

Battery Inversion Protection

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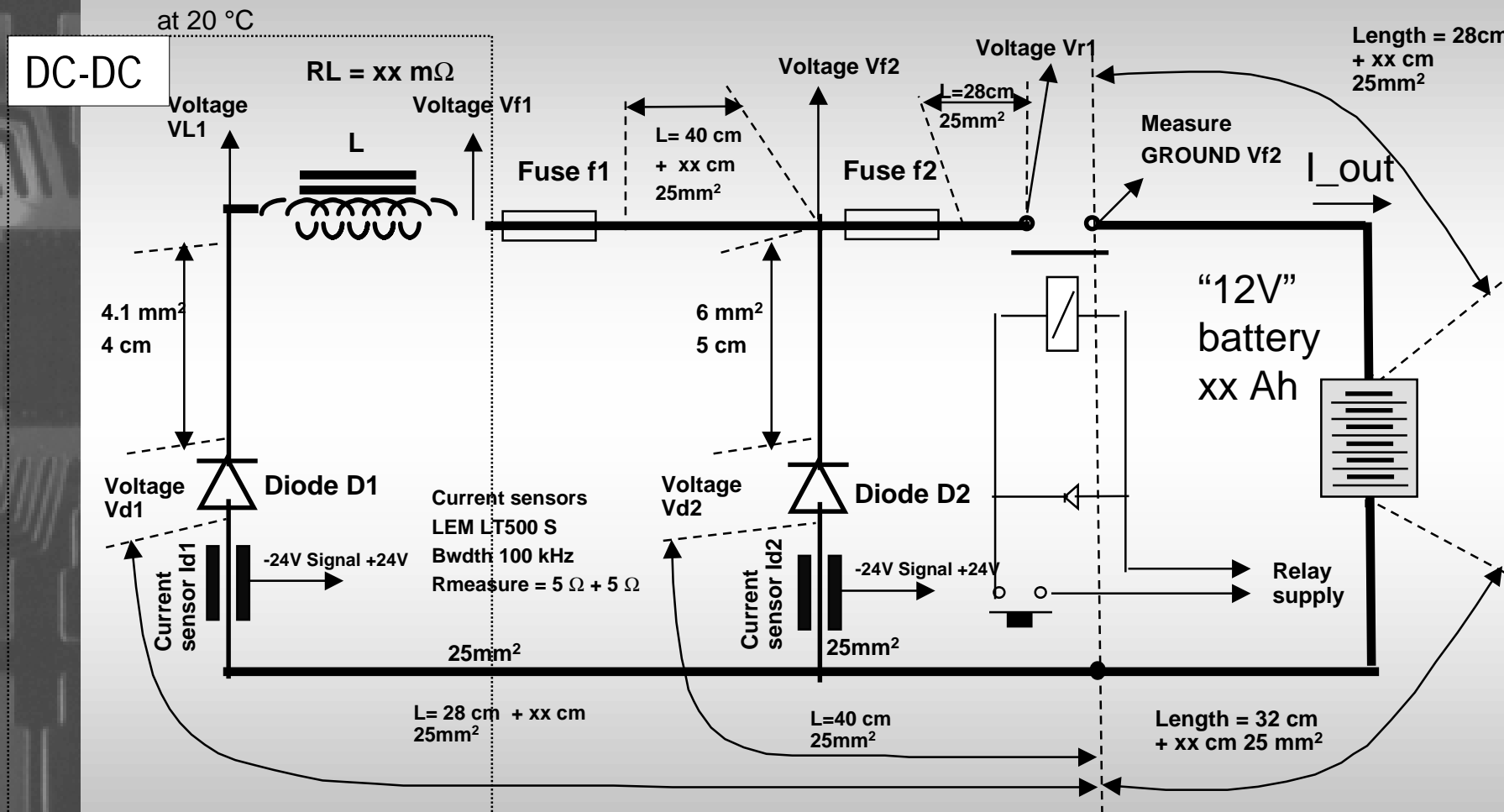
Conclusion

Objectives of the test

- Check the behaviour of the DC-DC converter freewheeling diode in case of battery inversion
- Check the possibility of using silicon diode instead of schottky diode for battery inversion protection
- Check the influence of battery capacity and cable length on short circuit current
- Measure corresponding current, voltage drop and blowing time
- Derive value for maximum negative voltage to be considered in draft standard.

