Authors' Responses to the Reviews of JoVE Submission JoVE63342

First we would like to express our sincere thanks to the Editor for their time and effort in handling our manuscript. We would also like to thank the three anonymous reviewers very much for their valuable comments and suggestions on our paper which help us to improve the paper. We have carefully considered those comments and suggestions, and thoroughly checked and revised the paper accordingly. For review convenience, the revised parts in the paper are highlighted with a blue background. The following is a detailed description about how we have addressed the reviewers' concerns in the revised manuscript.

Responses to the Editorial comments

Q - 1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. Please define all abbreviations at first use.

A - Thank you for your patience and effort to handle this paper. We have revised the manuscript following your valuable comments. The paper has been thoroughly proofread and all abbreviations are defined in the revised manuscript.

Q - 2. Please revise your title to be within 150 characters and describe your paper more accurately. Maybe something like "A circuit-based system for online experimentation in engineering education"?

A - Thank you for your suggestion. This work discusses three examples for visualizing online experimentation using an online experimentation system, which can be used for teaching, learning and research. Your suggested title can only cover the first example. To cover all three protocols, we have revised the title to "Interactive and visualized online experimentation system for engineering education and research".

Q - 3. Please rephrase the Summary to clearly describe the protocol and results in complete sentences between 10-50 words.

A - The Summary has been rephrased accordingly, as presented on Page 1.

"This work discusses an online experimentation system that can provide visualized experiments including the visualizing of theories, concepts, and formulas, the visualizing of the experimental process with 3-D virtual test rigs, and the visualizing of control and monitoring using widgets such as a chart and a camera."

Q - 4. Your protocol describes three modules that are quite specific and can perhaps be used by students and teachers for those specific topics. As stated earlier, please revise your title so that readers understand exactly what the paper and video will show. If you believe that this system is useful for other disciplines (even in engineering), please include brief notes after the steps where modification is possible and explain what the modification should be to be useful to those other fields.

A - Thank you for your valuable suggestions. We have revised the manuscript accordingly.

Q - 5. Please ensure that all text in the protocol section is written in the imperative tense as if telling someone how to do the technique (e.g., "Do this," "Ensure that," etc.). Any text that cannot be written in the imperative tense (e.g., provide extraneous details, optional steps, or recommendations) may be added as a "Note." Descriptions, explanations about equations etc should be moved to the introduction or discussion. This will also help keep the video portion (highlighted text) of your protocol within the three-page limit.

A - Thank you for your comments. We have revised the manuscript accordingly. Descriptions, explanations about equations *etc*. have been moved to the discussion.

Q - 6. Please adjust the numbering of steps and sub-steps of the Protocol to follow the JoVE Instructions for Authors. For example, 1 should be followed by 1.1 and then 1.1.1 and 1.1.2 if necessary. Please refrain from using bullets or dashes.

A - Thank you for your comments. Bullets or dashes are not used in the original manuscript. The wrongly numbered section 1 (2.1 and 2.2) in Protocol 2 in the original manuscript have been revised to section 1 (1.1 and 1.2).

Q - 7. Please format the manuscript as: paragraph Indentation: 0 for both left and right and special: none, Line spacings: single. Please include a single line space between each step, substep and note in the protocol section. Please use Calibri 12 points and one-inch margins on all the side. Please include a ONE LINE SPACE between each protocol step and then HIGHLIGHT up to 3 pages of protocol text for inclusion in the protocol section of the video. We can only film action steps written in imperative tense. We cannot film calculations, derivations, or any mathematical equations. Please ensure that the highlighted steps form a cohesive narrative with a logical flow. To ensure you do not exceed three pages of highlighted text, do not highlight notes and merge shorter, related, highlighted steps so that a step contains 2-3 actions and not more than 4 sentences.

A - Thank you for your patience and effort to handle this paper. We have revised the manuscript following your valuable comments.

Q - 8. Please note that your protocol will be used to generate the script for the video and must contain everything that you would like shown in the video. Please add more details to your protocol steps. Please ensure you answer the "how" question, i.e., how is the step performed? Alternatively, add references to published material specifying how to perform the protocol action. Please ensure

the inclusion of specific details (e.g., button clicks for software actions, numerical values for settings, etc) to your protocol steps. There should be enough detail in each step to supplement the actions seen in the video so that viewers can easily replicate the protocol.

A - We have checked the protocol steps and any additional necessary steps have been added.

