



New Prospects for Mechatronic Systems for Chassis and Engine Technology

8. Aachener Kolloquium Fahrzeug- und Motorentechnik 1999

5. Oktober 1999

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Examples of upcoming mechatronic systems

Chassis

- Electromechanic / Electrohydraulic Brakes
- Electromechanic / Electrohydraulic Power Steering
- Active Roll and Pitch Control
- Full Active Suspension (**A**ctive **B**ody **C**ontrol)

...

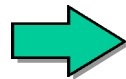
Engine

- Variable Valves (up to EMVS)
- Idle-Stop Function
- Exhaust Emissions Control
- Variable Fans and Pumps for Fuel, Coolant, Lubricant
- Belt-less Engine (esp. Electrical Air Conditioning)

...



Active Body Control in Mercedes CL



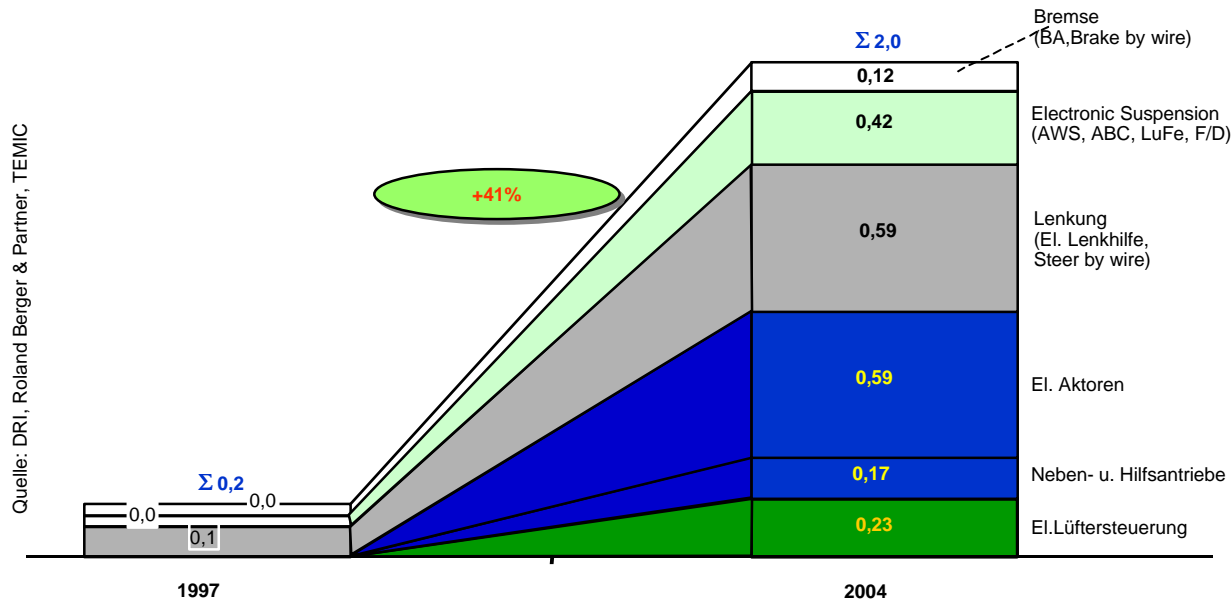
Superior Handling and Safety !!!

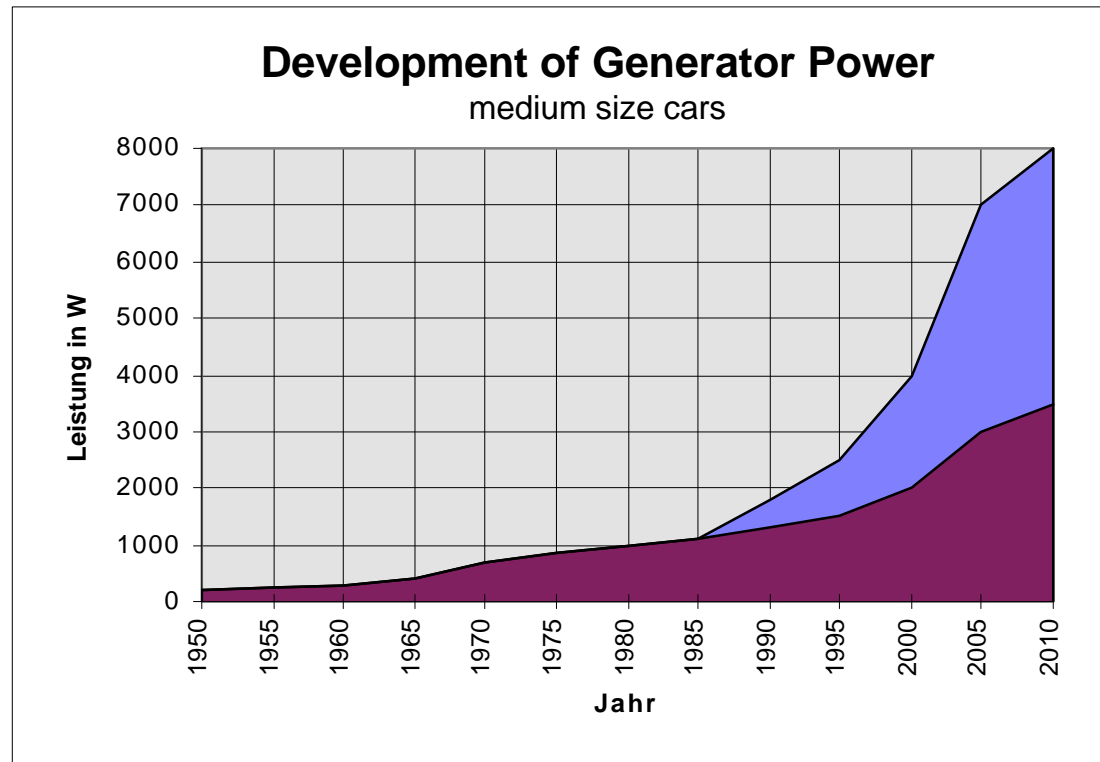


42V PowerNet

Electrical actuators and electrically driven auxiliaries will see a dynamic increase within the next years ($\geq 35\%/y$)