Test bench

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Resistance of 25 mm² = 0,72 mΩ/m

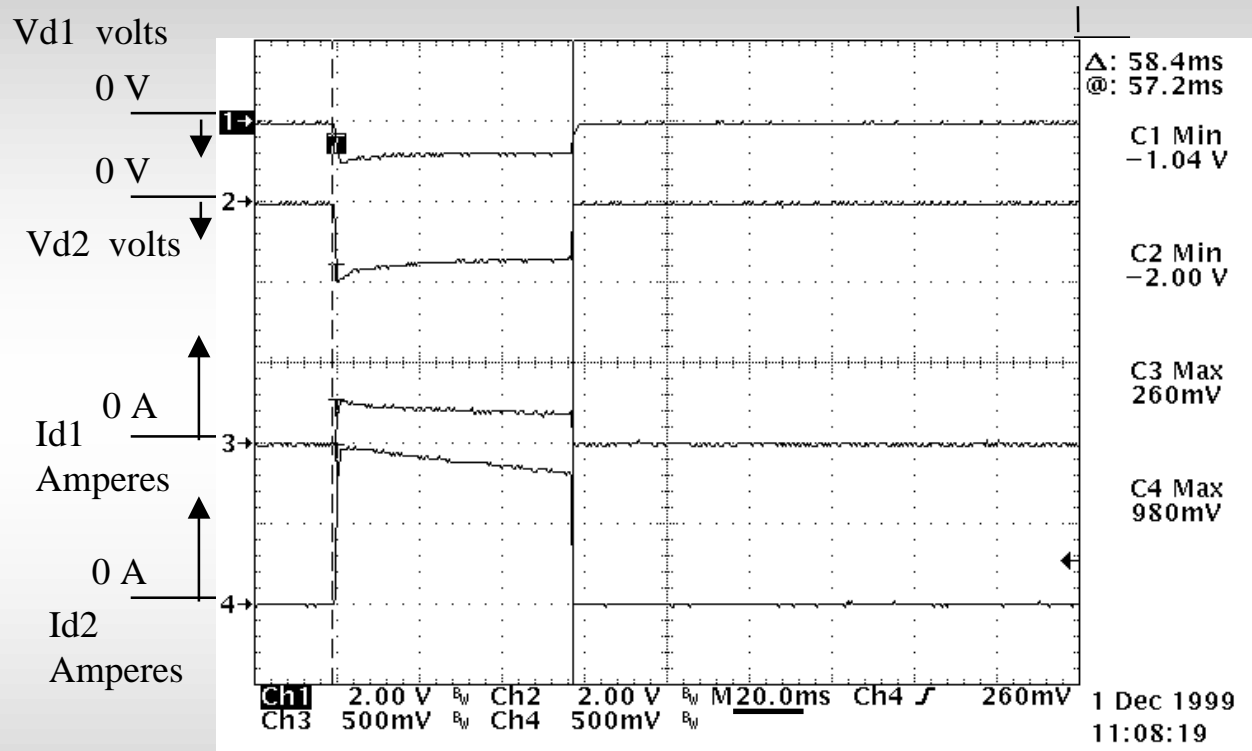
Results Overview

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Schematic	diode	diode	fuse	fuse	Battery	Blowing times ms		i1 Amperes (peak)	i2 Amperes (peak)	Peak voltage drop D1 [V]	Peak voltage drop D2 [V]	total cable length (cm)		Result
	D1	D2	F1	F2		Ah	F1					F2	battery - D 2	
12,20	schottky 75 HQ 045	schottky 60 CNQ 45	80 maxi	125A midi	50	∞	58,4	260	980	1,04	2	468	496	12,23
13,20	schottky 85 HQ 045	schottky 175 BGQ 045	80 maxi	125A midi	50	∞	206	240	520	1,04	1,84	830	860	13,22
12,0	schottky 85 HQ 045	schottky 100 BGQ 045 BsC	80 midi	125A midi	130	∞	14,6	760	1440	1,28	3,28	130	160	12,7
14,00	schottky 85 HQ 045	schottky 175 BGQ 045	80 maxi	125A midi	130	∞	58	220	980	1,12	2,32	830	1260	14,2
12,0	schottky 85 HQ 045	schottky 175 BGQ 045	80 midi	125A midi	130	∞	13,1	580	1620	1,2	2,8	130	160	12,6
12,20	schottky 75 HQ 045	standard recov 85 HF 020	80 maxi	125A midi	50	∞	62,8	260	960	1,12	1,92	130	160	12,22
12,00	schottky 85 HQ 045	standard recov pressfit 8AF BsC	80 midi	125A midi	130	∞	18,3	1180	1300	2,8	13,68	130	160	12,8
12,0	schottky 85 HQ 045	standard recov 85 HF 020	80 midi	125A midi	130	∞	12,6	540	1700	1,28	2,4	130	160	12,5

