Comparison of Capacitor Performance

DaVinci Labs

Technical Report #1

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Rev. B, 2015-11-28

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Revision History

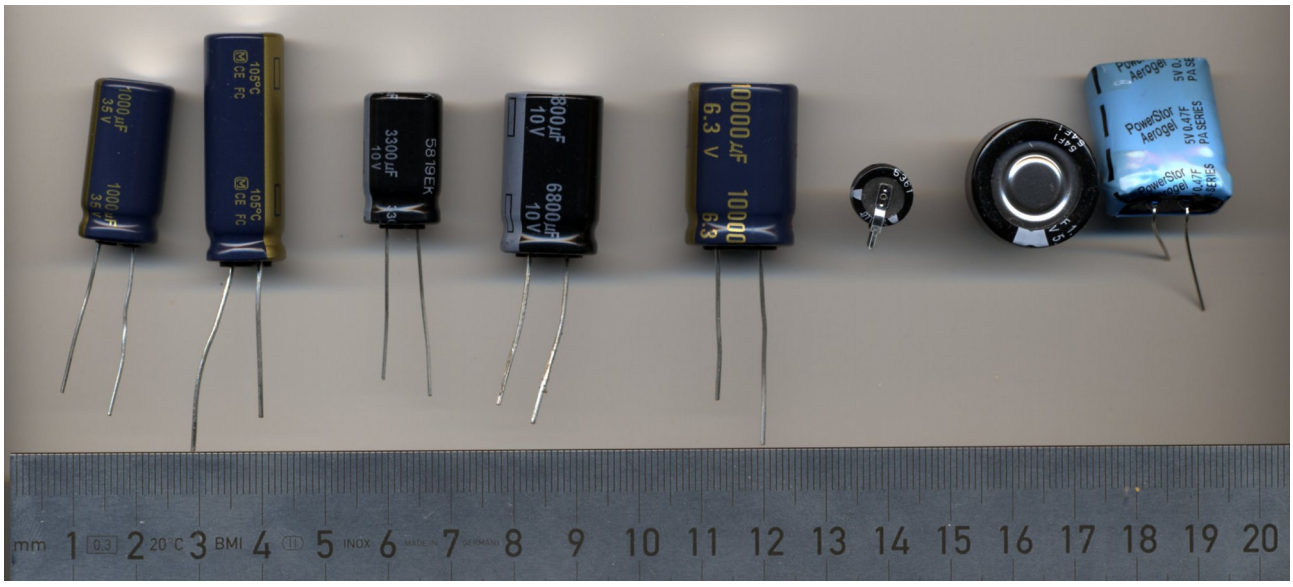
Date	Rev.	Author	Changes
2015-11-28	A	Alex	Initial version, cap #1-#6
2015-11-28	B	Alex	Added cap #7, #8, added weight of each capacitor
2015-12-01	D	Alex	After review: moved elkos and small fixes

Abstract

The performance of eight capacitors is evaluated. Five capacitors are electrolytic capacitors, while the other three capacitors are SuperCapacitors:

1. Panasonic EEUFC1V102, 1000 μF, 35 V, ESR 0.03 Ω (Reichelt RAD FC 1.000/35)
2. Panasonic EEUFC1C332, 3300 μF, 16 V, ESR 0.02 Ω (Reichelt RAD FC 3.300/16)
3. Panasonic EEUFR1A332B, 3300 μF, 10 V, ESR 0.018 Ω (Reichelt RAD FR 3.300/10)
4. Panasonic EEUFR1A682B, 6800 μF, 10 V, ESR 0.012 Ω (Reichelt RAD FR 6.800/10)
5. Panasonic EEUFC0J103S, 10000 μF, 6.3 V, ESR 0.02 Ω (Reichelt RAD FC10.000/6/3)
6. Panasonic EECS0HD 224, 0.22 F, 5.5 V, ESR < 75 Ω (Reichelt SPK 220.000µF-V)
7. Panasonic EECF5R5U105, 1.0 F, 5.5 V, ESR < 30 Ω (Reichelt SPK 1,0F)
8. Cooper Bussmann PowerStor PA-5R0H474, 0.47 F, 5.0 V, ESR 0.2 Ω (Ebay)

   The picture below shows the different capacitors, with #1 being on the left and #8 on the right hand side.