Market volume world wide [Mrd. DM]





- Former prognosis from 1985 for 2005 (1,4kW) already exceeded by far
- Steep increase predicted for the coming years
- Reason is substitution of (up to now) mechanically supplied power
- Wide range due to peak power from a lot of variants and extras
- 1948: “There will never be a need to go to higher voltages than 6V”



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Durchlaufende Systeme

Klassifikation	Anwendung	elektr. Leistung [W]	Dynamik	mittl. Einschaltdauer
Lüfter und Gebläse	Kühlerhauptlüfter	650 - 850	gering	gering .. hoch
	Innenraumgebläse	230	gering	gering .. mittel
	Sekundärluftpumpe	540	mittel	gering
Pumpen	Kühlwasserpumpe	800	gering	hoch
	Ölpumpe	800	mittel	hoch
	Scheibenreinigungspumpe	100	gering	gering
	Kraftstoffpumpe	150	mittel	mittel ... hoch
	Unterdruckversorgung	250	gering	gering...mittel

Positioniersysteme

Klassifikation	Anwendung	elektr. Leistung [W]	Dynamik	mittl. Einschaltdauer
Elektro-Mechanisch	Fensterheber	150	gering .. mittel	gering
	Schiebedach	120	gering	gering
	Sitz	80	gering	gering
	Lenkradsteller	45	gering	gering
	Spiegel	2	gering	gering
	Leuchtweite statisch	2	gering	gering
	Heckklappenschließer	120	gering	gering
	Türöffner	120	gering	gering
	Klimaklappensteller	10	gering	gering
	Elektr. Zentral-Verriegelung	5	gering	gering

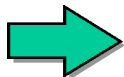
Dynamische Aktoren

Klassifikation	Anwendung	elektr. Leistung [W]	Dynamik	mittl. Einschaltdauer
Elektro-Hydraulisch	ABS-Rückförderpumpe	250	mittel	gering
	Elektr. Lenkhilfpumpe OCE	900	hoch	gering .. mittel
	Steller für Verdeckantrieb	330	gering	gering
	EH-Pumpe für AWS (2 Stück)	je 480	sehr hoch	gering ... hoch
	EH-Pumpe für ABC (4 Stück)	je 800	sehr hoch	gering ... hoch
	Handkraftaktor Sbw	tbd.	hoch	gering ...hoch
	Bbw-Aktor (4 Stück)	je 280	sehr hoch	gering...hoch
	Hydraulik-Prop.-Ventil	30	sehr hoch	gering ...hoch
Elektro-Pneumatisch	EPS Steuerventile	30	hoch	gering
Elektro-Mechanisch	EMVS	2400	sehr hoch	hoch
	Starter-Generator-Dämpfer ISAD	3500	hoch	hoch
	E-Gas-Steller	120	hoch	gering...mittel
	Leuchtweite dynamisch	150	mittel	gering...mittel
	Aktive Motorlager	tbd.	sehr hoch	hoch
	Autom. Kupplung	tbd.	mittel .. hoch	gering



Mechatronic systems require actuators :

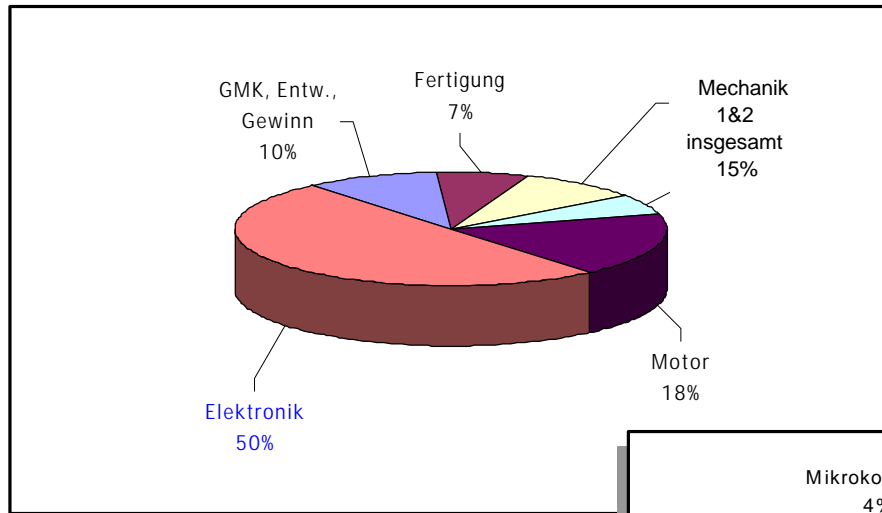
- **An increasing number of actuators will be used in a variety of systems**
- **Actuators will be critical for the realization of new functions and key buying factors**
- **The specifications for the actuators tend to more precisely controlled, more dynamic actuators**
- **Actuators need to be compact, lightweight, low noise, maintenance free, easy to control and simple to integrate and - of course - at lowest possible cost.**



