Introduction

- 42V and the influence on semiconductors
- Door module solution today
- Power window and door lock at 42V
- Mixed 14V/42V door module
- Single 42V door module
- Conclusion
Effects of 42V PowerNet on Silicon

Conditions:
P_{\text{load}} = \text{const.}
P_{\text{loss}} = \text{const.}
V_{\text{max}} = V_N + 30\text{V}

Conductance $\sim 1/V_N$

Specific $R_{\text{ON}} \sim e^{c(V_N+30\text{V})}$

Resulting silicon area

Nominal Supply Voltage $V_N$ [V] vs. Conductance, Silicon Area [%] vs. Specific $R_{\text{ON}}$ [%]
Cost Saving Potential for Power Applications

PROFET

14V

20A

280W

TO218

PV=1.7W

RON=2.9mΩ

dramatic cost reduction: chip area + package + mounting

calculation at Tj=100°C

PROFET

42V

6.5A

280W

D-PAK

PV=1.1W

RON=18mΩ

Semiconductors for AUTOMOTIVE SOLUTIONS
Cost Saving Potential for Power Window

TRILITHIC
Smart Power Bridges

Parameters of Power-Pack:
- $P_v = 100\%$
- $R_{ON} = 50\, m\Omega$
- $R_{thJ\_Air} = 21\, K/W$
- $R_{thJ\_Case} = 0.5\, K/W$

14V:
- $P_v = 22\%$
- $R_{ON} = 100\, m\Omega$
- Parameters of P-DSO-28:
  - $R_{thJ\_Air} = 60\, K/W$
  - $R_{thJ\_Pin} = 20\, K/W$

42V:
- $P_v : 100\%$
- $R_{ON} = 50\, m\Omega$

Parameters of P-DSO-28:
- $R_{thJ\_Air} = 60\, K/W$
- $R_{thJ\_Pin} = 20\, K/W$

Dramatic cost reduction:
chip area + package + mounting

14V:
- $I_L = 20/40\, A$

42V:
- $I_L = 6.6/13\, A$
Construction of a Today’s 14V Door Module

Inputs:
different Switches

Outputs:
H-Bridges (window, lock)
half-Bridges (Mirror)
highside Driver (Heating)

Control:
Microcontroller
BUS-Interface

Supply:
Voltage Regulator

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Infineon Products for Today’s 14V Door Modules

- Integrated H-bridges for power window and door lock motors.
- Integrated 3 fold half bridges with SPI control for mirror
- Smart power HS-switch for mirror heating
- Bus-driver for CAN
- Intelligent voltage regulator for supply
Infineon Products for Today’s 14V Door Modules

Semiconductors for AUTOMOTIVE SOLUTIONS
## Load Currents for 14V and 42V Door Actuators

<table>
<thead>
<tr>
<th></th>
<th>14V</th>
<th>42V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>contin. / peak</td>
<td>I (A)</td>
</tr>
<tr>
<td>Mirror heating</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Mirror adjust</td>
<td>0.15 / 0.25</td>
<td>0.05 / 0.1</td>
</tr>
<tr>
<td>Door lock</td>
<td>0.2 / 2</td>
<td>0.1 / 0.7</td>
</tr>
<tr>
<td>Power window</td>
<td>9 / 35</td>
<td>3 / 11</td>
</tr>
</tbody>
</table>
Alternatives of 42V Door Module System

Supply:

14V  42V
1A  3A

Actuators, Loads:

14V  42V

1A linear
0.1A linear
0.1A linear

42V
DC/DC or PWM

14V  42V  42V
0.2-1A 0.1A 0.1A

5V  5V  5V

Semiconductors for AUTOMOTIVE SOLUTIONS
Realization of a mixed 14V/42V-Module with existing Semiconductors and Actuators

<table>
<thead>
<tr>
<th>Actuator</th>
<th>Actuator Supply (V)</th>
<th>Supply (V)</th>
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<tbody>
<tr>
<td>Mirror heating</td>
<td>42</td>
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<td>14</td>
<td>14</td>
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<tr>
<td>Door lock</td>
<td>14 PWM</td>
<td>42</td>
</tr>
<tr>
<td>Power window</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Can bus</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Voltage regulator</td>
<td>5</td>
<td>14</td>
</tr>
</tbody>
</table>
Available 42V Semiconductors in different Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Product-family</th>
<th>Concept</th>
<th>Application</th>
<th>Time Schedule ES / Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPT4/90</td>
<td>Smart Power ICs</td>
<td>SPT4/90</td>
<td>Gasoline Direct Injection V_{Nom} = 70V / 42V / 24V</td>
<td>9/98 TLE customized</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V_{AZ} &gt; 80V</td>
<td>Truck Applications</td>
<td>6/00 TLE 6361 5+3.3+2.5V</td>
</tr>
<tr>
<td>S-SMART/80</td>
<td>Smart Power Switches</td>
<td>V_{Br} &gt; 80V</td>
<td>Truck ABS / TRC / VDC V_{Nom} = 42V / 24V</td>
<td>6/98 BSP 365 5Ω</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V_{AZ} &gt; 65V</td>
<td>High Current Switches</td>
<td>9/99 BSP 752R 200 mΩ</td>
</tr>
<tr>
<td>S-FET2/75</td>
<td>FET / TEMPFET</td>
<td>S-FET2/75</td>
<td>Starter-Generator V_{Nom} = 42V / 24V</td>
<td>9/98 BTS 723 2* 95 mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V_{Br} &gt; 75V</td>
<td>DC / DC Converter</td>
<td>2/00 BTS 6163D 16 mΩ</td>
</tr>
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<td></td>
<td>10/98 BTS 660P 9 mΩ</td>
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<td>open BTS 560P 4 mΩ</td>
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<td>open BTS 282Z-7 8.0 mΩ</td>
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<td></td>
<td>11/99 SPP 80N08S2 8.0 mΩ</td>
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<td>9/99 SIPC 49S2N08 4.0 mΩ</td>
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Realization of a H-bridge for 42V Power Window with existing Semiconductors

