tw node to the <u>Cyphal</u> bus. ftware. | o separate files that wi This application acts li | ill run in two sep ike an adapter bet | arate terminal: ween the UAVCA | s. Each pr N network | ocess and th | ▲3 x connects e Flight | ≿12 ^ ∖ Stand | |
| | python examples | Create Run Config | guration: 'example_1_main' | | × | | | | | | |

| ✓ Image: Value of the main | Name: example_1_m | ain | <u>S</u> tore as proje | From the PyCharm terminal run the command: |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------|---------------------------------------------|--------------------------------------------------------------|
| > D public_regulated_data_types | | | | erial,transport-udp]' |
| > 🗀 zubax_dsdl | Run | | <u>M</u> odify options | ✓ Alt+M |
| nitpy | 🐟 Project Default (Pyt | thon 3.11 (flightstand-api-mai | n)) C:\Users\Tutorials\Desktop\flightstand- | -api-m 🗸 the same result. In Pycharm, you can right-click in |
| 🔁 example_1_main.py | | | | t menu. Next copy/paste the following lines into the |
| n example_1_plant.py | script v -api- | main/languages/python/exam | nples/canbus_cyphal/example_1_main | n.py |
| 🕏 example_2_airspeed_sensor.py | Press Alt for field hints | | | |
| 🗟 example_2_hardware.png | Working directory: | sktop/flightstand-api-main | /languages/python/examples/canbu | s_cv |
| 😒 example_3_hardware.png | | | | |
| 🕏 example_3_telega_ESC.py | Environment variables: | MENTID=2346; UAVCAN | PUBHEATER_VOLTAGEID=23 | 47; 🗉 |
| M4 README.md | | Separate variables with semicr | olon: VAR=value; VAR1=value1 | |
| nitpy | | | | |
| n advanced_grpc_data_streaming.py | Open run/debug tool | window when started $	imes$ | Add content roots to PYTHONPATH | |
| n data_polling.py | | | | m the context menu. You should see no errors and so |
| necording.py | Add source roots to H | THONPATH X | k | |
| ල external_hardware_interface.py | | | | |
| PID_constant_thrust.py | | | | |
| Second Stream Terminal Local × RunMarkdown × | ? | | OK Cancel | Apply |
| -metadata, pycyphal, pkg-about, libpcap | | | | |
| Successfully installed cobs-1.1.4 importlib-m | etadata-6.8.0 importlib-re | sources-6.0.1 libpcap-1 | .11.0b7 numpy-1.25.2 nunavut | t-1.9.0 packaging-23.1 pkg-about-1.0.8 pycyphal-1.15.2 pyds |
| dl-1.20.0 pyserial-3.5 python-can-4.2.2 pywin | 32-306 pyyaml-6.0.1 tomli- | 2.0.1 typing-extensions | -4.7.1 wrapt-1.15.0 zipp-3.1 | 16.2 |
| [notice] A new release of pip available: 22.3 | .1 -> 23.2.1 | | | |
| [notice] To update, run: python.exe -m pip in | stallupgrade pip | | | |
| රි (venv) PS C:\Users\Tutorials\Desktop\flightst | and-api-main\languages\pyt | hon> | | |
| □ flightstand-api-main > languages > python > examples > | canbus_cyphal > 👶 example_1 | _main.py Upda | iting skeletons | 21:21 LF UTF-8 4 spaces Python 3.11 (flightstand-api-main) a |

14. Click 'OK' then right click and click 'Run example 1 Main'.

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7. Connect a CAN ESC

15. You need a license key to use this feature \rightarrow simply email <u>support@tytorobotics.com</u> to request the license key associated with your Flight Stand.

16.Once you have the license key, open the Flight Stand software, and on the 'Setup' tab click 'License', enter your license key, and hit Enter.

| Flight Stand Software v1.9.3 | - 🗆 X |
|-------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TYTO ROBOTICS | < Setup > |
| Hardware No boards detected, check USB | ① Language / Langue / 语言选择 Units of measurement Debug tools License |
| | Use a license key to unlock some features. Contact sales@tytorobotics.com to obtain a license key. |
| | License key: key/eyJhY2NvdW50ljp7Im SLicense activated |
| | Perpetual license: no expiration date Works offline until: Thu Sep 14 2023 00:40:11 GMT-0400 (Eastern Daylight Time) API external hardware feature: enabled ① |

| 3 | |
|-----------------|---|
| Real-time plots | 2 |

17. The Flight Stand software will restart and the license key tab will then show that the license has been activated.

- 18.Go to Pycharm and click 'Run example 1 Main'.
- 19.In the Flight Stand software, confirm that you've connected a simulated heater.
- 20.In Pycharm, open example_1_plant.py
- 21.Copy the environment variables into the runtime configuration and hit run.
 - a.In the Flight Stand software, you will now see an output control for the heater in the 'Manual control' tab.