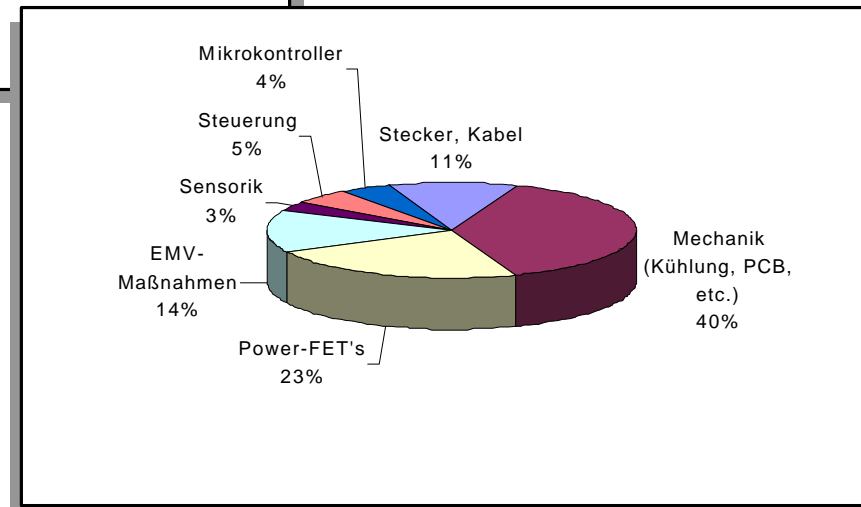
Mechatronic systems need a cost effective power supply and power electronics



Cost of a Typical Actuator System



Electronics only



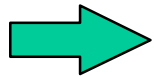


Generator power is small compared to engine power:

1 ... 3 %

but:

The peak engine power is rarely used; electrical peak power, however, comes not from the generator, but from the battery.

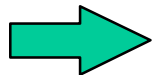


Energy consumption of the electrical system has been underestimated !

Equivalences:

100 W electrical power is equivalent to ca. 0,15 l/100km

i.e. a typical average power of 800W costs



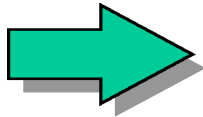
1,2 l/100km or ca. 14%



Definition of a New Electrical Power System

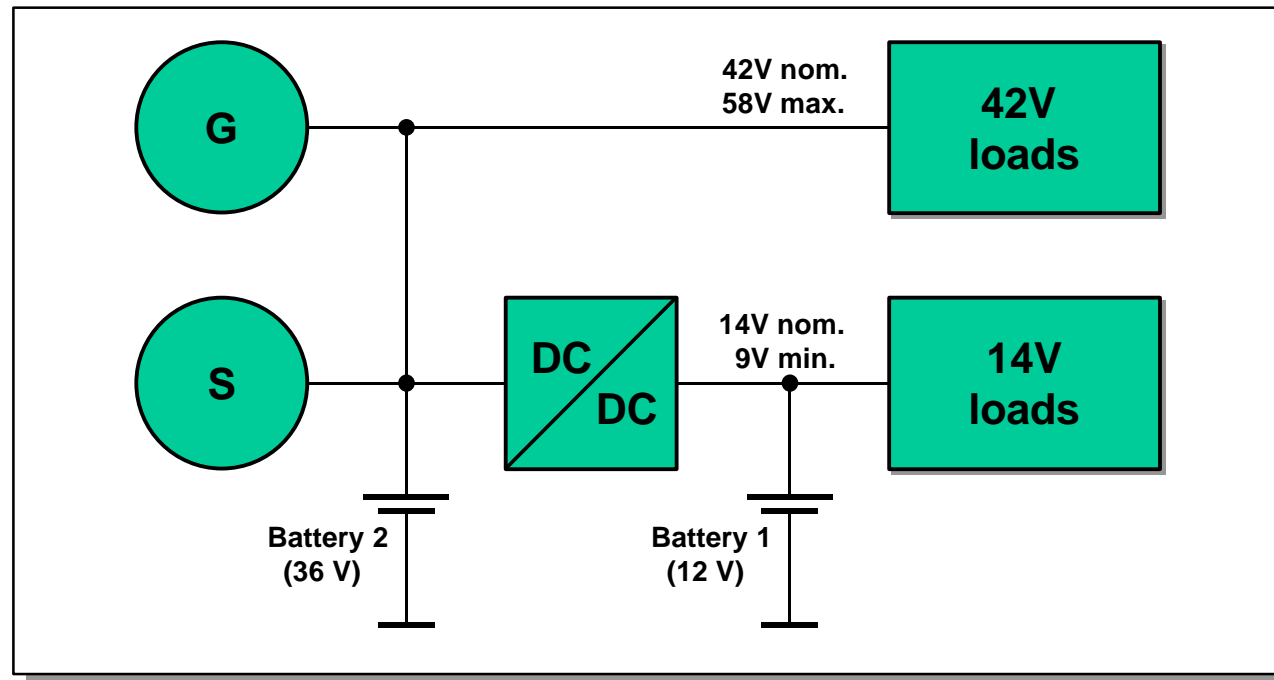
With the goals:

- High power capability
- adopted to the technological properties of power electronic components
- cost efficient
- high energy efficiency
- international acceptance in order to achieve high production volume



More information at <http://web.mit.edu/consortia/auto-consortium/articles.htm>

Basic Configuration of the 42V PowerNet



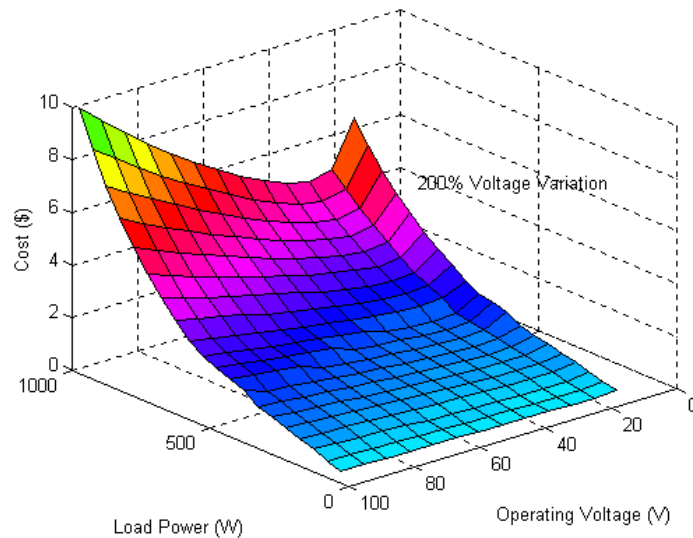
- High total efficiency
- significant reduction in cost of powerelectronics, higher technological power limit
- lower voltage tolerances upward and downward
- Improvement of supply quality through Smart Power instead of relais
- Improvement of starting reliability and supply reliability through 2 independent batteries



