BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Elektrische Antriebe in Segelflugzeugen

Oktober 1973

Brditschka MB-E1

MTOW ca. 500kg

E-Motor 10kW/100V (Bosch)

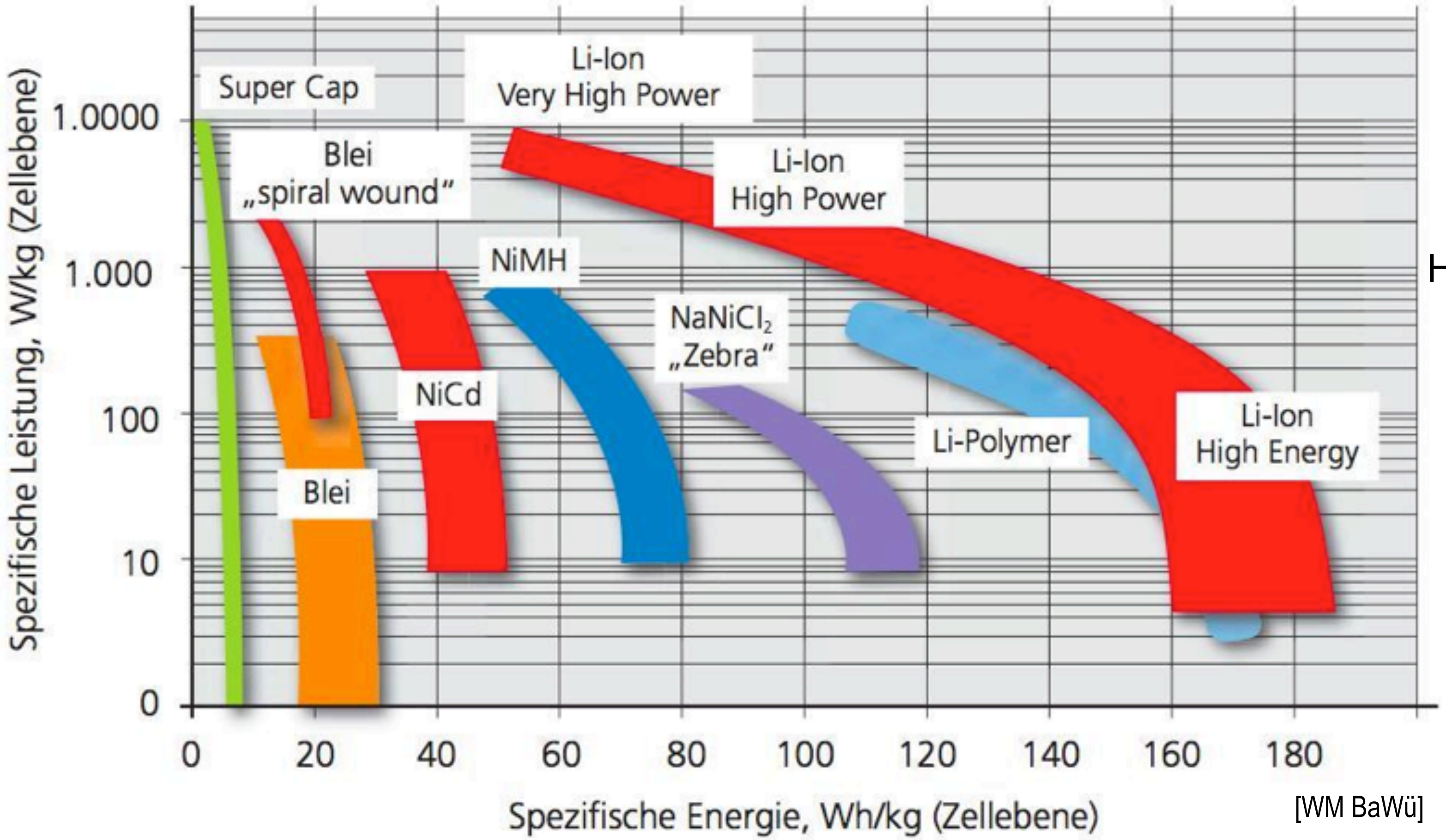
Akku-System Ni-Cd ca. 1kWh

Flugzeit 12 min

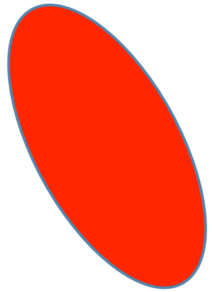
Elektrischer Höhengewinn 350m

[HB-Flugtechnik]

Wie haben sich elektrische Energiespeicher entwickelt?



Heute (3/2018)



250Wh/kg

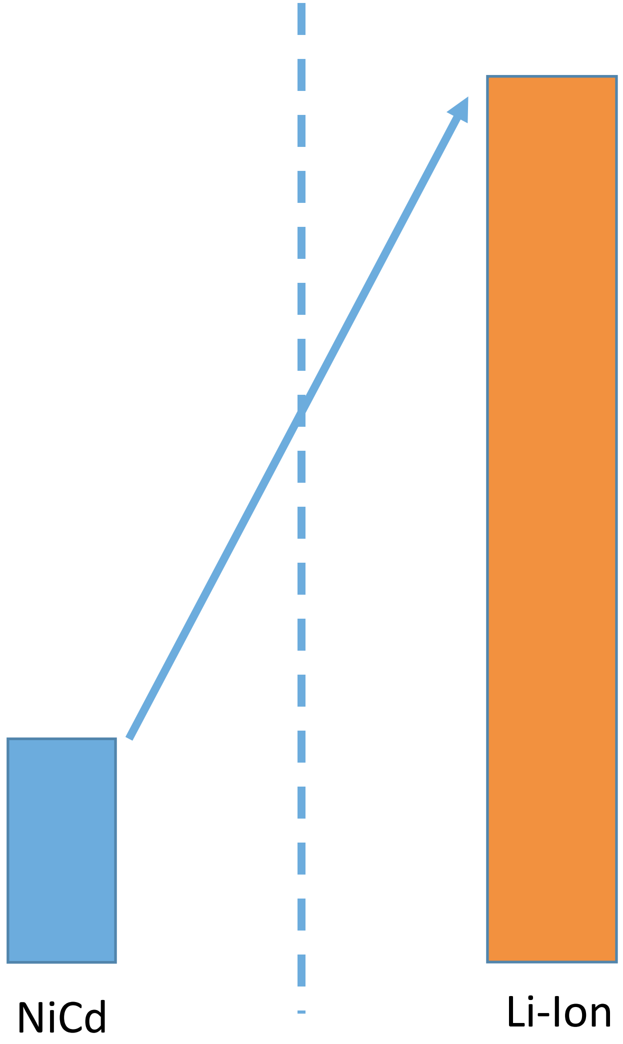
BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Entwicklung der Energiedichte

1985

NiCd-System

0,4 kWh/10 kg



2016

LiIon-System

1,6 kWh / 10kg

4-fache Energiedichte

Bei gleicher Masse !

Beispiel: FES-Akkupack

Masse (2 Packs)	30 kg
Energieinhalt	4 kWh
Energiedichte (netto*)	133 Wh/kg (7,5 kg/kWh)

LZ-Design

*)Incl. BMS, Gehäuse, Stecker,…

Wieviel Energie steckt in den Akkus? *)

2 kWh

1 L

4 kWh

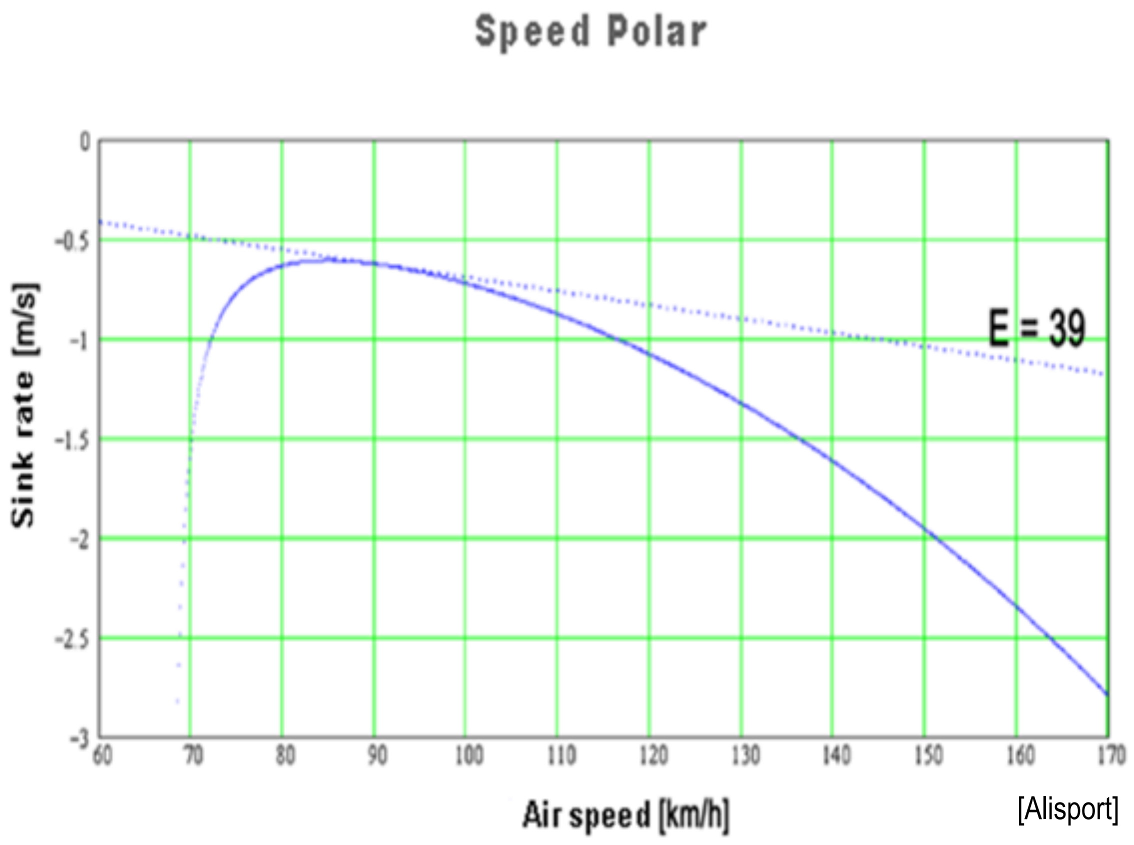
2 L

[LZ-Design]

*) unter Berücksichtigung der Wirkungsgrade von Verbrenner- und Elektroantrieb

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Wie weit, wie hoch reicht eine Akkuladung?



