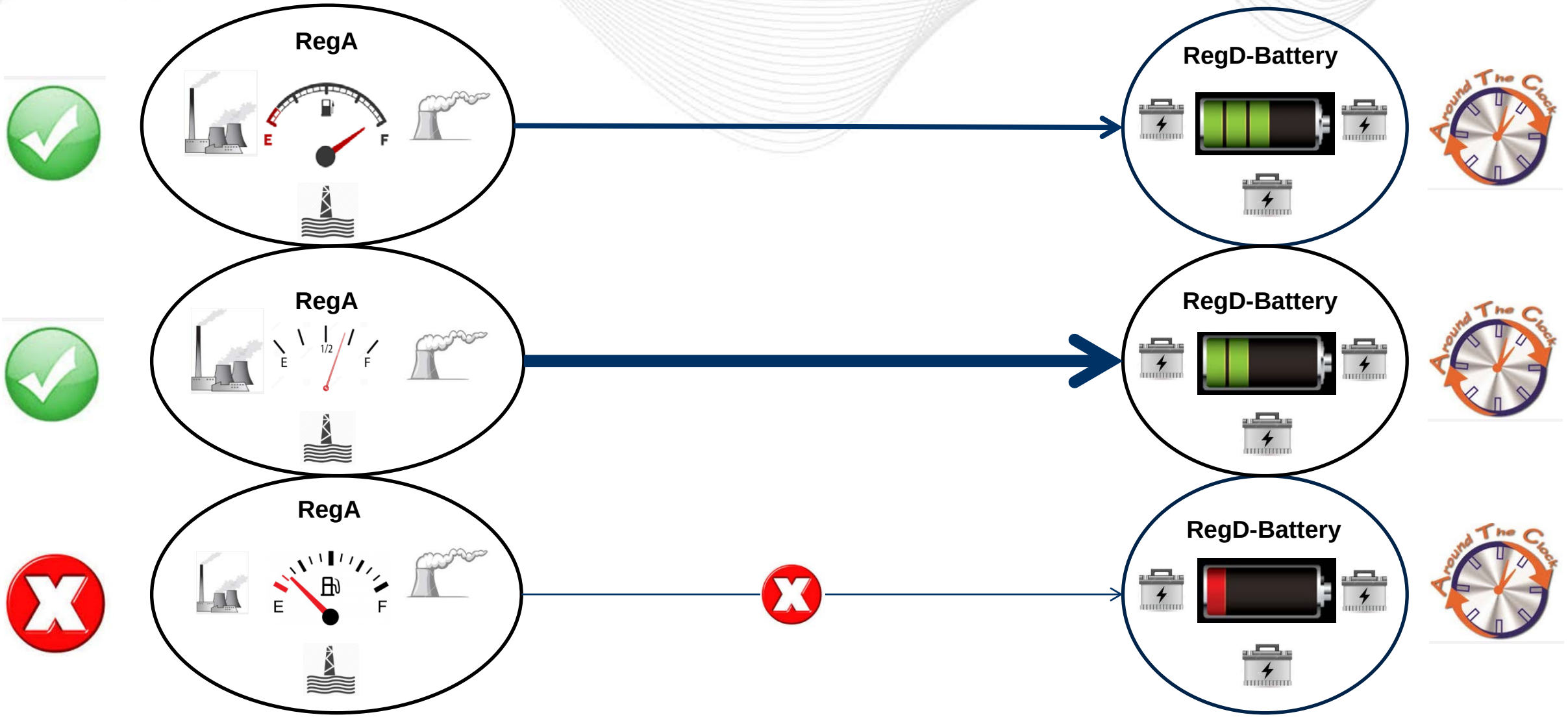
Conditional Neutrality

Regulation Today and New

Value	Today	New
RegA Signal	Always controls ACE to 0 over time	Always controls ACE to 0 over time
RegD Signal	Always returns to 0 over time, regardless of impact to ACE	Always controls ACE to 0 over time
RegD Energy Accumulation	Not utilized	Is estimated for neutrality payback “State of Charge” (SoC)
RegA Signal and RegD Signal	Are independent	Work together to control ACE and assist one another
When ACE deviation is large	RegA ramp is accelerated	Neutrality payback is suspended; control ACE to 0; Conditional Neutrality

Conditional Neutrality



Regulation Today Details

- Controller attempts to keep RegD signal neutral (centered around 0) regardless of how that impacts ACE control (even if that means going in the opposite direction of ACE).
- If RegD signal becomes too far from neutral, controller will arbitrarily bring that signal back to neutral.
- RegA has no information of what RegD is doing and continues providing ACE control no matter what position RegD is at.