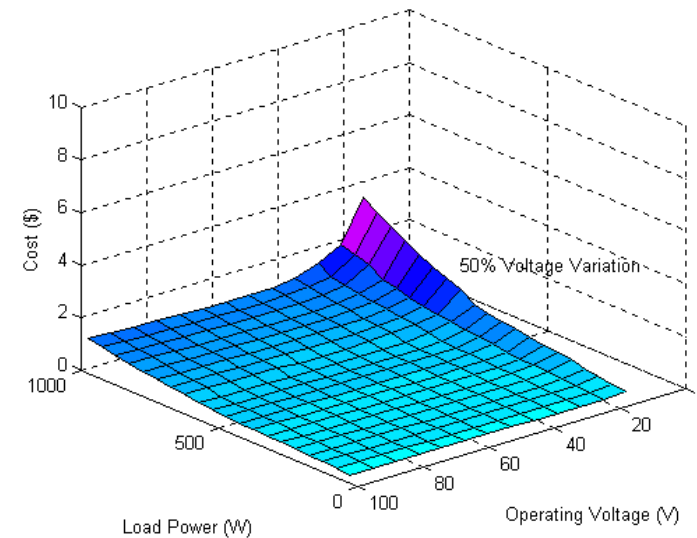
Selection of voltage level :

- Due to cable sizes and semiconductor cost as high as possible
- In batteries a high cell number (at 1,5 ... 3,5 V/cell) increases cost
- For shock hazard protection stay within limits given by standards:
 - VDE 0100/410, VDE 0800/1:
 - 60 V at DC
 - 25 V at 50 Hz
 - 55 V at 10 kHz
 - 70 V at 20 kHz
 - 80 V at 30 kHz
 - SAE J2232:
 - 65 V at DC
 - IEC (in preparation)
 - 55 V at DC ($\pm 10\%$)
- International standards are similar, but only limited applicability on vehicles (all rely on basic investigations in Germany, Austria and USA)
- Process of international standardization for vehicle voltages initialized

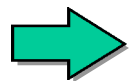
Influence of Operating Voltage and Switched Power on the cost of semiconductor switches



actual situation



possible



Voltage stability has significant effect on semiconductor cost

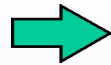
Data from PhD-thesis Dr. K. Afridi, MIT, 1998:
 "A Methodology for the Design and Evaluation of Advanced Automotive Electrical Power Systems"



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Research and Technology

Goal: International Standardization of High Power Electrical Systems



Cooperation in Consortia

USA

since 1994

“42V PowerNet”

**Consortium on Advanced
Automotive Electrical / Electronic
Components and Systems,
Prof. Kassakian, MIT:**

**Audi, BMW, DaimlerChrysler, Ford,
General Motors, Honda, Peugeot,
Renault, Toyota, Volvo**

**AMP, Bosch, Delphi, Dow, Eaton,
ISAD, Johnson Electric, Magneti Marelli,
Motorola, Siemens, Infineon,
United Technologies, Yazaki, ...**



Europe

since 1995

“42V - Bordnetz”

**Forum Bordnetz,
Prof. Ehlers, Fa. SICAN:**

**Audi, BMW, DaimlerChrysler,
Ford, MAN, Opel, Porsche,
VW, Fiat, Peugeot, Renault**

**Bosch, Conti, DAUG, Delphi,
Harting, Hella, Infineon, ITT,
Kostal, Lucas, Philips, SGS,
Siemens, Valeo, VDO, Varta**

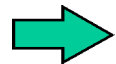
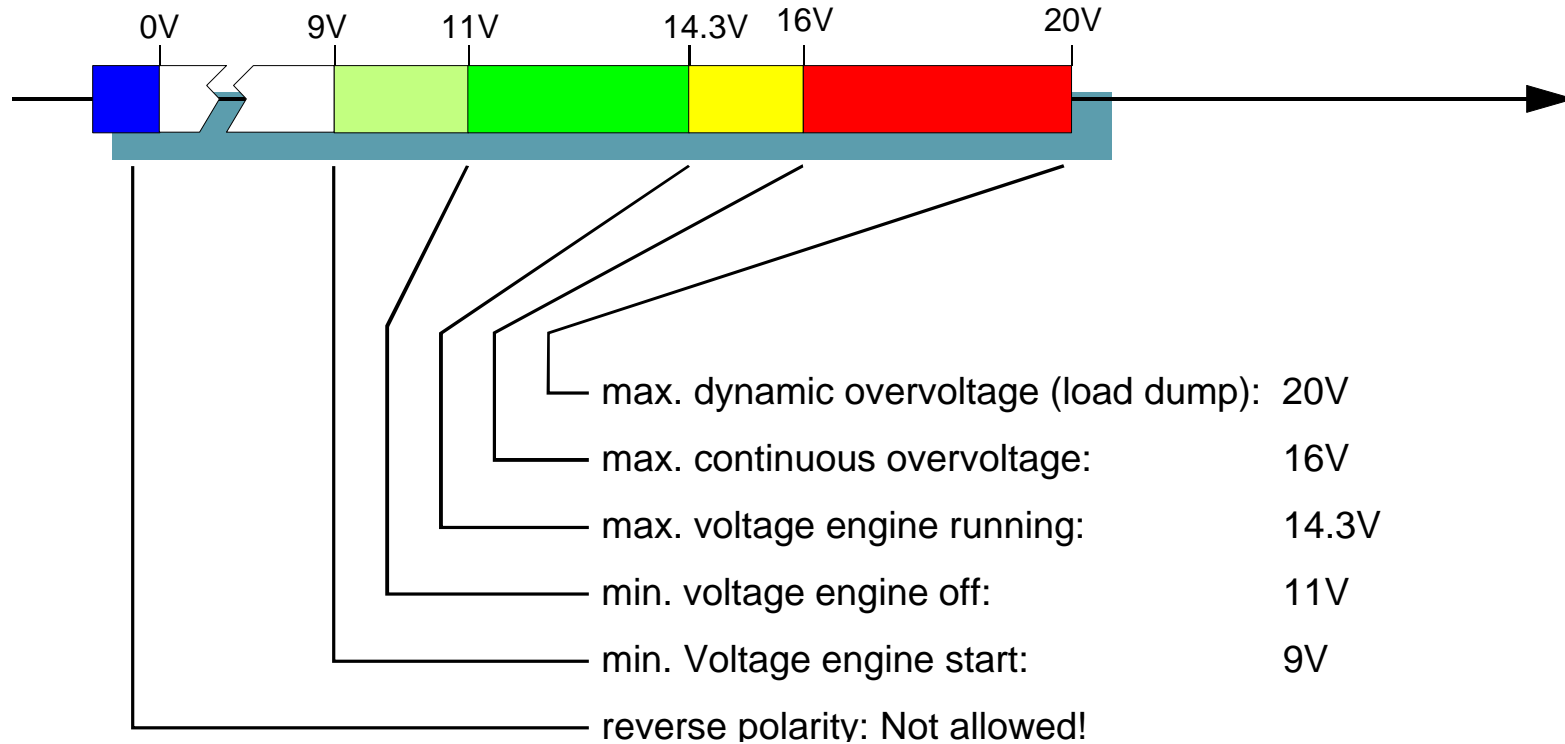