Discrete realization with double highside switch and two standard MOSFETs
Protection against over-temperature, short circuit to GND and short of load

DC Current 3A / 11A

BTS723
Package P-DS014
R_{DSON} = 2*95mΩ
V_{BB(AZ)} ≥ 65V

SPD 28N05
Package: DPAk
R_{DSON}: 26mΩ
V_{DS(BR)} ≥ 55V

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Realization of a H-bridge for 42V PWM Door Lock with existing Semiconductors

Discrete realization with double highside switch and two standard MOSFETs and PWM
Protection against over-temperature, short circuit to GND and short of load

PWM Current 0.15A / 2A, >3kHz

Semiconductors for AUTOMOTIVE SOLUTIONS
Comparison between the Door Lock Currents at 14V DC and 42V PWM Supply Voltage

14V door lock motor at 14V DC

- Inrush current: 2A, 4ms
- Complete locking cycle: 2A, 500ms

14V door lock motor at 42V PWM

- Inrush current: 2A, 4ms
- Complete locking cycle: 2A, 500ms

PWM: >3kHz
Realization of a mixed 14V/42V-Module with existing Semiconductors and Actuators

Only power window and mirror heating is realized as a 42V actuator.

The 14V door lock motor is driven with PWM on 42V supply.

All other loads are still driven with 14V.

No cooling!
Realization of a mixed 14V/42V-Module with existing Semiconductors and Actuators
Realization of a mixed 14V/42V-Module with existing Semiconductors and Actuators

See demonstration setup at booth #7400, Michigan Hall
### Realization of a mixed 14V/42V-Module with existing Semiconductors and Actuators

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Realization of a 42V-Module with mixed 14V/42V Actuators

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42V Door Module with mixed 14V/42V Actuators and new designed 42V Semiconductors

- **Switch mode Power Supply** multiple outputs
- **Power Window integrated H-bridge**.
- **Anti-trap Protection 42V**
- **Mirror Heating 42V switch**
- **Mirror 3 integrated half-bridges with PWM**
- **Central Locking integrated H-bridge with PWM**
- **Mirror Heating 42V switch**
- **Bus System**
- **Logic Supply with a step down converter**

**SAE 2000**
24V PowerNet
SAE 2000
42V door, Page 22

**Semiconductors for AUTOMOTIVE SOLUTIONS**

A. Graf, AI AP I
42V Door Module exclusively with 42V Actuators and new designed 42V Semiconductors

All loads are designed for 42V
All semiconductors are optimized for this operation
Chip integration shows cost savings

Semiconductors for AUTOMOTIVE SOLUTIONS
Door Module exclusively with 42V Actuators and optimized 42V Semiconductors (Vision)

- **Anti-trap Protection**: 42V
- **Central Locking**: integrated H-bridge 800-1400mΩ / path
- **Mirror Heating**: 42V single Switch 1Ω in PDSO14
- **Window**: integrated H-bridge 80-150mΩ / path
- **Logic & Protect**
- **Power Supply**: multiple outputs
- **Logic & Protect**
- **Mirror**: 3 integrated half-bridges path resistance e.g. 5Ω
- **PDSO14**
- **Bus-Transceiver**: with 42V supply
A Door Module’s Road From 14V To 42V viewed by semiconductor content and partitioning

- Standard devices
- Cooling necessary

14 V chip set

- Application specific
- No cooling

42 V

Now integration of all functions saves costs

Semiconductors for AUTOMOTIVE SOLUTIONS

A. Graf, AI AP I
A Door Module’s Road From 14V To 42V
viewed by semiconductor content and partitioning

- 14V chip set
  - no cooling
  - not optimized, available today

- 42V application specific
  - no cooling
  - now integration of all functions saves costs

<table>
<thead>
<tr>
<th>Costs</th>
<th>Mounting Area</th>
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<tbody>
<tr>
<td>100</td>
<td>70</td>
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<tr>
<td>80</td>
<td>50</td>
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<tr>
<td>50</td>
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Conclusion

- With 42V there is a dramatic cost reduction of power electronics for power window
- A mixed 14V/42V door module can be realized with existing mass semiconductors and actuators
- If at least the actuators for power window, door lock and mirror heating are designed for 42V, a monolithic door module electronic is feasible