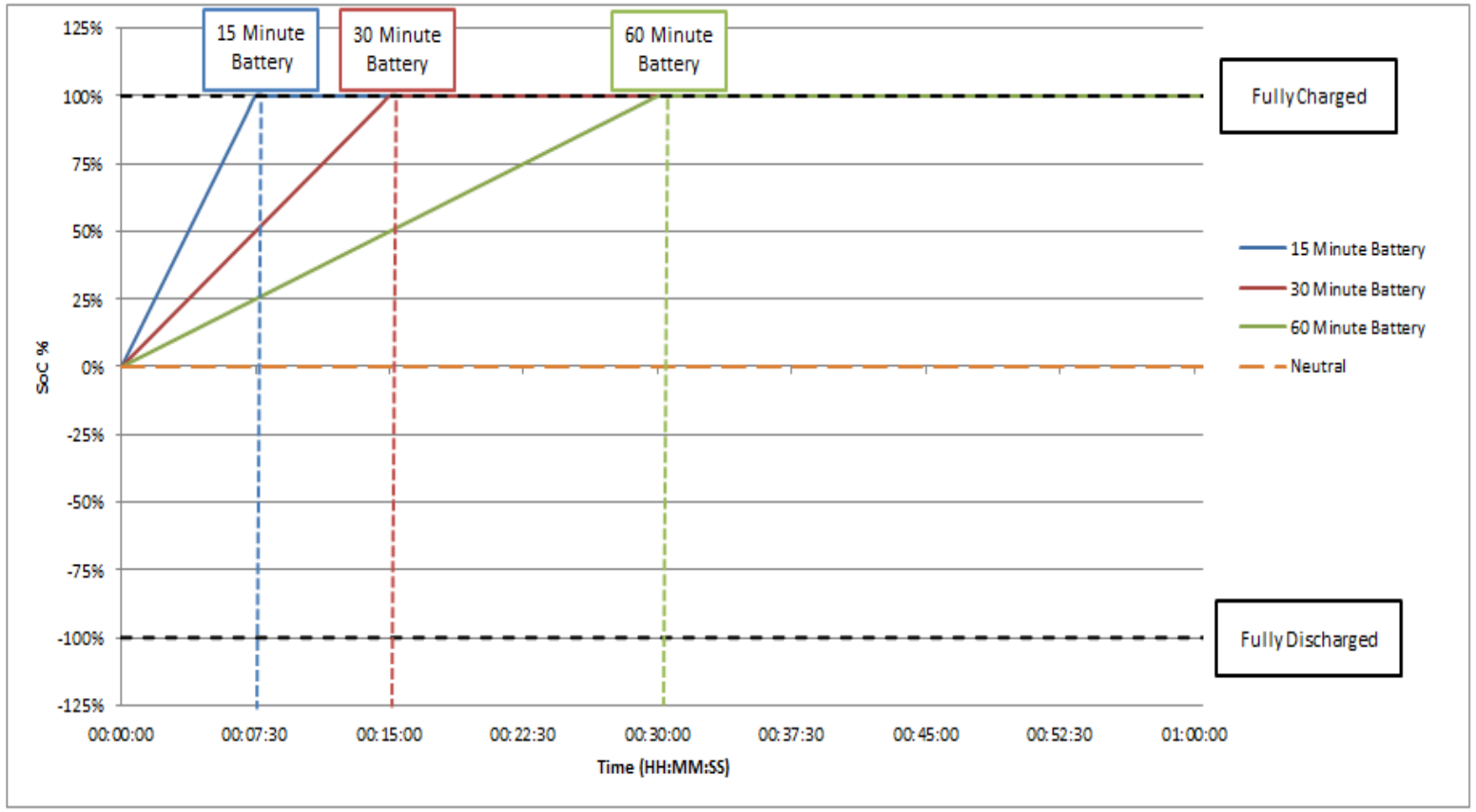
Regulation New Details

- RegA and RegD now work together to control ACE.
- The controller monitors the simulated State of Charge (SoC) of RegD and is constantly sending a signal to RegA to help RegD. How much RegA helps RegD depends on how close RegD is to its SoC limits.
- Sometimes ACE goes outside of the capabilities of RegA + RegD and both products need to do their best to both control ACE. Because of this, RegA no longer has any additional capacity to support RegD's SoC management **(Conditional Neutrality)**

15/30/60 Minute Conditional Neutrality

So what is the difference to the controller between 15/30/60 minute conditional neutrality?

The controller monitors the SoC of the RegD signal and decides how much payback is needed based on how close the SoC is to the limits. The larger the number (15/30/60 minute) the longer it will take before the SoC reaches the limit, resulting in less help requested from RegA.