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14V - Level:

(preliminary specification)



- **Lowest voltage (no longer 6 V) 20% higher**
- **highest voltage (no longer ca. 40V) 150% lower**

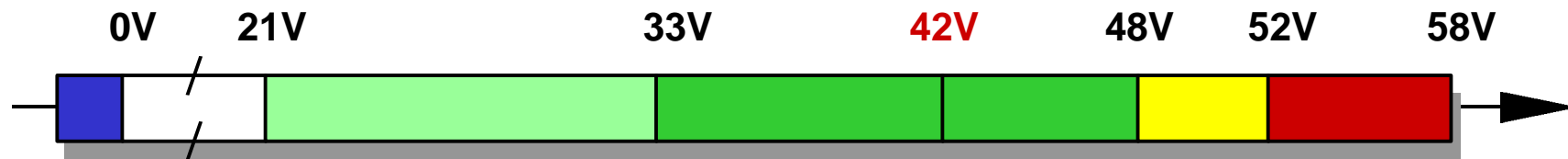


42V PowerNet








Research and Technology

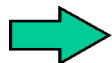
42V - Level:

(preliminary specification)



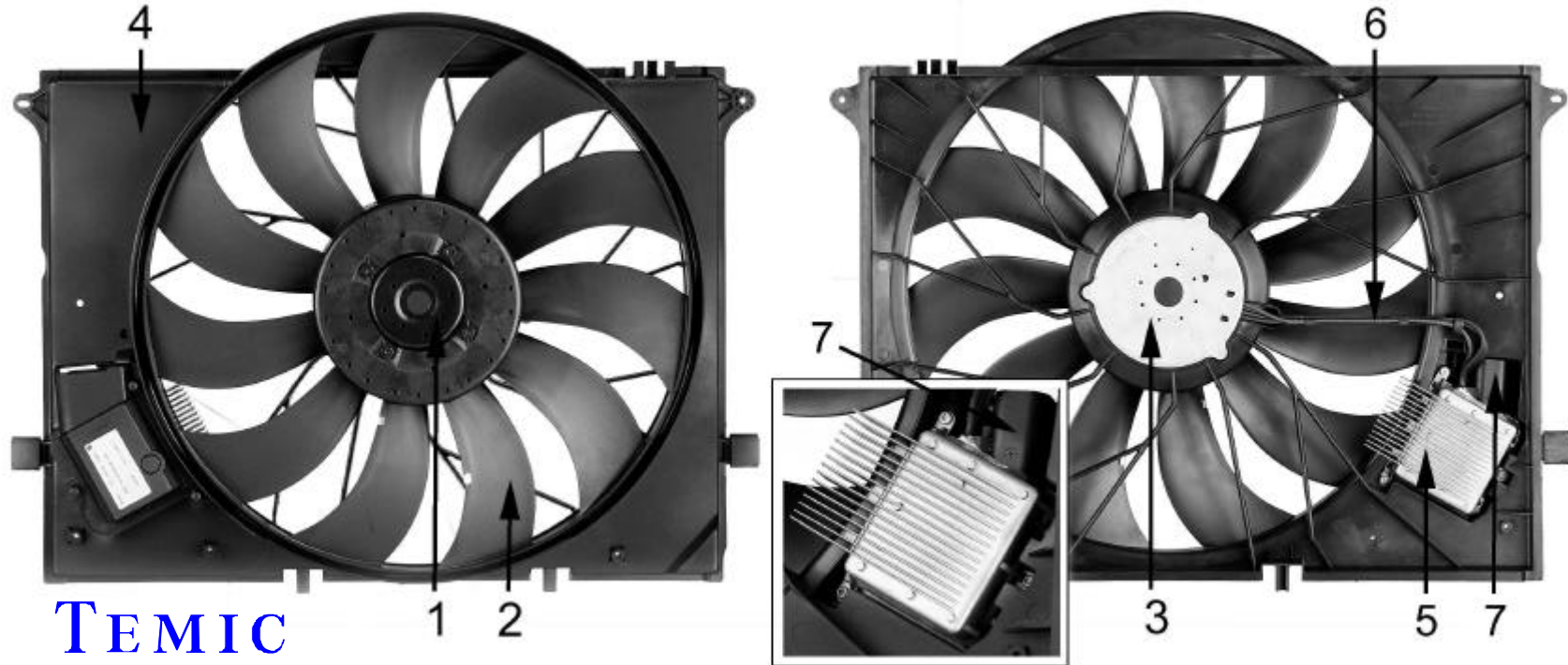
42V

	max. dynamic overvoltage (load dump)	58V
	max. continuous voltage	52V
	max. voltage engine running (effective)	48V
	nominal voltage	42V
	min. operating voltage	33V
	min. dynamic voltage (engine start)	21V (18V)
	reverse polarity: only small values will be allowed !	