Leistungsbedarf für den Horizontalflug

(Mtow = 300kg; vh = 90 km/h; polares Sinken = 0,65 m/s)

$$P_{mech} = \frac{\partial h}{\partial t} * G$$

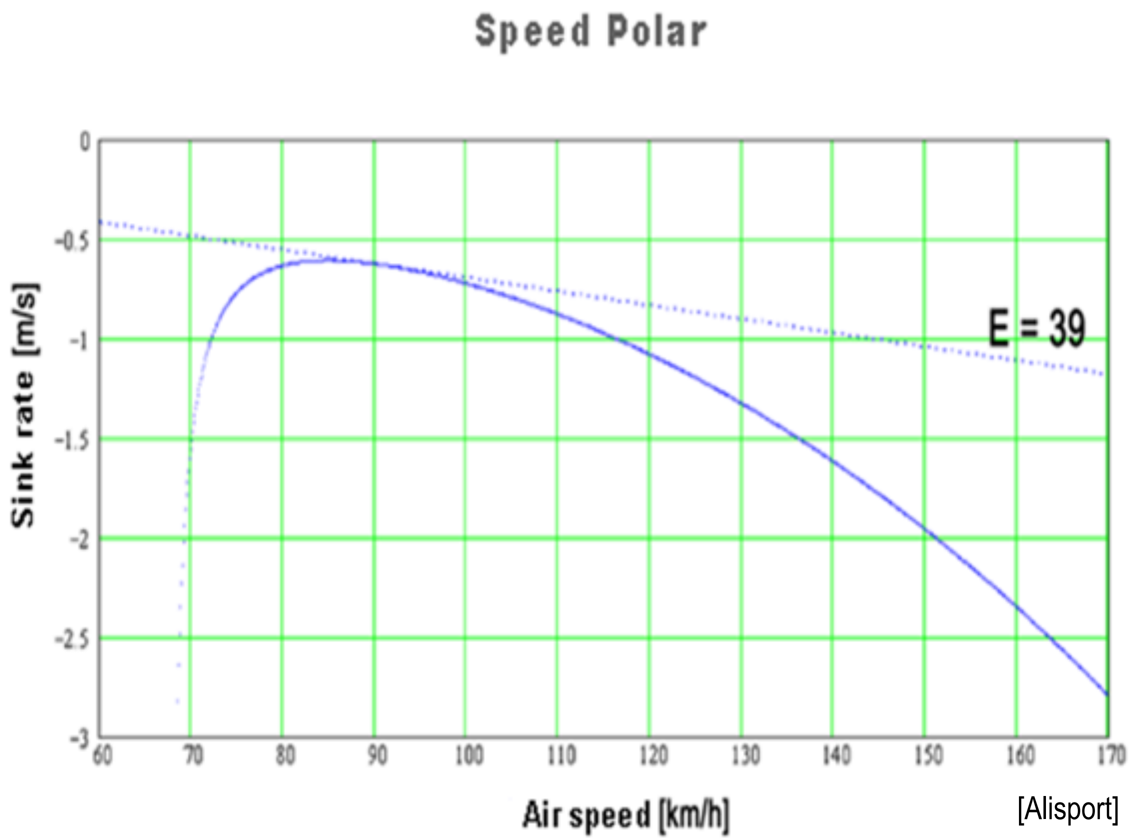
$$P_{mech} = \frac{0,65m}{s} * 300kg * 9,81m/s$$

$\eta_{(prop)} = 50\%$

$$P_{mech} = 1,91kW$$

$$P_{el} = 4\ kW$$

Wie weit?



[Alisport]

Reichweite im Horizontalflug

P_{el} = 4 kW !

„Tankinhalt“ = 4kWh

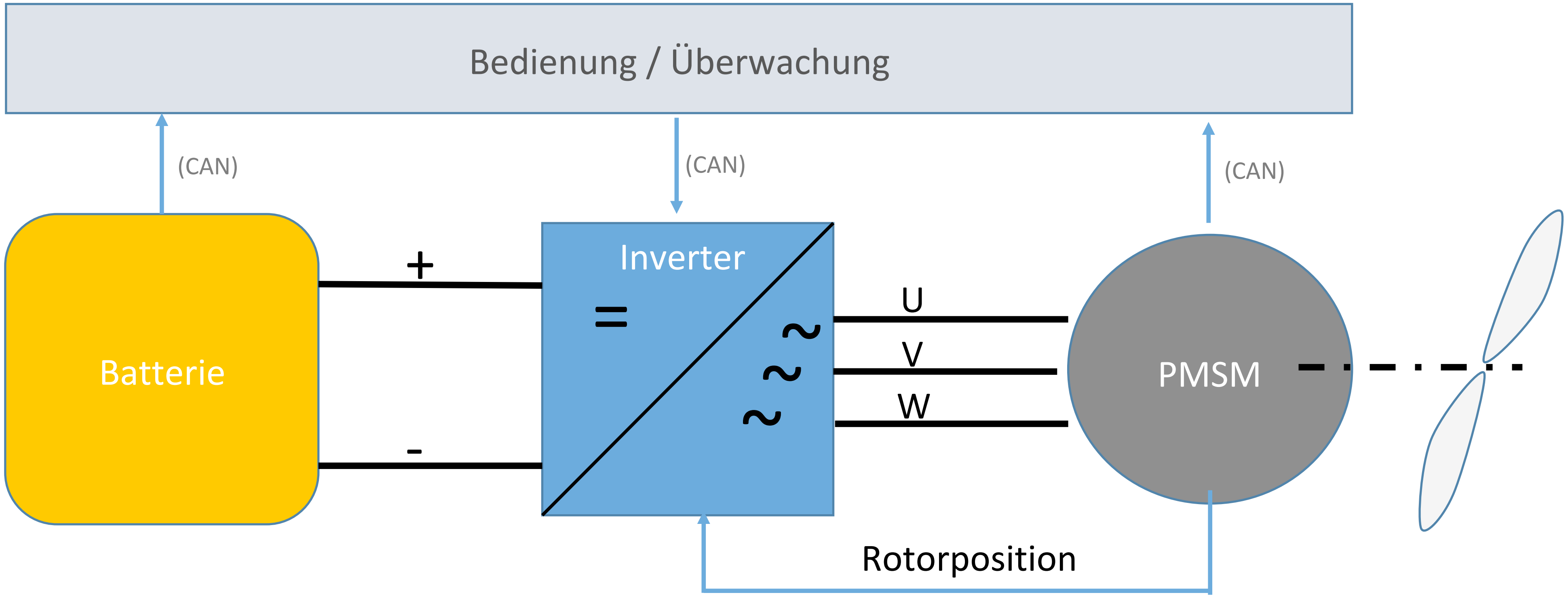
Flugzeit = 1h **!**

Reichweite = Flugzeit x Geschwindigkeit

Reichweite$_{(90km/h)}$ = 90 km **!**

Welche Komponenten hat ein Elektroantrieb?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.



ASG32-EL	400V	80A	Sinus	~	2300 rpm
FES	114V	190A	Block		4500 rpm

Welche Elektromotoren kommen zum Einsatz?

Bürstenmotor

~~**Preisgünstig**~~
~~**Bürstenfeuer**~~
~~**Verschleiß**~~

Asynchronmotor*)

~~**Preisgünstig**~~
~~**Hohes Gewicht/kW**~~

ESM
(Elektrisch erregte Synchron Maschine)

~~**Preisgünstig**~~
~~**Hohes Gewicht/kW**~~
~~**Großer Bauraum**~~
~~**Schlechterer Wirkungsgrad**~~

PMSM
(Permanent Magnet erregte Synchron Maschine)

Teuer
Geringes Gewicht/kW
Kleiner Bauraum
hoher Wirkungsgrad

Derzeit alternativlos!

Alle Elektromotoren brauchen ein Drehfeld!

*)Einsatz im KFZ(Tesla, ZOE,….)

Der Umrichter (Inverter) erzeugt das Drehfeld

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

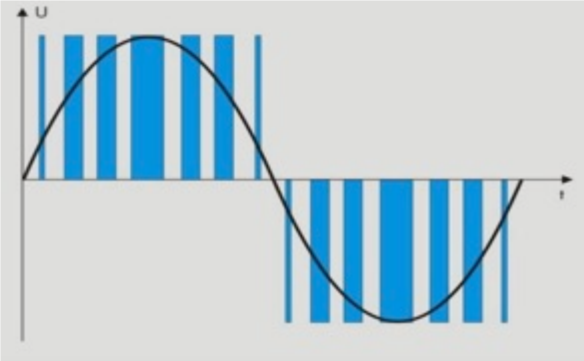
Sinus-Kommutierung

Spannungslage > 400V

IGBTs

Geringe Schaltverluste

? [?]

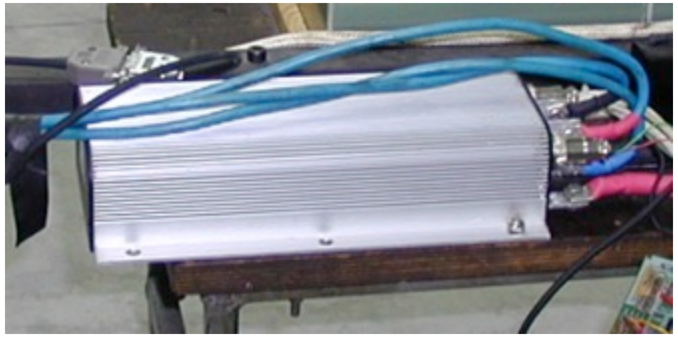


Block-Kommutierung

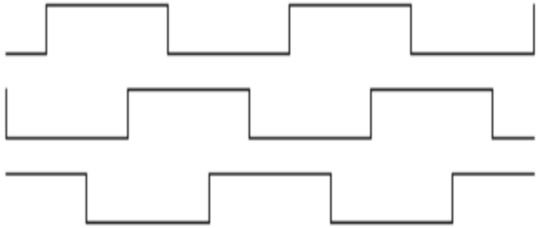
Spannungslage < 130V

MOSFETs

<u>Sehr</u> geringe Schaltverluste



Kelly-Inverter [Eckert]



Welche Motoren kommen zum Einsatz?

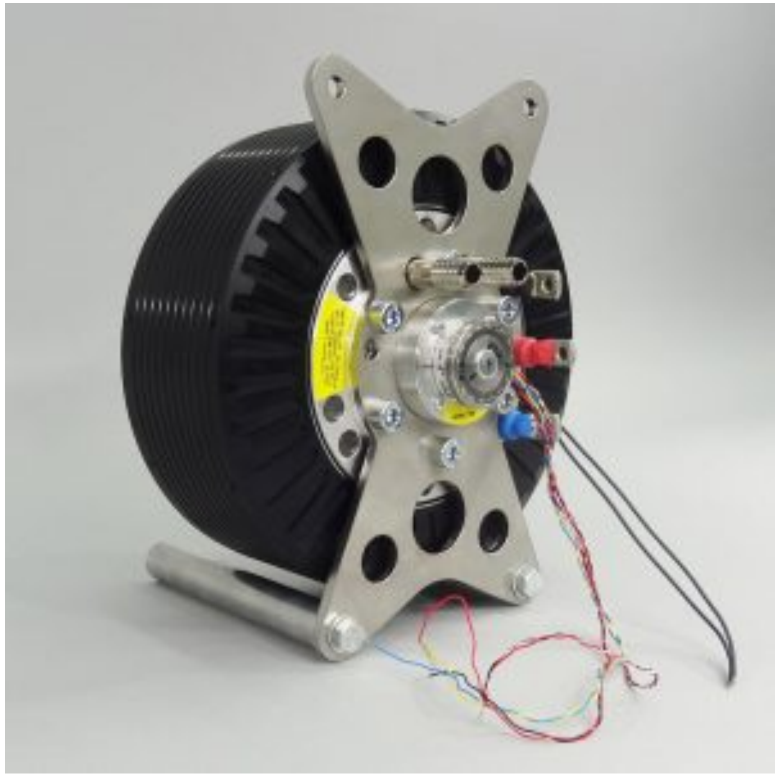
BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Beispiel EMRAX 228

Geringes Rastmoment („no cogging“)

Masse	**12kg**
Leistung	**50 kW (67PS) *)**
Leistungsdichte$_{50kW}$	**4,2 kW/kg**
Kommutierung	**Sinusförmig**
EMF	**1V/10rpm**

100V → 1000rpm



[Enstroj]