Q - 9. Please remove all commercial language from your manuscript and use generic terms instead. All commercial products should be sufficiently referenced in the Table of Materials (e.g., Google Chrome, Microsoft Edge, Mozilla Firefox, etc.)

A - All commercial languages are removed from the manuscript. MATLAB is mentioned in the discussion, we think it can be referenced in the manuscript.

Q - 10. Line 117: what is this remote controller and where is it located?

A - The sentence has been revised as "Wait until the designed block diagram is generated into an executable control algorithm that can be downloaded and executed into the remote controller that is deployed at the test rig side for the execution of control algorithms" in Lines 103-105, Page 3.

Q - 11. Please remove the embedded figures from the manuscript text.

A - All embedded figures are removed from the manuscript text.

Q - 12. Please include all the figure legends after Representative Results and upload all figures as separate PDF files.

A - We have revised accordingly.

Q - 13. As we are a methods journal, please revise the Discussion to explicitly cover the following in detail in 3-6 paragraphs with citations:
a) Critical steps within the protocol
b) Any modifications and troubleshooting of the technique
c) Any limitations of the technique
d) The significance with respect to existing methods
e) Any future applications of the technique

A - Thank you for your advice. The discussion part has been revised accordingly.

Two sentences have been added in Lines 280-283, Page 7 to emphasize the critical steps within the protocol and any modifications and troubleshooting of the technique.
"Before the compilation of a control algorithm that can be used for real-time experimentation, simulation should be conducted to address potential issues. Using the system, control algorithms can be applied to other different test rigs once they are integrated into the proposed system."

Descriptions, explanations about equations *etc.* have been moved to the Discussion part.

Q - *14. Is the website https://www.powersim.whu.edu.cn/react open source? Please move all the URLs/ websites to Table of Materials and refer them in the manuscript text wherever needed. Sort all materials alphabetically.*

A - Currently the website is accessible to everyone. The URL has been removed to the Table of Materials and all materials are sorted alphabetically. As suggested by Reviewer 2, the URL has been added in the introduction.

Responses to reviewer 1's comments

Q1 - The paper introduces three protocols for online experimentation in Control Engineering through the use of the NCSLab online labs platform. Each protocol is related to a different lab visualization example: 1) visualizing of theories, concepts, and formulas, 2) visualizing of the experimental process with 3-D virtual test rigs, and 3) visualizing of control and monitoring using widgets such as a chart and a camera.

The protocol is easy to follow and even I was able to reproduce the steps, for Example 1, in the NCSLab website.

Major Concerns:
I have no major concerns to point out regarding this paper.

A - Thank you for your comment. We have thoroughly checked the manuscript again to improve the manuscript.

Minor Concerns:
Q2 - A minor concern is that the paper presents three protocols for three different experiments / systems. However, they are all grouped as online experiments, so it makes sense to me to present them together in the same paper and video.

A - Thank you for your comments. Three separate visualized experiments are provided in this paper for online experimentation, which will be presented together in this single paper and the corresponding video. we have revised the manuscript to avoid confusion.

Q3 - A more important minor concern is that authors should make more clear for the reader that Sections 1, 2 and 3 present separate examples. I suggest them to, for example, named them as Example 1: First-Order System Using Circuit-Based Experimentation Protocol, Example 2: Interactive and Visualized Virtual Experimentation Protocol, Example 2: , Example 3:...

A - Thank you for your good suggestions. We have made it clear that three separate examples are demonstrated in the revised manuscript on Line 74, Page 2. We have also renamed the Protocol names to make it clearer following your suggestions.

Q4 - The last thing is that the image quality of some Figures must be improved; especially when they are shown in a one-page scale.

A - Sorry for the inconvenience. We uploaded clear Figures in the JPG format, but it resulted in blur-generated figures. We have fixed this issue in this revised version.

Responses to reviewer 2's comments

Manuscript Summary:
The paper is generally well-written. My comments are as follows:

Major Concerns:
Q1 - Authors mentioned that this online experimentation tool can be used for real-time experimentation using the equipment set up located at Wuhan University. But the authors didn't mention how many users can access the equipment at a time. Is there any scheduler facility available for the users to schedule their experimentation at a particular time. If a scheduler is available, please provide the steps to schedule an experimentation at a particular time.

A - Thank you for your comments. We have achieved for the experiment. For physical test rigs, a queue scheduling mechanism that is based on First Come First Served rule. While for virtual test rigs, concurrent access scheduling has been achieved, and test verified that virtual experimentation is capable of supporting 500 concurrent users. We had mentioned in the original manuscript that before a user can conduct an experiment, he/she has to apply for the control first, which is the step of scheduling. We have made it clearer in the revised manuscript in Lines 162-168, Page 3.