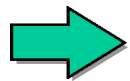


- Existing semiconductor technology applicable
- No decentralized reversed voltage protection necessary

EC (electronically commutated) Motor Cooling Fan for S-class, 600W / 850W electrical power



TEMIC



Conversion to 42V allows savings >15% of total system cost

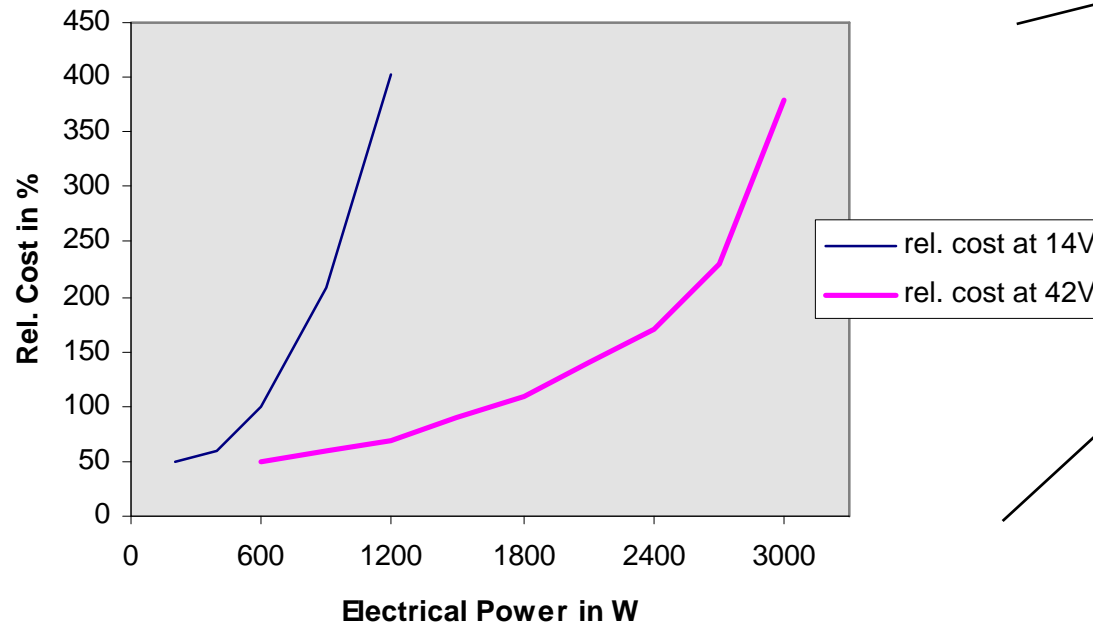


42V PowerNet

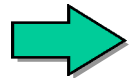
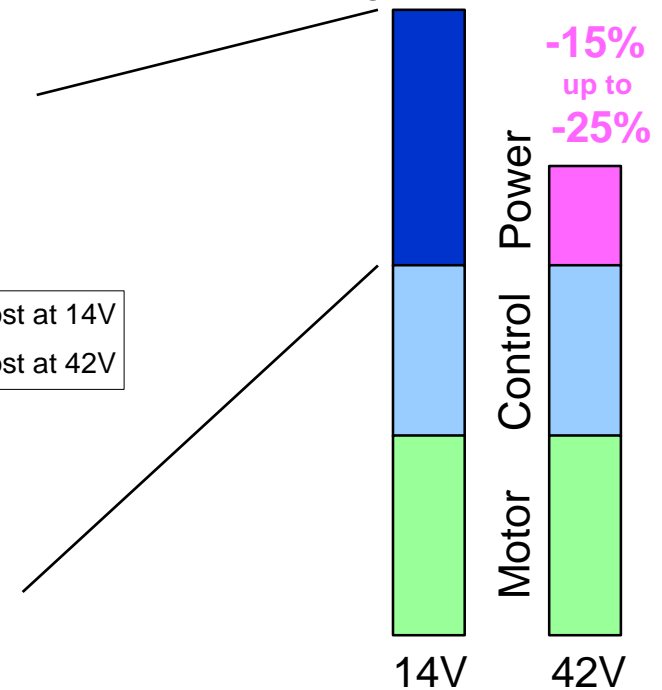
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Relative Cost of Power Dependant Components in Electronic Motor Controllers

(these are 50% of total electronics cost at 600W, 14V)