Oscillogram Result 12.23

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

Diode D1: schottky 75 HQ 045
 Diode D2: schottky 60 CNQ 45
 Fuse f1: Maxi 80 A => not blown
 Fuse f2: Midi fuse 125 A => blown

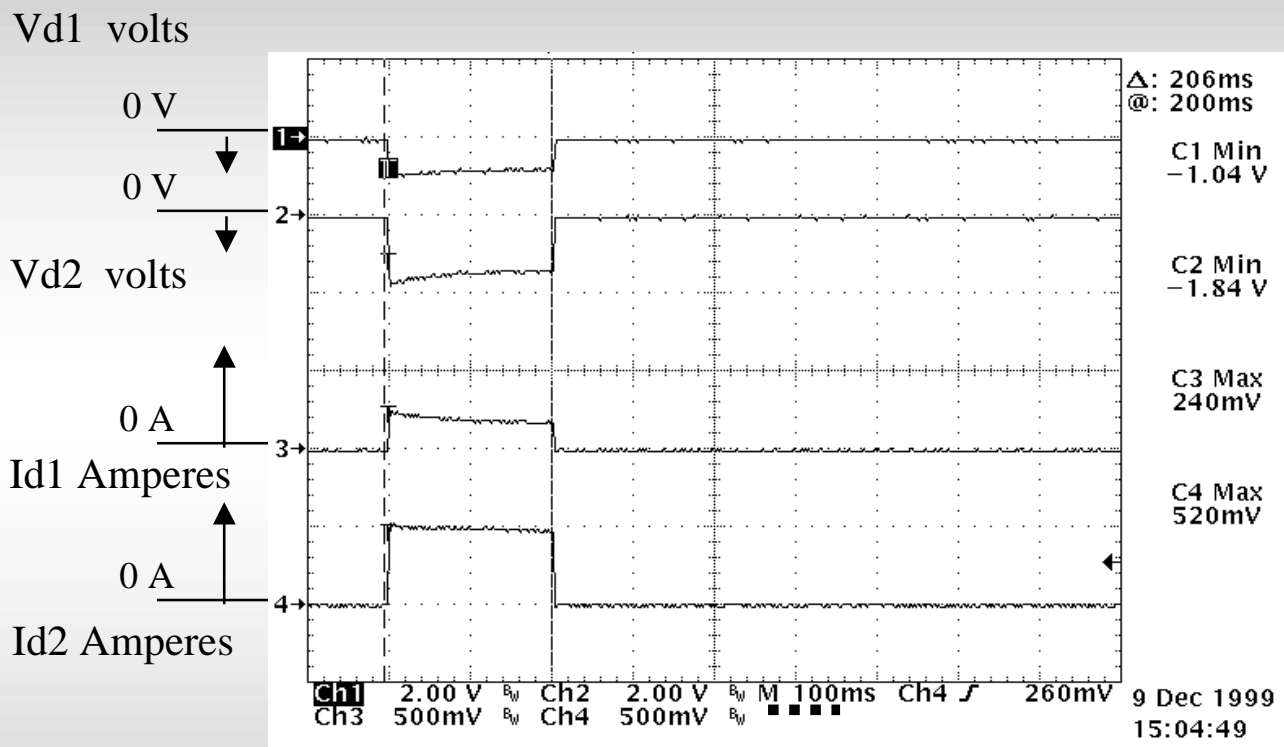
Battery : 50 Ah

Horiz: X: ms/div

Reduce original figure by a factor of 85%

Oscillogram Result 13.22

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

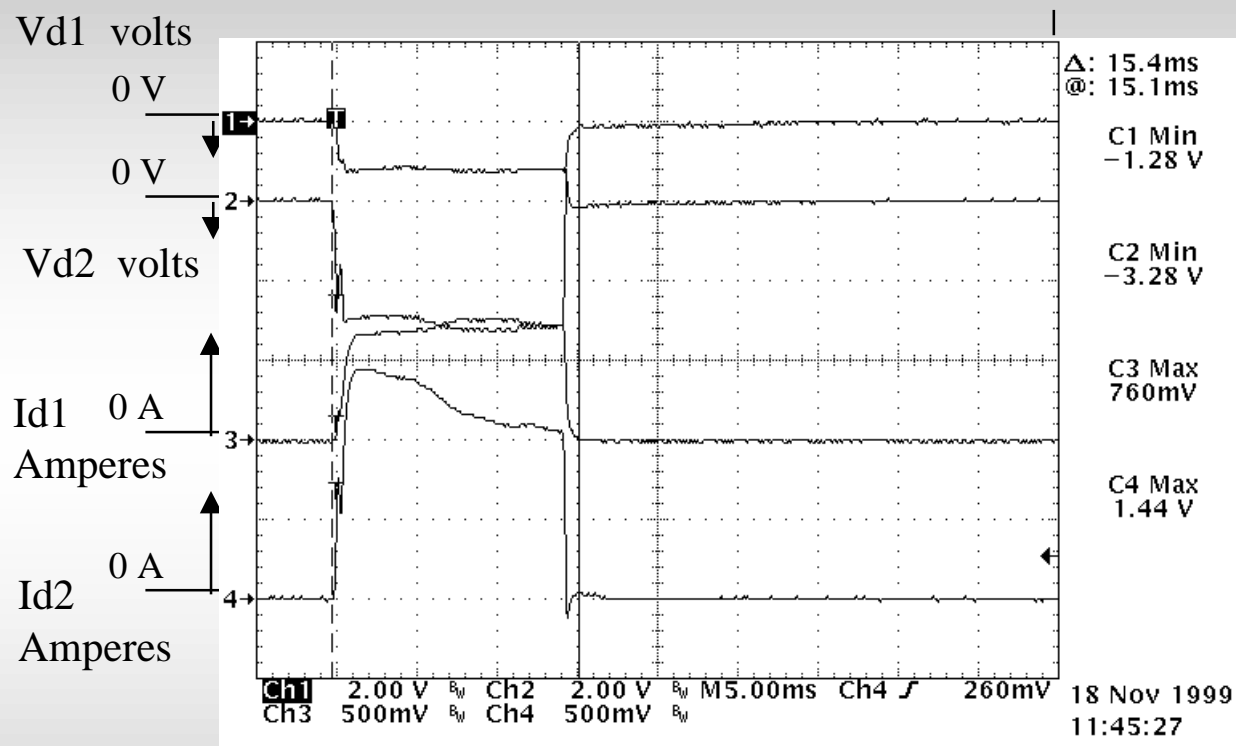
Diode D1: schottky 85 HQ 045
 Diode D2: schottky 175 BGQ 045
 Fuse f1: Maxi fuse 80A
 Fuse f2: Midi fuse 125 A => Blown