Test Setup

To simulate the power used in the DaVinciDriver, which draws up to 80 mA current, the capacitor is first charged with 5V, and then discharged through a resistive load of 55Ω, resulting in a current of ≈100 mA.

Measurements are taken with an AnalogDiscovery PC-based oscilloscope from Digilent Inc.

Measurements

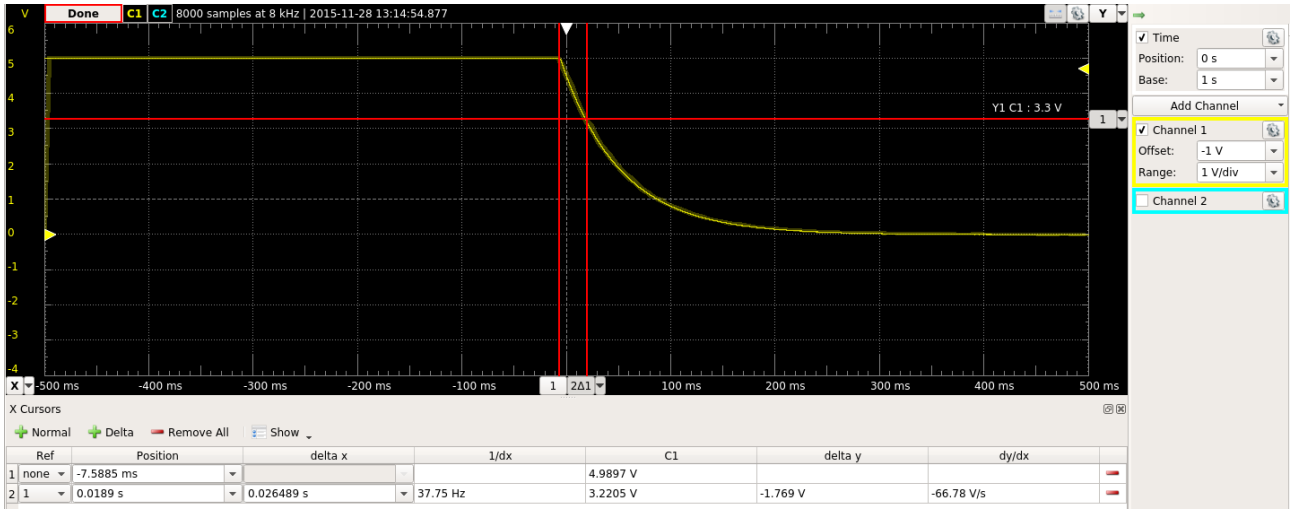
Table 1 summarizes the measurement results.

#	Capacitor	Nickname	Capacity	ESR	Discharge Time to 3.3V	Weight
1	EEUFC1V102		1000 µF	0.03 Ω	0.026 s	6 g
2	EEUFC1C332		3300 µF	0.02 Ω	0.092 s	8 g
3	EEUFR1A332B		3300 µF	0.018 Ω	0.092 s	4 g
4	EEUFR1A682B		6800 µF	0.012 Ω	0.1907 s	8 g
5	EEUFC0J103S		10000 µF	0.02 Ω	0.3015 s	10 g
6	EECS0HD 224	Old small GoldCap	0.22 F	< 75 Ω	0.005 s	1 g
7	EECF5R5U105	Old big GoldCap	1.0 F	< 30 Ω	7.601 s	8 g
8	PA-5R0H474	New blue SuperCap	0.47 F	0.2 Ω	13.282 s	4 g