7. Connect a CAN ESC

| Flight Stand Software v1.9.3 | - D X |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| TYTO ROBOTICS | Manual Control |
| Hardware | Data recorder |
| <pre>example_1 simulated plant</pre> | Take Save |
| Powertrains | Title: Untitled Record sample and new |
| Extra output mappings | |
| Heater voltage: 0 | Output control |
| Extra input mappings | Danger! Activating outputs may cause the motor to spin. Experiment |
| Room temperature: 15 °C | approach energized equipment while in software cutoff mode. Read the product user manual for more safety directives. |
| | Powertrain1: Heater voltage |

22.Set up the Yukon software, which will allow you to interact with CAN bus Cyphal devices. Go to <u>www.github.com/opencyphal/yukon</u> then scroll down to GitHub releases

a.Click the hyperlink then scroll down and click to download the Yukon.exe file. 23.Open the Yukon file. Here we will set up the DSDL name space.

a.Note that the Zubax DSDL files are specific to Zubax Cyphal CAN devices, and other manufacturers may have different DSDL files that you need to import.

24.Click on the 'Settings' tab and click 'Add path' then 'Browse'. Navigate to the downloaded Flight Stand API folder. Go to 'languages' \rightarrow 'python' \rightarrow 'examples' \rightarrow 'canbus_cyphal' and select 'public_regulated_data_types'.



7. Connect a CAN ESC

| ② Yukon 2023.3.45 | - 0 X |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| File View Help | |
| Monitor X Registers X Settings X DroneCAN X | Transports X Register logs X & X |
| Changes are automatically saved after a second but you are expected to reload the page for settings to take effect. Reload the page from View - Reload or press CTRL + R | UDP CAN |
| DSDL search directories | UDP |
| | UDP interface 127.0.0.0 |
| C:\Users\Tutorials\.cyphal | UDP MTU 1200 |
| | Node ID 127 |
| I Browse Remove | Service transfer multiplier 1 |
| Add path Add string | On GNU/Linux systems, for fixing UDP packet sniffing permissions: |
| | sudo setcap cap_net_raw+eip "\$(readlink -f PATH |
| Firmware updates | Start this transport Copy to Yakut |
| Directory path | |
| Browse Remove | |
| 2 Enabled | |
| File pathdeleted | |
| | |
| Monitor view Remove | |
| Colors | Transports list X |
| Publisher color | |
| lightgreen | |
| Messages X Status X | |
| 23-08-14 14:14:07 Frontend W: Press CTRL+SPACE to maximize the panel under your mouse | |

25.Click 'Add path' → 'Browse', then navigate to the same subfolder, but this time select the 'zubax_dsdl' folder. Scroll to the bottom of the page and click 'Save configuration'.

26. Close and restart the Cyphal software.

27.In the 'UDP interface' field in the top right panel, change the value to 127.0.0.<u>1</u>

| ② Yukon 2023.3.45 | | - | O | × |
|---------------------------------------------|------------------------------|-------------------------------------|---------|--------------|
| File View Help | | | | |
| Monitor X Registers X Settings X DroneCAN X | Transports X | Register logs \times | | 3 o X |
| | UDP | | CAN | |
| | | UDP | | |
| | UDP interfa | ace 127.0.0.1 | | |
| | UDP MTU 1 | 1200 | | |
| | Node ID 1 | 127 | | |
| | Service tra | ansfer multiplier | : 1 | |
| | On GNU/Linux packet sniff | systems, for fi ing permissions: | xing UI | P |
| | sudo setcap ca | ap_net_raw+eip "\$(r | eadlink | -f PATH ▶ |
| | Start this t | ransport Copy to | Yakut | |

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7. Connect a CAN ESC

28. Click 'Start this transport'.

- a. If you get the error 'Cannot find wcap.dll library', you will need to download the Npcap software (free) from <u>www.npcap.com</u>. Scroll down to 'Downloading and Installing Npcap Free Edition', and download the Npcap installer, then complete the installation process.
- 29.Once the installation is complete, go to Yukon and click 'Start this transport' again.
- 30.In Pycharm, ensure only example_1_plant is running, then right click on the line next to 2346 in Yukon. Click 'Subscribe to 2346' then 'Subscribe' in the pop-up window. This will enable the real time simulated temperature in the Flight Stand Software.