Battery : 50 Ah

Horiz: X: ms/div

Oscillogram Result 12.7

SIEMENS



Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

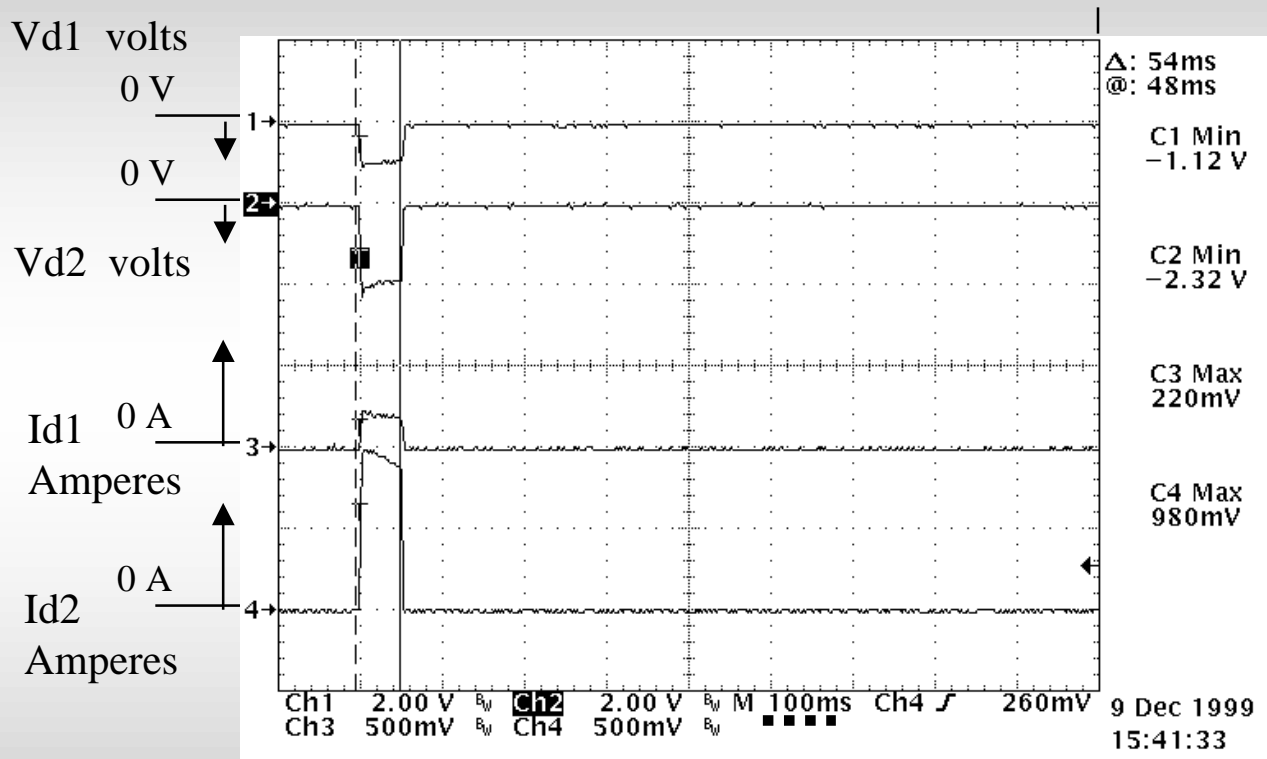
Vertic: Y4 : 500 A/div.

Horiz: X: ms/div

Diode D1: schottky 85 HQ 045
 Diode D2: 100 BGQ 045 => Blown SC Battery : 130 Ah
