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## PhotosynQ Help Manual

*Last Modified: Sep 13, 2017*

### Account Basics

#### Creating an account

1. You can create an account from the website (<https://photosynq.org>), the desktop app, or the mobile app.
  - **Website:** click on the ‘sign up’ button in the upper right corner of the website.
  - **Desktop app:** Download the photosynq app from the chrome webstore and select “sign up.”
  - **Mobile app:** Download the photosynq app from the Google Playstore and select “no account? Register here.”
2. Create a username and password for your account. This login will be used across the PhotosynQ platform.
3. Check your email for a confirmation.
  - If you do not see it, check your spam folder.
  - Hit confirm and your account has been created!
4. Now go back to the website or app and sign in.

#### Troubleshooting

- [x] Make sure that you are connected to the internet!
  - [x] Sometimes the confirmation emails end up in your SPAM folder. Make sure to check it first.
- 

#### Edit your Profile

Your profile on PhotosynQ will help others to learn more about you and start collaborations. Here you can find how to make changes to your profile.

#### Fill out the user information

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Account Settings**.
3. Make changes to your profile.
4. Click on **Update** to save your changes!

#### Add a profile photo

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Account Settings**.
3. Scroll to the bottom of your profile form and click on **Select Photo**.
4. Select the photo you would like to use and click **Open**.

5. Click on **Update** to save your new photo!

\*\*\*Tip:\*\*\* Adding a biography and a photo will help other users who may be interested in collaborating with you!

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## Manage your password

If you forgot your password or you want to change it, you can do this easily at any time.

### Reset your password

If you forgot your password go to <https://photosynq.org>:

1. Click on **Login** in the top menu bar.
2. Select **Click here to reset** below the login form.
3. Type in your email address and click on **Send me reset password instructions**.
4. Open your email inbox and click on the link.
5. Set your new password.

### Change your account password

You know your password and you want to change it, go to <https://photosynq.org>:

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Account Settings**.
3. Type in your new Password and type it again into the Password confirmation.
4. Click on **Update** to save your new password!

### Troubleshooting

- [x] Sometimes the confirmation emails end up in you SPAM folder. Make sure to check it first.
- 

## PhotosynQ Glossary

To help you getting started, here is a list of commonly used terms to help you to familiarize yourself with PhotosynQ.

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Term	Definition
<b>Device</b>	On PhotosynQ, computers, phones and tablets are generally called <b>Devices</b> .
<b>App</b>	Program that can be installed on a Device.
<b>Instrument</b>	Equipment that connects to <b>Apps</b> and are used to take <b>Measurements</b> (e.g. the MultispeQ).
<b>Contribution</b>	<b>Measurements</b> taken for a project and submitted to PhotosynQ.
<b>Discussion</b>	Projects, Protocols and Macros have a discussion section, to facilitate the easy exchange of ideas between users.
<b>Discussion Post</b>	In a discussion, every comment, question or shared image is called <b>Post</b> .
<b>Discussion Thread</b>	In Projects, <b>Discussions</b> can have multiple Topics or <b>Threads</b> . Protocols and Macros only have one <b>Thread</b> .
<b>Firmware</b>	The software installed on an instrument.

Term	Definition
<b>Flag</b>	Some measurements might be of low quality, so they can be <b>flagged</b> . <b>Flagged</b> data is hidden during analysis but is <b>NOT</b> deleted from the project.
<b>Macro</b>	<b>Macros</b> are small pieces of code connected to a <b>Protocol</b> to help analyzing the measurement, right after it is finished.
<b>Project</b>	<b>Measurements</b> collected on PhotosynQ are organized and stored in <b>Projects</b> . Users can define <b>Protocols</b> and <b>Project Questions</b> for each <b>Project</b> .
<b>Project Administrator</b>	<b>Project Administrators</b> get invited by a <b>Project Lead</b> to help manage the <b>Project</b> and take measurements.
<b>Project Collaborator</b>	<b>Project Collaborators</b> join projects or get invited by a <b>Project Lead</b> or <b>Administrator</b> to take measurements.
<b>Project Data Viewer</b>	A web app that allows users to filter, visualize, and map their data online.
<b>Project Lead</b>	The <b>Project Lead</b> is the person who initially creates a project. Also, the <b>Project Lead</b> invites <b>Administrators</b> and <b>Collaborators</b> .
<b>Project Questions</b>	Answering these <b>Questions</b> before every measurement improves the analysis and documentation of each contribution.
<b>Protocol</b>	<b>Protocols</b> are instructions for an instrument on how to conduct a measurement.
<b>Series (Data Viewer)</b>	Measurements can be grouped into <b>Series</b> by using the answers to the Project Questions.
<b>Synchronize (or Sync)</b>	Apps need to synchronize with PhotosynQ to provide you up to date Projects, Protocols and Macros.
<b>Thresholds (Data Viewer)</b>	For measured parameters <b>Thresholds</b> can be set to see a specific range of values.

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## Sign in to PhotosynQ

Sign in to access your work on PhotosynQ. You can only have one account active at a time.

### Web

1. Click on **Login** in the top menu bar.
2. Enter your email address and password.
3. If you wish to stay signed in, check **Remember me**
4. Click on **Sign in**.

### Android

1. Tap the PhotosynQ icon to start the app.
2. Enter your email address and password.
3. Tap on **Login**.

### Desktop (Google Chrome)

1. Start the app using the chrome app launcher.
2. Enter your email address and password.
3. Click on **Sign in**.

\*\*\*Tip:\*\*\* Make sure you have an internet connection when you sign in so your work can be synchronized.

---

## Change your email address

Need to change your current email address? No problem. Just follow the steps to update your profile to maintain you access to you account

### Update your email in your user profile

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Account Settings**.
3. Update your email address.
4. Click on **Update** to save your changes!
5. Open your inbox and click on the confirmation link inside the email just send to you.

**Note:** Please note that the change is not effective until you have confirmed the change in the confirmation email!

### Troubleshooting

Before you contact us, make sure you checked the following steps:

- [x] If the confirmation email is not in your inbox, please check your spam folder as well.

**Last resort:** Please contact us (support@photosynq.org), so we can try to help you out.

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## Your subscriptions

PhotosynQ makes it easy to stay on top of everything. Use subscriptions to be notified when new posts are made in the **Forums** or in one of your **Projects**.

### Adjust your notification intervals

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Subscriptions**.
3. Adjust the interval notifications are emailed to you (*No emails, Daily summary, Real time*).

\*\*\*Tip:\*\*\* Daily summaries are a good way of keeping up without having too many emails in your inbox.

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## Project Invitations

Others can invite you to collaborate on a project.

## Accept Invitations

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Invitations**. The little badge indicates if there are new invites.
3. Check your list of available invitations and click on **Join** if you want to collaborate.

**Note:** You will receive an email as well. Click on the link inside the email to join the Project.

**\*Tip:\*\* Below the project name it is indicated if you are invited as a Collaborator or Administrator\*\*.**

The screenshot shows the user profile page for 'Photosynq' (MSU/PRL, photosynq1@gmail.com). The page has a green header with navigation links: Discover, Create, Forums, Learn More, Help, Photosynq, Sign out, and a search bar. The profile card on the left shows 3 Collaborators and a list of actions: New Project, Invitations (2), Subscriptions, and Account Settings. The main content area has tabs for About, Activity, Projects, Collaborations, and Network. Under 'Recent Projects', there is 'LICOR Comparisons'. Under 'Recent Collaborations', there is 'Maker Faire Tour!'. Under 'Recent Comments', it says 'No Comments'. A statistics section at the bottom shows: 80 CONTRIBUTIONS, 1 PROJECTS, 1 COLLABORATIONS, 0 DATA FLAGGED, 0 PROTOCOLS, 0 MACROS, 0 FORUM POSTS, and 3 NETWORK.

## Decline Invitations

1. Open your user page by clicking on your name in the top **Menu**.
2. On the left hand side click on **Invitations**. The little badge indicates if there are new invites.
3. Check your list of available invitations and click on **Decline Invitation** if you don't want to collaborate on this project.

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## Sign out of PhotosynQ

It is quick and easy to sign out of PhotosynQ and you can sign back in at any time.

### Web

1. Click on **Sign out** in the top menu bar.

### Android

1. Tab the overflow menu in the top left corner.
2. Tab on your photo to bring up your profile.
3. Tab on **Logout**.

### Desktop (Google Chrome)

1. Click on your photo in the left menu bar.
2. At the bottom of the appearing dialog click on **Sign out**.

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## Deactivate your PhotosynQ account

If you would like to leave PhotosynQ and deactivate your account, please contact us (support@photosynq.org).

## Apps

### PhotosynQ on computers, phones and tablets

To take measurements with your instrument you need to have a device with an app installed. Downloads are available on <https://photosynq.org/software>

### Apps are available for which platforms?

1. Android (mobile)
2. Desktop (Google Chrome)
  - Mac OS X
  - Windows
  - Linux

### Will there be an iOS App?

No, at least not in the near future. The current hardware of the MultispeQ is not able to communicate with iOS devices due to Bluetooth limitations.

## Troubleshooting

If you have trouble getting the apps to work, please try this first:

- [x] Make sure you have the latest updates for your operating system installed.
- [x] Restart the device before installing.
- [x] Make sure you have sufficient storage.
- [x] Make sure you have an internet connection.