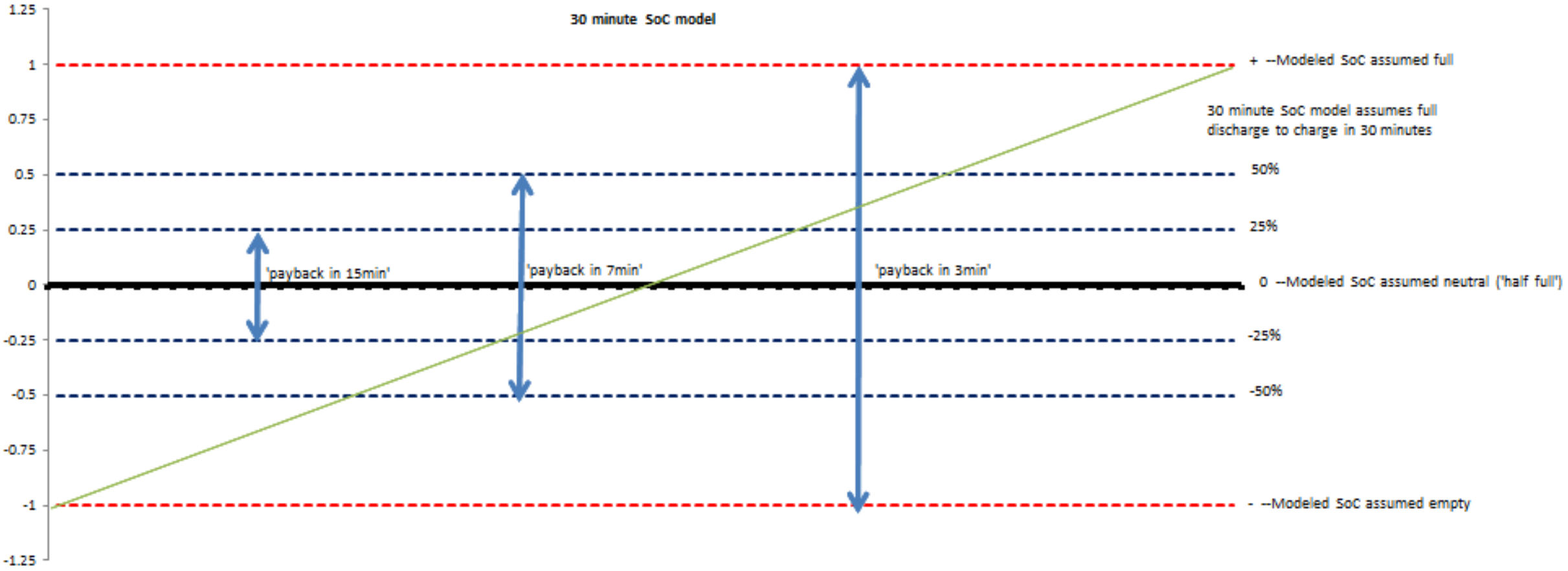
- Controller attempts to keep battery neutral, therefore starting point for a potential excursion is neutral SoC (0%)
- If signal requests full lower (charge), batteries would charge until they reach 100% SoC
- The larger the battery, the longer it takes for battery to get to full SoC (100%)
- The longer it takes to do so, the less help needed from RegA to balance SoC
- RegA always helping regardless of SoC (if available to do so), the size of batteries determines how hard RegA will work