 Fuse f1: Midi fuse 80 A => not blown
 Fuse f2: Midi fuse 125 A => blown

Oscillogram Result 14.2

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

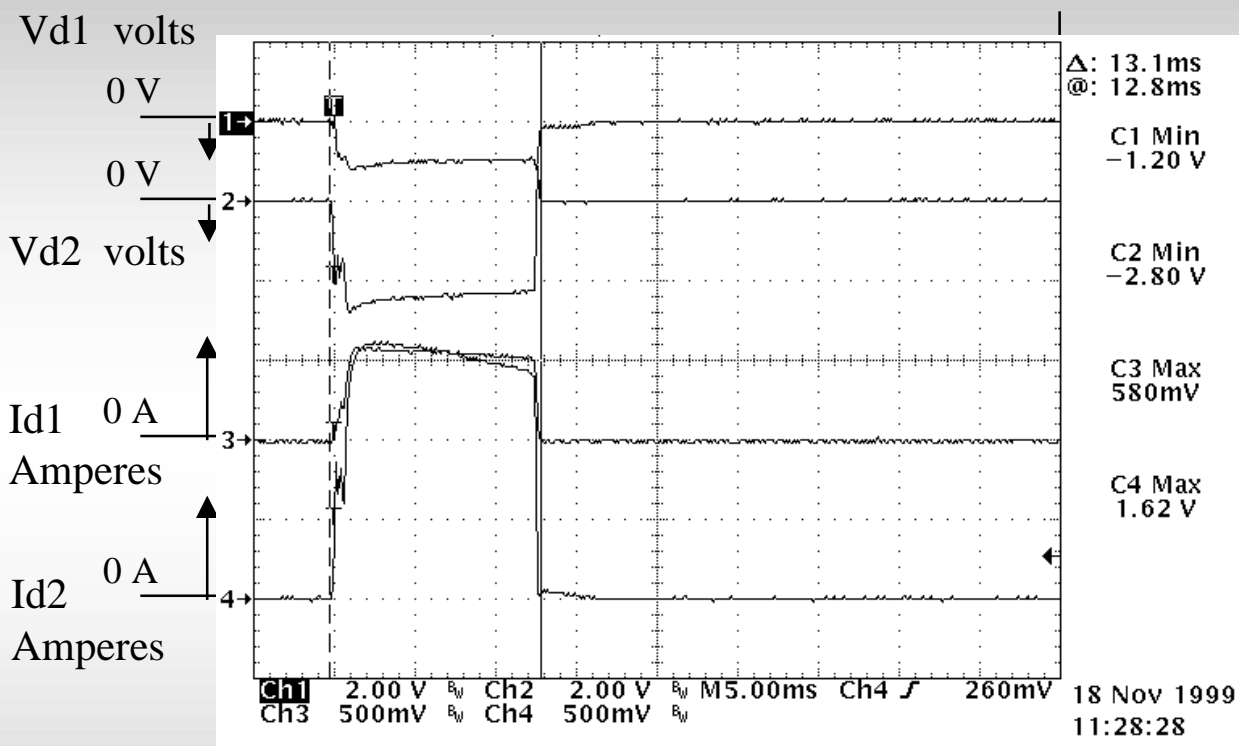
Diode D1: schottky 85 HQ 045
 Diode D2: schottky 175 BGQ 045
 Fuse f1: Maxi fuse 80A
 Fuse f2: Midi fuse 125 A => Blown