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## PhotosynQ for Android

Taking measurements in the field, on the move? You can use the app to find and join projects, take measurements and contribute them.

### Which Android Devices are supported?

Currently all devices running Android v4.4 or greater are supported. However some devices might have issues. In this case help us and send us an email.

### Download the PhotosynQ app

1. Search for **PhotosynQ** in the Google Play store.
2. Tab the **Install** button. Check your permissions and **Accept**



## Troubleshooting

Sometimes the app does not work as expected. Please try this first:

- [x] Make sure you have the latest version of the app.
  - [x] Make sure you have the latest Android Updates installed.
  - [x] Restart the app.
  - [x] Make sure you have sufficient storage.
  - [x] Make sure you have an internet connection.
- 

## PhotosynQ for Desktops

Taking measurements in the in the lab, developing new measurement protocols?

### Download the PhotosynQ app

1. Search for *PhotosynQ* in the Chrome Web Store.
2. Click on **ADD TO CHROME**. Check your permissions and click on **Add app**

## Troubleshooting

Sometimes the app does not work as expected. Please try this first:

- [x] Make sure you have the latest version of the app and the chrome browser.
- [x] Restart the browser.
- [x] Make sure you have sufficient storage.
- [x] Make sure you have an internet connection.

## Compatability with other browsers

Currently only Google Chrome has the ability to communicate with serial devices like MultispeQ.

---

## Connect an Instrument

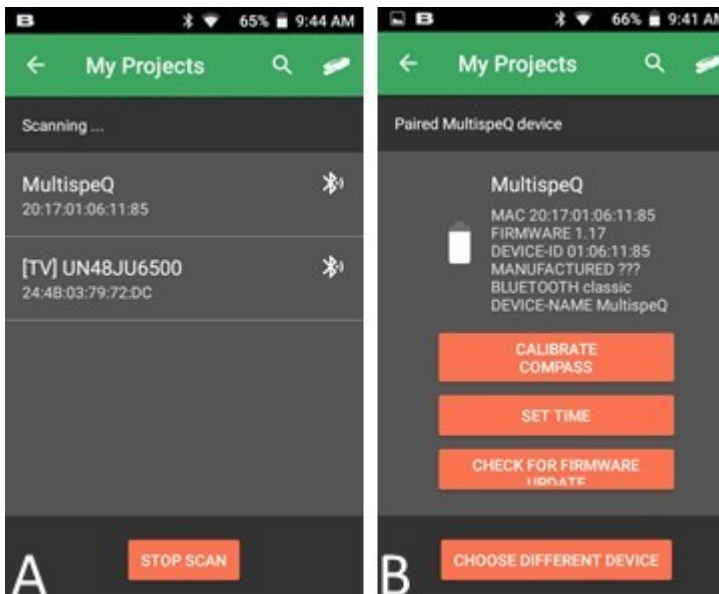
You can use Bluetooth or USB to connect your Instrument with your device. Depending on the instrument and device, some connection options may not be available.

**Before connecting your MultispeQ to the Android or Desktop App you need to turn on the MultispeQ by pressing and holding the power button for 5 seconds**



## Android - Bluetooth

1. Go to the **My Projects** page within the app.
2. Select the instrument icon on the top right of the page.
3. A list of available Bluetooth instruments will appear.
4. Below the Instrument name will be its ID. This should match the MAC address on your instrument (screen A, below)
  - If your instrument does not appear, click on **SCAN DEVICES**
  - You may have to click **SCAN DEVICES** multiple times before your instrument appears.
5. Select on the appropriate instrument.
6. A pop-up will appear asking to pair the device by entering the instrument PIN. **The PIN is 1234 and is the same for every MultispeQ.**
7. After pairing the MultispeQ, you will be taken back to the Device list. Select your MultispeQ from the list, if the screen B (below) appears your device is connected.



## Desktop - USB

1. Select **Settings** from the left menu bar.
2. Choose the **Device** tab from the dialog.
3. Pick the port the Instrument is connected to from the dropdown menu:
  - Windows: **COM{number}**
  - Mac OS: **usbmodem{number}**
  - Linux: **ACM{number}**
4. Connect the device by clicking on **Connect**.

## Desktop - Bluetooth

1. Make sure you have your Instrument connected to your Device through your OS preferences. The code for pairing is **1234**.
2. Select **Settings** from the left menu bar.
3. Choose the **Device** tab from the dialog.
4. Pick the port the Instrument is connected to from the dropdown menu:
  - Windows: **COM{number}**
  - Mac OS: **Devicename\_{number}**
  - Linux: **Not available**
5. Connect the device by clicking on **Connect**.

## Troubleshooting

If you are having trouble connecting to your instrument, please go through this checklist first:

- [x] Make sure your instrument is fully charged (at least 6h, or over night).
  - [x] Make sure you have turned on the instrument by pressing and holding the power button for 5 seconds. **The device will automatically shut off after 3 hours of inactivity**
  - [x] If you were using the instrument with another mobile device, you will need to press and hold the power button for 5 seconds to disconnect it from the previous device and make it available to a new device.
  - [x] If you are using Windows 8 or lower, make sure you have the serial driver installed.
- 

## Finding projects in the PhotosynQ app

**Projects are the lifeblood of PhotosynQ, so it is important to understand what you are looking at!**

- Inside the app, you can find all the projects you have either created or joined. You can do this by selecting the menu in the upper left corner of the app and then selecting **My Projects**.
- Everyone is automatically joined to the tutorial project, Getting Started with MultispeQ
- Check out the overview and directions for the project.

1. These are sometimes the only source of communication between the project creator and you.

2. Reading the directions is vital to taking proper measurements.

- Any additional questions about projects can be asked on the project discussion online.

## Projects

### What are projects?

Data on the PhotosynQ platform is organized into projects. Project data can be analyzed, shared and discussed in collaboration with the PhotosynQ community. Any member of the PhotosynQ community can create a project or can contribute data to open projects.

The creator of a project is the **Project Lead**, who:

1. Chooses the measurement protocol to be used
  2. Defines the project questions
  3. Decides who can contribute to the project
  4. Invites **Administrators** and **Collaborators** to the project
- 

### Join a project

Join projects to contribute measurements and receive notifications when new posts are made to the discussion.

## Website

When you visit the project page, click on **Join** in the left menu bar.

## Android

When you visit a new project click on **Join**.

## Desktop (Google Chrome)

In the right column click on **Join**

\*\*\*Tip:\*\*\* Some projects cannot be joined, since they are limited to a closed group of users. If you are interested in joining, ask for an invitation as a collaborator.

---

## What is a Project?

Data collected in PhotosynQ is organized and stored in Projects. Users define the Protocols and Project Questions for each Project.

## Create a new Project

1. Click on the 'create' tab from the top **Menu**.
2. Add a project name
3. Select a project category
4. Click on 'Start a New Project.'

\*\*\*Tip:\*\*\* Selecting a project category helps the project creation tool suggest the most appropriate protocols for your project.

---

## What is a Protocol?

These are instructions that are sent to the instrument on how to conduct a measurement. Which parameters you measure will be dependent on which protocol you choose for your project.

\*\*\*Tip:\*\*\* Read the protocol description carefully to be sure that it is measuring what you want to measure and that it is compatible with your instrument.

## Choosing a Protocol

### Choosing 1 suggested protocol

1. Suggested protocols for your project (based on the project category) will appear on the left.
2. On the right will be a description of the protocol.
3. Click on the protocol
4. Click on 'Save and Next'

**Note:** You will only be able to select **one** protocol using this method, if you want to select more than 1 protocol, keep reading...

## Choosing more than 1 suggested protocol

1. Click on 'Advanced.'
2. A list of all suggested protocols will appear on the left.
3. To select a protocol, click on it or drag it over to the protocol list on the right.
4. Select additional protocols the same as in step #3. **Protocols will run in the order that they are listed on the right**
5. Click on 'Save and Next'

### *Tips:*

- You can change the order of protocols by dragging them up or down the list
- Hovering over the protocol name will bring up a pop-up window with the protocol description. Click on 'Read More' in the pop up to bring up the full protocol description.

## Choosing protocols from the whole protocol list

1. If the suggested protocols are not appropriate for your project, click on 'Advanced' below the suggested protocols
2. Click on 'Click to show all protocols' to bring up the full list of protocols available on PhotosynQ
3. To select a protocol, click on it or drag it over to the protocol list on the right.
4. Select additional protocols the same as in step #3. **Protocols will run in the order that they are listed on the right**
5. Click on 'Save and Next'

### *Tips:*

- You can change the order of protocols by dragging them up or down the list
- Hovering over the protocol name will bring up a pop-up window with the protocol description. Click on 'Read More' in the pop up to bring up the full protocol description.

## Does the order of Protocols matter?

The protocols will run in the order that you select them. Depending on what you are measuring, it may be important to keep them in a certain order. For example, measure photosynthetic yield before measuring relative chlorophyll content so that the LED's from the relative chlorophyll content measurement do not affect your photosynthetic yield value.