*) 100 kW kurzzeitig bei 5500 rpm

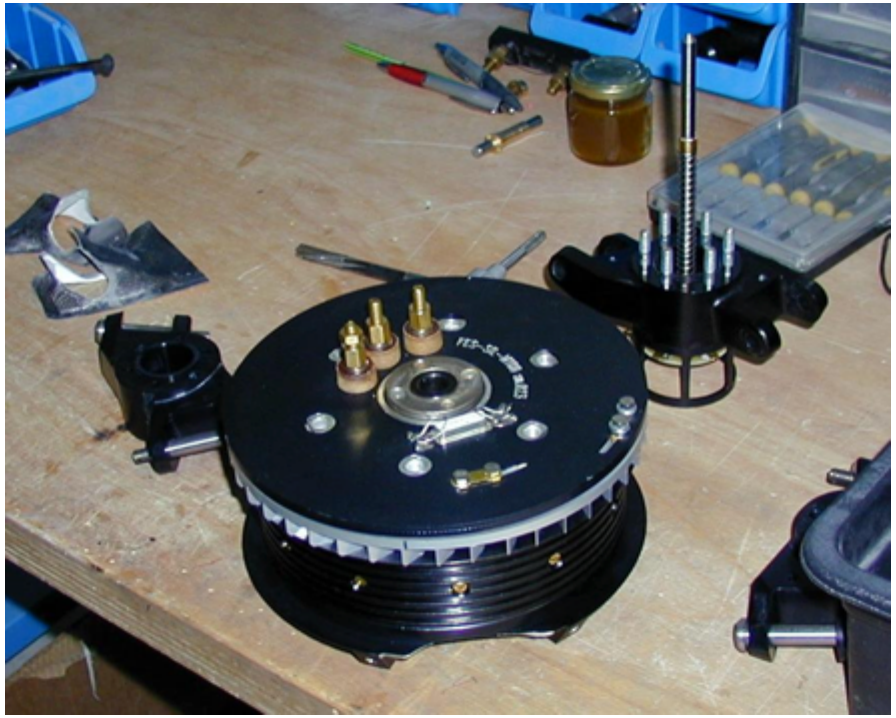
Welche Motoren kommen zum Einsatz?

Beispiel **FES M 100**

Hohes Rastmoment („cogging“)

Masse	**7 kg**
Leistung	**22 kW (29 PS)**
Leistungsdichte$_{22kW}$	**3,1 kW/kg**
Kommutierung	**Block**
EMF	**1V/45rpm**

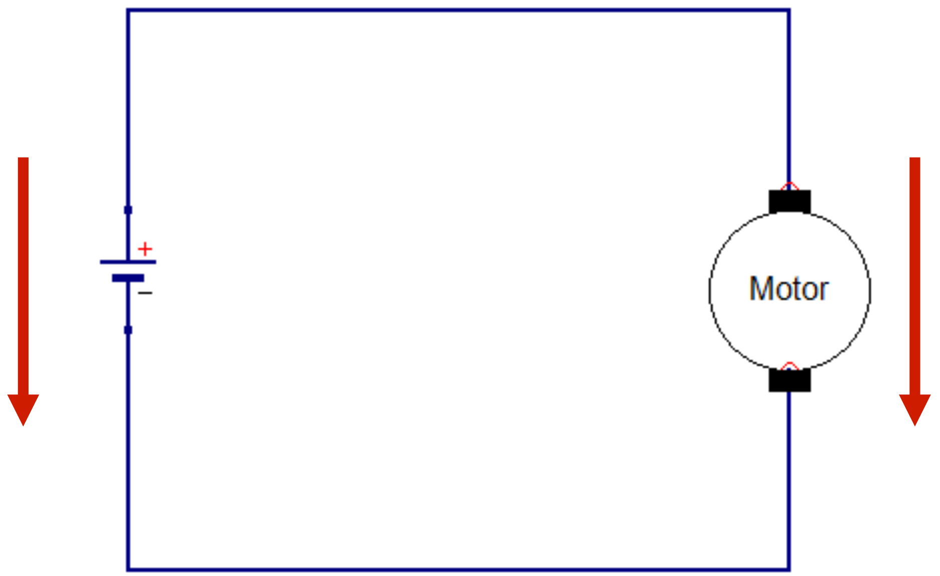
100V → **4500rpm**



[Eckert]

Gibt es eine Drehzahlbegrenzung?

Ein rotierender Motor erzeugt seinerseits eine Spannung, die der Quelle entgegenwirkt!



EMF (Back EMF)

Welche Akku-Zell-Typen gibt es?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

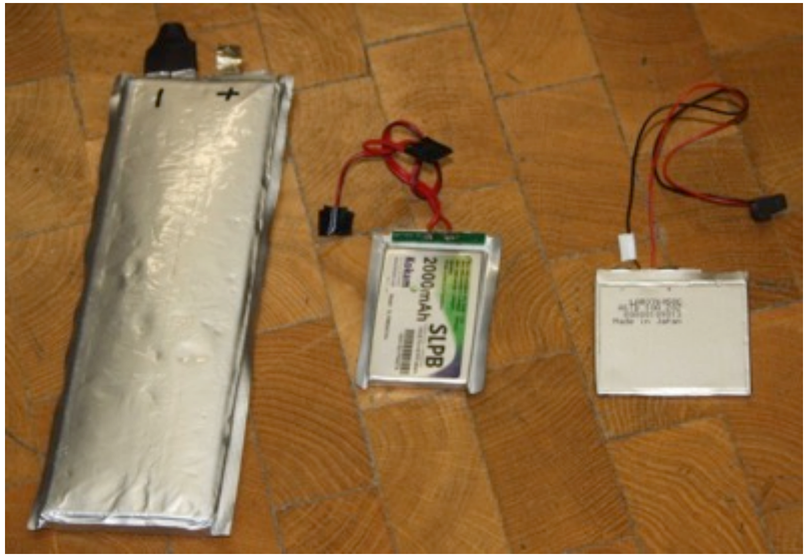
Rundzellen

[Eckert]

Prismatische Zellen

[Eckert]

Pouch-Zellen



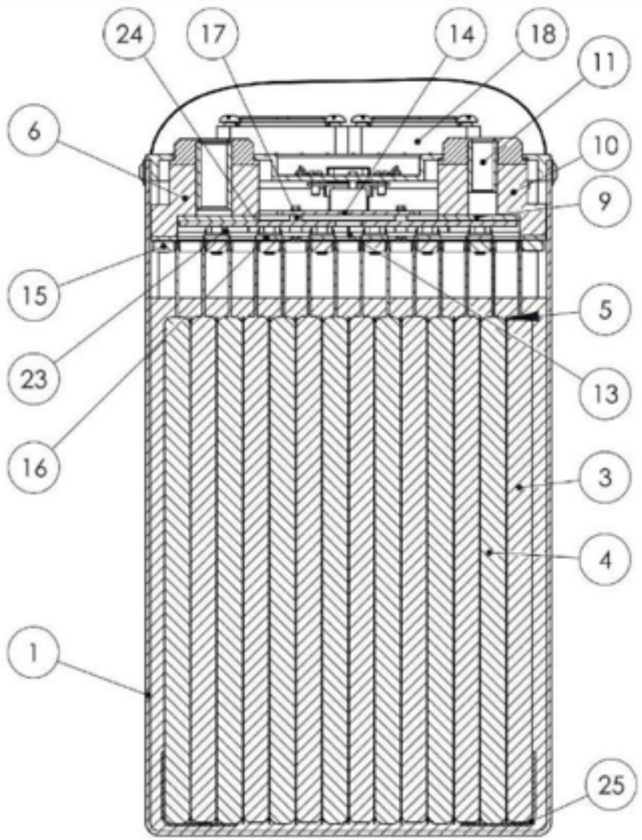
[Eckert]

Welche Akku-Zellen kommen im Flugzeug zum Einsatz?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

High Power „**Pouch**“-Zelle (Coffeebag)

FES-Battery-Pack

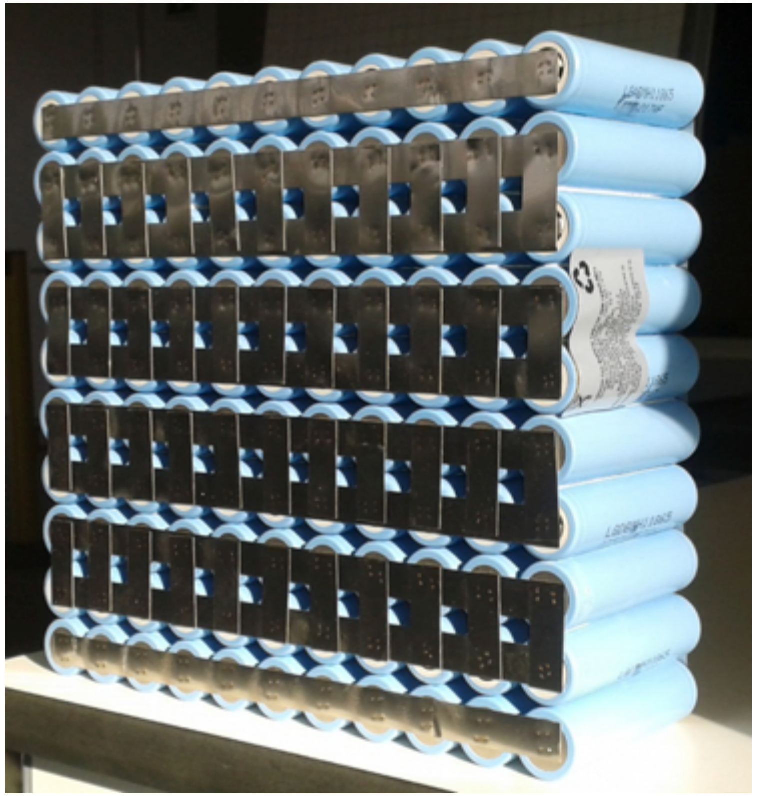


[LZ-Design]

Welche Akku-Zellen kommen im Flugzeug zum Einsatz?

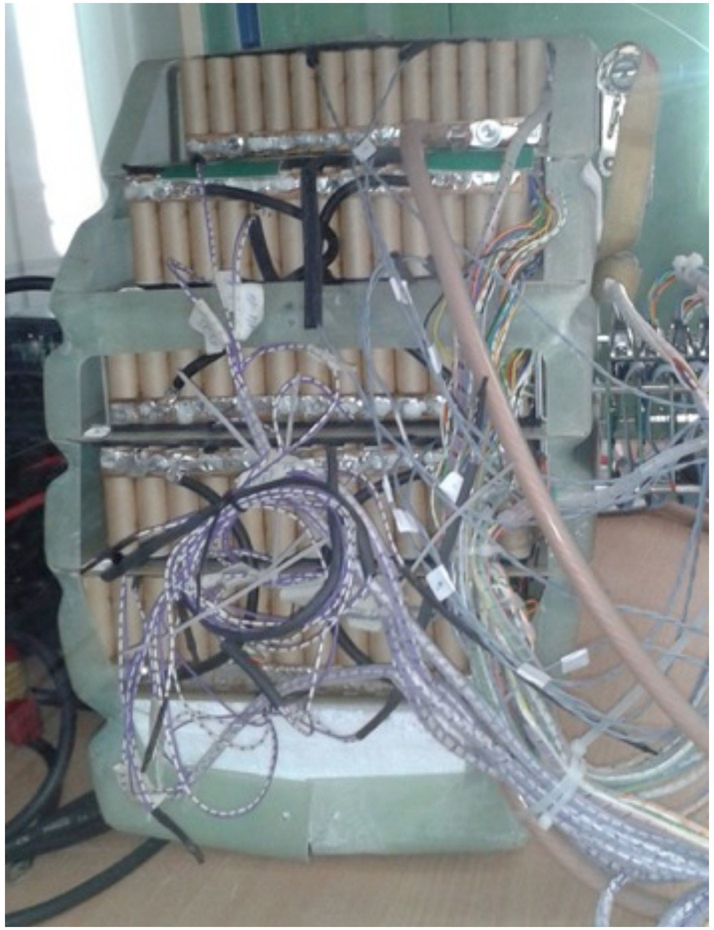
BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

High Power **Rundzelle**



[Eckert]

Akkupack für einen Motorroller



ASG32-EL Prototyp [Eckert]

„Nomenklatur“ von Batteriepacks?