Battery : 130 Ah

Horiz: X: ms/div

Oscillogram Result 12.6

SIEMENS



Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

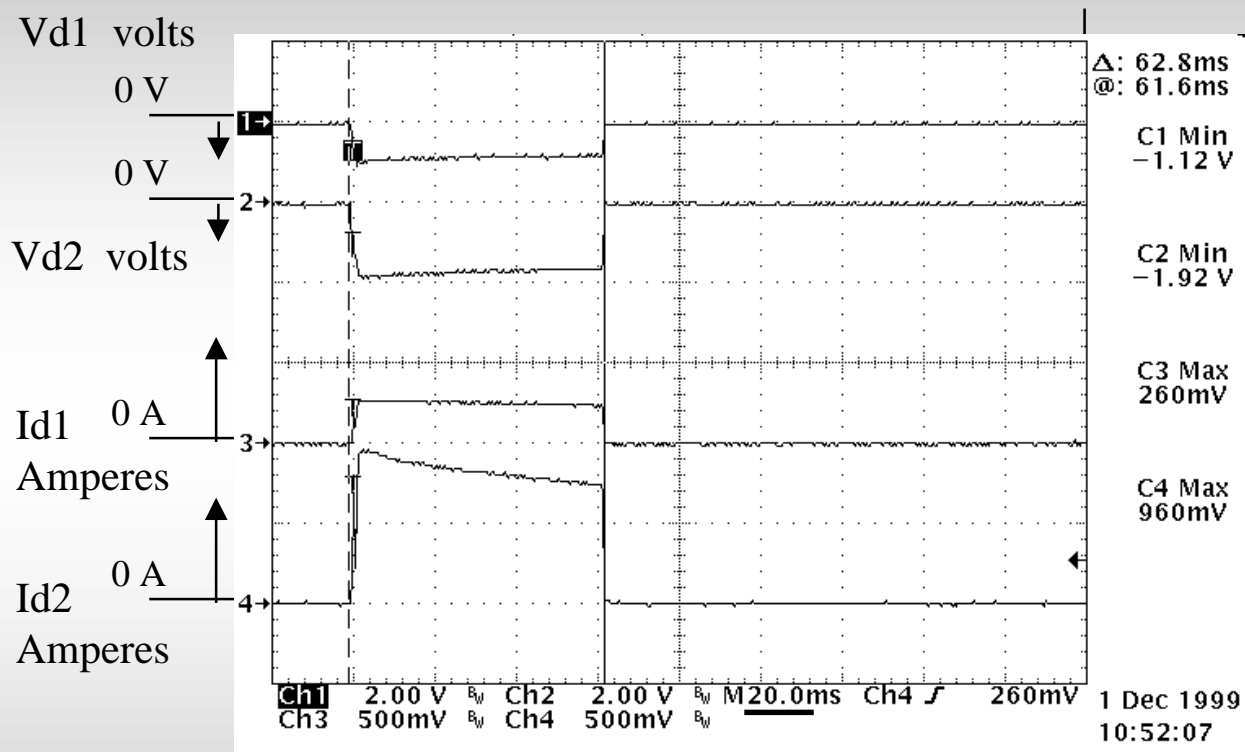
Diode D1: schottky 85 HQ 045
 Diode D2: 175 BGQ 045
 Fuse f1: Midi fuse 80 A => not blown
 Fuse f2: Midi fuse 125 A => blown