Screenshots

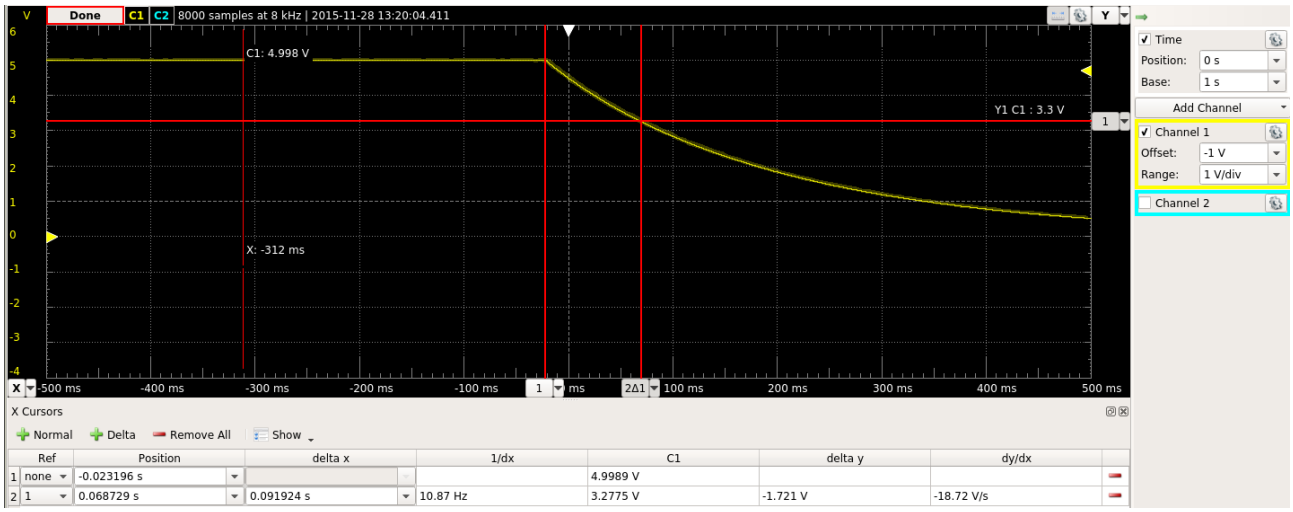
The following screenshots show the discharge curves of the capacitors. Please note that the x-axes have different scales in order to show all relevant data.

Capacitor #1, EEUFC1V102 : 1000 µF Electrolytic



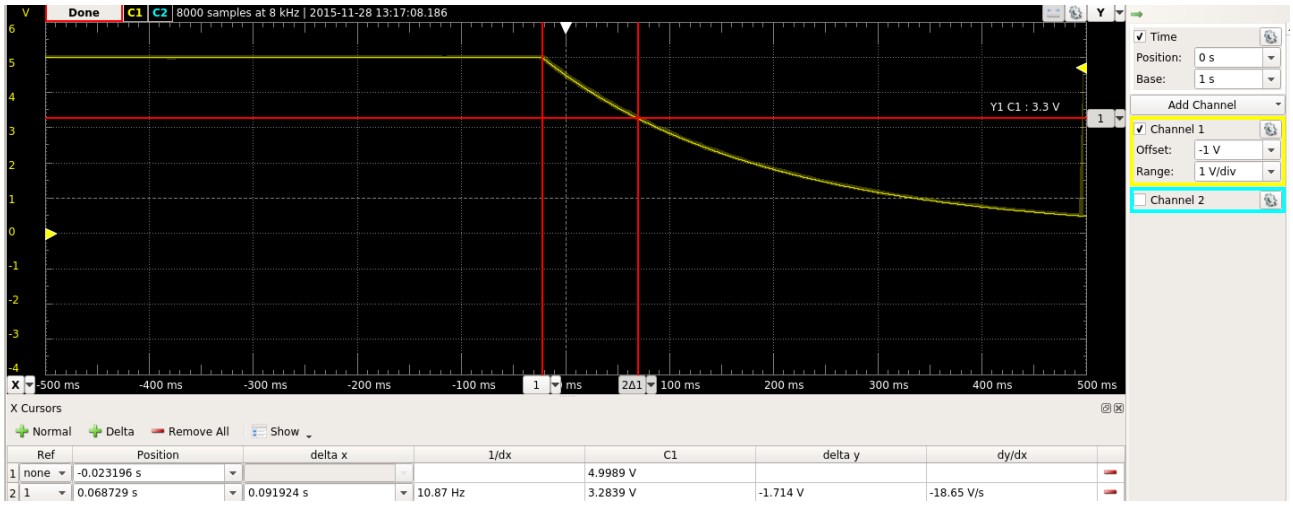
Discharge time of 0.026 s with a very low ESR. Good performance, but too low capacity for our purposes.