---

## What is a Project Question?

In Projects you can define Questions which have to be answered before each measurement (optional). These Questions can be used to input additional non sensor data (e.g. plant height) or to filter and categorize your measurements when you explore your Project data. Project Questions are important for improving the analysis and documentation of every contribution. Example questions could include:

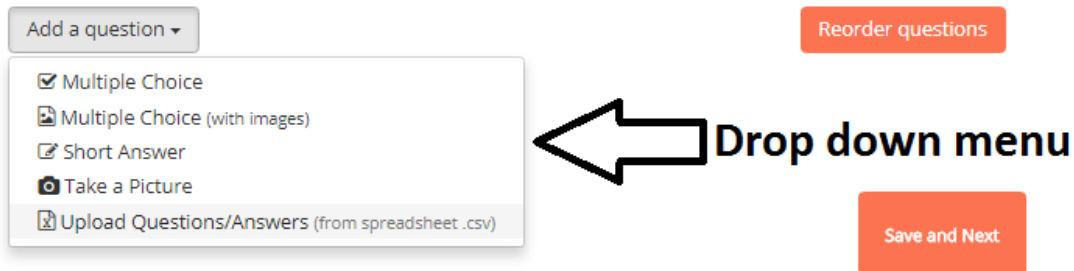
- What is the variety?
- What is the treatment?
- What is the replicate?
- any many more...

\*\*\*Tip:\*\*\* See the tutorials on more information on Project Questions.

## Adding Project Questions

1. Select the type of question you want to add from the 'Add a question' drop down menu.

2. See below for instructions on creating each type of question.
3. Click 'Add a question' to add another question, you can add as many questions as you need.
4. To reorder questions, click on 'Reorder Questions.'
5. Drag the questions into the new order.
6. Select 'Done reorder.'
7. If you have added all of your questions and you are happy with the order of the questions, click on 'Save and Next.'



### Multiple Choice:

This is the best choice if you know all of the possible answers to the question

1. Input the question in the 'Question' box
2. Input the first answer in the 'Answers' field.
3. Click on 'ADD ANSWER' to add an additional answer box
4. Once you have input all of your answers, select 'Save.'

\*\*\*Tip:\*\*\* Each answer needs to have its own answer box

### Multiple Choice (with images):

This type of question is particularly useful if the images help to answer the question. An example might be determining the growth stage of a crop by inputting images of each growth stage as possible answers

1. Input the question in the 'Question' box
2. Drag and drop first image into the box or click on the box to choose the file to upload. It may take up to a minute for the file to upload.
3. Once you have selected the image, an 'Image Text' box will appear. **You must add an image description in the box.**
4. Drag and drop or select another image and repeat step 3.
5. Once you have added all of your answers, select 'Save.'

### Short Answer:

This type of question is best if you do not know all of the possible answers when you create the project.

1. Input the question into the question box.
2. Select 'Save.'

## Take picture

Choose this question type if you want to force the data collector to take an image for **EVERY** measurement that is collected.

1. Input the picture instructions into the question box.
2. Select 'Save.'

## Upload Questions/Answers form spreadsheet (.csv)

This option is best for projects that involve a large population of plants or many project questions. For directions on how to set up your .csv, see the 'Using the csv Upload Feature' document.

1. Drag and drop the csv into the box or click on the box to choose the csv file to upload.
2. Select 'Save.' It may take up to a minute for the file to upload.

## Is there a limit to the number of Project Questions?

**No**, but keep in mind that you will have to answer each question in the field, which can slow down data collection.

---

## Project Locations

Project locations allows others to find interesting projects in their vicinity and start collaborations.

1. When you are creating a project, your project creation tool will automatically select your current location. If the project is too be located in another location, click on the red 'X' to delete the current location.
2. Click on 'Add Location' to add a another location.
3. You can search the location by entering in the location name or address in the search location bar or you can input the Latitude and Longitude.
4. Repeat steps 2 and 3 to enter has many locations as needed.
5. When you are finished click 'Save and Next.'

## How precise is the location data?

For the location your mobile device uses assisted GPS which has a maximum precision of 7.8 meters (25.6 feet) due to US trade restrictions (<http://www.gps.gov/systems/gps/>).

---

## Adding a Project Description

### Project Description

Type in a project overview, or provide measurement instructions in the Project Description box (you can use standard markdown to enrich your text).

### Category

Select one or more project categories from the Category drop down menu, that you feel best describe your project. **At least one project category is required for each project.** These categories help users browse and search for projects.

## Tags

You have the option to add tags to your projects. An individual tag must be all one word (no spaces).

## Photos

You can add photos to your project by dragging and dropping them into the Photos box or by clicking in the photos box and selecting your photos.

**\*\*\*Tip:\*\*\*** Uploading a unique project photo can help you quickly find your project, especially in the Android App

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## Editing a Project

If you have administrative rights on a project, either because you created the project or because you were added as an Administrator, then you can make changes to a project at any time.

1. Go to the project homepage on <https://photosynq.org>.
2. Using the 'Options' drop down menu on the left of the screen, select what you want to edit.
3. Once you have finished making changes, you can 'Save and close' or you can navigate through other sections of your project using the 'Back' and 'Save and Next' buttons.

**Note:** If you do not see the 'Options' menu on the left side of your projects homepage, this means that you do not have administrative access to this project.

---

## Managing Project Settings

Project settings allow Project Lead's to decide you can contribute data to the project and who can act as an administrator on the project.

1. Select who can contribute to your project by selecting 'anyone' or 'contributors only' from the drop down menu.

**\*\*\*Tip:\*\*\*** If you have a large project where you may have many different data collectors, then it is easiest to select 'anyone' instead of individually inviting everyone who will collect data.

1. If you selected 'Collaborators only' you will need to invite each collaborator
2. To invite collaborators, enter their email address in the box 'Invite Collaborator' and click 'Add.'
3. You can add as many collaborators as you need.
4. Each collaborator will receive an invitation email, they are not collaborators until they follow the link in the email.
5. Once you have finished adding collaborators, select 'Create Project.'

**Note:** All the confirmed collaborators will be listed on the bottom left under 'Collaborators' and all outstanding invitations will be listed on the bottom right under 'Invitations.'

## View & Analyze Data

### View your Project Data

You can view the data collected for your project at an time to follow the progress.



## Browser

1. Bring up your profile by selecting **Your Name** from the top menu bar.
2. Navigate to your project by selecting it from the **Projects** or **Collaborations** Tab.
3. Select **View Data** from the menu on the left of the Project page.

**Note:** If you have collected more than 1000 measurements or you have a slow internet connection it might take a while to load all the data.

## Troubleshooting

If you use a mobile device to analyze the data, the memory might not be sufficient enough to display everything.

We strongly recommend to use a **Desktop Computer** to view and analyze your data!

---

## Use the Dashboard

The dashboard can show a number of **Panels** showing what is important to you. You can drag and rearrange panels as you like. Click on the big + to bring up the panel selection dialog, or add plots from the plot view.

\*\*\*Tip:\*\*\* Next time you view the project data, your dashboard will be restored.

## Plots

You can plot parameters against each other using the plot tool.

1. In the menu bar above the plot select **Dashboard**
2. Enter a name or use the suggested and click on **OK** to add the plot to your dashboard.

\*\*\*Tip:\*\*\* You can click on panels with plots to load the plot into your plot view.

## Measurements

Panel	Function
<b>Parameter Average</b>	Show average and distribution for the selected parameter
<b>Contributions</b>	Show user contributions in total and for the last 30 days

**\*Tip:\*\*\* A click on a Parameter Average Panel will bring up the statistics summary for each Series\*\*.**

## Quality Control - Flagged Data

Panel	Function
<b>Instrument</b>	Flagged and un-flagged data points per instrument
<b>User</b>	Flagged and un-flagged data points per user

\*\*\*Tip:\*\*\* These panels can help you identifying issues with a user, device or with the approach in general in which measurements are taken.

## Troubleshooting

Sometimes your dashboard settings disappear the next time you load the project data. Make sure you allow the browser to store information in your browsers **local storage**.

---

## Plot Data

The “first” step to look at your data is to plot parameters against each other. This is an easy way to identify trends, find outliers and identify low quality measurements.

### View Plots

1. Just select the **Plot View** from the right menu underneath the Project name.
2. Select the type of plot and adjust the **Settings**.
3. Enter a plot title if you don't like the auto-suggestion.
4. Click on **Plot** to close the dialog and show the plot.

---

## Different Plot Types

### Scatter

You have a couple options for scatter plots, using **Makers**, **Lines** or **both**. The contour plots will only show lines.

1. Select the **Parameters** you would like to graph.
2. When you select markers, you can add additional parameters for marker size and color.

### Bar

Bar charts available to display averages. You can display the **standard deviation or error** along with the average.

1. Pick the **Parameter** you would like to average.
2. You can group the averages by a **Category**. Currently only the project questions are available as categories.

### Histogram

There are two types of histograms, a **regular** bar chart and a **2D histogram** for two parameters. The values are displayed as a heat map. Further you have **box plots** available.





1. Pick the **Parameter** from the dropdown menu.
2. Box plots can be grouped by a **Category**. Currently only the project questions are available as categories.
3. For the 2D histograms, select a second Parameter and a color gradient.

**\*Tip:\*\*** Adding Marker Size and / or Color\*\* will help to emphasize differences and trends, as well as show relationships between Parameters.


---

## Working with Plots

### Navigation

- **Zoom in:** click on the  in the bar or draw a rectangle while holding down the left mouse button
- **Zoom out:** click on the  in the bar to zoom out in steps
- **Reset Zoom:** click on  in the bar or left double click on the plot to reset the zoom level
- **Scroll Zoom:** Use the scroll-wheel of your mouse to zoom in and out.
- **Pan:** Click on the  icon from the bar to active the pan mode.