| ② Yukon 2023.3.45 | | - 0 × |
|------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| File View Help | | |
| Monitor X Registers X Settings | | Transports X Register logs X 8 🗆 🗙 |
| Name demo.plant Software Version 0.0.0 Hardware Version 0.0 Node ID 43 Uptime 00:00:40 | 7510 uavcan.node.port.List 7509 uavcan.node.Heartbeat uavcan.node.Heartbeat | UDP CAN UDP |
| Health NOMINAL VSSC 0 | 2346 uaycan, si, sample, temperature. | UDP interface 127.0.0.1 |
| Mode OPERATIONAL Restart Save Estop Cmd Parameters Send command Choose firmware | 7509 Subscribe to 2346 7509 uavcan.node.Heartbeat heater_voltage Publish to 2346 2347 uavcan.si.unit.voltage.Scalar 430 Remove all subscribers of 2346 uavcan.node.GetInfo Subscribe to 2347, 2346 synchronously 385 uavcan.register.List 384 Department of 2010 public | UDP MTU 1200 Node ID 127 Service transfer multiplier 1 On GNU/Linux systems, for fixing UDP packet sniffing permissions: |
| | 384 uavcan.register.Access | sudo setcap cap_net_raw+eip "\$(readlink -f PATH |



31. Do the same for line 2347, but click 'Publish to 2347' and 'Add number field'. Choose

'volt' and in the last text box enter '5' to set the voltage to 5 V.

32.Click 'Enable' and you'll see the Kelvin temperature measurement slowly start to increase in the window above.





7. Connect a CAN ESC

33. Terminate the previous two examples in Pycharm and open 'example_3'

- 34.Connect your ESC to your computer. For the Zubax ESC, connect one USB cable to power the ESC, and the other USB cable to connect the Babel device.
- 35.Open Yukon and make sure the hardware is set up correctly. Go to 'Settings' and make sure that all the required DSDL files are present, like the Zubax DSDL.
- 36.In the right panel, navigate to 'CAN' and 'SL/CAN', ensure you are using COM3, then click 'Start this transport'.
- 37. Scroll to the 'Unassigned ports' table and link the fields to the appropriate ports:
 - a.Next to 'zubax.physics.dynamics' enter '100'.
 - b.Next to 'zubax.physics.electronics' enter '101'.
 - c.Next to 'setpoint_rat_torque' enter '111'.

| Witten 20 | 23.3.45 | | | | | | | | | | | |
|-----------------|--------------------|-------------------|-------------------|------------------|------|------|----|-----|-----|-----|-----|--|
| File View | Help | | | | | | | | | | | |
| Monitor X | Registers \times | Settings \times | $DroneCAN \times$ | | | | | | | | | |
| Restart | t Save | Estop | 430 | .node.ExecuteCom | 7510 | 7509 | 22 | 435 | 430 | 385 | 384 | |
| <u>Telega d</u> | <u>0C3</u> | | uavcan 385 | .node.GetInfo | | | | | | | | |
| Cancel | SelfTest N | AotorID | uavcan | .register.List | | | | | | | | |

| 02 | Domonotore | 204 | | | | |
|-------|-----------------|------------|--------------------------------------------|--|--|---|
| Cilla | Farameter | 301 | uavcan.register.Access | | | Ť |
| | Send command | | | | | |
| c | Choose firmware | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | Unassigned ports | | | |
| | New a | subject id | compact | | | |
| | | | zubax.telega.Compac | | | |
| | New a | subject id | zubax.telega.DQ.1.0 | | | |
| | 100 | ÷ | dynamics | | | |
| | 100 | 1 | zubax.physics.dynam | | | |
| | New a | subject id | feedback zubax.service.actua | | | |
| | | | power | | | |
| | New a | subject id | zubax.physics.elect | | | |
| | New s | subject id | temperature | | | |
| | | | low level io | | | |
| | New a | subject id | <pre>zubax.low_level_io</pre> | | | |
| | New s | subject id | readiness | | | |
| | | | zupax.service.Readi | | | |
| | New a | subject id | zubax.physics.dynam | | | |
| | N | which id | setpoint_rat_torque | | | |
| | New a | subject 1a | zubax.primitive.rea | | | |
| | New s | subject id | setpoint_rat_torque zubax.primitive.nat | | | |
| | | | setpoint rat veloci | | | |
| | New s | subject id | zubax.primitive.nat | | | |
| | New s | subject id | setpoint_rat_voltage | | | |
| | | | setpoint rat voltag | | | |
| | | | CONTRACTOR AND A CONTRACTOR | | | |

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7. Connect a CAN ESC

38. Click 'Restart' in the left panel to restart the connection.

- 39. In the 'Monitor' tab, right click on the 'power' arrow and select 'Subscribe to 101' then right click on the 'dynamics' arrow and select 'Subscribe to 100'. Click 'Subscribe' again in both pop-up windows.
- 40.Right click on 'setpoint_rat_torque' and select 'Publish to 111'. In the 'Publisher' window, click 'Add number field' and select 'value (0)' then enter 0.05 for torque (in Nm) in the right-most text box.
- 41.Click 'Enable' and the ESC will cause the motor to spin. If there was a load on the motor, it would limit the speed to the RPM associated with 0.05 Nm.



42.Open example_3_telega_ESC.py and change the port in line 44 to COM3 as this is the port the ESC is connected to.