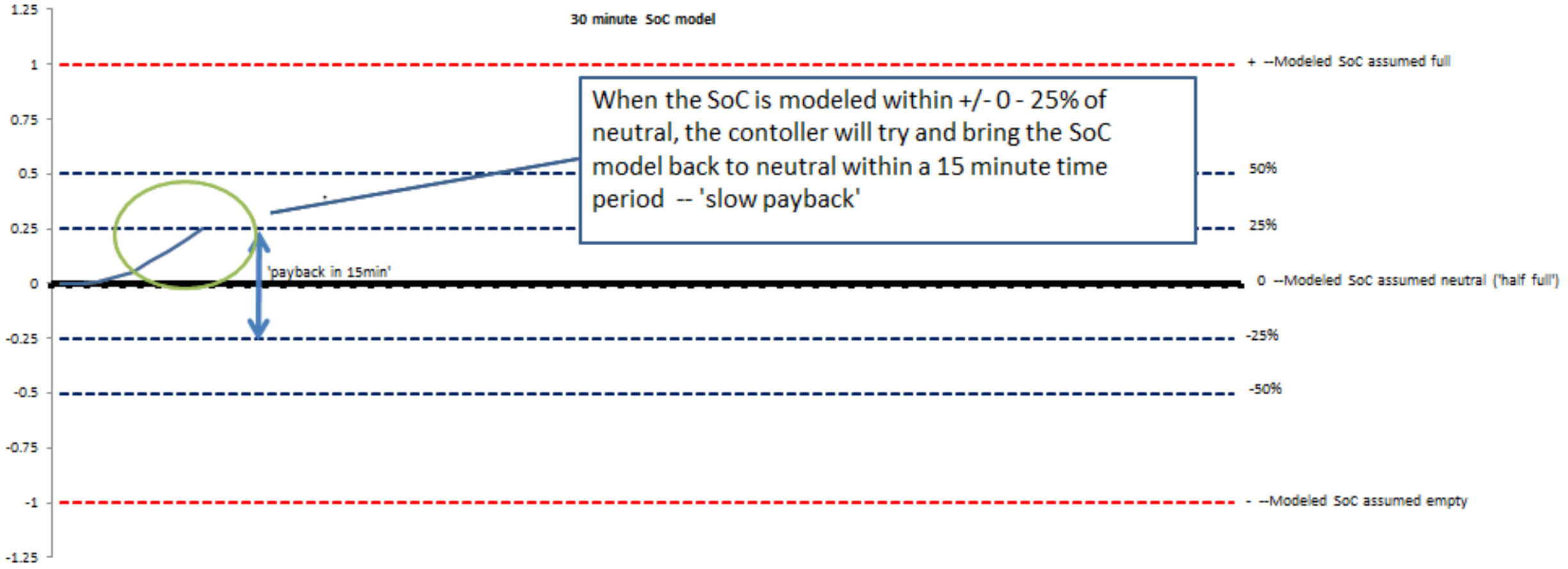
Summary of Conditional Neutrality

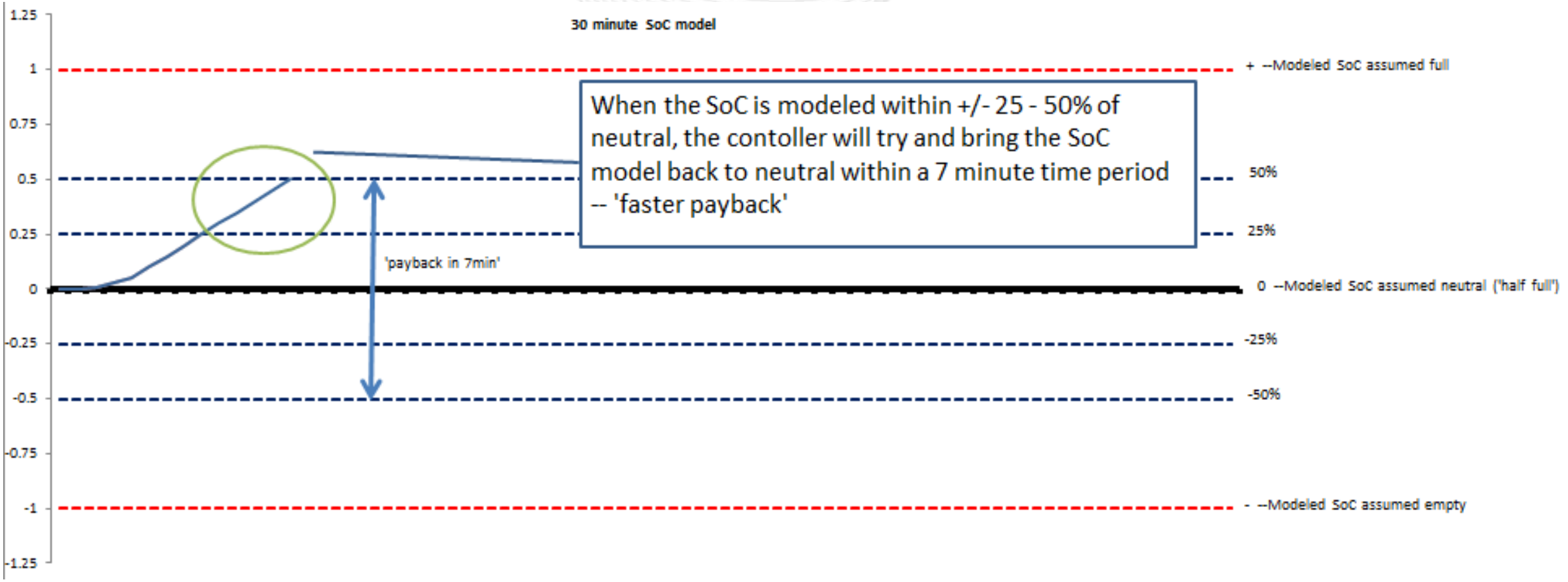
- Payback is always calculated to utilize RegA to balance the neutrality of RegD when available, even if SoC is close to neutral.
- As the simulated SoC of RegD becomes closer to limits, larger payback is calculated so that RegA can help bring the SoC back to a neutral state faster.
- If the RegD resources are larger duration batteries, RegA will not have to work as hard to help maintain energy neutrality
- If RegA resources are fully utilized controlling ACE, RegA will not be able to supply payback that is requested to assist RegD **(conditional neutrality, RegA supplies neutrality if system conditions allow)**