Battery : 130 Ah

Horiz: X: ms/div

Oscilloscope Result 12.22

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

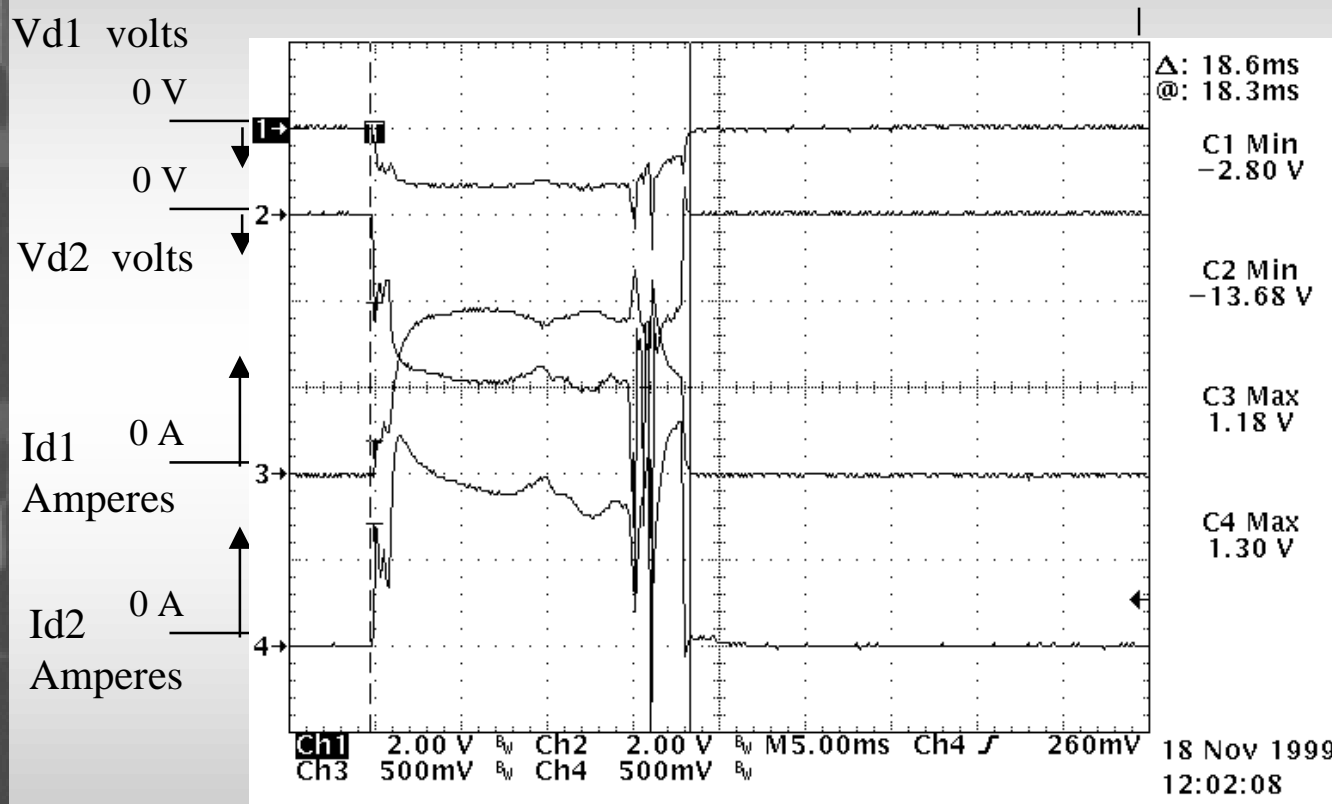
Diode D1: schottky 75 HQ 045
 Diode D2: 85 HF 020
 Fuse f1: Maxi 80 A => not blown
 Fuse f2: Midi fuse 125 A => blown

Battery : 50 Ah

Horiz: X: ms/div

Oscillogram Result 12.8

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

Diode D1: schottky 85 HQ 045
 Diode D2: pressfit 8AF => Blown SC
 Fuse f1: Midi fuse 80 A => not blown
 Fuse f2: Midi fuse 125 A => blown