Beispiel

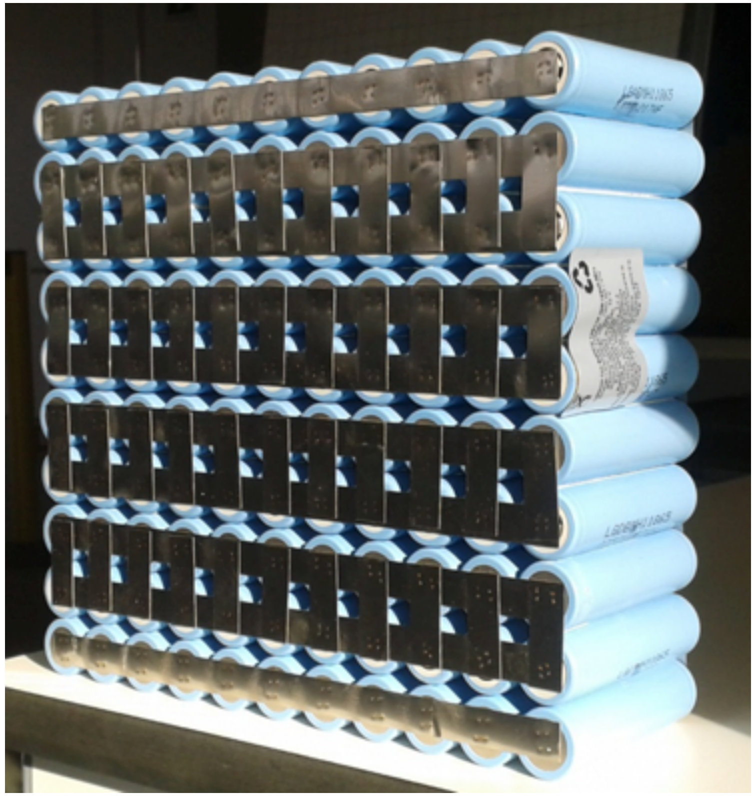
10s11p

10 Zellspannungen in Serie

10 x 3,6V = 36V

11 Zellströme parallel

10 x 15A = 150A



Welche Akku-Zellen kommen im Flugzeug zum Einsatz?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

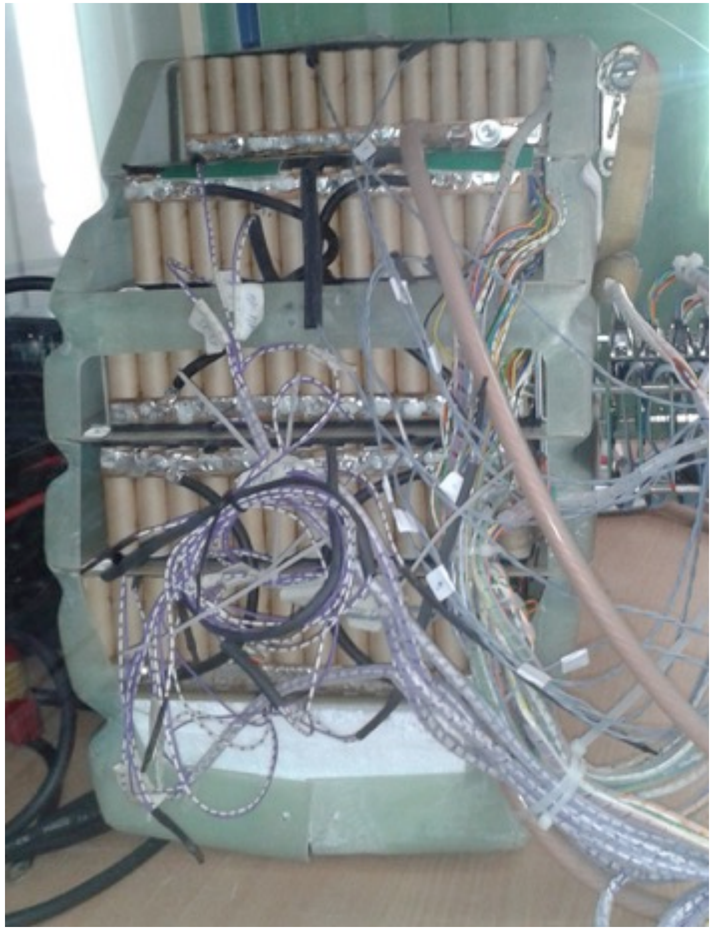
ASG32-EL Prototyp

110s 13p

400V

200A

80 kW max !



[Eckert]

Welche Behandlung brauchen Akkus?

Datenblatt beachten!

Ladeschlußspg.

Spannungen

No.	ITEM	VALUE	REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah	Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V	
	Lower limit voltage	2.7V	
	Upper limit voltage	4.2 ±0.03V	
3	Max. Conti. Charge Current	120A	CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A	
	Peak Discharge Current	480A	Less than 10sec
5	Operation Temperature Range	Charge: 0 ~ 45°C	@60±25% R.H.
		Discharge: -20 ~ 60°C	
6	Storage Temperature Range	less than 1 year -20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months 25 ~ 40°C	
		less than 1 week 40 ~ 60°C	
7	Weight	Max. 1,030.0g	
8	Cell Dimension	Length : Max.222.0mm	Except for tab length
		Width : Max.214.0mm	
		Thickness : Max.10.7mm	Initial full charge

Welche Behandlung brauchen Akkus?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Datenblatt !

Spannungen

Entladeschlußspg.

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Welche Behandlung brauchen Akkus?

Datenblatt !

Ströme

Ladestrom

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Welche Behandlung brauchen Akkus?

Datenblatt !

Ströme

Entladestrom

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Welche Behandlung brauchen Akkus?

Datenblatt !

Temperaturlimits **beim Laden**

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Welche Behandlung brauchen Akkus?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Datenblatt !

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Temperaturlimits

beim Entladen

Welche Behandlung brauchen Akkus?

BADEN-WÜRTTEMBERGISCHER
LUFTFAHRTVERBAND E.V.

Datenblatt !

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Ladeverfahren

Welche Behandlung brauchen Akkus?

Datenblatt !

Spannungen
- Ladeschlußspg.
- Entladeschlußspg.

Ströme
- Ladestrom
- Entladestrom

Temperaturlimits
- beim Laden
- beim Entladen

Ladeverfahren

No.	ITEM	VALUE		REMARK
1	Rated Capacity	Typ. 41.0Ah Min. 40.0Ah		Charge@0.2C(8.0A) Discharge@0.5C(20A)
2	Nominal Voltage	3.7V		
	Lower limit voltage	2.7V		
	Upper limit voltage	4.2 ±0.03V		
3	Max. Conti. Charge Current	120A		CC-CV charging is required End Condition: 0.05C(2.0A) or 5Hr Temperature: 23±3℃
4	Max. Conti. Discharge Current	320A		
	Peak Discharge Current	480A		Less than 10sec
5	Operation Temperature Range	Charge:	0 ~ 45°C	@60±25% R.H.
		Discharge:	-20 ~ 60°C	
6	Storage Temperature Range	less than 1 year	-20 ~ 25°C	@60±25% R.H. SOC 50 ±5%
		less than 3 months	25 ~ 40°C	
		less than 1 week	40 ~ 60°C	
7	Weight	Max. 1,030.0g		
8	Cell Dimension	Length : Max.222.0mm		Except for tab length
		Width : Max.214.0mm		
		Thickness : Max.10.7mm		Initial full charge

Was passiert im Betrieb?

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Entladevorgang

↓

Spannung sinkt

↓

Temperatur steigt

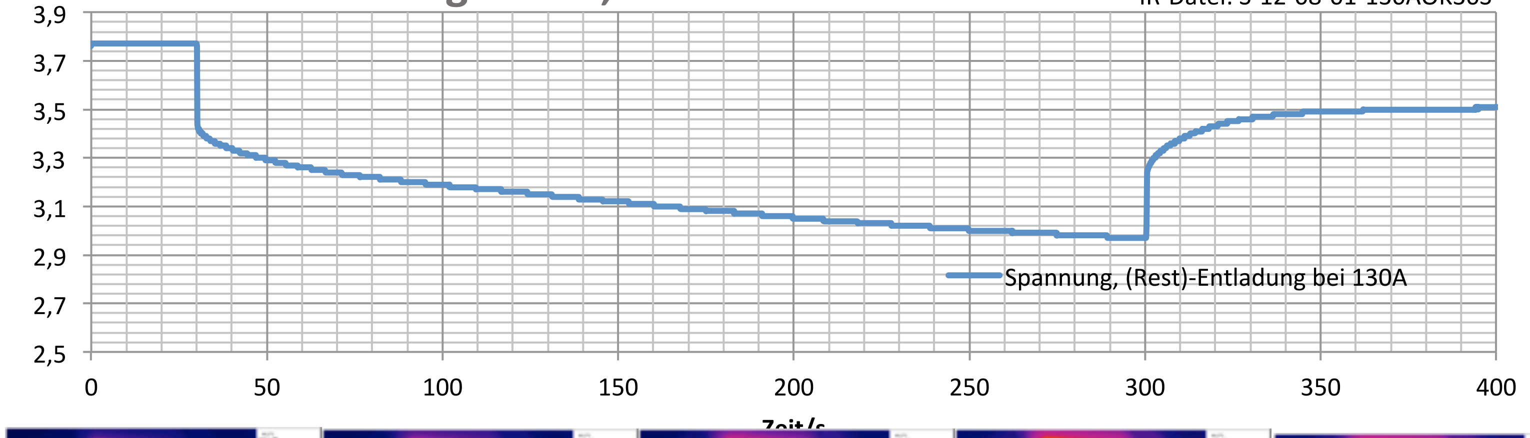
↓

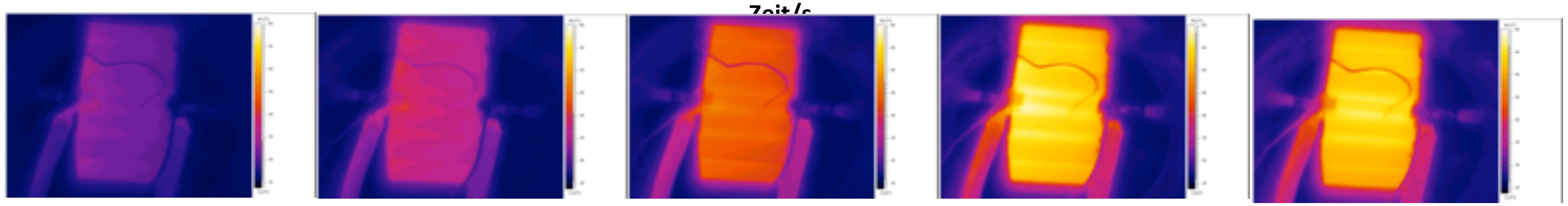
Energieinhalt sinkt

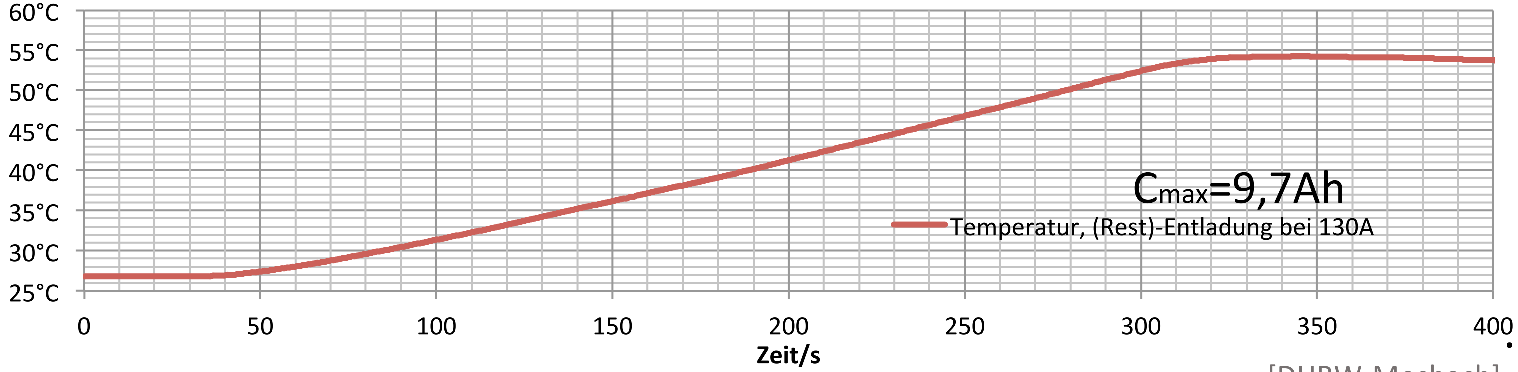
↓

Gefahrenpotential sinkt

Energie raus, → Wärme rein!







