Epic Power Converters, S.L.
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AN031
High-speed elevators
Power peak and energy saving

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Application Note - AN031

High-speed elevators
Power peak and energy savings

1. Introduction

Buildings higher than 100m are becoming more usual as the population density in big cities increases. To deal with the space limitation and the high square-meter cost inside these cities, buildings must be built higher and more efficient. With high buildings, big and fast elevators must be installed.

Such elevators can move at standard speeds between 4 and 8 m/s with loads ranging 1200-2000 kg. These conditions lead to the use of high-power variable frequency drives that can deal with the initial acceleration (consumption) and deceleration (generation) power peaks.

In Fig. 1 and Fig. 2 a simulation for a 1600 kg 6m/s elevator is depicted. With maximum imbalance conditions the peak consumption power can be 3.5 times higher than the nominal power (70 kW). The generation peak power is similar to the nominal one.

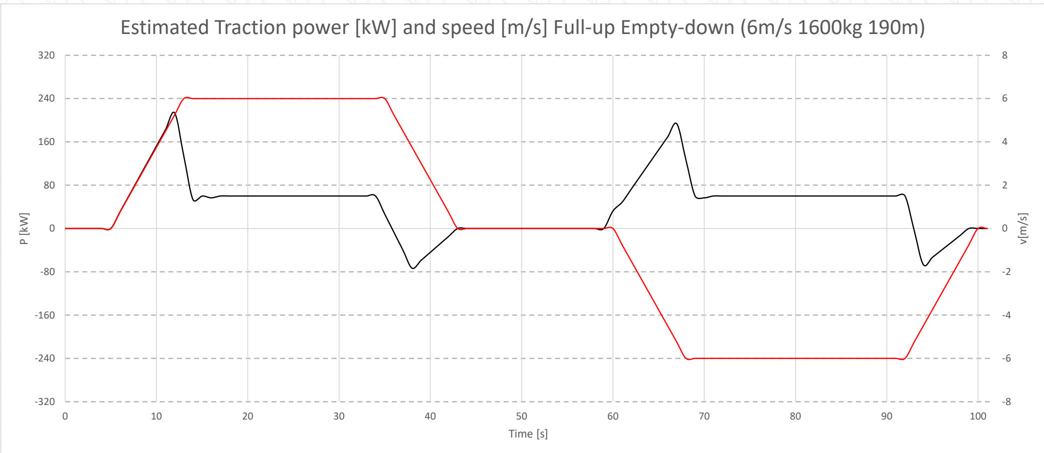


Fig. 1: Power and speed profile estimation for maximum imbalance

With minimum imbalance conditions the peak consumption power can be 1.6 times higher than the nominal consumption power (70 kW). The generation peak power in the braking event can be 2.5 times higher the nominal consumption power.