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7. Connect a CAN ESC

| 2 | E flightstand-api-main ~ Version con | trol ~ | | | | | | | | ᇢ example_1_p | olant ~ | ⊳ | đ: | é | 2+ (| ς ε | <u>ۋ</u> | - (| ð | × |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------|-----------------------------------|-------------------------------------|---------------------------|----------------------------------|------------------------------------------|------------------------|-----|----------|------|---------------------------------------|---|
| | Project ~ | M4 READ | ME.md | 🌏 example | e_1_main.py | 🕙 exa | cample_3_har | rdware.png | 🌏 examp | ole_3_telega_ESC.p | ру × | 🔷 exa | ample_1_pl | ant.py | | | | | : | ¢ |
| 8 | flightstand-api-main C:\Users\Tutorials languages go js python examples canbus_cyphal public_regulated_data_type zubax_dsdl _init_py example_1_plant.py example_2_airspeed_sensor example_3_telega_ESC.py | 34 35 36 37 38 39 40 41 42 43 42 43 44 45 46 47 48 49 50 50 51 | Don't f setting follows <u>https:/</u> 2) To e 3) Usin the COM CYPHAL UAVCAN_ UAVCAN_ UAVCAN_ UAVCAN_ UAVCAN_ UAVCAN_ UAVCAN_ UAVCAN_ | forget to c g up a tele s the same //www.youtu ensure corr ng the same 1 port used PATH=.\pub CANIFAC CANIFAC CANIFAC CANBITE SUBTELE SUBTELE PUBCONT | lose Yukon ga ESC, you port assign <u>be.com/watc</u> ect softwar method exp by your <u>Zu</u> lic_regulat E= <u>slcan</u> :COM 8; 42; ATE=1000006 METRY_DYNAM METRY_DYNAM METRY_DOWEM | or any o bu should inments as <u>ch?v=_nGi</u> ire setup, ire setup, ir | other exten be able to s in the l: <u>i3y3FqvU</u> , confirm of in example el: _types\;.\: 0; =100; 1; ; I | ernal tools o to make your inked video example_1.py e_1, set the zubax_dsdl; | using the motor spi , y is worki environme | same COM inten in from Yukon/Y | rface. Yakut ing to as fol | Here before o run t | is a use continu this exam | ful vide ing. Thi ple. te the C | o to s exa OM# t | he | 4 🔺 6 | ☆ 12 | , , , , , , , , , , , , , , , , , , , | |
| | M∔ README.md ॡ _initpy | 52 53 | 5) Run | the Flight | Stand Soft | tware. | | | | | | | | | | | | | | |

- 43.Set up the runtime environment by copy-pasting the runtime variables into the configuration: right click \rightarrow 'Modify Run Configuration'. In the environment variables line, Ctrl A then Ctrl V to replace the variables \rightarrow Apply.
- 44.With the Flight Stand software open, right click on 'example_3_telega_ESC.py' and select 'Run example_3_telega_ESC.py'.
- 45. If the 'Zubax ESC' appears in the Flight Stand software under 'Hardware', then you've

successfully performed the connection.

| Flight Stand Software v1.9.3 | | X |
|------------------------------|----------|------------------------------------------|
| TYT Roboti | | < Hardware → Ø Tare sensors |
| Hardware Subax Myxa ESC | | Connect simulated board |
| Powertrains | | Path: COM3 |
| Inputs | | Status: connected |
| Current: | 0 A | |
| Voltage: | 15.01 V | Identification Firmware Built-in systems |
| Derived measurements | | |
| Electrical power: | 0 W | Path: external_1 |
| Extra output mappings | | Model number: MYXA-A1 |
| ESC throttle: | off | Serial number: Fdqb |
| Extra input mappings | | Identify |
| Room temperature: | inactive | (dentity) |

46. Under the 'Powertrain Mappings' tab, ensure that the Zubax ESC is mapped correctly.

47. Test the connection by activating the ESC in the 'Manual Control' tab.



8. Connect and Configure Analog Sensors (Input Transformations)

The Input Transformations software tab allows you to connect and configure 3rd party analog sensors, synching the data with your other Flight Stand measurements.

We will explain how to connect a sound level meter, though these steps can be applied to any kind of sensor.

Video tutorial: <u>https://www.youtube.com/watch?v=2uMntS8-XE4</u>

Steps:

- 1. Verify that the Flight Stand hardware is connected via USB.
- 2. Navigate to the Input Transformations tab.
- 3. Click "Add new transformation".



| Components | | |
|-------------------------|-------------|--|
| ESC: | 1 | |
| Power Source: | 1 | |
| Control | | |
| ESC throttle: | off | |
| Inputs | | |
| Current: | 0.1214 A | |
| Voltage: | 21.5 V | |
| Force Fz (thrust): | -0.1745 kgf | |
| Torque MZ (torque): | 0.0685 N·m | |
| Rotation speed: | 0 rpm | |
| Derived measurements | | |
| Electrical power: | 2.611 W | |
| Mechanical power: | 0 W | |
| Motor & ESC efficiency: | 0 % | |
| Propeller efficiency: | 0 gf/W | |
| Powertrain efficiency: | -66.84 gf/W | |
| | | |