"Note: "Request Control" is the scheduling mechanism for the system. Once a user is granted the control privilege, the user can conduct experiments with the corresponding test rig. For physical test rigs, only one user can occupy the test rig at a time, and the queue scheduling mechanism has been implemented to schedule other appliers based on the First Come First Served rule [11]. For Virtual test rigs, massive number of users can be concurrently supported. 500 concurrent user experimentation has been tested effectively. For the circuit-based system, 50 users can access the system at a time."

Q2 - Another question I had in my mind is what would happen if a user creates a wrong circuit diagram (such as reversing the polarity of the diode, capacitor, failing to ground the circuit). Is there any real-time feedback mechanism available to alert the user regarding this error or the system will calculate the output based on the wrong circuit? Kindly provide the details of the precautions taken to avoid such errors.

A - Thank you for your comment.

The circuit-based system is based on simulation. For simulation, the great advantage is that the users can conduct their operations freely and they do not have to worry about the consequences since their mis-operations will cause no harm to themselves and to the system and test rigs, especially in an online laboratory.

After a circuit-based system is designed, the user is supposed to run a simulation. For some cases, for example, failing to ground the circuit, the simulation and compilation results will warn the user, which can help them to recheck the designed circuit. For other cases, for example, reversing the

polarity of the capacitor, no warning message will be shown when a user tries to conduct a simulation or compilation, but the simulation result may not be as supposed. So the user can re-check the system.

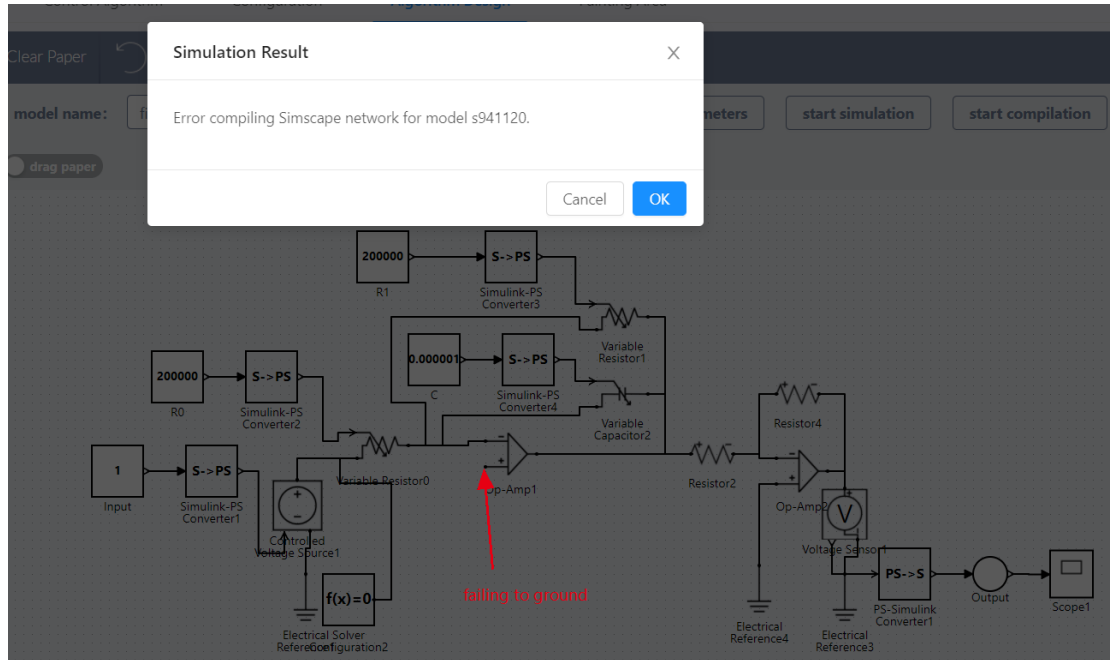The following is an example of creating a wrong circuit diagram.