[DHBW-Mosbach]

Wie gefährlich sind Akkus?

Farnborough House
Berkshire Copse Road
Aldershot, Hants GU11 2HH
Tel:01252 510300
Fax: 01252 376999
www.aaib.gov.uk

AAIB
Air Accidents Investigation Branch

AAIB Bulletin S3/2017
SPECIAL

ACCIDENT

Aircraft Type and Registration:	HPH Glasflugel 304 eS, G-GSGS
No & Type of Engines:	1 LZ Design D.O.O FES-HPH-M100 brushless electric motor
Year of Manufacture:	2016 (Serial no: 059-MS)
Location:	Parham Airfield, West Sussex
Date & Time (UTC):	10 August 2017 at 1121 hrs
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fire damage to FES batteries and FES battery compartment
Commander's Licence:	British Gliding Association Gliding Certificate
Commander's Age:	55 years
Commander's Flying Experience:	314 hours (of which 25 were on type) Last 90 days - 9 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Notification

At 1530 hrs on 10 August 2017, the Air Accidents Investigation Branch (AAIB) was notified of a battery fire occurrence involving an HPH Glasflugel 304 eS electric self-sustainer sailplane during landing at Parham Airfield, West Sussex. The occurrence was initially referred to the British Gliding Association (BGA) for investigation in accordance with an existing Memorandum of Understanding between the AAIB and the BGA for non-fatal gliding accidents. Having conducted an initial investigation, the BGA requested further assistance from the AAIB, resulting in the AAIB launching a Field Investigation on 21 August 2017.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

Figure 1

Fire in the FES battery compartment following the landing roll

Wann wird es gefährlich?

- **Überladung (falsches Ladeverfahren/Ladegerät)**
- **(einmalige!) Tiefentladung**
- **Kurzschluss**
- **Mechanische Beschädigung**
- **Temperaturen > 60°C**

Was schadet Akkus?

- Lagern im vollgeladenen Zustand
- Lagern bei tiefen/hohen Temperaturen
- Laden bei tiefen/hohen Temperaturen
- Entladen unter die Ladeschlußspannung
- Falsches Ladeverfahren/falsches Ladegerät
- Mechanischer Stress

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Does ! Wie macht man's richtig !

- **Sicherung für den „Worst Case"-Fall nahe bei den Akkuzellen**
- **LiIon-Akkus immer überwachen (Zellspannungen, Zelltemperaturen) BMS ist unerlässlich!**
- **Gegen mechanische Beschädigungen schützen (insbes. „Pouch"-Zellen)**
- **Betrieb und Lagerung bei moderaten Temperaturen**

  Bei moderaten Temperaturen „einwintern"
- **Einlagerung (über Winter) im teilentladenen Zustand (50%)**

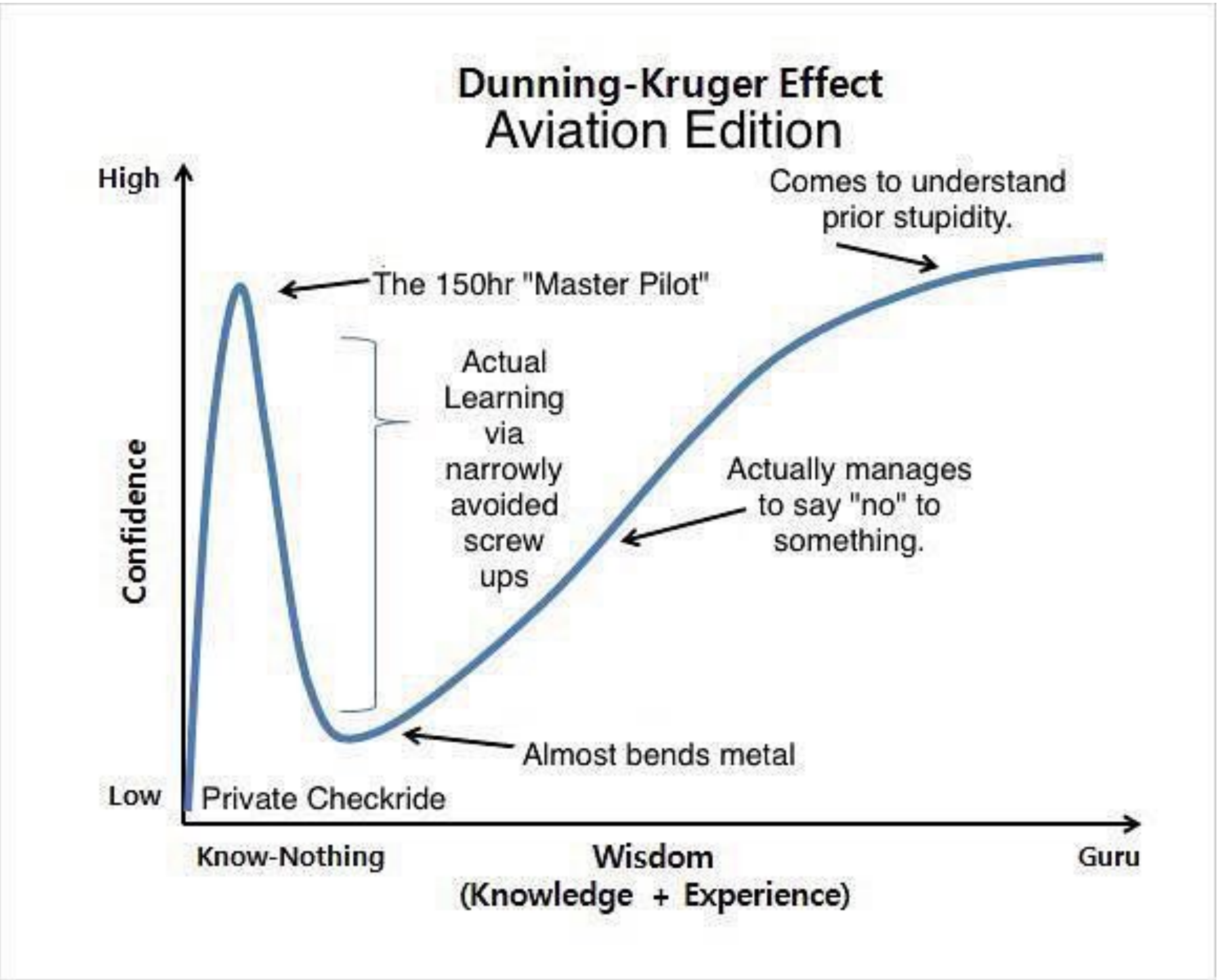
Don‘ts! Was man nicht tun sollte !

- **Entladene Akkus unterschätzen !**

  Entladene Akkus haben immer noch gefährlich hohes Spannungspotential und gefährlich hohe Kurzschlussströme!

- **Zellen nicht „mischen“ (Bauart, unterschiedliche Chemien, Alter, Ladezustände)**

Wie weit, wie hoch?



Entwicklung des Vertrauens in etwas Neues

„Kognitive Verzerrung“ (Dunning-Kruger-Effekt)

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

BADEN-WÜRTTEMBERGISCHER LUFTFAHRTVERBAND E.V.

Vielen Dank fürs Zuhören!

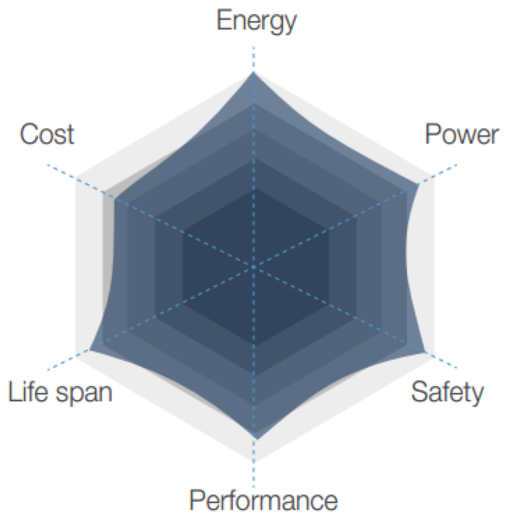
Fragen?

Wann sind Batterien am Ende

Lade-/Entladekapazität < 80% Messen!

Innenwiderstand doppelt so hoch wie im Neuzustand BMS, während des Ladevorgangs

Wie weit, wie hoch?



NMC + LFP+LTO (NANO)