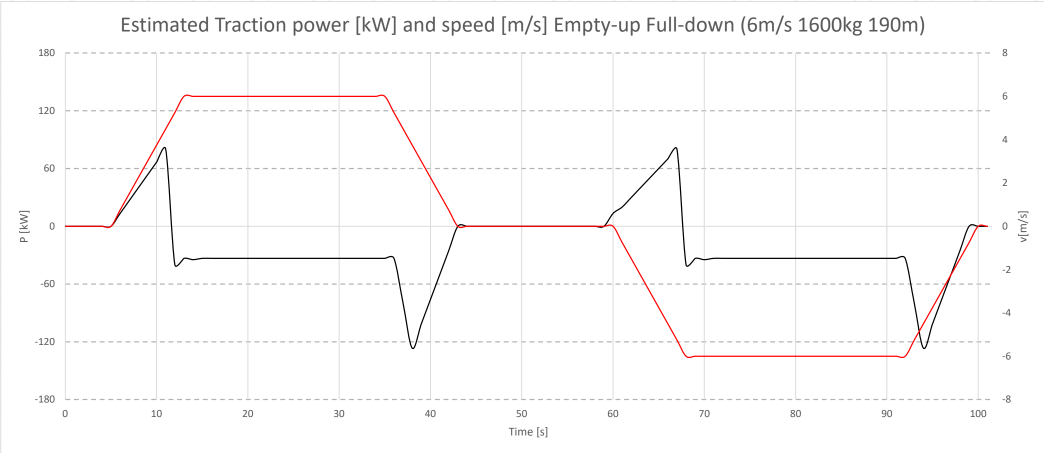


Fig. 2: Power and speed profile estimation for minimum imbalance

The motive of this study is exploring the possibility of reducing the peak consumption power from the mains and the peak braking power while achieving a better energy use.

To do so, epic power products can be connected to the DC bus of the variable frequency drive (VFD) in order to absorb or return energy to it when required. Including a bidirectional converter and supercapacitors it is possible to reduce the consumption and generation peak power from the mains and to the braking resistors.

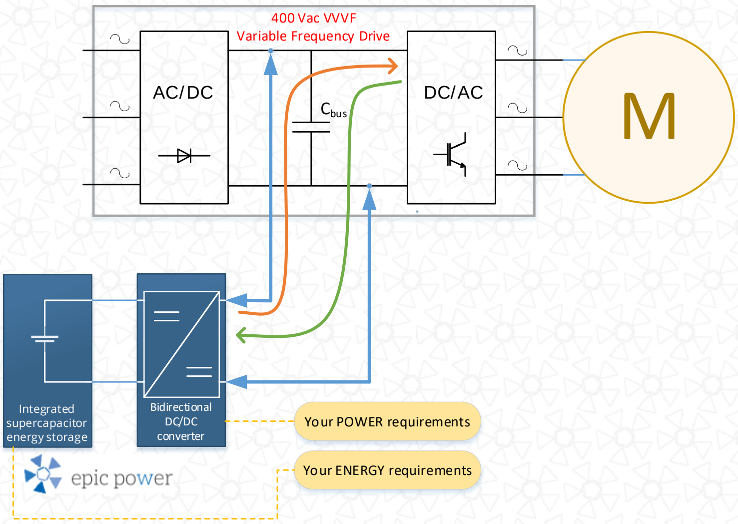


Fig. 3: General schematic for DC connection between epic power converter and VFD

Energy calculation

To be able to size the supercapacitors and the converter it is important to estimate the excess power for consumption and generation. In Fig. *4* and Fig. *5* the power profile going up with cabin fully loaded and with cabin empty is been separated into different polygons to estimate easily the energy/area covered.

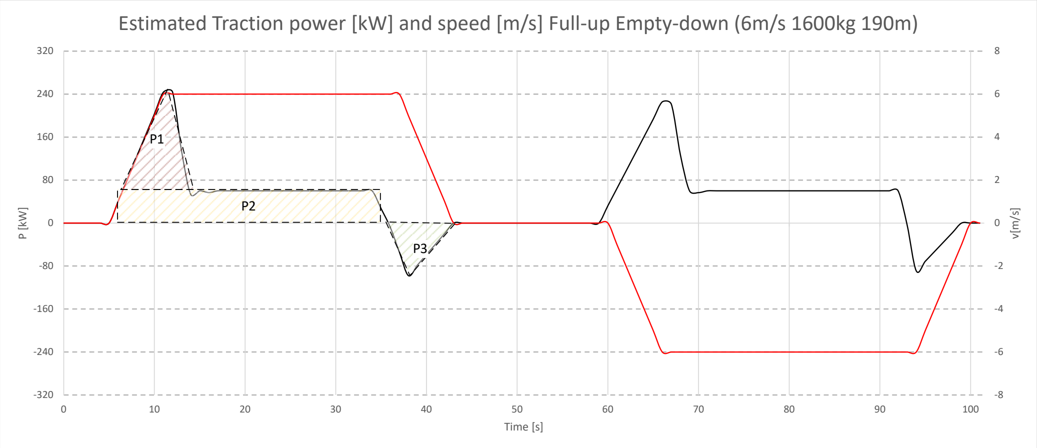


Fig. 4: Power profile distribution in simple polygons in full-up movement (P1-P2-P3)