### Save Plot as an image

1. Select **Save** from above the plot and save the Plot as an image (.png)
2. Click on the  icon in the bar and save the Plot as an png.

### Save Plot data

1. Select **Save** from above the plot and save the Plot data as a comma (.csv) or tab (.txt) delimited file.
- 

## Special functions (Scatter Plots)

Scatter plots, in contrast to the other available ones have an extended set of functionality.

### Measurement Details


Click on a marker of a **Scatter Plot** to open a new window and view the measurement details.

### Select Data Points

Scatter plots allow you to select data points by using the box or lasso selection tool from the bar. The dialog offers two options:

1. Add the selected data as a new Series.
2. Save the selected data points with the corresponding measurement ids, project questions and time stamps as a comma delimited file (.csv).

### Linear Regression

1. Select **Analysis** from above the plot to fit different linear regressions to your plot (only for scatter plots).
  2. There will be one regression line per series.
  3. The activity log will be displayed (or click on  and select activity log) displaying the equations. Further the equations are displayed in the plot legend.
-

## The Map

The map allows you to superimpose your collected measurements on a map.

### View Maps and Heat Maps

1. Just select the **Map View** from the right menu underneath the Project name.
2. The color of the markers on the map represents the **Series**

\*\*\*Tip:\*\*\* Click on the marker to see the measurement details.

---

### Series

1. By default the marker color represents the series.
2. If a heat map is shown, just select **Series** from above the map.

\*\*\*Tip:\*\*\* To zoom out and show all measurements, click on above the map.

### Heat maps

Heat maps allow you to see spacial trends.

1. Select the **Parameter** from the dropdown menu you want to superimpose from above the map.
2. Click on **Heatmap** and select the gradient for coloration.

\*\*\*Tip:\*\*\* You can hover over a marker the value is highlighted on the gradient on the legend in the lower right corner.

---

## The Spreadsheet

The spreadsheet allows you to view and download the data in the familiar spreadsheet layout.

### View the Spreadsheet

1. Just select the **Spreadsheet** from the right menu underneath the Project name.
- 

### Protocols

1. In case you use multiple protocols, select **Protocols** from above the spreadsheet.
2. Pick the protocol you want to view.
3. Select **More** from above the spreadsheet to select additional information including *Users, Device IDs, Notes, Photos, Location* and *Status (e.g. flagged)*

### Download spreadsheet

1. Select **Save** from above the spreadsheet and pick the format you want to use.

### Measurement Details

1. Click on the number in the **ID** column to see measurement details.
-

## Statistics

A very basic set of statistical tools for your project data analysis.

### View the Spreadsheet

1. Select the **Statistics** from the right menu underneath the Project name.
2. Choose the type of statistics you wish to perform and select the significance level.



Summary   Student's t-test   Chi Square test   ANOVA   95 %   **Select Test Here**   ?

**Summary**  
Create an individual summary for each series and one parameter

**Student's t-test**  
Test if two series are significantly different from each other.

**Chi Square test**  
Test if selected category is dependent on the selected series.

**ANOVA**  
Test if more than two series are significantly different from each other.

---

### Summary

1. Pick the parameter you want the statistical summary generated for and click on **Show Summary**.

### Student's t-test

1. Pick the parameter and the two series you want to compare.
2. Select one-tailed or two-tailed, depending on your dataset.
3. Click on **Run t-test** to show the results.

## Student's t-test



### Select Parameter

Phi2



Parameter to compare

### Select Two Series

1 Irrigated control

2 Rainfed control

3 SWRT



Select exactly two series. Hold down the alt key to select multiple series

One tailed

Two tailed

Run t-test

## ANOVA

1. Pick the parameter and at least two series to compare.
2. Check **Create correlation matrix** to generate a table of t-test.
3. Click **Run ANOVA**.

## ANOVA



### Select One Parameter

Phi2



Parameter to compare

One-Way ANOVA

### Select Series at least two

1 Irrigated control

2 Rainfed control

3 SWRT

2 Rainfed control

Make sure you created your series filtering only by one parameter!

Create correlation matrix

A correlation matrix will compare each series performing a student's t-test

Run ANOVA

### Chi Square test

1. Pick the parameter that you want to test for.

**Note** the parameter must be a categorical variable.

1. Pick at least 2 series to compare.
2. Click **Run Chi Square test**.

### Series (Data subsets)

Series are subsets of your complete project dataset. You can generate them by **filtering** your dataset based on your **project questions**.

**\*Tip:\*\*** You start out with the Whole Dataset\*\* selected. When you have filtered your dataset, it will be restored, the next time you load your project data.

### Add a Series

1. Select + **Add** to show the filter dialog.
2. Adjust your filters and select the + **Add** button below the available filter options to create a series.
3. For details on how to filter your project data, see filters.

### Remove a Series

1. Hover with your pointer over the series and click on × to remove the series.
2. Confirm that you want to remove the selected series.

**\*Tip:\*\*** You can remove all series at once, opening the dropdown menu and selecting Remove all Series\*\*.

### Rename a Series

1. Hover with your pointer over the series and click on to edit the series.
2. Change the name in the input field and click on .

### Change the Series Color

1. Hover with your pointer over the series and click on to edit the series.
2. Change the color by selecting one of the available color options.

### Show / Hide a Series

1. Click on a series to show or hide it in the view.

### Troubleshooting

- [x] Sometimes your dashboard settings disappear the next time you load the project data.
  - [x] Make sure you allow the browser to store information in your browsers **local storage**.
- 

### Filter data

You can filter your data by **Project Questions**, **Users**, **Devices** and **Time** or combinations of those. These subsets are called **Series**.

### Apply Filters

1. Select + **Add** to show the filter dialog.
2. Expand Project Question or Questions you want to filter by.
3. Select your answer or answers for each Question.

**\*\*Tip:\*\*** See the examples on how the series are generated.

### Add a single Series

1. Make your filter selections.
2. Select + **Add** below the available filter options to create one series.



## Add multiple Series

1. Make your filter selections.
2. Select and choose **Import as separate series**.

## Presets

Instead of selecting filters you can simply click on presets and select one of the available options to generate the corresponding **Series**.

## Examples

Adding a single or multiple **Series** has a different logic in which filters are applied

### Single Series:

All of the measurements that include any of the selected filters will be contained in **one series**.

The screenshot shows a user interface for creating series from filters. On the left, under the 'Filter' tab, several filters are listed: Block, Leaf location, station, Variety, Weeks after plant, Collaborators, Devices, and Time & Date. The 'Leaf location' filter is expanded, showing 'Top', 'middle', and 'bottom' options, with 'Top' selected. The 'Variety' filter is also expanded, showing '1 Tutti', '2 Sy4045', and '3 Pan 7049' options, with '1 Tutti' and '2 Sy4045' selected. A blue arrow points from these filter selections to the 'Series' tab on the right. In the 'Series' tab, a single series is listed: 'Top - 1 Tutti, 2 Sy4045' with a count of 56. Below the series list, there is a note: 'Series are filtered subsets of the project's dataset'. At the bottom, there is a button '+ Add' and a 'Presets' dropdown menu. A tooltip above the '+ Add' button reads 'Add Series according to selected filters'. Below the '+ Add' button, there is a note: 'Select subsets of your dataset by using the project questions as filters and group them as series'.

### Multiple Series:

This selection will generate a separate series for each unique combination of filters.

**Filter** Add Series ← Back to Series

- ▶ Block
- ▼ Leaf location
 

Top  
 middle  
 bottom
- ▶ station
- ▼ Variety
 

1 Tutti  
 2 Sy4045  
 3 Pan 7049
- ▶ Weeks after plant
- ▶ Collaborators
- ▶ Devices
- ▶ Time & Date
 

Import as separate series  
(Generates possible filter combinations)

+ Add
Presets

📌 Select subsets of your dataset by using the *project questions* as filters and group them as series

**Series** + Add

- 1 Tutti Top 26
- 2 Sy4045 Top 30

📌 Series are filtered subsets of the *project's* dataset

## Set Thresholds

You can set ranges for individual *numeric Parameters*, allowing you to exclude outliers or focus on specific ranges of values. Thresholds for multiple *Parameters* can be defined at the same time.

## View Thresholds

1. On the right hand side, just select the thresholds tab.

## Add Thresholds

1. Select **Add** to add a new Threshold

### Licor V Par

🌐
📈
🌍
📅
📊

**Series**

+ Add

Presets

- Whole Data Set 550

1. Choose the **Parameter** and set the range.
2. Add more Thresholds if you like.
3. Select **Apply** to reflect the thresholds in your views, except for the spreadsheet view.

Thresholds [← Back to Series](#)

---

Parameter ×

angle ▼

45 to 90

---

[+ Add](#) [× Remove All](#) [✓ Apply](#)

\*\*\*Tip:\*\*\* Thresholds are applied only for the duration of a session, unlike flagged data. This allows you to exclude outliers, especially when you are not the project administrator or lead.

### Remove Thresholds

1. Click on × to remove the corresponding threshold.
2. Select **Apply** to reflect the changes in your views, except for the spreadsheet view.

## Protocols

### Protocol Basics

Protocols are instructions for Instruments like the MultispeQ on how to run a measurement.