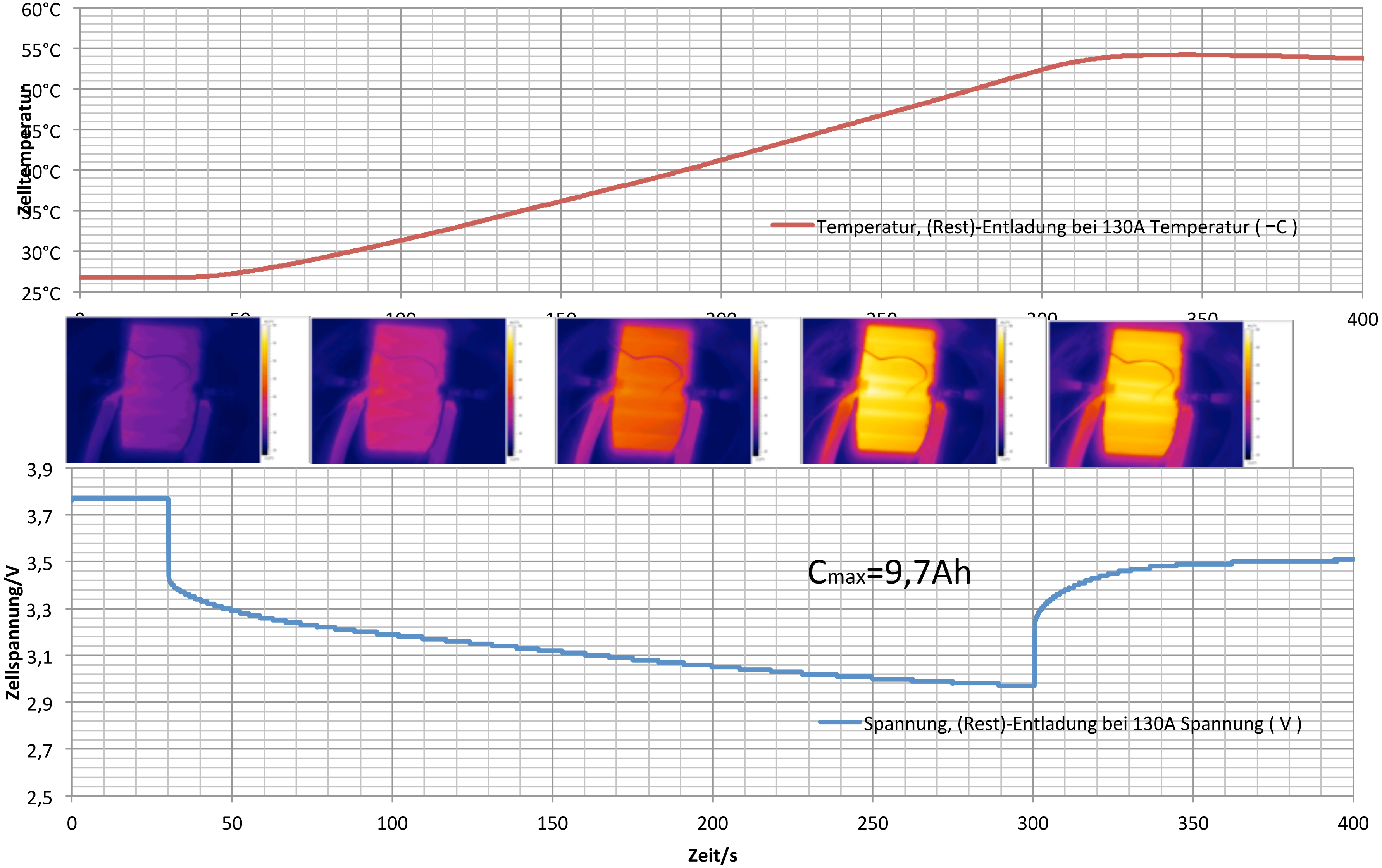
Advantages

- Specially designed for defense & aerospace application
- This hybrid type cell has incorporated the advantages of NMC, LFP and LTO cells in one cell. It is suitable for extremely volatile and dynamic operational conditions. The high power, energy and safety features allow the NANO cells to be flexibly applied in various applications.

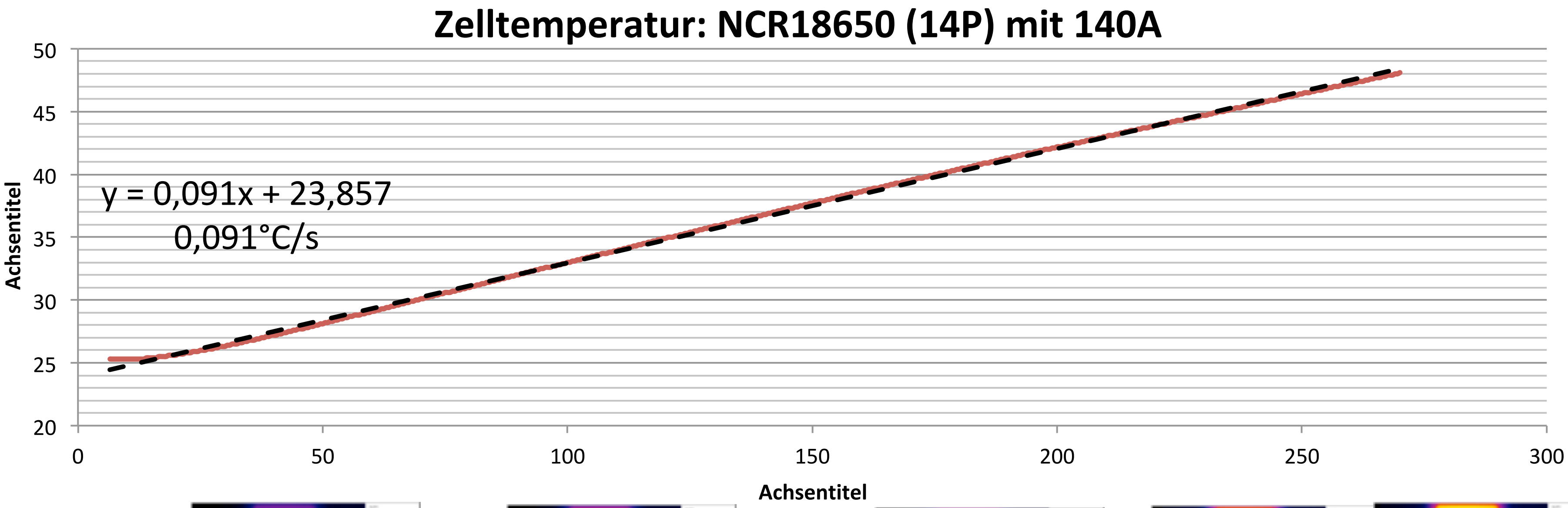

FEEDBACK
AGND
RS232
CAN BUS
X10
X1
M3
8
M2
6

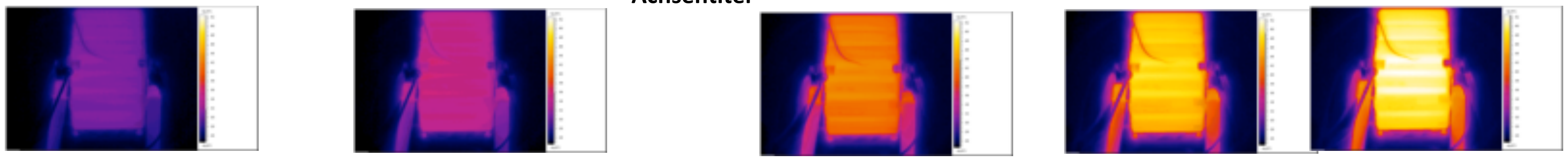
Entladeverhalten 130A ohne Kühlung

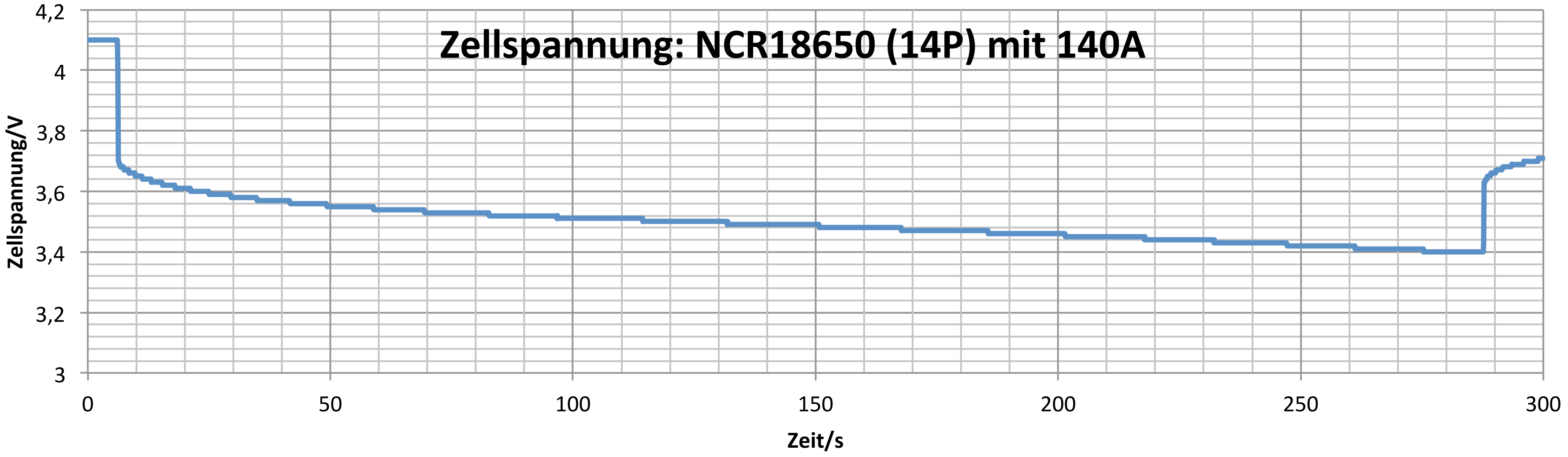
IR-Datei: S-12-08-01-130AOK30S

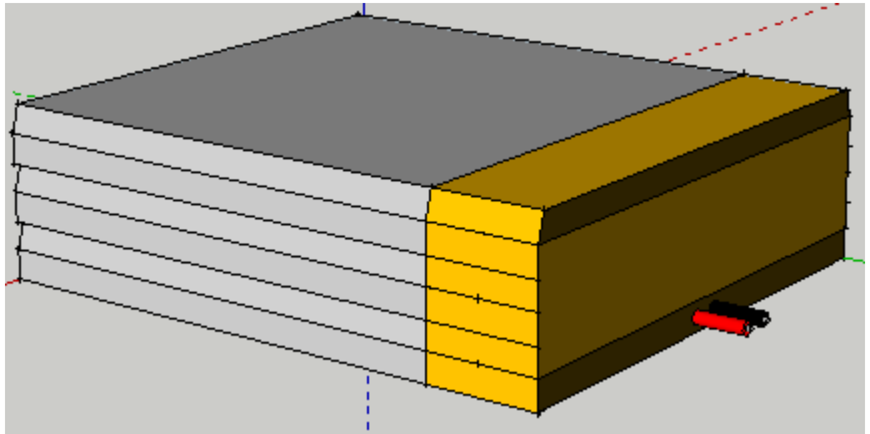


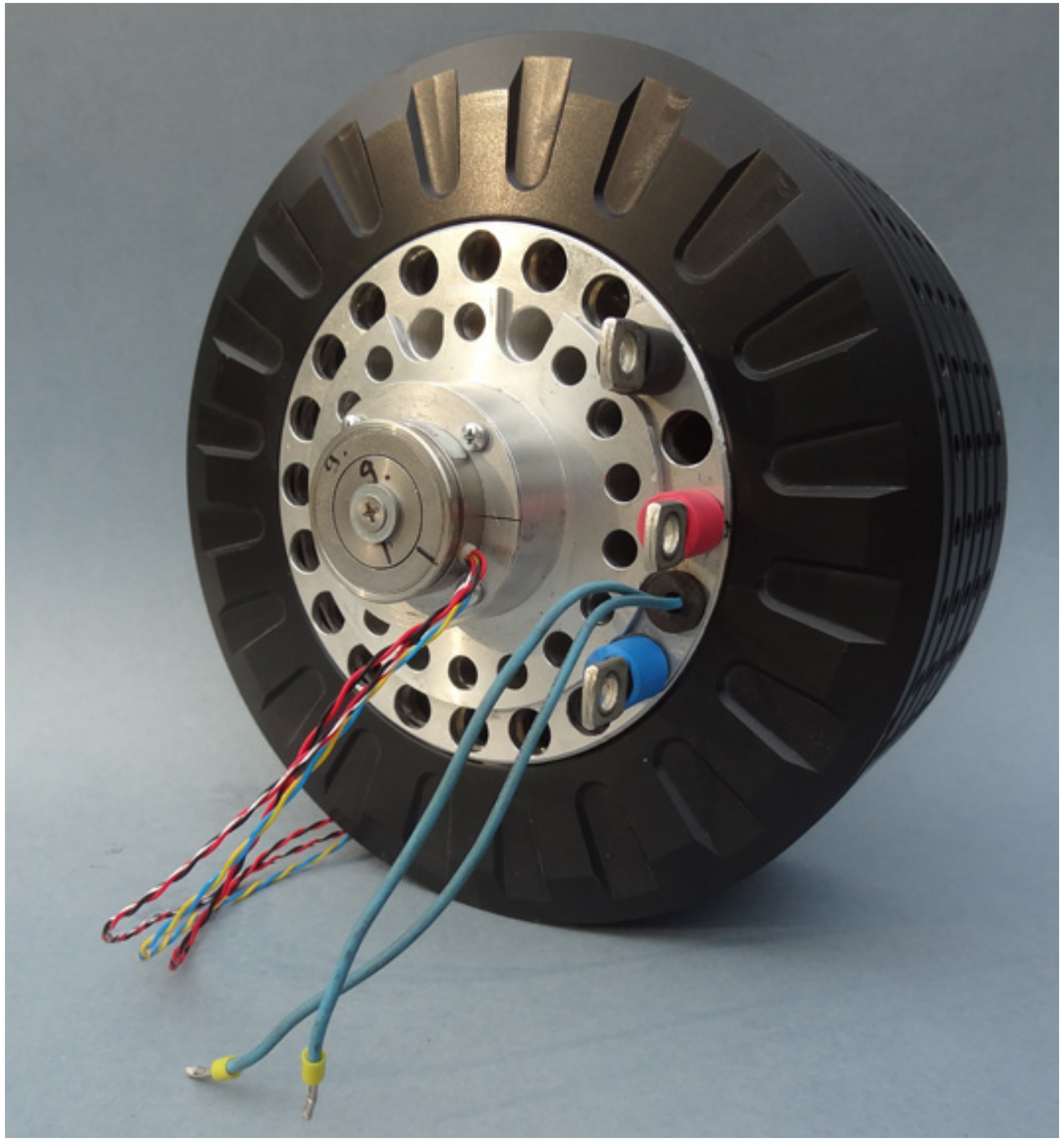
Entladung Panasonic NCR18650 (14P!) mit 140A