Capacitor #2, EEUFC1C332: 3300 µF Electrolytic



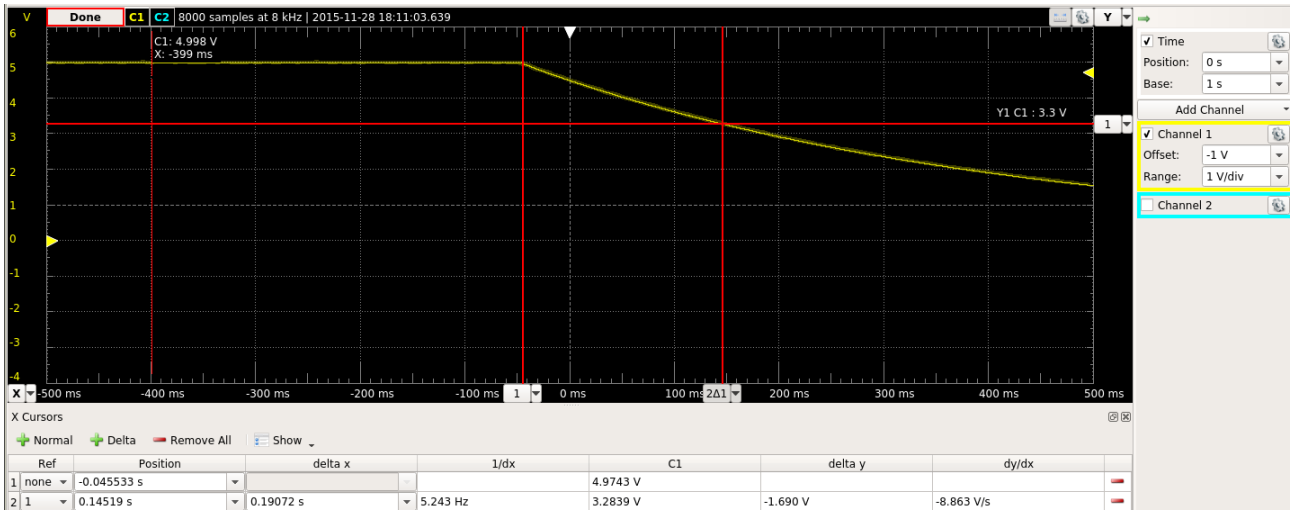
Discharge time of 0.092 s and low ESR. Same good performance as the smaller electrolytic capacitor #1 with 3x capacity. Still too little capacity for our purposes.

Capacitor #3, EEUFR1A332B: 3300 µF Electrolytic



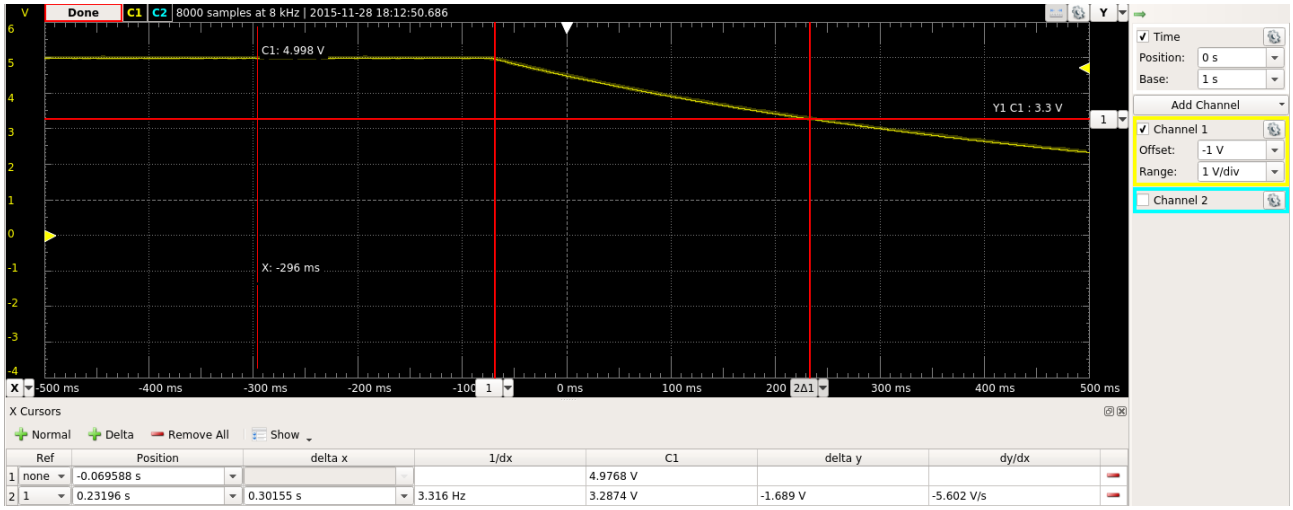
Essentially the same performance as the previous capacitor, #2, with a nearly identical datasheet. However, this capacitor only has half the physical size of capacitor#2.