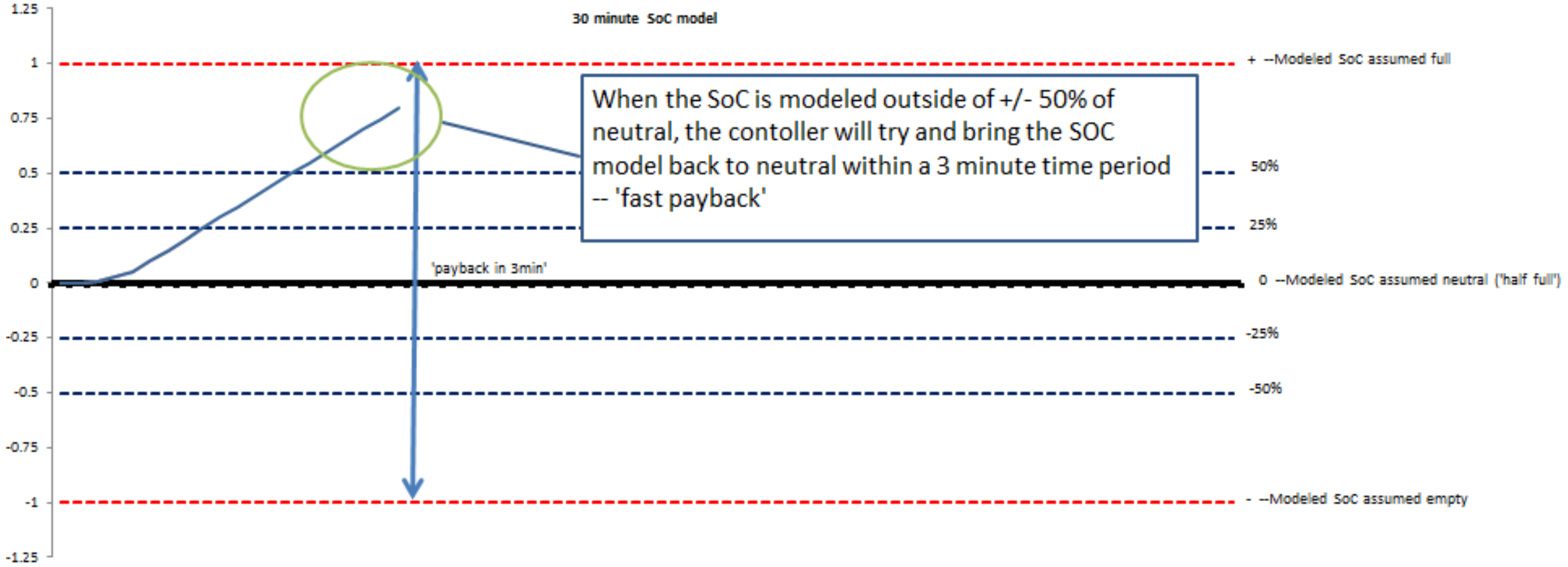
Appendix

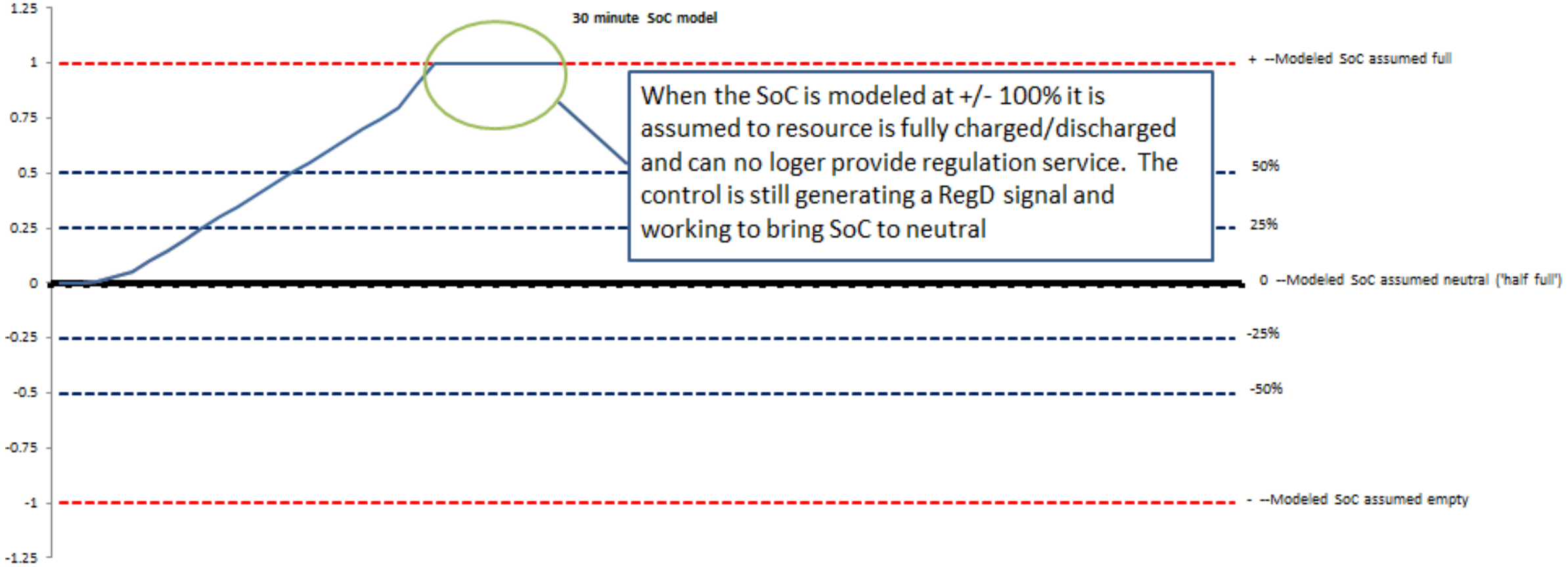
How it technically works

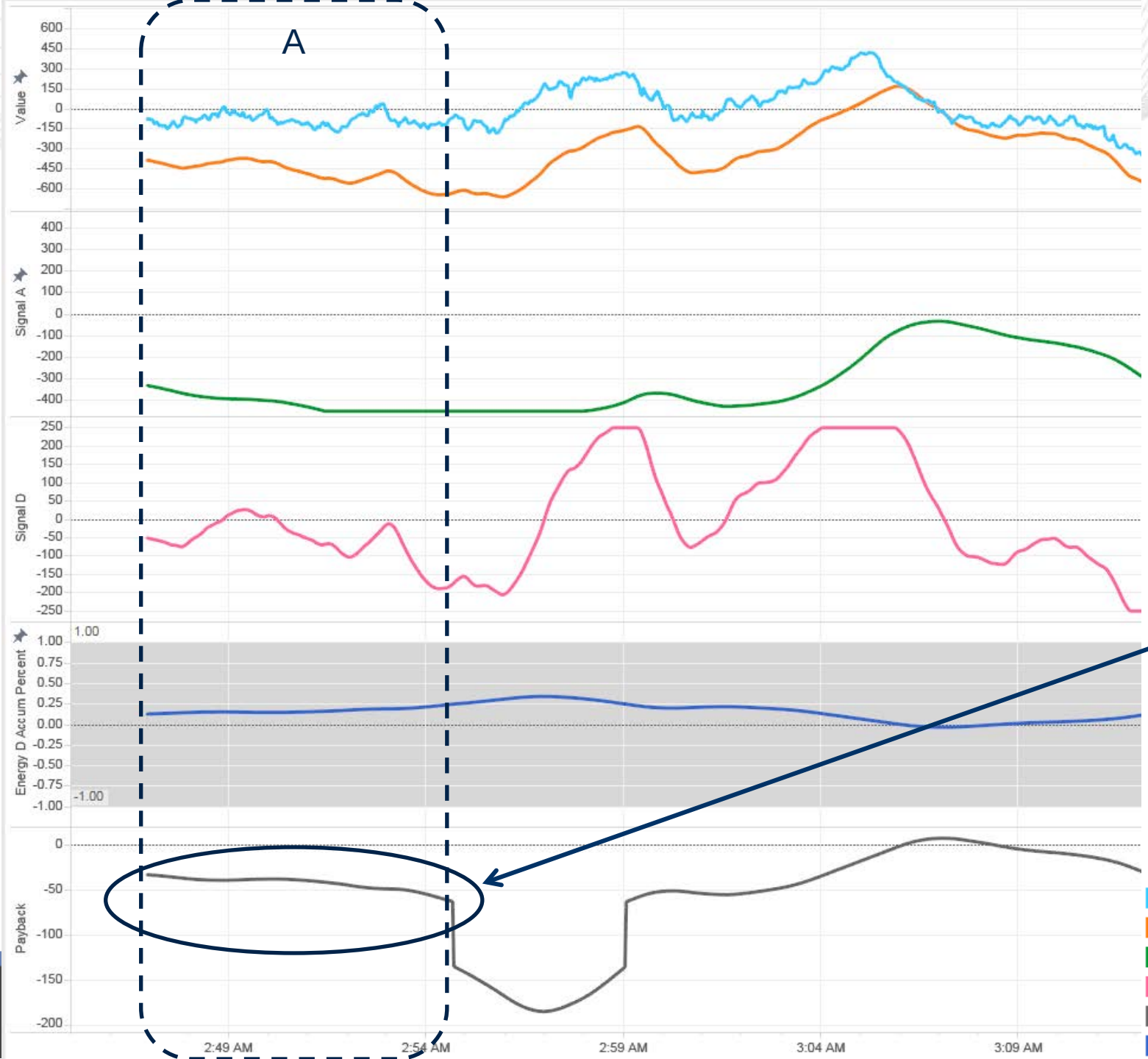

30 minute SoC model
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
+ --Modeled SoC assumed full
30 minute SoC model assumes full discharge to charge in 30 minutes
50%
25%
0 --Modeled SoC assumed neutral ('half full')
-25%
-50%
- --Modeled SoC assumed empty
'payback in 15min'
'payback in 7min'
'payback in 3min'


30 minute SoC model
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
+ --Modeled SoC assumed full
50%
25%
0 --Modeled SoC assumed neutral ('half full')
-25%
-50%
- --Modeled SoC assumed empty
'payback in 15min'
When the SoC is modeled within +/- 0 - 25% of neutral, the contoller will try and bring the SoC model back to neutral within a 15 minute time period -- 'slow payback'


30 minute SoC model
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
+ --Modeled SoC assumed full
50%
25%
0 --Modeled SoC assumed neutral ('half full')
-25%
-50%
- --Modeled SoC assumed empty
'payback in 7min'
When the SoC is modeled within +/- 25 - 50% of neutral, the contoller will try and bring the SoC model back to neutral within a 7 minute time period -- 'faster payback'