### Can any Protocol run on any Instrument?

No, Instruments have different configurations, so Protocols might trigger the wrong lights, or request a sensor that is not available. Make sure that the Protocol is compatible with your Instrument.

### Protocols can be associated with Macros

Macros are small pieces of code that help you analyze a measurement. After a measurement is done, a macro can be applied to make calculations based on the measurement results.

### Does a Protocol need a Macro?

No, you don't have to have a Macro for a Protocol. Yet most of the measurements require a Macro since they need to be analyzed further to provide useful information.

---

### View your Protocols

All the protocols you have developed on PhotosynQ are accessible to you at any time.

## Desktop (Google Chrome)

1. Open your protocols by selecting **Protocols** from the left menu bar.
2. Click on the **My Protocols** to list all your protocols, if it is not already available.
3. Click on a protocol in the list to show detailed information in the side bar.
4. Click on **Run** to run a protocol, or double click on it in the list.

**\*Tip:\*\*** In case you want to see the work of others, select **Explore\*\*** from the top menu.

## Android

1. Tap the overflow menu in the top left corner.
  2. Select **Quick Measurements** from the menu.
  3. Tap on a protocol in the list to **run** it.
- 

## Create a new Protocol

If you want setup your own measurements, or make changes to existing ones.

## Desktop (Google Chrome)

1. Make sure you have the desktop app installed and you are signed in.
2. Open your protocols by selecting **Protocols** from the left menu bar.
3. Connect the device you want to use the protocol with.
4. Click on the **+ New** button to open the protocol editor.
5. Start building your protocol...

**\*Tip:\*\*** Use **Run\*\*** to test your protocol at any time.

## Troubleshooting

When you have issues running the protocol on your device, make sure you check the following things first:

- [x] Make sure, that there are no errors or warnings indicated.
  - [x] Check if your device is connected and can run already existing protocols.
  - [x] Confirm, that the latest update is installed on your device.
- 

## Save a Protocol

Once you are done, save your work use it for your projects and and share it with the community.

## Desktop (Google Chrome)

1. Select **Protocol** from the menu and click on **Save**.
2. Add a protocol name, description and pick a category.
3. Make sure, the correct macro is connected (not mandatory)
4. Close the dialog by selecting **Save**.

## Troubleshooting

If you have issues saving the protocol, make sure you check these things first:

- [x] When a Protocol is finished, no warnings or errors are indicated.
  - [x] Make sure you have a name, description and category.
  - [x] Check that the name is not already existing.
- 

## Edit a Protocol

You can change one of your protocols or extend an already existing one at any time.

### Desktop (Google Chrome)

1. Select **Protocols** from the left menu bar.
2. Click on the protocol in the list and click on **Edit** in the sidebar.
3. Make your changes to the protocol.
4. Select **Protocol** from the top menu and click on **Save**.
5. Update the description if needed.
6. Close the dialog by selecting **Save**.

**\*Tip:\*\*** Often it is easier to start altering an already existing protocol. To save it change the name too and the only option available is Save as\*\*.

## Troubleshooting

If you have issues saving the protocol, make sure you check these things first:

- [x] When a Protocol is finished, no warnings or errors are indicated.
  - [x] Make sure you have a name, description and category.
  - [x] Check that the name is not already taken.
- 

## Run a Protocols

All the protocols you have developed on PhotosynQ you can use independent from projects.

### Desktop (Google Chrome)

1. Open your protocols by selecting **Protocols** from the left menu bar.
2. Double click on a protocol in the list or click on a list and select **Run** from the sidebar.

**\*Tip:\*\*** Use Add next to Run\*\* in the sidebar to run multiple protocols one after another.

**\*Tip:\*\*** You can use the protocols from others when you select Explore\*\* from the top menu.

## Android

1. Tap the overflow menu in the top left corner.
  2. Select **Quick Measurements** from the menu.
  3. Tap on a protocol in the list to **run** it
-

## `__protocol_set__`

Treating protocols as integrated sets.

Protocols are separate units which produce separate data sets. Using `__protocol_set__`, multiple protocols can be chained together into one protocol.

**Note:** This is different from chaining protocols together in a project. There, the protocols are still separate units within a measurement.

**Input:** array

**Code:**

```
"__protocol_set__": [{ Protocol 1 },...],
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## `adc_show`

When “`adc_show`” is 1, the readings taken by the ADC (analog to digital converter) on the sample and hold circuit are outputted in “`data_raw`” instead of the normal output. No other output is recorded, and only the last set of adc readings is shown (all other readings are not outputted). By default there are 19 samples, but this can be changed using “`number_samples`”.

**Input:** number

**Values:** 0, 1

**Code:**

```
"adc_show": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/adc\\_show](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/adc_show)

---

## `autogain`

The `autogain` function is added to the main section of the protocol. Multiple `autogain` functions can be run in a single protocol, and the indexed values should be useable throughout the experiment.

<index> which index to store gain settings (0-9)  
<pulsed\_LED> which pulsed LED to test (0-9)  
<detector> which detector to use (0-3)  
<pulse\_duration> what duration to use (in microseconds) (1-200)  
<target\_value> what target value to use (0-65535, recommended: 40000-50000)

**Input:** nested array

**Code:**

```
"autogain": [ [ <index>, <pulsed_LED>, <detector>, <pulse_duration>, <target_value> ], ... ],
```

**Type:** protocol

**Editor:** fixed

**Last Edited:** August 17, 2017

---

## averages

“averages” sets the number of times to average the protocol. The protocol will be repeated equal to the number of averages, and the resulting data will be averaged and outputted as a single data point. Averaging is often used to reduce noise and improve the quality of measurements.

**Input:** number

**Values:** 0 - 10000

**Code:**

```
"averages": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/averages>

---

## averages\_delay

“averages\_delay” defines the delay between protocol averages in in milliseconds (ms).

**Input:** auto

**Values:** 0 - 9999999999

**Code:**

```
"averages_delay": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/averages\\_delay](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/averages_delay)

**Dependencies:**

- averages
- 

### **dac\_lights**

When “dac\_lights” is set to 1, “pulsed\_lights\_brightness” and “nonpulsed\_lights\_brightness” settings will be interpreted by the device as 12-bit values (0 - 4095) directly controlling the LED voltage (via the DAC), instead of microEinsteins (uE). This is used during factory calibration.

**Note:** Setting brightness to high using raw DAC values could permanently disable LEDs, so be careful!

**Input:** number

**Values:** 0, 1

**Code:**

```
"dac_lights": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/dac\\_lights](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/dac_lights)

---

### **detectors**

“detectors” defines which detectors are being measured, and in what order. The chosen “meas\_light” supplies the light source to be measured. The detector measurement is recorded in “data\_raw” in the data received from the MultispeQ, which is then graphed for the user. When “detectors” is set to 0, no detector is read and responses will be recorded as zero.

**Input:** nested array

**Values:** 0 - 4

**Code:**

```
"detectors": [[<detector>], ... ],
```



**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/detectors>

**Dependencies:**

- pulses
  - pulse\_length
  - pulse\_distance
  - pulsed\_lights
  - pulsed\_lights\_brightness
- 

### **energy\_min\_wake\_time**

The value of time is in milliseconds, and must be between zero and  $10^6$  milliseconds. This setting changes the delay between shutting off the 5V (following `energy_save_timeout`) and the wake up time. The `energy_min_wake_time` is needed to prevent brown out following the initiation of energy save.

**Important:** Note that the change in `energy_min_wake_time` will remain in effect until the instrument is reset, when it will return to the default value of 10 s.

**Input:** number

**Values:** 0 -  $10^6$

**Code:**

```
"energy_min_wake_time": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **energy\_save\_timeout**

Adjusting Energy Save Timeout Time. The value of time is in milliseconds, and must be between zero and  $10^6$  milliseconds. This setting changes the `energy_save_timeout` time to prevent interference from the requirement for a 7 second wake up time from power save mode.

**Important:** Note that the change in `energy_save_timeout` will remain in effect until the instrument is reset, when it will return to the default value of 120 s.

**Input:** number

**Values:** 0 - 10<sup>6</sup>

**Code:**

```
"energy_save_timeout": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## **environmental**

**environmental** defines which additional sensor(s) to measure. The **environmental** calls occur at the very beginning of the measurement, prior to any pulses. Some sensors require additional information, like specifying which pin to measure, brightness, etc. In addition to sensor measurements, there are also calls to flip digital pins on/off or set a pwm which could be used to control external lights or even motors. Below is the full list of parameters available in **environmental**.

The returned sensor values from most **environmental** calls are accessible inside a protocol using Expressions (details). Adjusting protocols in real time based on these values can be very handy for certain types of protocols.

**Input:** nested array

**Code:**

```
"environmental": [[<sensor>], ... ],
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/environmental>

---

## **environmental\_array**

“**environmental\_array**” defines additional sensors or functionality, just like “**environmental**”. However, “**environmental\_array**” returns sensor data once per pulse, as defined in “**pulses**”. This allows a string of sensor measurements to be used in a single macro. The advantage is you can calculate and return in real time things like rates of change, minima and maxima, etc. See examples for details. **Note:** “**pulsed\_lights\_brightness**” must NOT be set to zero for any given pulse set for the sensors set in “**environmental\_array**” to measure.