Capacitor #4, EEUFR1A682B: 6800 µF Electrolytic



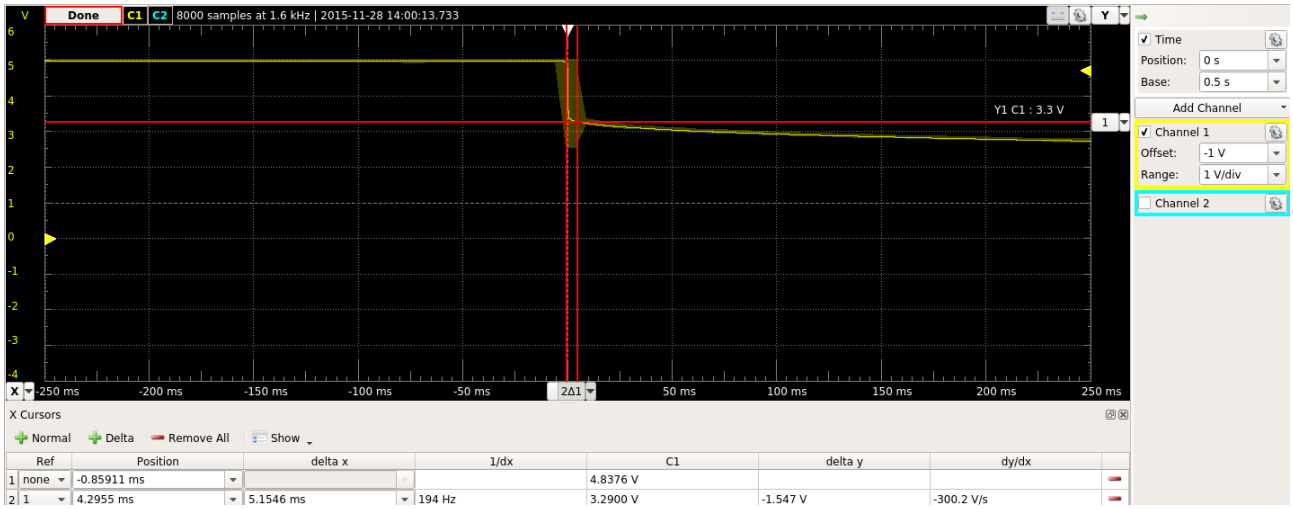
Standard electrolytic capacitor similar to #1-#3. Its bigger capacity extends the holdover time to 0.19 s, which is still not enough for our purposes.

Capacitor #5, EEUFC0J103S: 10000 µF Electrolytic



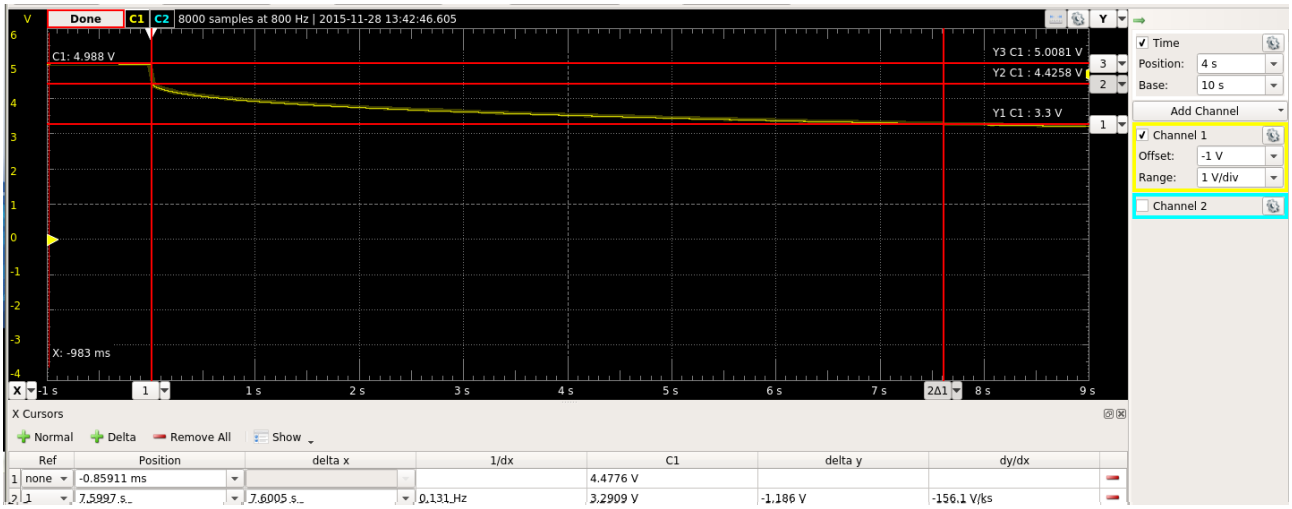
The highest capacity capacitor with 10000 µF and an expected holdover time of 0.3 s. Not enough, especially considering the weight of this capacitor.