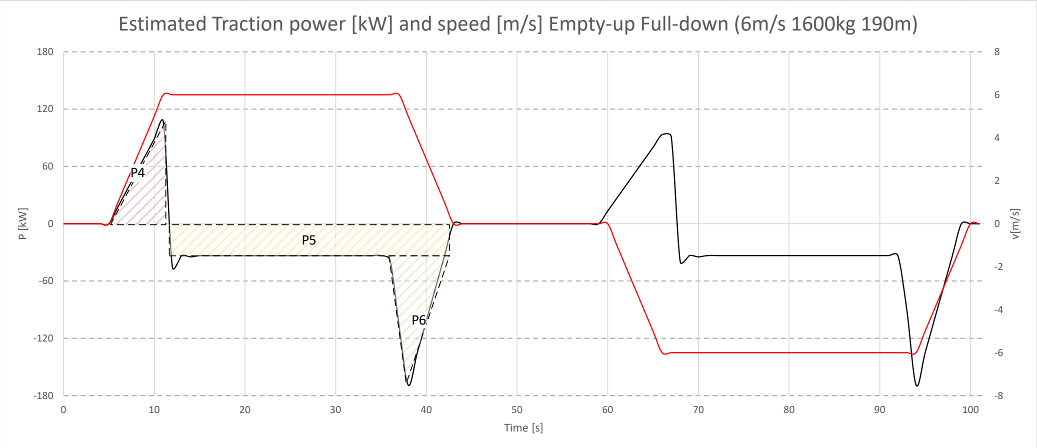


Fig. 5: Power profile distribution in simple polygons in Empty-up movement (P4-P5-P6)

With polygon P1 to P6 distribution it is possible to size energy and power of the auxiliary element attached to the VFD. In Table *1*, the peak power and the energy included in each one of the P1-P6 pieces is shown.

Table 1: Peak power and energy distribution of the elevator operation

	P1	*P2*	*P3*	*P4*	*P5*	*P6*
Peak power	226 kW	60 kW	-89 kW	107 kW	-33 kW	-169 kW
Energy	214 Wh	466 Wh	98 Wh	103 Wh	284 Wh	116 Wh

epic power proposal

There are two solutions that could be interesting for a case like the one explained in this document. The first one would be to just focus on the peak reduction for consumption and generation without paying attention to the energy savings. The second one would be focusing on both peak and energy savings, but with a bigger solution. In this section, both options are discussed.

1. Peak reduction

In this scenario the DC/DC converter is:

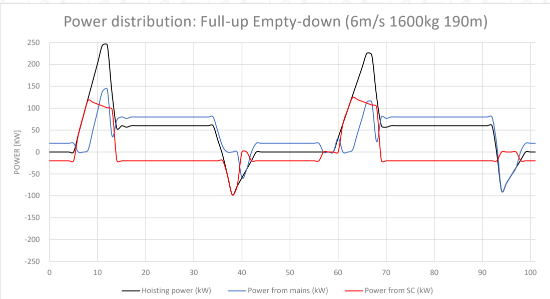
- Commanded to discharge the supercapacitors at the maximum rate (configurable) for X seconds with each new start (acceleration being X the time required to move the cabin at nominal speed).
- Commanded to charge the supercapacitors at the maximum rate (configurable) for X seconds with each new deceleration.
- Responsible of maintaining a valid state of charge in the supercapacitors to be able to provide and absorb energy in the event of acceleration or deceleration.

And the supercapacitors are sized:

- To provide the power and energy required in P1 and absorb the power and energy generated in P6. These two are the worst case scenario that the supercapacitors would be dimensioned to comply with.