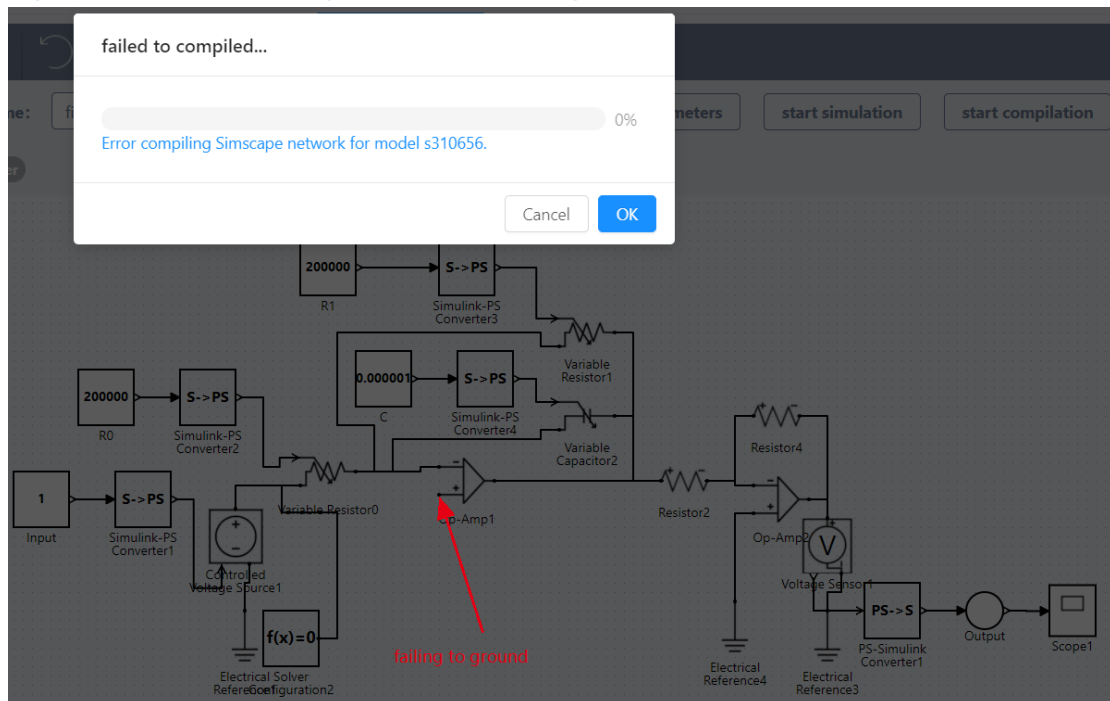Figure a: Simulation warning when a user fails to ground circuit

Figure b: Compilation warning when a user fails to ground circuit

In our system, reversing the polarity of the capacity will not cause any error or warning similar to MATLAB/Simulink.
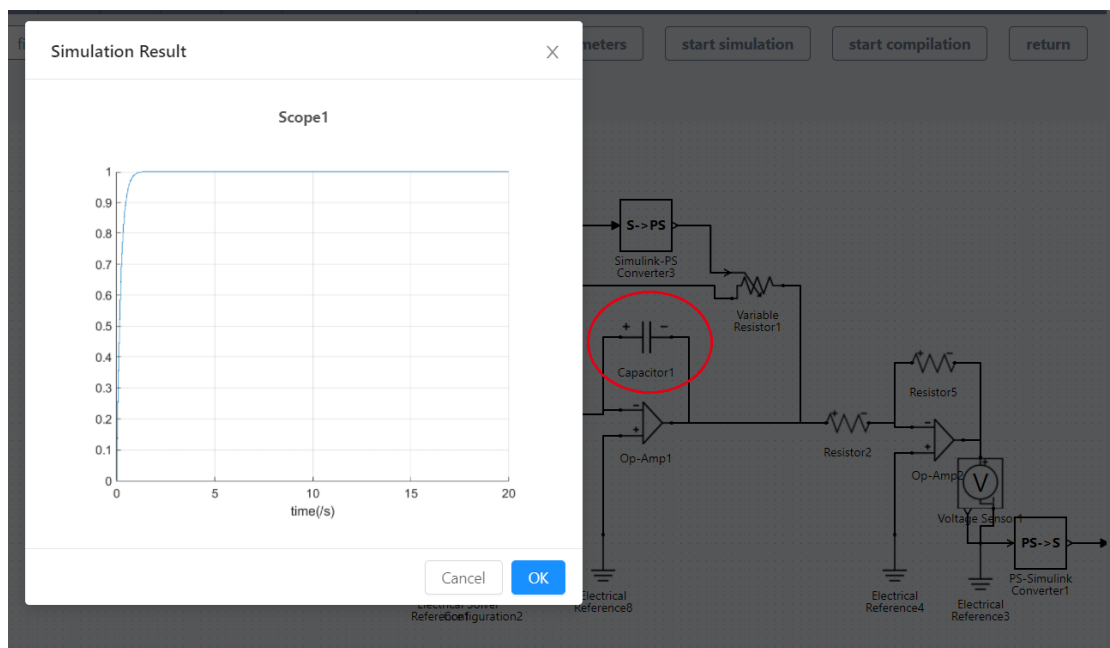
Figure c: Reversing the polarity of the capacity.