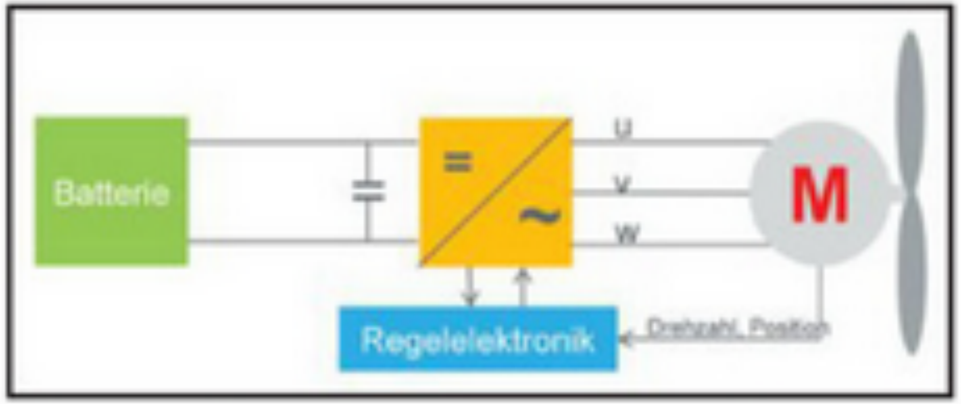











Batterie
=
~
U
V
W
M
Regelelektronik
Drehzahl, Position


Kokam
Great Power for Everyone
Kokam
Kokam
Kokam
Great Power for Everyone
Kokam
Great Power for Everyone

Farnborough House
Berkshire Copse Road
Aldershot, Hants GU11 2HH

Tel:01252 510300
Fax: 01252 376999
www.aaib.gov.uk

AAIB
Air Accidents Investigation Branch

AAIB Bulletin S3/2017
SPECIAL

ACCIDENT

Aircraft Type and Registration:	HPH Glasflugel 304 eS, G-GSGS
No & Type of Engines:	1 LZ Design D.O.O FES-HPH-M100 brushless electric motor
Year of Manufacture:	2016 (Serial no: 059-MS)
Location:	Parham Airfield, West Sussex
Date & Time (UTC):	10 August 2017 at 1121 hrs
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fire damage to FES batteries and FES battery compartment
Commander's Licence:	British Gliding Association Gliding Certificate
Commander's Age:	55 years
Commander's Flying Experience:	314 hours (of which 25 were on type) Last 90 days - 9 hours Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

Notification

At 1530 hrs on 10 August 2017, the Air Accidents Investigation Branch (AAIB) was notified of a battery fire occurrence involving an HPH Glasflugel 304 eS electric self-sustainer sailplane during landing at Parham Airfield, West Sussex. The occurrence was initially referred to the British Gliding Association (BGA) for investigation in accordance with an existing Memorandum of Understanding between the AAIB and the BGA for non-fatal gliding accidents. Having conducted an initial investigation, the BGA requested further assistance from the AAIB, resulting in the AAIB launching a Field Investigation on 21 August 2017.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

Figure 1

Fire in the FES battery compartment following the landing roll

Volumen der Rauchgase

Ca. 3500 Liter !

Je voller der Ladezstand, desto mehr Gasentwicklung

Gase sind brennbar, benötigen jedoch Luftsauerstoff um zu verbrennen!

Gase sind toxisch

Je geringer der Ladezustand, desto weniger dramatischer verlauf des „Runaway“

18650

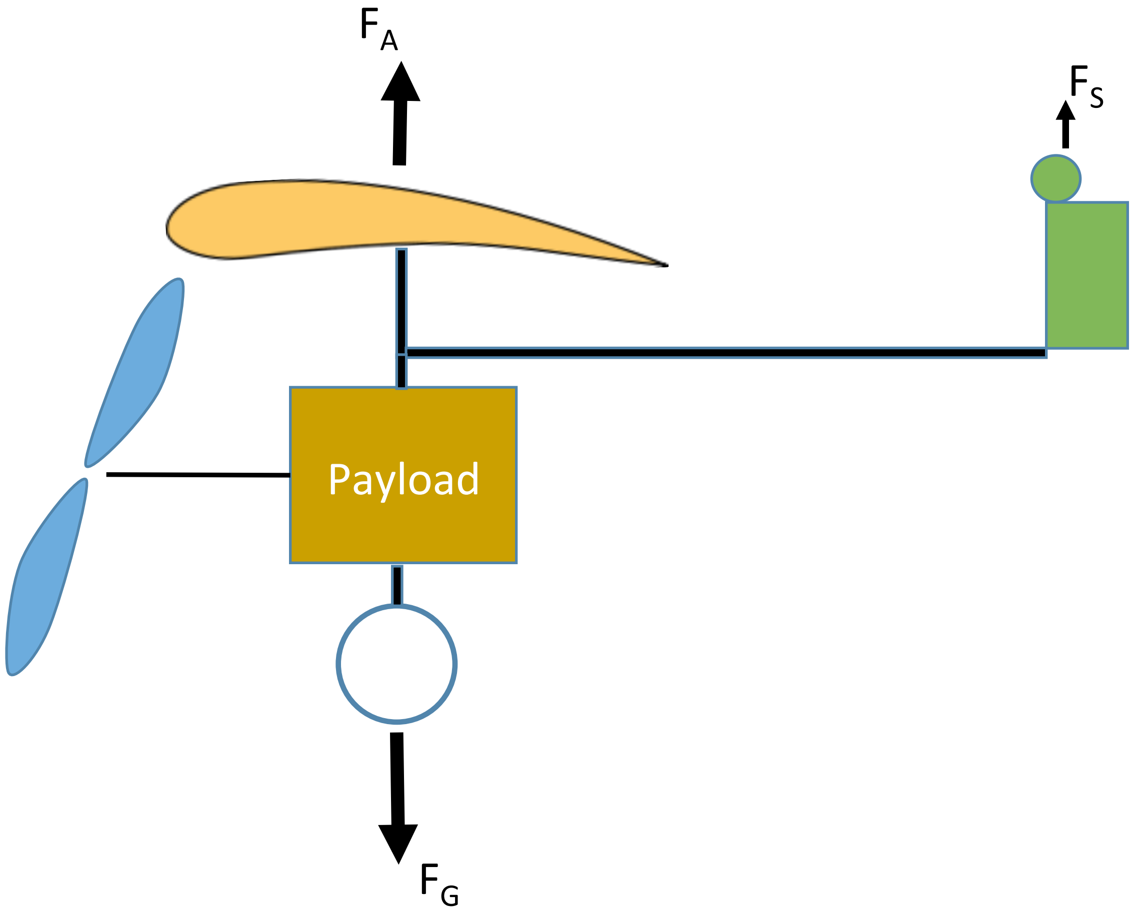
10 Wh/Zelle

Rauchgas ca. 8-10 Liter/Zelle

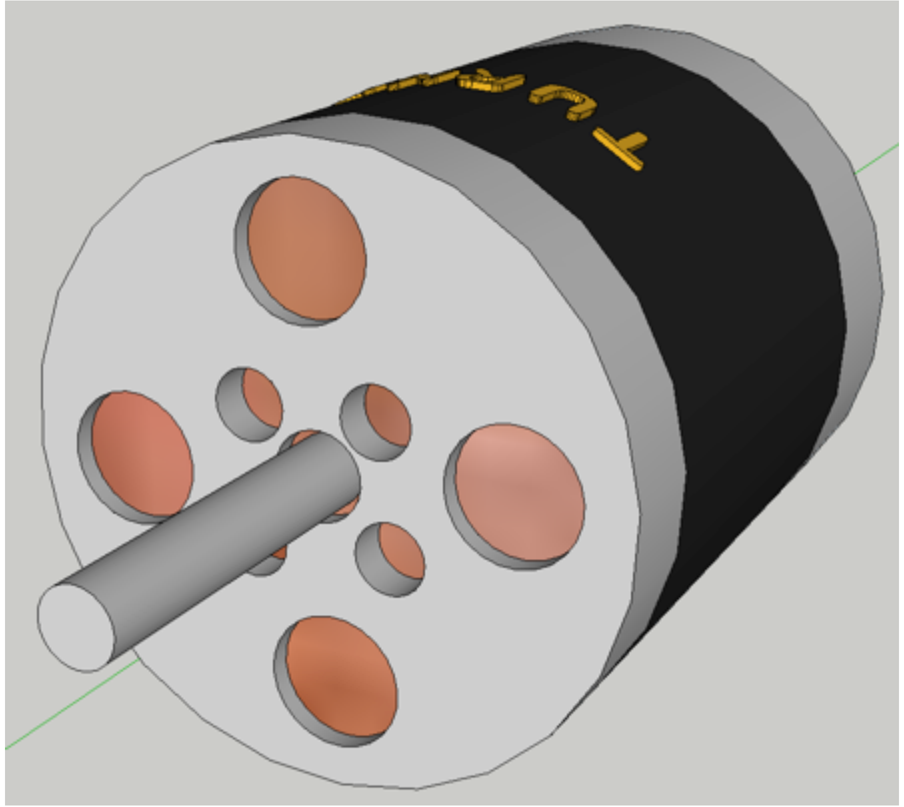
Ca. 1000 Liter Rauchgas/kWh (bei 100% SOC)