Capacitor #6, EECS0HD 224: 0.22 F GoldCap



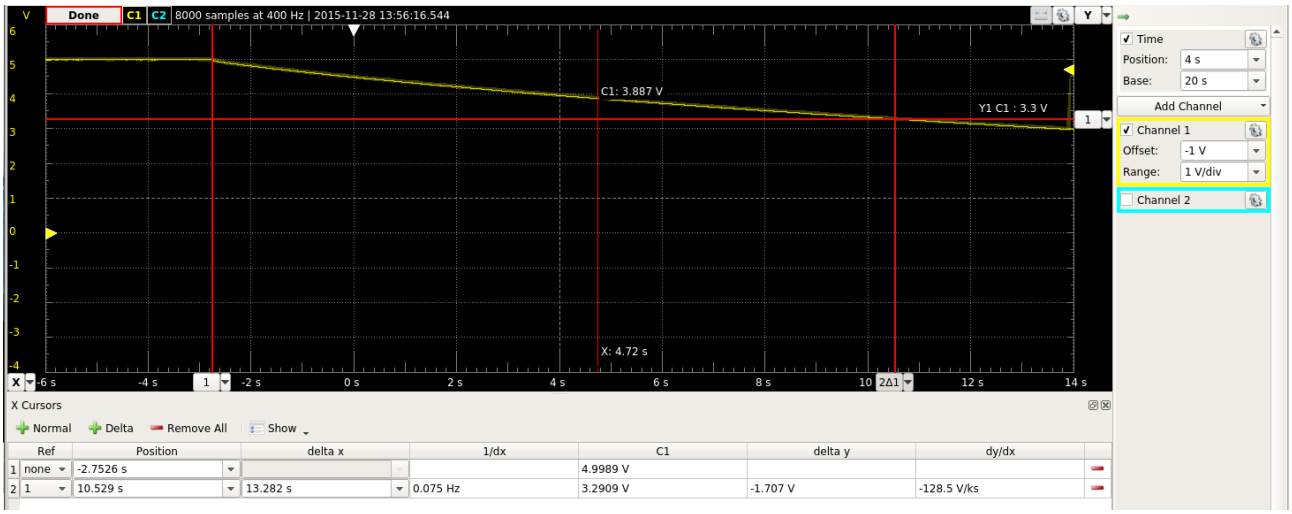
This is the first capacitor we bought, exhibiting a initial voltage drop of nearly 1.7 V down to 3.3 V which is the minimum acceptable limit. This is caused by a very high ESR value. It is by far the smallest capacitor and according to the data sheet more applicable to backup memory and real-time clocks. It is not intended for milliampere usage scenarios.

Capacitor #7, EECF5R5U105: 1.0 F GoldCap



A much bigger capacitor in physical size than #6 and with 4x its capacity, this capacitor performs better due to its lower ESR value. Compared to the other capacitors the ESR value is still too high and clearly visible in the screenshot above: a step of 0.8 V. Total time to support our car's circuit is acceptable with more than 7 seconds hold-over time.

Capacitor #8, PA-5R0H474: 0.44 F PowerStor SuperCapacitors



This capacitor combines the low ESR of the ordinary electrolytic capacitors #1-#5 with the high capacity of the GoldCaps, resulting in an extraordinary holdover time of over 13 seconds. A very good performance considering a price under 1 €, less than the price of the 1.0 F GoldCap #7 which costs 1.60 €.

Conclusion

Capacitor #8 clearly stands out in this comparison. Longest holdover time at a good price and low weight. The only drawback is its physical size of 24x20x10 mm^3.