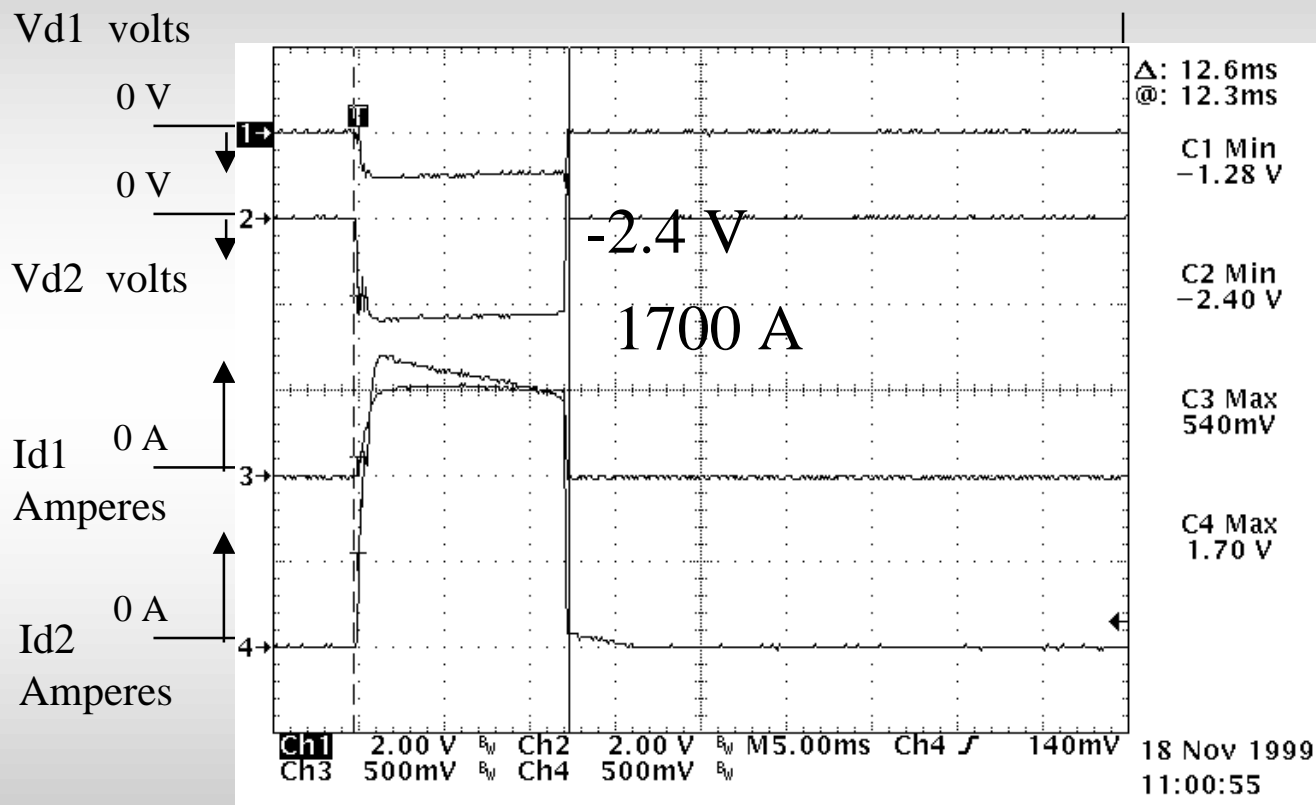
Battery : 130 Ah

Horiz: X: ms/div



Oscillogram Result 12.5 (maximum peak current)

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Ubatt_nominal = 13.0 V

Vertic: Y1: 2 V/div.

Vertic: Y2: 2 V/div.

Vertic: Y3 : 500 A/div.

Vertic: Y4 : 500 A/div.

Horiz: X: ms/div

- Diode D1: schottky 85 HQ 045
- Diode D2: 85 HF 020
- Fuse f1: Midi fuse 80 A => not blown
- Fuse f2: Midi fuse 125 A => blown



Conclusion

- Schottky diode for wrong polarity protection can be replaced by a cheaper silicon diode with sufficient dimensioning
=> no major change on blowing time, maximum current and current distribution.
- The current in the freewheeling diode is limited by cable length and coil resistance (1/2 to 1/3 of the protection diode current).
- Blowing time F2 in the range of 20,5 ms at 1700 A to 200 ms at 520 A.

Conclusion

- Maximum peak reverse voltage 2,8 V at battery inversion.
- F1 did not blow except if D2 blew
- Main problem: automotive fuses today are designed for protection of cables which have a much higher time constant than diodes expensive over sizing of diodes necessary in order to avoid destruction at battery inversion.
- Proposals for standardization of the future 14V PowerNet:
 - 3V during 50 ms and 2.5V during 250 ms
 - or
 - 3V during 250 ms (worst-case)