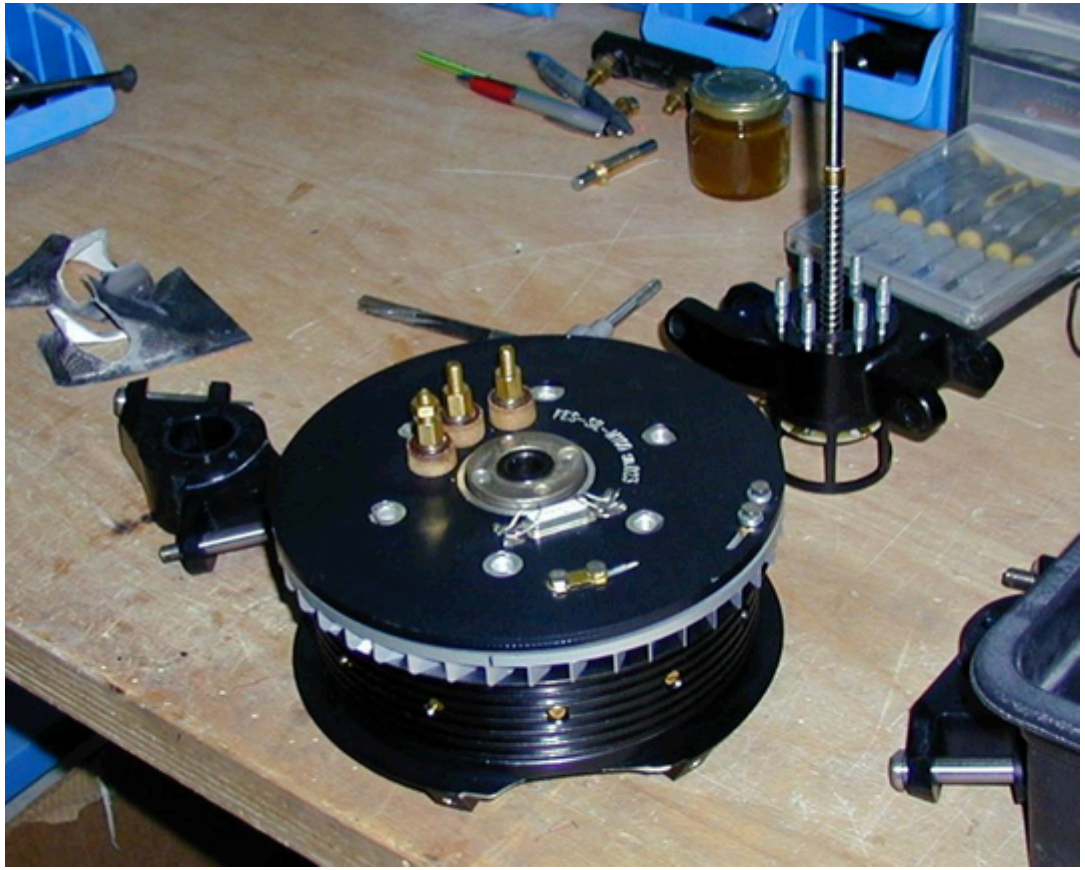
Ein Tragwerk alleine macht noch nicht glücklich!

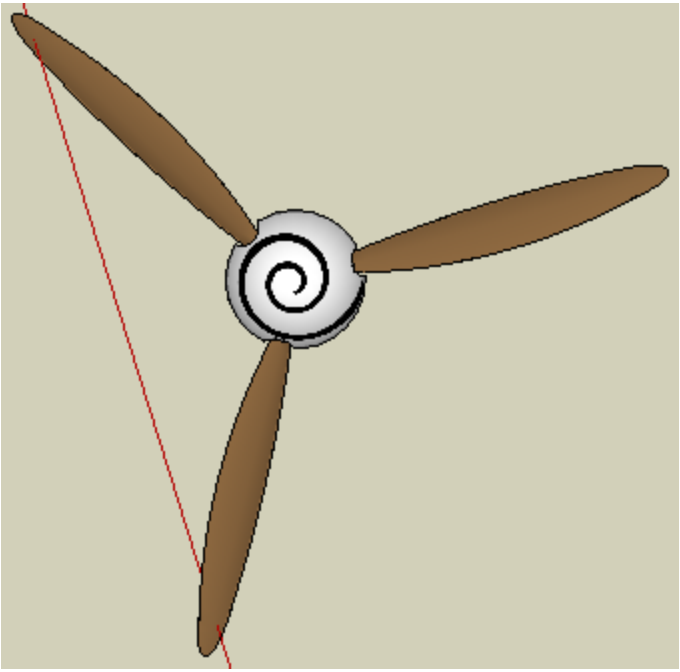
oder – **Wozu braucht ein Flugzeug ein Triebwerk?**

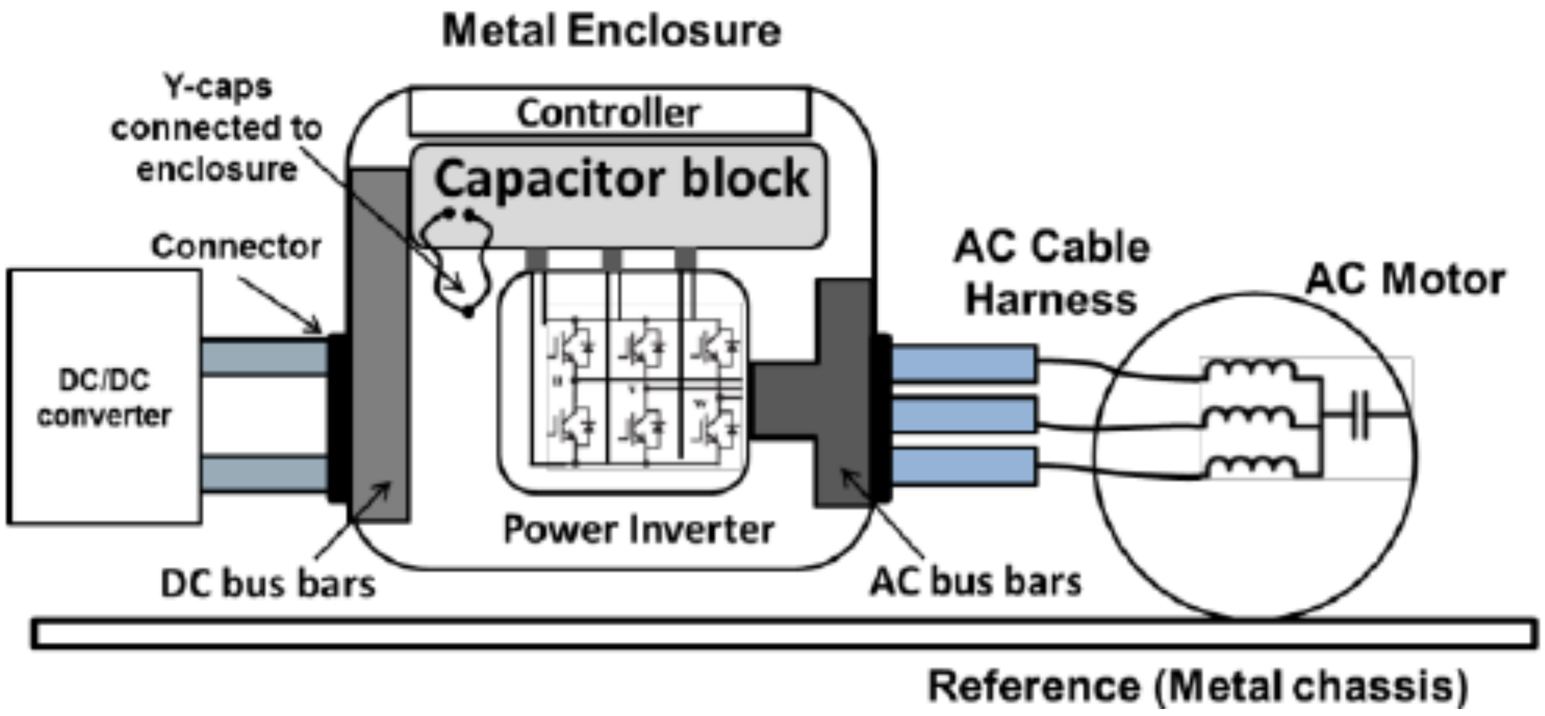


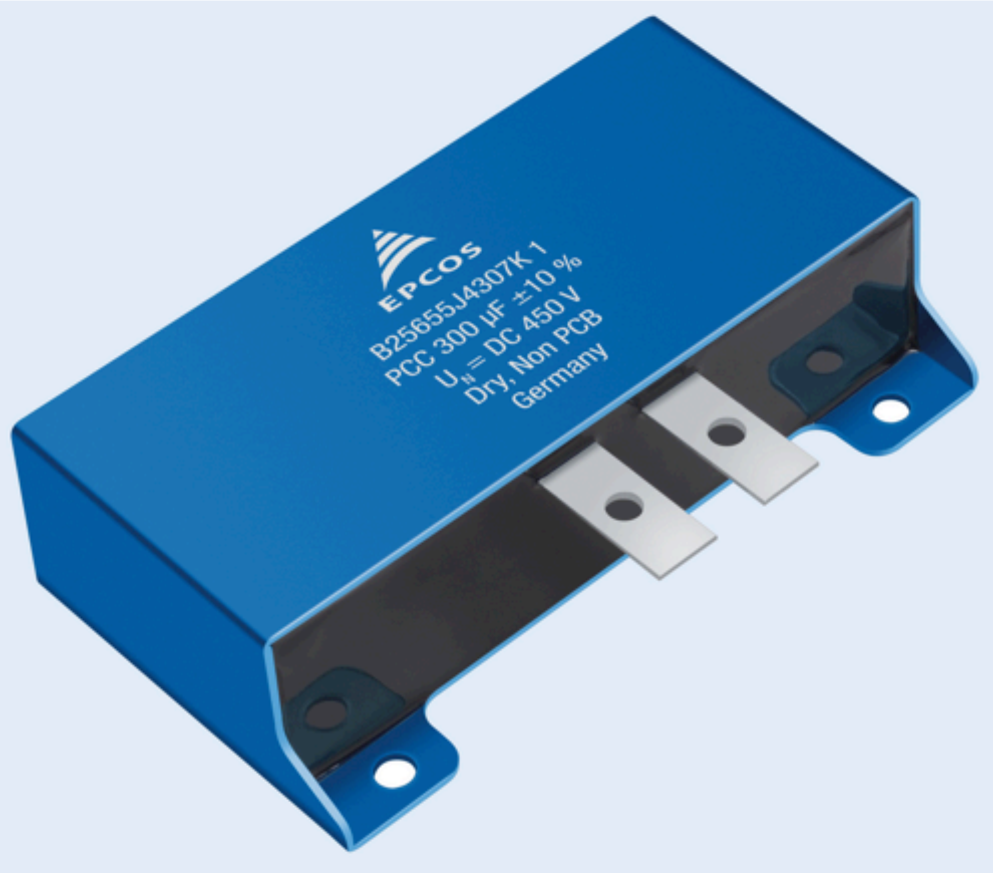

GP-12-300
★SOFT START 300W
POWER INVERTER
DC TO AC POWER SURGE 1000W
RoHS








Metal Enclosure
Y-caps
connected to
enclosure
Controller
Capacitor block
Connector
DC/DC
converter
AC Cable
Harness
AC Motor
Power Inverter
DC bus bars
AC bus bars
Reference (Metal chassis)


EPCOS
B25655J4307K 1
PCC 300 µF ±10 %
U_N = DC 450 V
Dry, Non PCB
Germany

Y-Kondenatoren

Kabel

Widerstand und Induktivität

Kabellängen

Nach DIN VDE nicht anwendbar Feste Verlegung und Dauerbetrieb

Kabelquerschnitte

1m (DIN, 95mm2) = 0,85 kg (nur Cu o. Isolierung)

Gewicht

1m (Daumen, 25mm2) = 0,22kg (nur Cu)

Gewicht proportional zum Querschnitt

1m (Daumen, 35mm2)= 0,31kg (nur Cu)

Abschalteinrichtungen

Sicherungen

Schalter, Schütze

Kontakte

Kontaktübergänge

Steckverbinder

Spannungslagen

IMD

Akkus richtig laden

Eine Wissenschaft für sich!

Das „richtige“ Ladegerät verwenden!

Geeignete Messinstrumente (zu erschwinglichen Preisen)

- Isolationstester z.B. UNI-T

- Zangenamperemeter