**Input:** nested array

**Code:**

`"environmental_array": [[<number>], ... ],`

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/environmental\\_array](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/environmental_array)

**Dependencies:**

- pulses
  - pulse\_length
  - pulse\_distance
  - pulsed\_lights
  - pulsed\_lights\_brightness
- 

## ir\_baseline

Text with markdown formatting, no html

**Input:** number, array, nested array, string

**Code:**

`"command name": <number>,`

**Type:** protocol

**Editor:** table, fixed, editor instructions

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

---

## label

Each protocol or sub-protocol can now output a `label` that can be used to indicate something about the protocol, conditions etc.

**Input:** string

**Code:**

`"label": <string>,`

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **light\_intensity**

Instead of setting a fixed for an LED, use this parameter to acquire the ambient light intensity using the PAR sensor to recreate it inside the instrument.

**Code:**

```
"light_intensity"
```

**Type:** parameter

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **max\_hold\_time**

This parameter sets the time (in ms) at which the hold commands timeout. The default value is 15000, or 15 seconds. This value applies to the following control points: `start_on_open`, `start_on_close`, `start_on_open_close`.

**Input:** number

**Code:**

```
"max_hold_time": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **message**

“message” sends text to the user between pulse sets, and waits for a response before proceeding. Set to “0” to not send a message. “message” should have the same length as “pulses”.

**Input:** nested array

**Values:** `alert` - message with an OK button, `prompt` - message with an OK and Cancel button, `confirm` - message with an OK and Cancel button and text input box

**Code:**

`"message": [[<message type>, <message>], ... ]`,

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/message>

**Dependencies:**

- pulses
  - pulse\_length
  - pulse\_distance
- 

### **nonpulsed\_lights**

“nonpulsed\_lights” defines which lights are not pulsed (always on) during a pulse set, and in what order.

**Input:** nested array

**Values:** 0 - 10

**Code:**

`"nonpulsed_lights": [[<number>], ... ]`,

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/nonpulsed\\_lights](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/nonpulsed_lights)

**Dependencies:**

- pulses
  - pulse\_distance
  - pulse\_length
  - nonpulsed\_lights\_brightness
-

## nonpulsed\_lights\_brightness

“nonpulsed\_lights\_brightness” sets the brightness in microEinsteins (uE) of the nonpulsed lights. Definition of microEinsteins (uE) here.

**Input:** nested array

**Values:** 0 - 15000

**Code:**

```
"nonpulsed_lights_brightness": [[<number>], ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/nonpulsed\\_lights\\_brightness](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/nonpulsed_lights_brightness)

**Dependencies:**

- pulses
  - pulse\_distance
  - pulse\_length
  - nonpulsed\_lights
- 

## number\_samples

“number\_samples” sets the number of samples taken by the ADC (analog to digital converter) on the sample and hold circuit. The median value of these samples is then saved as a single detector value in “data\_raw”. The ADC is used to measure the detectors (1 - 4). This value is already set to the optimum value, and most signal noise comes from other source, but in certain cases increasing the value may yield improved signal.

**Input:** number

**Values:** 1 - 500

**Code:**

```
"number_samples": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/number\\_samples](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/number_samples)

## Dependencies:

- pulses
  - pulse\_length
  - pulse\_distance
  - detectors
- 

## open\_close\_start

When “open\_close\_start” is set to 1, the protocol waits until the user fully opens the clamp and closes the clamp before proceeding. Also works if the clamp starts fully open and then closes. Open and close is detected using the Hall effect sensor on the main body and magnet on the clamp (same sensor used to determine sample thickness). If the device is not calibrated, or calibration is off, or the clamping mechanism does not fully open or close, this function will not work. Calibration details can be found by typing print\_memory into the console - see thickness\_a, thickness\_b, thickness\_c, thickness\_min, and thickness\_max for relevant calibration values.

**Input:** number

**Values:** 0, 1

**Code:**

```
"open_close_start": <number>,
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/open\\_close\\_start](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/open_close_start)

---

## par\_led\_start\_on\_close

The Ambient light is recreated inside the instrument on closing the clamp. During the hold time, the ambient light is resampled in ~100 ms intervals and the LED output is adjusted to match. When the hold event occurs (e.g. the clamp is closed), the final ambient intensity and LED setting are held and used in the protocol. The number for the LED is defining the LED used for matching the ambient light intensity.

**Input:** number

**Code:**

```
"par_led_start_on_close": <number for LED>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **par\_led\_start\_on\_open**

The Ambient light is recreated inside the instrument on opening the clamp. During the hold time, the ambient light is resampled in ~100 ms intervals and the LED output is adjusted to match. When the hold event occurs (e.g. the clamp is closed), the final ambient intensity and LED setting are held and used in the protocol. The number for the LED is defining the LED used for matching the ambient light intensity.

**Input:** number

**Code:**

```
"par_led_start_on_open": <number for LED>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **par\_led\_start\_on\_open\_close**

The Ambient light is recreated inside the instrument on opening the clamp. During the hold time, the ambient light is resampled in ~100 ms intervals and the LED output is adjusted to match. When the hold event occurs (e.g. the clamp is closed), the final ambient intensity and LED setting are held and used in the protocol. The number for the LED is defining the LED used for matching the ambient light intensity.

**Input:** number

**Code:**

```
"par_led_start_on_open_close": <number for LED>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **previous\_light\_intensity**

Instead of setting a fixed for an LED, use this parameter to acquire the ambient light intensity using the PAR sensor to recreate it inside the instrument.

**Code:**



"previous\_light\_intensity"

**Type:** parameter

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## protocols

“protocols” sets the number of times to repeat the protocol. Unlike “averages”, this outputs data every time the protocol is repeated (instead of averaging the repeats and outputting data only once).

**Input:** number

**Values:** 0 - 999999999

**Code:**

"protocols": <number> ,

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/protocols>

---

## protocols\_delay

“protocols\_delay” defines the delay between protocol repeats in in milliseconds (us).

**Input:** auto

**Values:** 0 - 9999999999

**Code:**

"protocols\_delay": <number> ,

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/protocols\\_delay](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/protocols_delay)

**Dependencies:**

- protocols
- 

**pulse\_distance**

“pulse\_distance” defines the distance, in microseconds (us) between pulses.

**Input:** array

**Values:** 750 - 999999999999

**Code:**

```
"pulse_distance": [<number>, ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulse\\_distance](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulse_distance)

**Dependencies:**

- pulses
  - pulse\_length
  - pulsed\_lights
  - pulsed\_lights\_brightness
- 

**pulse\_length**

“pulse\_length” defines the length, in microseconds (us), of a pulse.

**Input:** nested array

**Values:** 1 - 150

**Code:**

```
"pulse_length": [[<number>], ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulse\\_length](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulse_length)

**Dependencies:**

- pulses
  - pulse\_distance
  - pulsed\_lights
  - pulsed\_lights\_brightness
- 

**pulsed\_lights**

“pulsed\_lights” defines which lights are pulsed, and in what order. When set to 0, no lights are pulsed and no readings are recorded (see Example section here for details).

**Input:** nested array

**Values:** 0 - 10

**Code:**

```
"pulsed_lights": [[<number>], ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulsed\\_lights](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulsed_lights)

**Dependencies:**

- pulses
  - pulse\_distance
  - pulse\_length
  - pulsed\_lights\_brightness
- 

**pulsed\_lights\_brightness**

“pulsed\_lights\_brightness” sets the brightness in microEinsteins (uE) of the pulsed lights. Definition of microEinsteins (uE) here.

**Input:** nested array

**Values:** 0 - 15000

**Code:**

```
"pulsed_lights_brightness": [[<number>], ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** [https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulsed\\_lights\\_brightness](https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulsed_lights_brightness)

**Dependencies:**

- pulses
  - pulse\_distance
  - pulse\_length
  - pulsed\_lights
- 

**pulses**

“pulses” defines the number of pulse sets, and quantity of pulses per set.

**Input:** array

**Values:** 1 - 8000

**Code:**

```
"pulses": [<number>, ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/pulses>

**Dependencies:**

- pulse\_distance
  - pulse\_length
  - pulsed\_lights
  - pulsed\_lights\_brightness
- 

**recall**

This command returns values from the device memory (EEPROM). This includes values saved by the user (see Examples below for details) as well as values saved during factory calibration. For a full list of saved values which can be recalled, see `expr.cpp` . Expressions may be applied to “recall” requests (more).

**Input:** array

**Code:**

```
"recall": ["userdef[<location>]", ... ],
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/recall>

---

## reference

The MultispeQ is designed to be able to nearly simultaneously measure two detectors (within ~4us), normalize and subtract the two signals from each other. This can be useful if there is a optical, electronic (interference), or LED (heating) artifact that needs to be removed. “reference” specifies another detector to be measured and subtracted from “detectors”.

**Note:** It is possible to add two additional detector circuits to the device, on the main body and clamp circuit boards. The devices come unpopulated by default. If added, these two additional detectors are available by settings `detectors` or `reference` to 2 (main body) or 4 (clamp). These can then also be used as reference or main detectors.

**Input:** nested array

**Values:** 1 - 4

**Code:**

```
"reference": [[<detector>], ... ],
```

**Type:** protocol

**Editor:** table

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/reference>

**Dependencies:**

- pulses
  - pulse\_length
  - pulse\_distance
- 

## save

This command saves a value to a location in the device memory (EEPROM). Expressions can be used on the saved values (more).

**Input:** nested array

**Code:**

```
"save": [[<location, <value>], ... ]],
```

**Type:** protocol

**Editor:** fixed

**Versions:**

1.17 1.16 1.14 1.11 1.10 1.08 1.07 1.06

**Devices:**

MultispeQ 1

**Last Edited:** June 6, 2017

**Url:** <https://github.com/Photosynq/PhotosynQ-Firmware/wiki/save>

---

**save\_trace\_time\_scale**

Saving Time Scale Values. Setting the value to 0 will inactivate the function (preset), setting it to 1 will activate the function. If activated `data_raw_time` will be added to the measurement, containing the timing information.

**Input:** number

**Values:** 0, 1

**Code:**

```
"save_trace_time_scale": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

**set\_led\_delay**

Pre-illuminating a sample. It is often useful to pre-illuminate a sample at a given light intensity, for a given amount of time.