- 4. Under "Name", enter an alias for the sensor (e.g., "Sound Sensor").
- 5.Select the unit type from the drop-down options or select "Custom units" and input "dB" for decibels.
- 6.Assign the voltage general analog input to variable "a".
- 7.In the "Formula" field, type the conversion formula provided in the sensor's

datasheet. I.e.: a * 50: Decibel Value (dBA) = Output Voltage (V) × 50



8. Connect and Configure Analog Sensors (Input Transformations)

| Flight Stand Software v2.0.0 | | | - |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| TYT Roboti | | < Input transformations > | Ø Tare sensors |
| Hardware SS15P-EMU (1002 Hz) Flight Stand 15 Standard - Fo | orce Measurement Unit (1002 Hz) | ← Cancel | |
| Powertrains Components ESC: Power Source: | 1 | Sound Sensor Unit type: ① Other (custom unit) dB | |
| Control ESC throttle: Inputs Current: Voltage: Force Fz (thrust): Torque MZ (torque): | off 0.1199 A 21.5 V -0.1744 kgf 0.0685 N·m | Formula inputs: Assign formula input sources as variables. To access the values within the formula, use alphabet let a: FS15P-EMU - Voltage general analog 1 b: Add formula input Formula: | tters starting with 'a'. For example write the formula as: '3.45*a'. Current value: 1.062 V |
| Rotation speed: Derived measurements Electrical power: Mechanical power: Motor & ESC efficiency: Propeller efficiency: Powertrain efficiency: | 0 rpm 2.579 W 0 W 0 % 0 gf/W -67.63 gf/W | <pre>? a*50 System limits: ① 0 to 130 I 		 dB Save</pre> | Current value: 53.09 dB |

8. Enter system limits based on the datasheet specifications to trigger an automatic

motor cut-off if the sound level exceeds the defined range.

9. Click "Save"



Hardware

Powertrains

Components ESC:

Power Source:

ESC throttle:

Inputs Current:

Voltage:

Force Fz (thrust): Torque MZ (torque):

Rotation speed:

Derived measurements Electrical power:

Mechanical power: Motor & ESC efficiency:

Propeller efficiency: Powertrain efficiency:

SFS15P-EMU (1002 Hz)

Flight Stand 15 Standard - Force Measurement Unit (1002 Hz)

1

off

0.1465 A

0.0685 N·m

21.5 V -0.1745 kgf

0 rpm

3.15 W 0 W

-55.4 gf/W

0 % 0 gf/W

| The system limits may not be sufficient to fully protect your hardware. Futher adjust the sensor limits to protect the equipment from overheating, under voltage, or |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| overloading. All control outputs will automatically go the their predefined safety cutoff value when any of these limits are exceeded. |

Stay safe: always respect equipment and component limits.

| Source | Current value | Cutoff min | Cutoff max | System limit |
|---------------------------------------------------------------------|---------------|------------|------------|---------------|
| Flight Stand 15 Standard - Force Measurement Unit Accelerometer X | -0.0034 g | None | None | None |
| Flight Stand 15 Standard - Force Measurement Unit Accelerometer Y | 1.013 g | None | None | None |
| light Stand 15 Standard - Force Measurement Unit Accelerometer Z | -0.083 g | None | None | None |
| light Stand 15 Standard - Force Measurement Unit Force Fz (thrust) | -0.1745 kgf | None | None | -15.3 to 15.3 |
| light Stand 15 Standard - Force Measurement Unit Rotation speed | 0 rpm | None | None | 0 to 95493 rp |
| light Stand 15 Standard - Force Measurement Unit Temperature IR | | None | None | -70 to 380 °C |
| light Stand 15 Standard - Force Measurement Unit Torque MZ (torque) | 0.0685 N·m | None | None | -8 to 8 N·m |
| S15P-EMU Current | 0.1465 A | None | None | -150 to 150 / |
| S15P-EMU Voltage | 21.5 V | None | None | 0 to 180 V |
| S15P-EMU Voltage general analog 1 | 1.077 V | None | None | -10 to 10 V |
| FS15P-EMU Voltage general analog 2 | -0.0015 V | None | None | -10 to 10 V |
| Fransformation - Sound sensor | 53.86 dB | None | 130 | 0 to 130 |

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8. Connect and Configure Analog Sensors (Input Transformations)

10. Navigate to the Powertrain Mappings tab.

11. Click "Extra mappings" and select "Transformations - Sound Sensor". Live data from the sensor can now be viewed in the left panel and in the real-time plots.