Considering the above conditions and the cycling current of a supercapacitor module there are two main solutions. One with 4 and other with 5 supercapacitor (SC) modules and 3 converters in parallel.

Fig. 6 shows the Hoisting power with Full-up / Empty down conditions in black, the power from the mains in blue and the power provided/absorbed by the epic power system in red. By including the epic power converter + capacitor solution, the peak power gets reduced from 244 kW to 143 kW in Fig. 6 (Left) and to 121 kW in Fig. 6 (Right).



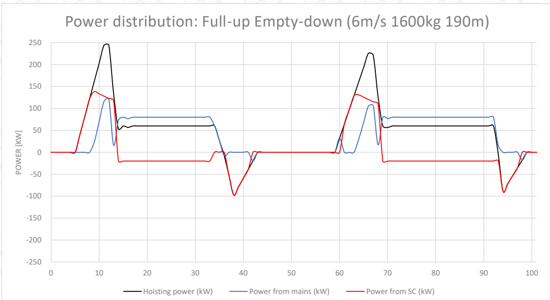


Fig. 6: Full-up/Empty-down with 3 x DC Converter & (Left) 4 x SC; (Right) 5 x SC

Fig. 7 shows the Hoisting power with Empty-up / Full-down conditions in black, the power from the mains in blue and the power provided/absorbed by the epic power system in red.
The consumption peak is provided completely by the epic power solution while the generation peak is reduced. As the current scenario compares the maximum imbalance going up and down, the peak reduction is optimized for both cases. In the Empty-up, Full-down scenario the energy going to the braking resistors is reduced from 169 kW to 100 kW.

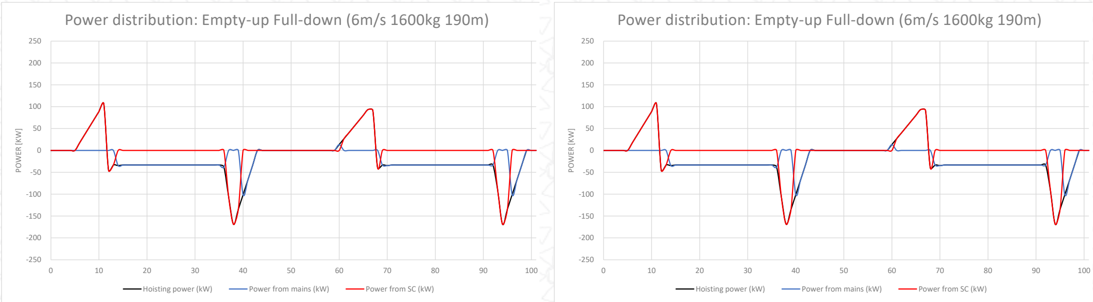


Fig. 7:Empty-up/Full-down with 3 x DC Converter & (Left) 4 x SC; (Right) 5 x SC

Only the scenarios with maximum imbalance have been considered for the calculation as the rest of cases will show lower peak consumption/generation power.

2. Peak & Energy reduction

In this scenario the DC/DC converter is:

- Commanded to discharge the supercapacitors at the maximum rate (configurable) for X seconds with each new start (acceleration being X the time required to move the cabin at nominal speed).
- Commanded to charge the supercapacitors at the maximum rate (configurable) for X seconds with each new deceleration.
- Responsible of maintaining a valid state of charge in the supercapacitors to be able to provide or absorb energy in the event of acceleration or deceleration.

And the supercapacitors are sized:

- To be able to absorb the energy generated in P5 and P6 so all the energy generated can be stored and reused

Considering the above conditions and the cycling current of a supercapacitor module there are two main solutions. One with 8 and other with 10 supercapacitor (SC) modules and 4 converters in parallel.