The following example gives two, 20 second pre-illuminations with the red LED (#2), the first at 0 uE and the second at 100 uE:

```
"set_led_delay": [
  [2, 20000,0],
  [2, 20000,100]
],
```

**Input:** nested array

**Code:**

```
"set_led_delay": [ [<number LED>, <number duration in ms>, <number PAR>],... ],
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **set\_light\_intensity**

Instead of measuring the ambient light intensity, use `set_light_intensity` to set a fixed light intensity. Use the parameters `light_intensity` or `previous_light_intensity` to use the defined light intensity.

**Note:** Instead of defining the light intensity for each pulse set use `set_light_intensity` to only have one place to change the light intensity.

**Input:** number

**Code:**

```
"set_light_intensity": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

### **start\_on\_close**

If set to 0, the command will be ignored. If set to 1, will wait until the clamp is closed, then proceed with the rest of the experiment.

**Input:** number

**Values:** 0, 1

**Code:**

```
"start_on_close": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## start\_on\_open

If set to 0, the command will be ignored. If set to 1 or higher, it will wait until the clamp is opened, then proceed with the rest of the experiment.

**Input:** number

**Values:** 0, 1

**Code:**

```
"start_on_open": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## start\_on\_open\_close

If set to 0, the command will be ignored. If set to 1, will wait until the clamp is opened then closed, then proceed with the rest of the experiment.

**Alias:**

- open\_close\_start

**Input:** number, array, nested array, string

**Code:**

```
"start_on_open_close": <number>,
```

**Type:** protocol

**Editor:** fixed

**Devices:**

MultispeQ 1

**Last Edited:** August 17, 2017

---

## Macros

### View your Macros

All the macros you have developed on PhotosynQ are accessible to you at any time.

### Desktop (Google Chrome)

1. Open you macros by selecting macros from the left menu bar.
2. Click on the **My Macros** to list all your macros, if it is not already available.
3. Click on a macro in the list to show detailed information in the side bar.

**\*Tip:\*\*** In case you want to see the work of others, select Explore\*\* from the top menu.



---

## Create a new Macro

If you want to analyze a measurement using your own calculation, create a macro to do the calculation for you.

### Desktop (Google Chrome)

1. Make sure you have the desktop app installed and you are signed in.
2. Open your macros by selecting macros from the left menu bar.
3. Click on the **+ New** button to open the macro editor.
4. Select a measurement from the dialog, the macro should analyze. If you don't have a measurement in your notebook, take one first and save it.
5. Start coding...

If you need more help on how to get started, please look at this [Tutorial](#)

---

## Save a Macro

Once you are done, save your work and share it with the community.

### Desktop (Google Chrome)

1. Select **Macro** from the menu and click on **Save**.
2. Add a macro name and a description.
3. If you want you can add a standard parameters for x and y plots. Only parameters calculated by your macro are available.
4. Close the dialog by selecting **Save**.

## Troubleshooting

If you have issues saving the macro, make sure you check these things first:

- [x] When a Macro done, make sure the output box is green, indicating that there was no error.
  - [x] Make sure you have a name, description.
  - [x] Check that the name is not already existing.
- 

## Edit a Macro

You can change one of your macros or extend an already existing one at any time.

### Desktop (Google Chrome)

1. Select **Macros** from the left menu bar.
2. Double click on the macro in the list or click on **Edit** in the sidebar.
3. Make your changes to the code.
4. Select **Macro** from the top menu and click on **Save**.
5. Update the description if needed.
6. Close the dialog by selecting **Save**.

**\*Tip:\*\*** In case you altered a macro someone else had made, change the name too. In this case you only have the option Save as\*\*.

## Troubleshooting

If you have issues saving the macro, make sure you check these things first:

- [x] When a Macro is done, make sure the output box is green, indicating that there was no error.
  - [x] Make sure you have a name and description.
  - [x] Check that the name is not already taken.
- 

## Coding and Functions

### Basic Guidelines

- Document your steps inside the code.
- Test your code with more than one measurement.
- Make sure that the code is fast and efficient.
- Output only what is really necessary to not overwhelm others who will use your macro based analysis.

**Note:** Try to make your code efficient, since can be used to evaluate several thousand measurements in a row.

### Code Structure

```
//=====
// Macro for data evaluation on PhotosynQ.org
// created: 11/3/2016
//=====

//Define the output object here
var output = {};

//Check if the key time exists in json
if (json.time !== undefined){

    //Add key time and value to output
    output["time"] = json.time;
}

//Return data
return output;
```

### Basic Requirements:

- The variable `output` is needed, as well as the `return output` statement at the end.
  - Add a new parameter to your Macro output using: `output['New Parameter'] = "Hello World"`
  - To access parameters from your Measurement use the **Variables** Menu. Variables selected will look like this: `json.variable` in the code.
  - Use the **Raw Trace** in the upper right corner to select a subsection of your trace if available.
-

## Helper Functions

Some functions are needed over and over again, like calculating the average, finding the maximum, etc. Just pick the function you need from the functions menu and it will get inserted at the position of your cursor into your code.

```
// Calculate the mean from an array
var values = [1,2,3,4,5,6]
output['Mean'] = MathMEAN(values)
```

---

## Order Parameters

Sometimes you have multiple parameters calculated. To show the most important parameters first, select **Order Parameters** from the functions Menu. It will insert a piece of code like this:

```
output["order"] = ["P1", "P3", "P2"];
```

Just replace P1, P2, etc. with the names of the parameters you want to be ordered and appear on top of the list. Not all parameters need to be listed here.

---

## Show additional Traces

The recorded trace `json.data_raw` will be shown with a measurement. In case you would like to show some extra traces based on your calculations, just add an array to your output parameters. This array need *more than 4 values* to be shown as a sparkline.

```
output["Additional Trace"] = [1,3,4,90,87,50,3,2,1,2,7,...];
```

---

## Show Colors

Sometimes representing a value as a color is more useful than a plain number. These three options are available:

- Hexadecimal: `#44bd78`
- RGB (Red, Green, Blue): `rgb(68,189,120)` (values from 0 to 255)
- RGBA (Red, Green, Blue, alpha): `rgba(68,189,120,0.5)` (values from 0 to 255), (alpha 0 to 1)

```
output['Your Parameter'] = '#44bd78'
output['Your Parameter'] = 'rgb(68,189,120)'
output['Your Parameter'] = 'rgba(68,189,120,0.5)'
```

---

## Return Feedback

If people take measurements in the field, they might run into quality issues, they cannot identify right away. Based on calculations you can add messages to alert users, that they might have to repeat the measurement. Three types of messages are available:

- **Info:** Just let users know that (color:blue)
- **Warning:** Give users a warning, that there might be something wrong and they should take a closer look (color: yellow)

- **Danger:** Use this message, when you think something went terribly wrong. In the future, measurements containing this message will be flagged as bad datapoints automatically. (color:red)

To add messages, use the Functions menu and select the type of measurement you need. Replace the word `message` with your message.

```
info('message',output);
warning('message',output);
danger('message',output);
```

---

## Restrictions

Some of the functions available in JavaScript are not allowed to be used in macros. All functions that require a user response like `alert`, `confirm` and `prompt` are not allowed. Also defining new functions or overwriting existing functions `function(){...}` is forbidden, as well as extending the prototype library `$.prototype`.

## Macros

### Instrument basics

#### What Instruments can be used with PhotosynQ?

In theory any instrument can be connected to PhotosynQ. But the output needs to follow the PhotosynQ format. To get started, use PhotosynQ enabled instruments like the MultispeQ.

#### What is the MultispeQ?

The MultispeQ is a sophisticated, hand-held meter that combines chlorophyll fluorescence, absorbance and absorbance kinetics measurements to provide detailed plant physiological data.

---

#### What does the MultispeQ measure?

The standard MultispeQ protocol measures the following parameters\*:

Parameter	What does it mean?
Light Intensity (PAR)	Photosynthetically active radiation. Fraction of the incoming light (400 nm to 700 nm) which can be utilized to drive photosynthesis

Parameter	What does it mean?
Relative Chlorophyll	Otherwise known as “SPAD,” relative chlorophyll is a measure of leaf “greenness”. This measurement is often correlated with leaf nitrogen levels
Phi2	Quantum yield of Photosystem II. This measurement is essentially the percentage of incoming light (excited electrons) that go into Photosystem II. Photosystem II is where most light energy is converted into food.

Parameter	What does it mean?
PhiNPQ	Ratio of incoming light that goes towards non-photochemical quenching. The plant regulating excess energy in such a way as to reduce damage to the plant.
PhiNO	Ratio of incoming light that is lost via non-regulated processes. PhiNO is the combination of a number of unregulated processes whose by-products can inhibit photosynthesis or be harmful to the plant.