| Flight Stand Software v2.0.0 | — |
|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Powertrain mappings Ø Tare sensors |
| Hardware SFS15P-EMU (1001 Hz) Flight Stand 15 Standard - Force Measurement Unit (1002 Hz) | A powertrain represents a combination of a motor, a propeller, and an ESC. A dual-motor setup would be represented as two powertrains. We currently support up to simultaneous powertrains. Each powertrain should be mapped with corresponding hardware sensors and outputs. |
| Powertrains | Powertrain 1 + |
| Motor: AXI811026KV115 Propeller: Xoar 26inch ESC: 1 Power Source: 1 | Assign extra hardware inputs and outputs to powertrain 1. Extra mappings are for display and control purposes only and are not used to calculate derived power measurements. Extra mappings: |
| ESC throttle: off Inputs Current: 0.1544 A Voltage: 215 V | Transformation - Sound sensor Value: 42.64 dB Remove from powertrain |
| Force Fz (thrust): -0.1747 kgf Torque MZ (torque): 0.0683 N⋅m Rotation speed: 0 rpm | Add extra input/output Select extra mapping to add |
| Electrical power: 3.32 W Mechanical power: 0 W Motor & ESC efficiency: 0 % Propeller efficiency: 0 af/W | |

-52.63 gf/W

Powertrain efficiency:

12. Proceed as you would with a regular test. The sound sensor data will have its own column in the data file exported to CSV.

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9. Remotely Control the Software

Remotely controlling the software is useful in many situations, such as using the software on a different operating system or enhancing user safety. This section explains how to set up a remote connection using two computers on the same network: one connected to the Flight Stand's Sync Hub via USB, and a second controlling the software remotely.

Be aware that this feature has some safety implications as anybody in the network can activate the motor, so ensure there is good communication within the team, the environment is controlled, and the network is private.

Video tutorial: <u>https://youtu.be/kfvCMsBG8mg</u>

Steps:

- 1. Ensure the Flight Stand software is closed, then right click on the software's shortcut.
- 2.Click on "Properties" and find the 'Target' field. At the end of the line, add the command line argument "--remote".
 - a. If this error appears: "the name is not valid", add a space before "--remote".

| General | Details Shortcut | Previous Versions | |
|------------------|-----------------------------|---------------------------------|---------|
| General | | compaubility | 11/ |
| F | light Stand Software | | 2 1 2 1 |
| | | | |
| Target type: | Application | | |
| Target location: | flight-stand-software | | |
| Target | ht-stand-software\Flight \$ | Stand Software.exe"remote | |
| | | | |
| Start in: | C:\Users\Lauren\AppDa | ta\Local\Programs\flight-stan | |
| Shortcut key: | None | | |
| Run: | Normal window | ~ | E. A. |
| Comment | This software provides the | ne interface to view and contro | |
| Open File L | ocation Change Ic | on Advanced | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

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9. Remotely Control the Software

3.When the software is opened, a warning message will appear in the left panel to indicate that the software is accepting remote connections from any device on the network.

| Flight Stand Software v1.9.2 | - 0 | × |
|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|----|
| TYTO ROBOTICS | < Setup → Ø Tare sensors | Ċ |
| Hardware | ● Language / Langua / 连言进程 | |
| O Synchronizing hardware time | Gertanguage / Langue / 店台边母羊 Onits of measurement Debug tools | 5 |
| Flight Stand 15 Standard - Force Measurement Unit | License | |
| | | |
| Remote mode activated | English 🔓 🗢 | |
| This software was launched with theremote command line | | |
| argument. It can be remote controlled from another device | | |
| on the network. Exercise caution as it can create unsafe | | |
| conditions (remote motor activation). | | |
| Powertrains | | |
| Components | | |
| Molonsure the Flight Stand software | | |
| Propeller: 1 | | |
| ESCULICK on "Properties"1 and find | | |
| Power source: 1 | | |
| Control Control | | |
| ESC throttle: | | |
| Inputs | Real-time plots | |
| The second se | | 10 |

4.On the same computer, find the computer's IP address by entering the command "ipconfig" in Command Prompt.





9. Remotely Control the Software

| Command Prompt | - | × | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|--|
| Ethernet adapter Ethernet: | | 1 | |
| Media State Media disconnected Connection-specific DNS Suffix . : | | | |
| Wireless LAN adapter Local Area Connection* 3: | | | |
| Media State Media disconnected Connection-specific DNS Suffix . : | | | |
| Wireless LAN adapter Local Area Connection* 4: | | | |
| Media State Media disconnected Connection-specific DNS Suffix . : | | | |
| Wireless LAN adapter Wi-Fi: | | | |
| Connection-specific DNS Suffix . : lan Link-local IPv6 Address : fe80::b26a:783f:61a7:c658%10 IPv4 Address : 192.168.86.57 Subnet Mask : 255.255.255.0 Default Gateway : 192.168.86.1 | | | |
| Ethernet adapter Bluetooth Network Connection: | | | |
| Media State Media disconnected Connection-specific DNS Suffix . : | | | |
| C:\Users\Lauren> | | | |

5.On the second computer, right click on the Flight Stand software shortcut.