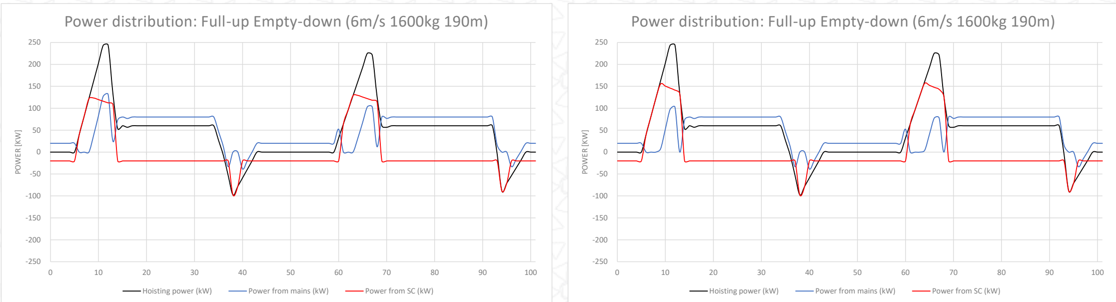


Fig. 8: Full-up/Empty-down with 4 x DC Converter & (Left) 8 x SC; (Right) 10 x SC

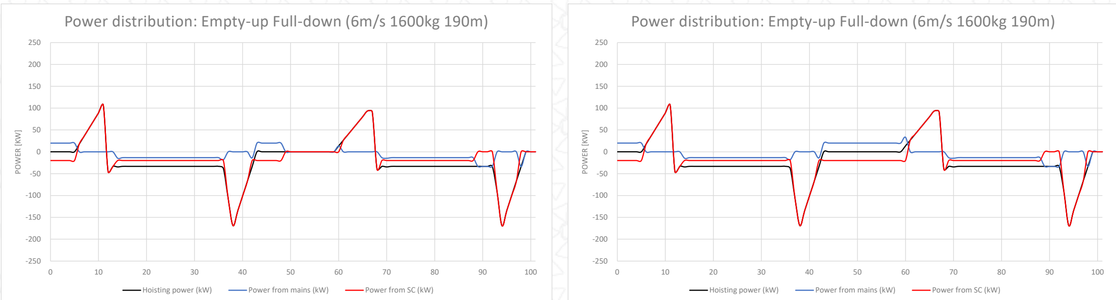


Fig. 9: Empty-up/Full-down with 4 x DC Converter & (Left) 8 x SC; (Right) 10 x SC

In both scenarios, the peak power for consumption and generation is highly reduced while almost all the braking energy is stored and reused without going to the braking resistors.

Conclusion

It is possible to reduce the mains power contracted for the building in a significant amount while saving partly or completely the peak and braking energy.

As can be seen in Table *2*, for a 6 m/s 1600 kg elevator of 190 m it is possible to size a solution to reduce mainly the peak power. Depending on the elevator speed, weight and acceleration, more or less supercapacitor modules and converters would fit.

Table 2: Summary estimated results in peak reduction proposal

Peak Reduction	*Full-up/Empty-down*		*Full-down/Empty-up*	
Configuration	4 x SC	5 x SC	4 x SC	5 x SC
Peak consumption reduction	101 kW	128 kW	107 kW	107 kW
Peak generation reduction	60 kW	60 kW	68 kW	68 kW
Energy saved per cycle	98 Wh	98 Wh	80 Wh	80 Wh

In Table 3, the optimization has been done according to the potential energy savings that can be achieved while ensuring a peak reduction as well.

Table 3: Summary estimated results in peak & energy reduction proposal

Peak & Energy Reduction	*Full-up/Empty-down*		*Full-down/Empty-up*	
Configuration	8 x SC	10 x SC	8 x SC	10 x SC
Peak consumption reduction	116 kW	143 kW	107 kW	110 kW
Peak generation reduction	80 kW	110 kW	169 kW	169 kW
Energy saved per cycle	98 Wh	98 Wh	305 Wh	305 Wh

epic power can provide tools to dimension the solution depending on acceleration time, the targeted peak reduction for consumption and generation and the energy saved.