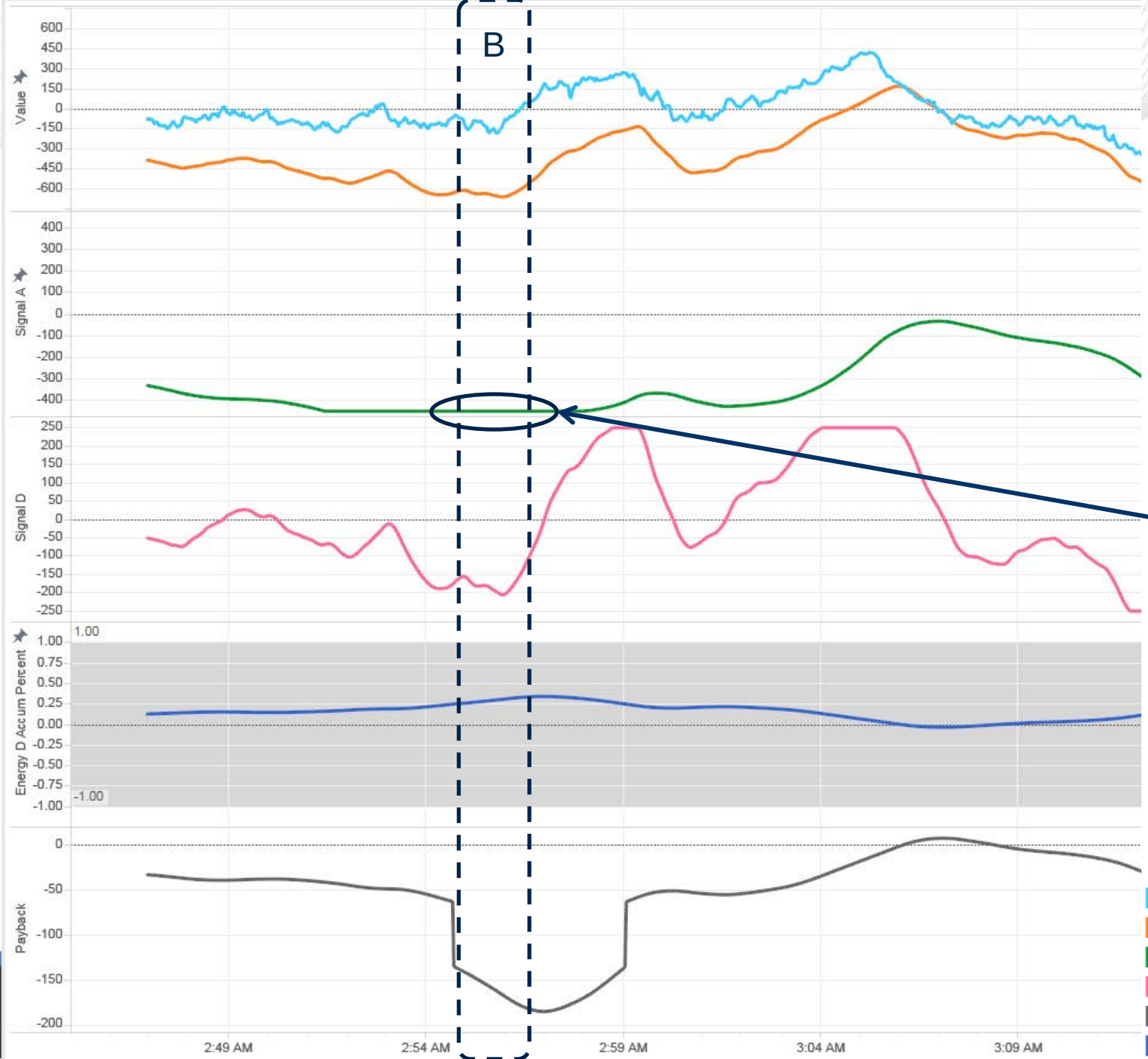

30 minute SoC model
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
+ --Modeled SoC assumed full
50%
25%
0 --Modeled SoC assumed neutral ('half full')
-25%
-50%
- --Modeled SoC assumed empty
'payback in 3min'
When the SoC is modeled outside of +/- 50% of neutral, the contoller will try and bring the SOC model back to neutral within a 3 minute time period -- 'fast payback'


30 minute SoC model
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
+ --Modeled SoC assumed full
50%
25%
0 --Modeled SoC assumed neutral ('half full')
-25%
-50%
- --Modeled SoC assumed empty
When the SoC is modeled at +/- 100% it is assumed to resource is fully charged/discharged and can no loger provide regulation service. The control is still generating a RegD signal and working to bring SoC to neutral



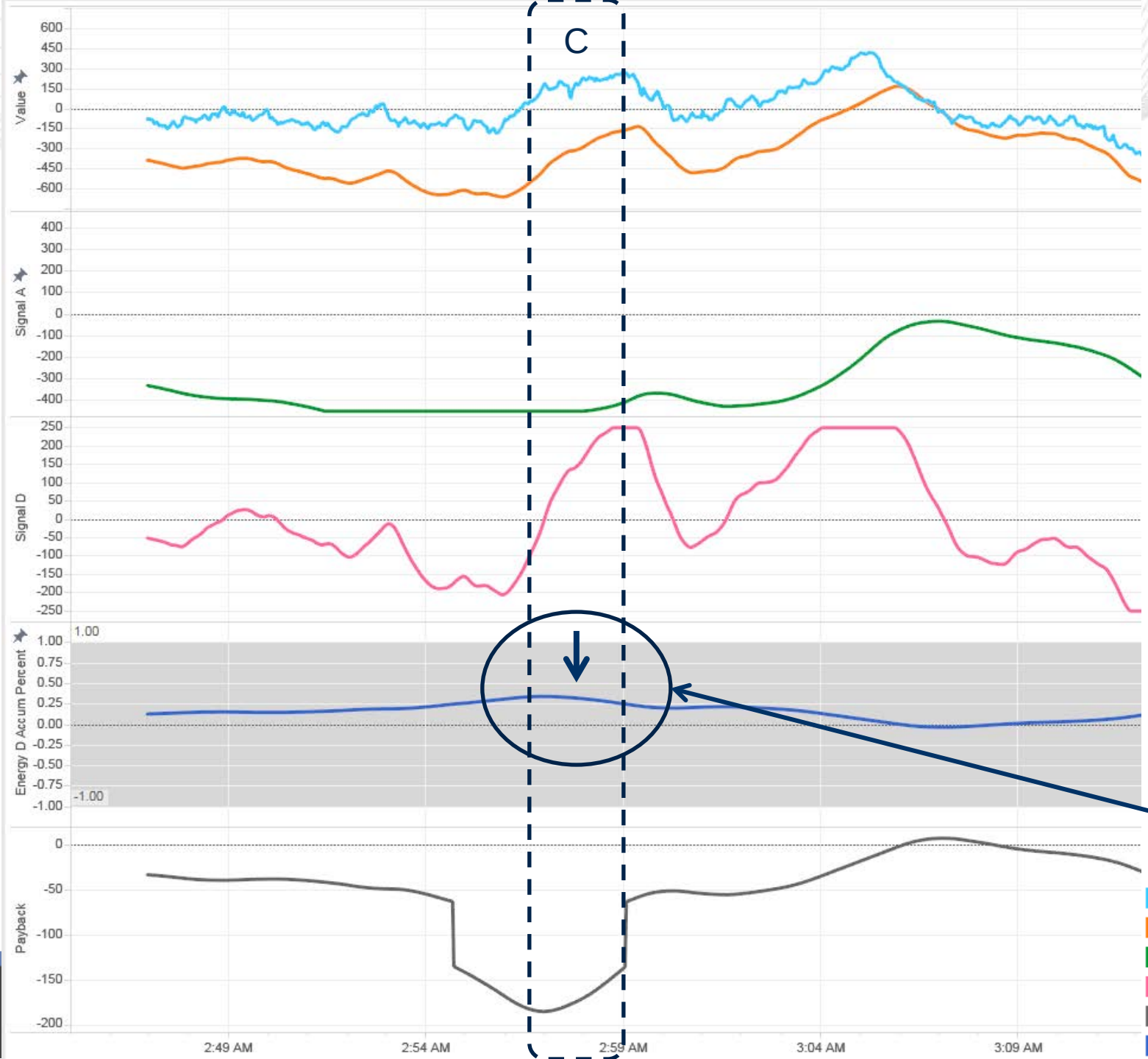
A

- Sum of RegA + RegD = Total Signal (orange) is more negative than ACS (light blue) due to integral piece of controller
- RegD energy (dark blue) is close to balanced
- Payback (grey) still calculated to try and keep RegD neutral