- 6.Click on "Properties" then find the "Target" field and at the end of the line, add the command line argument "--target=192.168.86.57:50051", the number before the colon being the first computer's IP address.
- 7.To test the connection, navigate to the "Manual Control" tab, activate the ESC and try increasing the throttle. The first computer and Flight Stand should mirror the input prompts.





10. Propeller Balancing

The Propeller Balancing software feature allows you to balance motors and propellers to G quality grades associated with the 21940-12:2016 ISO standard.

We will explain how to balance a 2-blade propeller, though these steps can be applied to propellers with any number of blades as well as motors.

Video tutorial: <u>https://youtu.be/YK-HO4V_Ons?si=pxNOqHQLI1XVUleF</u>

Steps:

1. Open the Balancing tab in the Flight Stand software. Click "New Balancing Session".

- 2. Enter the details of the powertrain and test parameters.
- 3. The correction radius is the distance from the center of the propeller where the correction weight will be placed. We placed the weight toward the blade tip to achieve the desired correction with minimal mass. To reduce the effect of the added weight on lift and thrust generation, add the tape closer to the propeller's base at 1/4- 1/3 of its radius.

4. Click "Create".

| TYTO ROBOTICS | | Balancing | | | | Ø Tare sensors |
|--------------------------------------------------------------------------------------------|---------------------------------|-----------------------------------------------|---|---------------------------------------------|------|----------------|
| Hardware | Flectrical Measurement Unit | ← Cancel New Balancing session | | | | |
| (1002 Hz) Flight Stand 15 Standard | Force Measurement Unit (1002 | Title (optional): | | Operator (optional): | | |
| Paulater las | | Balancing 26 inch prop | | Yasmin | | |
| Powertrains | | Motor (optional): | | Propeller (optional): | | |
| Control | | AXI | | 26 inch | | |
| ESC throttle: | off | | | | | |
| Current: Voltage: | 0.2684 A 25.38 V | Rotation speed: | | Vibration: | | |
| Force Fz (thrust): Torque MZ (torque): | -0.1255 kgf 0.0098 N·m | Flight Stand 15 Standard - Force Measurem 🗸 | 1 | Flight Stand 15 Standard - Force Measurem 🗸 | () | |
| Rotation speed: | 0 rpm | ESC throttle (optional): | | | | |
| Derived measurements | | Flight Stand 15 Standard - Force Measurem 🗸 🛛 | 1 | | | |
| Electrical power: Mechanical power: Motor & ESC efficiency: Propeller efficiency: | 6.811 W 0 W 0 % 0 gf/W | Rotor mass (kg): | | Operating speed (rpm): | | |
| Powertrain efficiency: | -18.42 gf/W | 0.5 | 1 | 2000 | 1 | |
| | | Correction radius (m): | | Quality grade (optional): | | |
| | | 0.32 | 1 | 6.3 | (1) | |
| | | Number of blades: | | | | |
| | | 2 🗸 | 1 | D | | |
| | | | | ros Cr | eate | |

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10. Propeller Balancing

5. Increase the throttle until the target RPM is reached, then click "Capture" to get a base reading. The software will indicate how much weight to add for the next trial run.6. Add the trial weight to the propeller at the correction radius specified in Step 1. Increase the throttle until the target RPM is reached, then click "Capture" to get a reading.



| Electrical power: | -142 W | Flight Stand 15 | | |
|-------------------------|------------|--------------------|----------|---------|
| Mechanical power: | -118.8 W | Standard - Force | x 1750 ÷ | |
| Motor & ESC efficiency: | 83.68 % | Measurement Unit - | | |
| Propelier efficiency: | 16.27 gf/W | ESC throttle | | |
| Powertrain efficiency: | 13.62 gf/W | | | |
| 5 | | | | |
| | | | | Capture |

7.The software will suggest a permanent correction weight to achieve a passing balancing grade. Add the weight to the propeller, increase the throttle and click Capture.





10. Propeller Balancing

| Jazdunaza | | Compating many | | | |
|----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|---|------------------|
| Flight Stand 15 Standard (1002 Hz) Flight Stand 15 Standard Hight Stand 15 Standard | - Electrical Measurement Unit - Force Measurement Unit (1002 | Correction run: Our software determined you should add a per 0.2772 grams on blade 2 Actual weight installed: | ermanent correction weight of: | | Reference marker |
| Long stop time | | Weight (grams) | Blade | | |
| Warning: a low rate limite | value means the motor will take | 0.278 | 2 | ~ | |
| unsafe conditions. | | | | | |
| Control | | | | | |
| SC throttle: | 1052 µs | | | | 2 |
| Current: /oltage: Force Fz (thrust): Forque MZ (torque): Rotation speed: Derived measurements | 0.2719 A 25.37 V -0.1247 kgf 0.0094 N·m 0 rpm | Target: 2000 rpm Rotation speed: 0 rpm (too slow () | | ß | |
| Electrical power: Mechanical power: Motor & ESC efficiency: Propeller efficiency: Powertrain efficiency: | 6.898 W 0 W 0 % 0 gf/W -18.08 gf/W | Flight Stand 15 Standard - Force Measurement Unit - ESC throttle | 750 \$ | | |