Parameter	What does it mean?
Leaf Temp Differential	The difference between <b>Ambient Temperature</b> and leaf temperature ( <b>contactless_temp</b> ). Negative numbers mean that the leaf is cooler than the surrounding air and vice versa.
Leaf Angle	The angle of the leaf, from 0 - 90 degrees
Ambient Temperature	Ambient temperature in degree Celsius (°C)
Ambient Humidity	Relative humidity in percent (%)
ECSt	Total magnitude of ECS (electrochromic shift) decay during a light-dark transition

Parameter	What does it mean?
vH+	Proton conductivity of the chloroplast ATP synthase
gH+	Steady-state rate of proton flux through the chloroplast ATP synthase
absorbance_wavelength	Absorbance of light from each wavelength that passed through the leaf
angle_direction	Abbreviated cardinal direction (e.g. NW - North West)
B	The raw amount of blue light captured by the PAR sensor
compass	Cardinal direction in degrees from North



Parameter	What does it mean?
compass_direction	Abbreviated cardinal direction (e.g. NW - North West)
contactless_temperature	Surface temperature in degree Celsius (°C)
FmPrime	Maximum variable fluorescence at steady-state conditions
FoPrime	Minimum variable fluorescence during dark phase after steady-state
Fs	Variable fluorescence at steady-state conditions
G	The raw amount of green light captured by the PAR sensor

Parameter	What does it mean?
LEF	Linear Electron Flux. The total flow of electrons from antennae complexes (where light is captured) into Photosystem II, taking the leaf absorptivity into account. Calculated as $LEF = \Phi_2 \times PAR \times 0.42$
NPQt	Estimate of non-photochemical quenching. The amount of incoming light that is regulated away from photosynthetic processes in order to reduce damage to the plant.

Parameter	What does it mean?
pressure	Atmospheric pressure (mbar) - This value is not corrected to sea level as found in weather reports
pitch	Pitch is the angle the instrument is held along the short axis
qL	Fraction of Photosystem II centers which are in the open state
R	The raw amount of red light captured by the PAR sensor
roll	Roll is the angle the instrument is held along the long axis

Parameter	What does it mean?
thickness	The thickness of the leaf as measured by the Hall Effect sensor embedded in the MultispeQ clamp.

\*Some of the parameters are not available for the beta version of the MultispeQ

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Check out this [Talk of what the MultispeQ measures](#) by Dr. Kramer

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#### Where can I find more information?

You can search <https://pubmed.com> or <https://scholar.google.com> if you are looking for scientific literature. Below you find a small selection of literature that will get you started:

Tietz, S., Hall, C. C., Cruz, J. A., Kramer, D. M. (2017) **NPQ<sub>(T)</sub>: a chlorophyll fluorescence parameter for rapid estimation and imaging of non-photochemical quenching of excitons in photosystem-II-associated antenna complexes** *Plant. Cell Environ.* 40(8), 1243–1255. doi:10.1111/pce.12924

Kuhlgert, S., Austic, G., Zegarac, R. Osei-Bonsu, I., Hoh, D., Chilvers, M. I., et al. (2016). **MultispeQ Beta: a tool for large-scale plant phenotyping connected to the open PhotosynQ network.** *R. Soc. Open Sci.* 3, 160592. doi:10.1098/rsos.160592.

Cruz, J. A., Savage, L. J., Zegarac, R., Hall, C. C., Satoh-Cruz, M., Davis, G. A., et al. (2016). **Dynamic Environmental Photosynthetic Imaging Reveals Emergent Phenotypes.** *Cell Syst.* 2, 365–377. doi:10.1016/j.cels.2016.06.001.

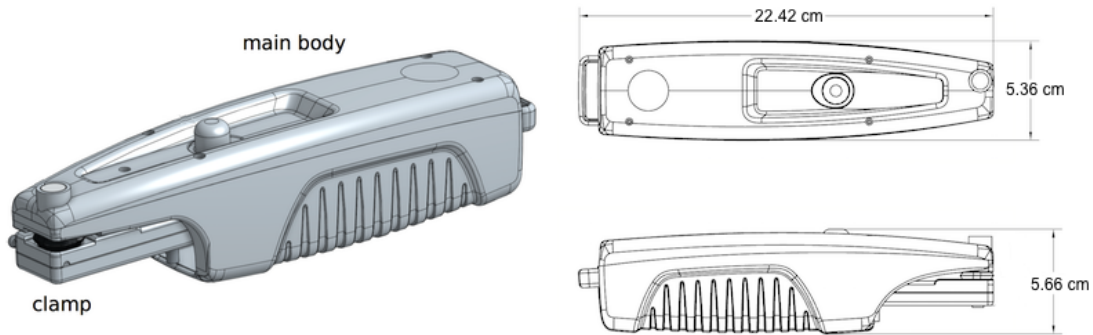
Kramer, D. M., and Evans, J. R. (2011). **The importance of energy balance in improving photosynthetic productivity.** *Plant Physiol.* 155, 70–8. doi:10.1104/pp.110.166652.

Baker, N. R. (2008). **Chlorophyll fluorescence: a probe of photosynthesis in vivo.** *Annu. Rev. Plant Biol.* 59, 89–113. doi:10.1146/annurev.arplant.59.032607.092759.

Kramer, D. M., Cruz, J. A., and Kanazawa, A. (2003). **Balancing the central roles of the thylakoid proton gradient.** *Trends Plant Sci.* 8, 27–32. doi:10.1016/S1360-1385(02)00010-9.

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## MultispeQ v1.0 Configuration



## Lights

There are sets of five LEDs each on the **main body** and the **leaf clamp**.

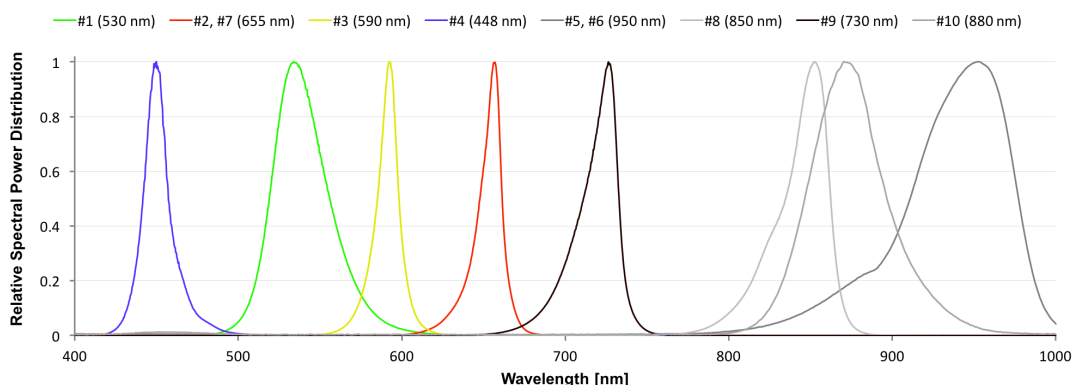
### Main Body

#	Emission Peak	Model	Specifications
1	530nm	LED (green), Lumileds, LXZ1-PM01	view
2	655nm	LED (red), Lumileds, LXZ1-PA01	view
3	590nm	LED (amber), Lumileds, LXZ1-PL01	view
4	448nm	LED (blue), Lumileds, LXZ1-PR01	view
5	950nm	LED (NIR), OSRAM, SFH 4441	view

### Leaf Clamp

#	Emission Peak
6	950nm
7	655nm
8	850nm
9	730nm
10	880nm

## Emission Spectra for LEDs



## Detectors

The MultispeQ v1.0 comes with two detectors. One covering the near infrared on the **main body**, the other covering the visual range on the **leaf clamp**.

#	Detection Range	Model	Specifications
1	700nm - 1150nm	Hamamatsu, S6775-01 (main body)	<a href="#">view</a>
3*	400nm - 700nm	Hamamatsu, S6775 (leaf clamp)	<a href="#">view</a>

\***Note:** The detector 3 is covered with a BG-18 bandpass filter with a center wavelength around 493 nm. If you are using the detector to detect signals on the edges of the detection range, expect the signal strength to be low.

## Sensors

The MultispeQ v1.0 has a set of sensors to measure the environmental parameters

Sensor	Model
Ambient Temperature, Humidity, Pressure (2x)	BOSCH, BME280
Contactless Temperature	Melexis, MLX90615SSG-DAG-000-TU
Accelerometer	Freescale, MMA8653FCR1
Magnetometer	Freescale, MAG3110FCR1
Hall Effect Sensor	TT Electronics, OHS3150U
PAR light sensor	AMS-TAOS USA, TCS34715FN + 700nm low pass filter

## Filters

The MultispeQ v1.0 has two filters, a Band Pass filter covering the visible light detector (#3) and a Low Pass filter used in the PAR sensor.

Filter	Model	Specifications
Band Pass	Schott, BG-18 1mm thickness	<a href="#">view</a>
Low Pass	UQC Optics, Hot Mirror HM-07	<a href="#">view</a>

## Battery

The MultispeQ v1.0 has a Li-ion battery which can be charged through the micro USB port.

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Battery	Model
Main	Soshine Li-ion 26650 Protected Battery: 5500mAh 3.7V

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## Tutorials & More

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