

From: Paul McGill mcgill@mbari.org
Subject: Re: SES batteries
Date: January 10, 2026 at 10:11 AM
To: Irene Hu irene@mbari.org
Cc: Alana Sherman alana@mbari.org

Hi Irene,

If you do some quick math you can see how critical the connections are. If you're drawing 7 A and you have even 0.1 ohms of resistance, you're going to drop 0.7 V. If you put your DMM on ohms and short the test leads together, even though the connections are big, fat banana plugs, you'll find it difficult to get the resistance below 0.1–0.2 ohms. This is why you must do four-wire measurements at higher currents.

Do you think it's worth trying to verify or should we just assume that the batteries are probably ok?

The number one priority is to be ready for the deployment, and you never want to let perfect be the enemy of good enough. At this point you just need to convince yourself that you haven't discovered something that would threaten the success of the mission. You were wise to bring these anomalies up to Alana and me, but we agree that what you're seeing is normal and the batteries should be fine.

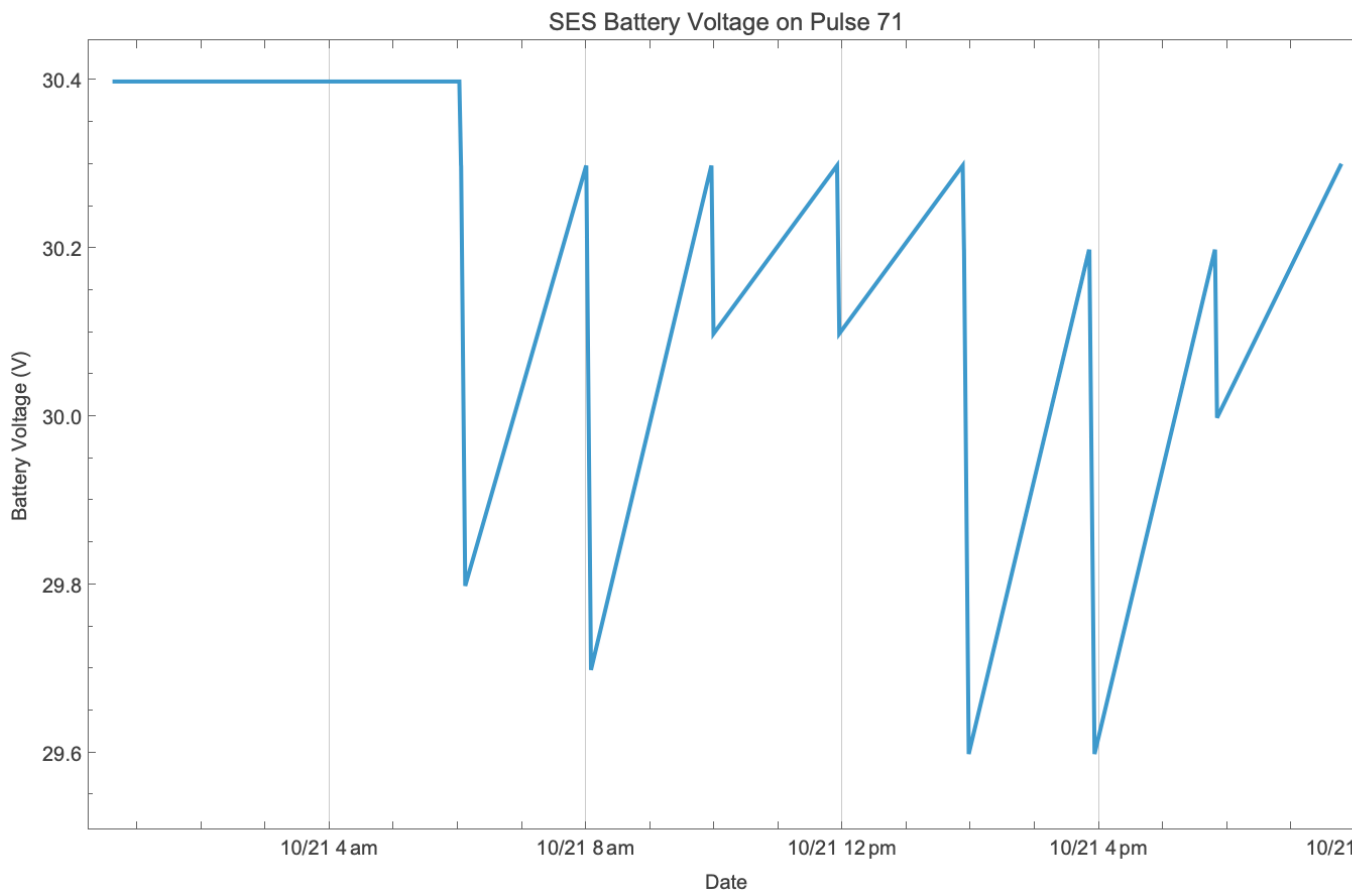
That being said, I'd always encourage you to fiddle with these measurements until you understand them. You could do some additional testing with a better setup even after the SES is deployed, workload allowing. And definitely put such testing in your weekly report. Eric is looking for good things to write about you in your evaluation, so make his job easy by showing initiative, curiosity, and self-education.