8.A green check mark will normally appear next to the Final quality grade, indicating the propeller is within tolerance. In some cases it may suggest an additional correction weight to achieve a passing balance. The test summary can be found in the Report tab.

| | by | Balancing | | Ø Tare sensors |
|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------------------|
| Hardware Flight Stand 15 Standa (1002 Hz) | ord - Electrical Measurement Unit | ← Back Balancing: Balancing 26 inc | h prop | |
| Flight Stand 15 Standa Hz) | rd - Force Measurement Unit (1002 | Execute Report | | |
| Long stop time Warning: a low rate limit a long time to stop unde seconds), potentially cau unsafe conditions. | ter value means the motor will take er a cutoff event (up to 10 using equipment damage and | Final quality grade: 1.444 v in tolerance Session information: Date: Mon Oct 07 2024 14:20:46 GMT-0400 (B | astern Daylight Time) | Reference marker |
| | | Operator: Yasmin | | × × |
| Powertrains | | Motor: AXI | | 1 |
| Control | | Propeller: 26 inch | | |
| ESC throttle: | 1000 µs | Blades count: 2 | N | |
| Installe | | Operating speed: 2000 rpm | L3 | |
| Currenti | 0.2677 A | Target quality grade: 6.3 | | |
| Voltage: | 25.37 V | Permissible unbalance: 0.015 g-mm | | |
| Force Fz (thrust): | -0.1244 kaf | Correction radius: 0.32 m | | |
| Torque MZ (torque): | 0.0094 N·m | Control output: Flight Stand 15 Standard - Fo | rce Measurement Unit - ESC throttle | |
| Rotation speed: | 0 rpm | Rotation speed sensor: Flight Stand 15 Stand | ard - Force Measurement Unit - rotation speed | |
| Derived measurements | | Vibration sensor: Flight Stand 15 Standard - | Force Measurement Unit - accelerometer X | |
| Electrical power: | 6.793 W | | | 2 |
| Mechanical power: | 0 W | | | |

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10. Propeller Balancing

9.When balancing a motor without a propeller, select Disk Mode under the "Number of Blades" section. When balancing a propeller with more than two blades, ensure you select the correct blade count.

Refer to the conventions below for marking your added weights:



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11. Gas Engine Testing

- 1.Open the Flight Stand software. Users should be familiar with the software before beginning. Use the previous sections of this document as a reference.
- 2. Verify that the latest version of the software is installed.
- 3.In the left-hand panel, ensure the FMU and DAQ are connected, indicated by a green check mark.
- 4. Navigate to the Powertrain Mapping tab and click on "Extra mappings". Map the throttle control to the servo port where the throttle device is connected.

| Flight Stand Software | | Manual control > | − □ × Ø Tare sensors |
|----------------------------------------------------------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Hardware | | Data recorder | |
| Force Measurement Unit Flight Stand DAQ | t (FMU) | Title: Manual test 1 Record Take sample | Save and new Clear |
| Powertrains | | Output control | |
| Control | | Danger! Activating outputs may cause the motor to spin. Experiment without a propeller installed to get familiar with the operation. Never | approach energized equipment |
| ESC throttle: | 1546 µs | while in software cutoff mode. Read the product user manual for more safety directives. | approven energized equipment |
| Inputs | | | |
| Current: | 1.649 A | Powertrain 1 - ESC | |
| Voltage: | 8.145 V | throttle | |
| Force Fz (thrust): | 0.08 kgf | | |
| Terraue M7 (terraue) | 0.0071 N m | | |



- 5. Navigate to the Manual Control tab. Click to activate the ESC throttle for the powertrain.
- 6.Ensure the throttle has full range of motion. Test the throttle servo to confirm that it can reach full stroke. Use the toggle bar to ensure it can reach full left and right, all positions.





11. Gas Engine Testing

- 8. Click the "Tare sensors" button in the top right of the software window.
- 9.Establish a safe test environment and prepare to start the engine. This guide assumes that gas has already been pumped to the carburetor.
- 10. Toggle the throttle bar to low speed.
- 11.Confirm the choke position and turn on the ignition unit. The ignition safety button should now be turned on.
- 12. Use a starter to ignite the engine and let it idle.
- 13. Keep the engine at medium speed if it is not yet broken in and check the colour of the smoke to see if the mixture is too lean or too rich.
- 14.Start the test use the throttle slider in the Manual Control tab to control the throttle.



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