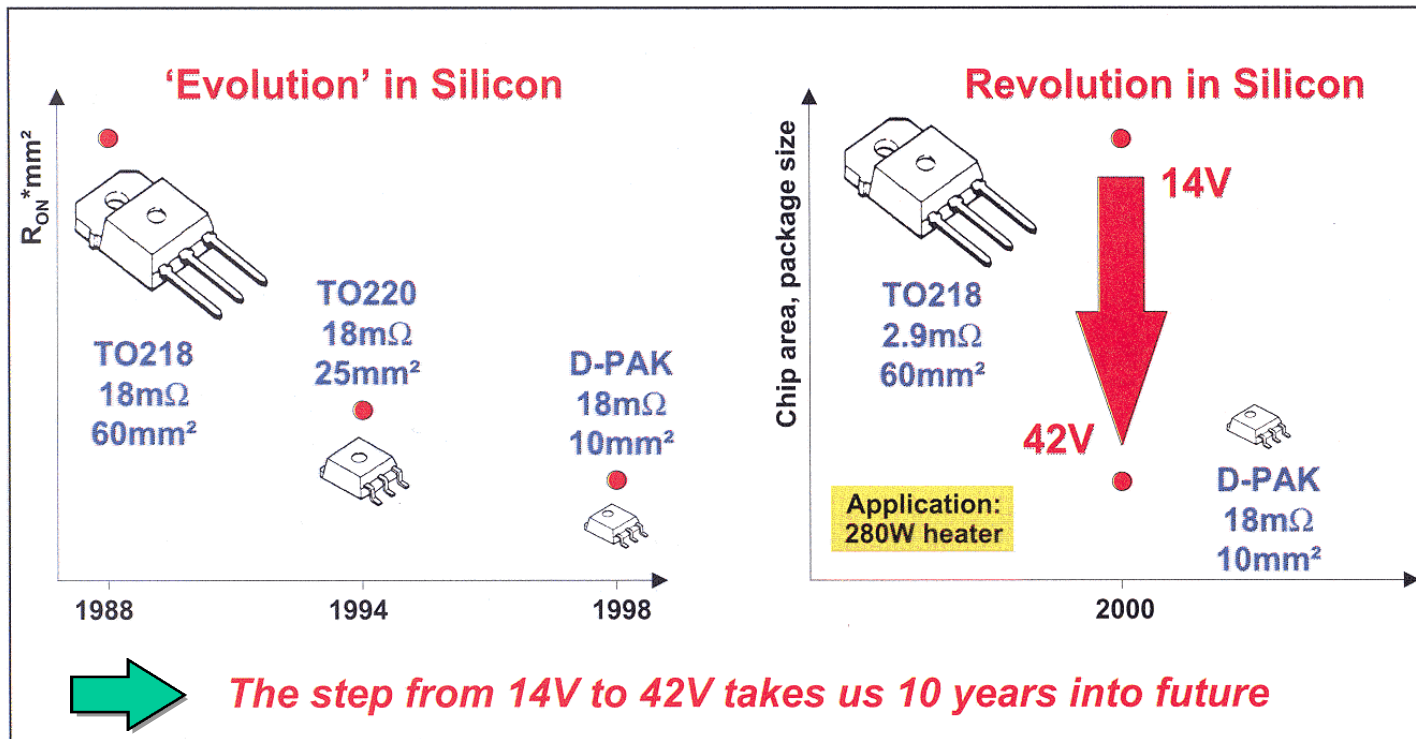


Example:
Material cost of high power EC Fan



- At high power very significant cost reductions with 42V
- Economic feasibility moves from 1kW up to 3kW at 42V

Results of Conference „42V PowerNet: the first solutions“ September 28 / 29, 1999

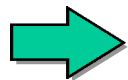


Graphic by
Infineon



Main Results of Conference „42V PowerNet: the first solutions“ September 28 / 29, 1999

- 10 years leap in semiconductor development through 42V
- increased alternator power of 6kW with 75% efficiency possible
- key components (fuses, semiconductors, batteries) all are, or will soon be, available
- wire harness: savings of 3 to 5kg (only cables) in vehicle with existing loads; connector savings are significant
- dc-motors: no significant effect in size or cost, but $\approx 600W$ limitation goes up by factor of 3
- dc/dc converter cost around 50EUR per kW



several car manufacturers declare: *42V is unavoidable !!*
introduction schemes is main focus now

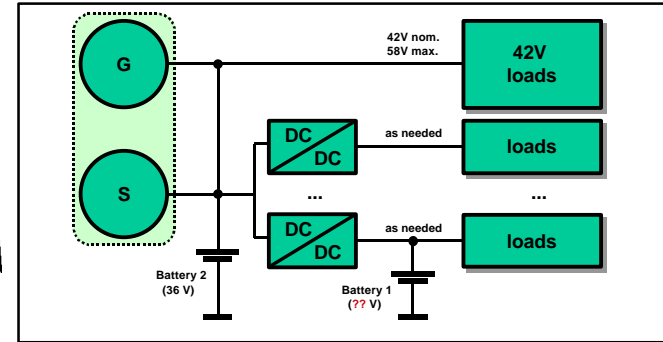
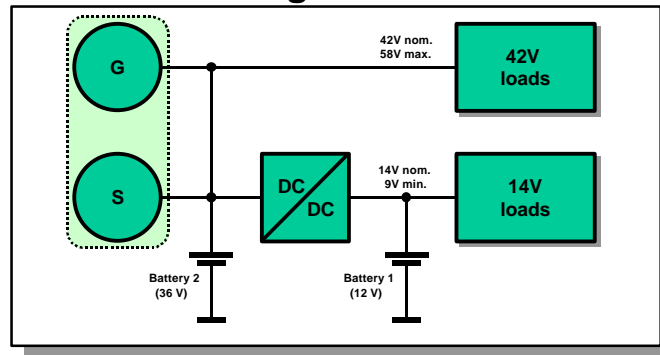


42V PowerNet

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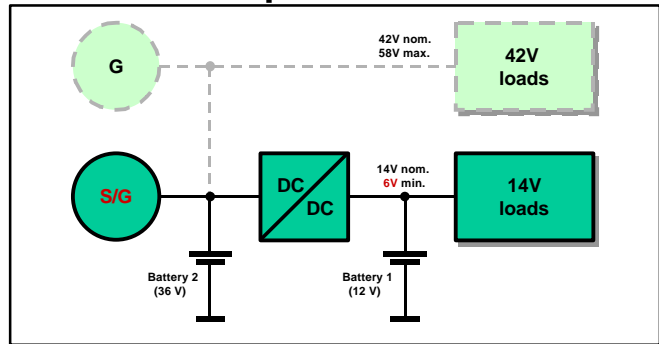
Introduction scenarios