Figure d: The polarity of the capacity is correct.

A NOTE has been added in 1.8 in Example 1 in Lines 99-102, Page 3 in the revised manuscript.

Minor Concerns:
Q3 - There are typographical errors in Figure 8 and 9. Set point is wrongly written as "setponit" and lambda is written as "lamda".

A - Thank you for your comment. We have replaced Figure 8 and 9 (Figure 5 and 6 in the revised manuscript) and fixed the two typographical errors. We have revised the main text accordingly.

Q4 - *Lack of consistency in naming parameters in Table 1. Resistor 0 and 1 written as R0 and R1. But 3 and 4 written as "Resistor3" and "Resistor4"*

A - Thank you for your comments. To avoid confusion, we have revised "Resistor3" and "Resistor4" in the original Figure 2 (Figure 1 in the revised manuscript) and Table 1 to "Resistor2" and "Resistor3", and written as R2 and R3 to keep consistency.

Responses to reviewer 3's comments

Manuscript Summary:

Q1 - The manuscript describes three activities that can be conducted in an engineering class, ranging from completely virtual to remote physical labs. The proposed activities are well-detailed with supporting images.

A - Thank you for your comment. We have further improved the manuscript following your, the editor's and the other two reviewers' valuable comments and suggestions.

Major Concerns

Q2 - To me, this reads like step-by-step instructions for a student completing these three particular lab activities. If this is meant for instructors, and not students, then it is unclear what the students are doing as it seems like the instructor would be doing all the work while students watch. I was not able to find anything generalizable in the protocols (ie, I do not see how I can implement this in my own classroom to teach anything other than these three concepts exactly as outlined). Can I vary any of the parameters? If so, which ones and how? The instructions are very well-written as specific examples of how this type of activity can be carried out. But how can this protocol be applied in another classroom that may need to achieve similar (but not exactly the same) learning outcomes? Can it be, or is this the only way that this approach can be used?

A - Thank you for your comment. The article provides three examples for engineering education and research. Regarding education, both teaching for teachers or instructors and learning for students are possible. The teacher can conduct classroom online experimentation using the proposed system and instructions while explaining the concepts, formulas and theories. In this scenario, the students can watch and learn, and the provided practice can potentially enhance their comprehension of theoretical knowledge. Students can also complete those lab activities in their after-class experimentation using the proposed system and instructions.

Currently, the system is open and can be accessed via https://www.powersim.whu.edu.cn/react at 24/7 basis. Other teachers or students outside Wuhan University can access the system can implement this in their own classroom to teach more than the provided three examples. Of course a user can vary the parameters as demonstrated in the three protocols, for example, Protocol 1 Step 1.16 and Protocol 2, Step 1.7.

The system provides several different physical and virtual test rigs, and allows users to design and implement their own control algorithms, and customize the monitoring interface, thus, it can definitely be applied to different classroom scenarios.

Q3 - Additionally, is this approach effective? Have students effectively learned from this approach? What evidence is there that they have?

A - Thank you for your comment. The circuit-based system is newly developed. The other two examples (Examples 2 and 3) have been applied into teaching and learning for several years, and the effectiveness has been verified by the Reference [6] in the revised manuscript.

In the future, we will continue to apply the approach in education and research, and properly evaluate the effectiveness after the applications.

Reference:
[6] Lei, Z., Zhou, H., Hu, W., and Liu, G.P. Unified and flexible online experimental framework for control engineering education. *IEEE Transactions on Industrial Electronics*. 69(1), 835–844 (2022).

Minor Concerns:
Q4 - *The introduction can be improved by discussing what tools/websites are necessary to execute the protocol. As it reads, I do not have a clear indication of what I would need to execute this protocol.*

A - Thank you for your suggestion. The tools/websites that are necessary to execute the protocol were provided in Protocol 1, Step 2 in the original manuscript. We have improved the introduction by adding the website in Lines 75-76, Page 2 in the last paragraph of the Introduction part in the revised manuscript.