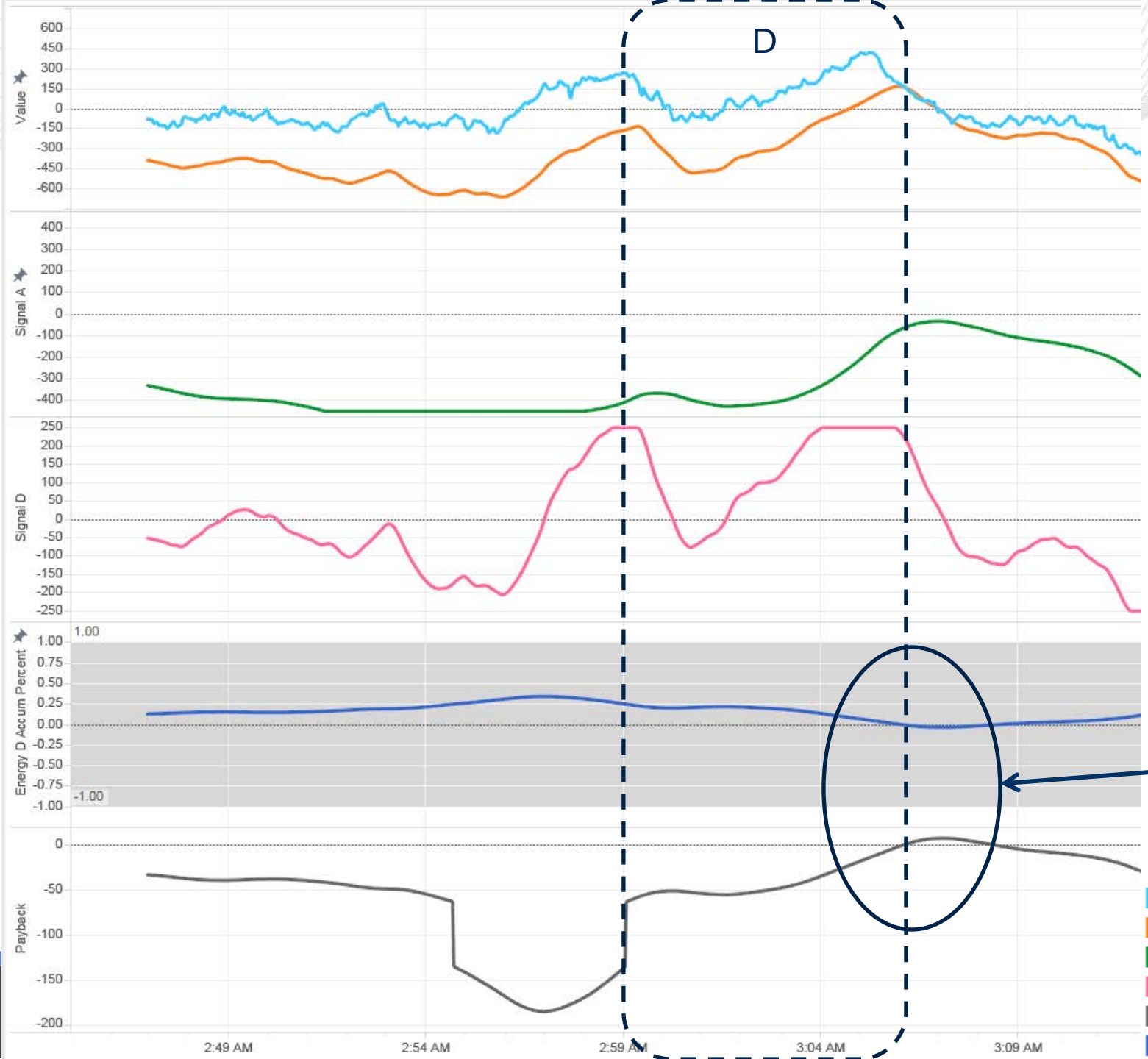
B

- RegD Energy Accumulation (dark blue) passes 25% which increases Payback help from RegA
- RegA (green) is already at full lower and cannot provide any additional help for neutrality
- Controller is still trying to get more help from RegA even though there is currently no extra room (conditional)



C

- ACS turns around which opens room on RegA
- RegD Energy still above 25%, therefore Payback term is still larger negative value keeping RegA at full lower
- RegD now goes to near full raise in order to balance out Payback
- RegD Energy goes down and starts to re-center to a neutral point



D

- Total Signal is still negative due to integral control
- RegD Energy is still not balanced, so RegA stays lower than controller desires to allow payback for neutrality
- RegD stays in the positive direction which brings neutrality back to center
- By the end of the D window, RegD energy is balanced and payback goes to 0

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- Payback is always calculated to utilize RegA to balance the neutrality of RegD when available, even if SoC is close to neutral.
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