Full Dual Voltage PowerNet

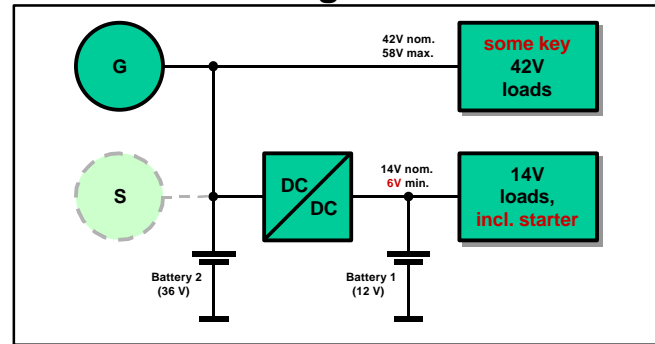


Distributed Conversion PowerNet

Small Idle-Stop Vehicle



Large Comfort Vehicle



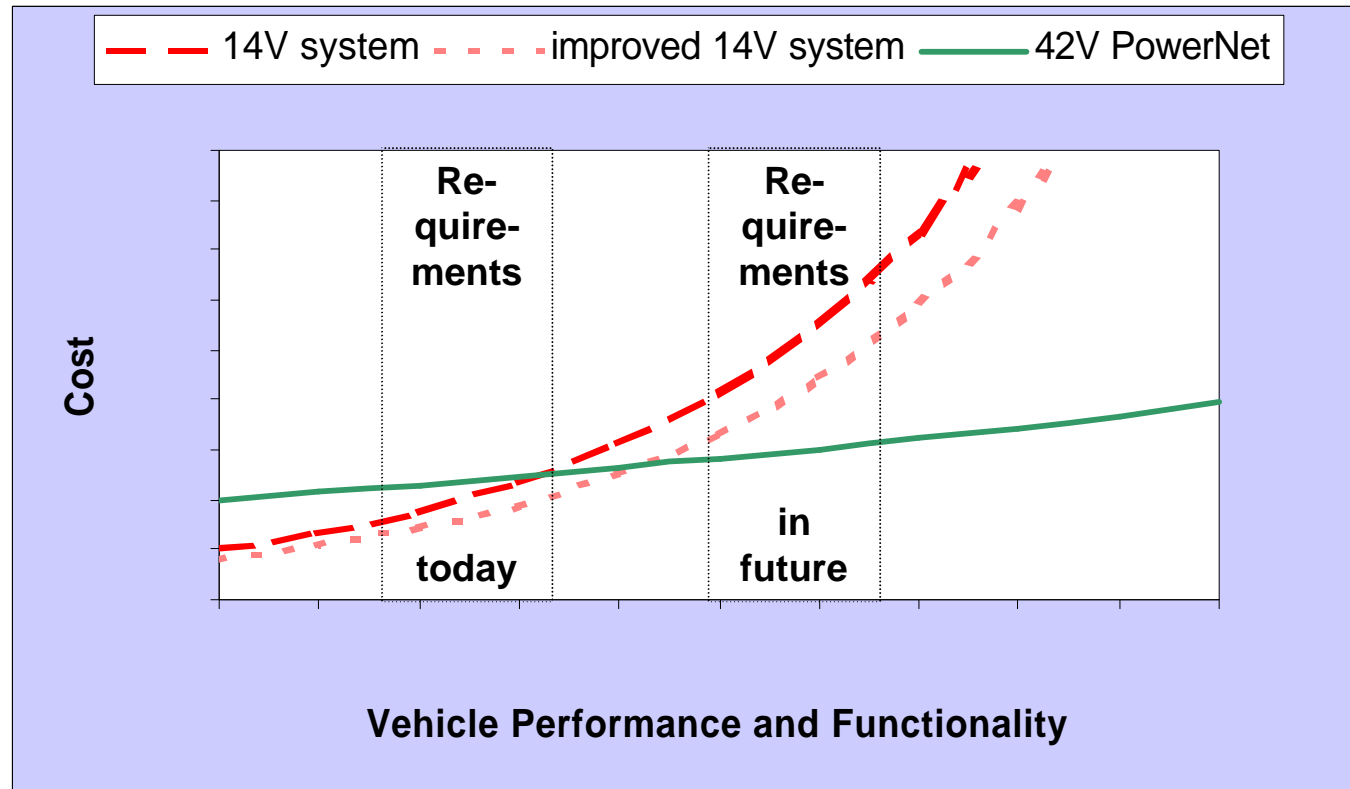


Further Results of Conference „42V PowerNet: the first solutions“ September 28 / 29, 1999

- Thermal management of power electronics and power connectors is much less problematic and less costly
- printed circuits OK for 42V,
with 9% larger intertrack distances
- 14V lamps driven with pwm 1:9 is possible
- Jump Start solutions are available
- 42V Specs designed to reduce EMI
(reduce / avoid pollution at the source)
- more than 50% of loads should be moved to 42V for cost effectiveness



42V PowerNet



Cost of electrical system (qualitatively) as a function of vehicle performance



What is still coming up ?

- Further international standardization (reverse polarity, EMI, battery connectors)
- Optimization of configuration and migration options (depends on loads)
- Redesign of components (semiconductors, capacitors, batteries, fuses ...)
- "Distribution" of cost of implementation
- First vehicles with 42V PowerNet expected in the years 2003 to 2005





Loads which need 42V

- Alternators larger than 3kW
- Heated Windscreen
- PTC Passenger Compartment Heater

- Motor Fan >800W
- Variable Water Pump
- Electric Air Conditioning
- Idle-Stop-Function (large engines)
- Integrated Starter Alternator
- Electromagnetic Valves
- Exhaust Emissions Control

- Brake-by-Wire
- Electric Power Steering (medium and large cars)
- Active Body Control

Loads with significant savings at 42V

- Alternator
- Decentralized DC/DC-Converters
- Multiplexed Systems / Smart Fuses / Diagnosis
- Heated Backlite (rear window defroster)
- Seat Heaters

- Heating / Ventilation / Air-Conditioning (variable fans)
- Idle-Stop Function (small engines)

- Smart Actuators
- Electrohydraulic Brakes
- Electric Power Steering (small cars)
- Active Roll Control