Another interesting thing is that measuring with the high current setup seems to sag the voltage for some time, even open circuit voltage. It recovers on the scale of maybe 5-10 minutes. Is this normal? Does it have to do with passivation?

No, it's probably not passivation, but instead ion depletion. The charge carriers in the electrolyte don't move like electrons in a wire, but instead have to diffuse through the medium. If you draw a large current then you deplete the ions and new ones have to form and diffuse throughout the electrolyte, which can sometimes take minutes or longer. You can see this effect if you short-circuit a big electrolytic capacitor. At first the voltage will be zero, but then it'll slowly rise in the first few minutes as the ions migrate. So, to answer your question, yes, it's normal.

I'm attaching another graph of the SES battery voltage showing that when sampling starts at 0600, the voltage dips and then slowly recovers before the next sample is processed two hours later.

I hope that helps,
Paul



On Jan 9, 2026, at 6:07 PM, Irene Hu <irene@mbari.org> wrote:

Thanks both!

I measured at the load and not the battery connector, and there were some alligator patch cables involved in the high current setup, so we could have some loss there. The lower current setup is actually more wiggly, but it's a little breadboard with 5 parallel resistors, so that could for sure have some bad connections. I don't see an easy way to clean up the setups with the materials on hand, though. Do you think it's worth trying to verify or should we just assume that the batteries are probably ok? I just found two more batteries in another box and they are approximately the same.

Another interesting thing is that measuring with the high current setup seems to sag the voltage for some time, even open circuit voltage. It recovers on the scale of maybe 5-10 minutes. Is this normal? Does it have to do with passivation?

Irene

From: Alana Sherman <alana@mbari.org>

Sent: Friday, January 9, 2026 3:22 PM

To: Paul McGill <mcgill@mbari.org>

Cc: Irene Hu <irene@mbari.org>

Subject: Re: SES batteries

Thanks Paul, excellent point about where you are measuring that voltage. I wonder if that is the difference with what we would expect. I am curious how long it takes to burn off all the passivation but I imagine that is not a simple answer.

You are earning that emeritus status :)
Alana

On Jan 9, 2026, at 2:35 PM, Paul McGill <mcgill@mbari.org> wrote:

Hi Irene,

Of course you can email or call me anytime. I can't always respond quickly (as you can see from your last message) but I'm always here for you.

The Electrochem 3B36 cells sit at about 3.9 V open circuit, but they quickly drop to 3.5–3.6 V under load. In addition to that, you have an isolation diode in each 4S string which will drop more voltage as current increases.

Your voltages don't sound too wildly off, just a bit low. Did you do a 4-wire measurement when you applied the load? In other words, did you back-probe the battery connector to make the voltage measurement instead of measuring the voltage at the load? It's easy to lose a few tenths of a volt in the wire leads or in janky connections. Your leads

should be as short as possible with a minimum number of connections.

The constantly varying voltage readings is a sign that a connection isn't solid or that the passivation hasn't all burned off. If it's passivation then it'll sort itself out during the deployment, as long as the voltage doesn't drop so low that the system browns out and can't run.

I'm going to agree with Alana and say that they should be fine. The most power that SES ever draws is about 25 W, or less than 1 A at 28 V. Spread across two 8S7P batteries (each battery is a pair of packs), each cell is providing less than 70 mA, which is a pretty light load.

For your reference of what's "normal", I'm attaching a plot of SES battery voltage from a deployment in 2019. The voltage stays pretty flat for 8–9 months, then falls to a lower plateau, for 1–2 months, then it really starts to drop. The SES was processing a sample every 120 minutes for this deployment, so your profile will be different if you're sampling on a more- or less-frequent interval, or if Rich's processing routine has changed a lot since then.

I hope that helps and let me know if you need any other input.

Cheers,
Paul

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On Jan 8, 2026, at 5:47 PM, Irene Hu <irene@mbari.org> wrote:

Hi Paul,

I heard I can still email you with questions, so was wondering if you could give some advice on these SES batteries.

Our next deployment will be from April to fall out in the bay (Packard cruise), so it would be really bad if the batteries don't last! These are the electrochem lithium packs that we use 2S2P in the housing. All of them probe a normal 15.7-ish V open circuit, but under load, the numbers were a little weird. With a ~120 ohm load, I was getting varying 13.5 to 14 V or so (like the number kept going up and down and up and down as I measured), and under 2.3 ohm load, I got 12.6-12.7 V. These numbers varied slightly between the 6 battery packs I measured, but they are all below the spec (attached- not sure if it's the latest version) of 13.1-15.48 V under 2 ohm load.

Two of the packs are from March 2023. These showed some signs of passivation so the numbers were worse before it burned off. The other four are from Nov 2024 and didn't show passivation signs.

Alana though they would probably be ok, since all of them are doing it, but agreed it's a bit lower than she would expect. What do you think?

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Cheers
Irene