Semiconductors – enablers of future mobility concepts

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NXP Semiconductors

High Performance Mixed Signal and Standard Product solutions that leverage our leading RF, Analog, Power Management, Interface, Security and Digital Processing expertise

- **Employee base:**
  - ~25,000 employees in more than 25 countries
  - R&D in Europe, US, and Asia
  - Manufacturing in Asia and Europe

- **Net sales:** $4.2 B in 2011

- **Leader in mixed-signal Auto Semiconductors**
  - #3 China
  - #1 Car Infotainment
  - #1 In Vehicle Networks
  - #1 Car Access & Immobilization
  - #1 Automotive Small Signal Discretes & Logic
'Green Driving' ...?
A sustainable and profitable business:

‘Consumers deeply desire new products ... and are excited about their use!’

Hypothesis:

‘Growth in Electromobility comes from focus on new segments rather than conventional cars with electric drivetrains’

Examples:
- Different mobility (car-sharing etc.)
- Different and emotional cars (the ‘i’- generation)
- User groups with direct economic benefit (city pizza service)
(Hybrid) Electric Vehicles are not new …

Lohner Porsche Mixte, 1902:
Serial Hybrid series car with combustion engine and 2 electric motors in the front wheels

General Motors EV1, 1996
Pure Electric car with Lead acid battery

… facing disadvantages vs. combustion engine vehicles:
• range limitations (insufficient storage)
• no charging infrastructure
• high cost for limited additional value

No consumer traction
Why will (Hybrid) Electric Vehicles be inevitable this time?

- Global Climate
- Global Crisis & Oil Resources
- Urban congestion
- Advanced Technology

![Graph showing average annual crude oil prices](chart.png)
(Hybrid) Electric Vehicles are not new …

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➔ Technology (storage, power, efficiency)
➔ Consumer focus (connected mobility)
Electromobility – a significant growth opportunity for the semiconductor industry

- Today‘s market of automotive semiconductors:
  ~ 23 billion US$ (~8 % of total semiconductors market)

- Semiconductors content of electric drivetrain >2x of conventional powertrain

  Semiconductor $ per conventional vehicle
  2011: 250-300 US$
  2020: 400-450 US$

  Semiconductor $ per electric vehicle
  2011: ~900 US$
  2020: ~750 US$
Semiconductors & Electromobility … win - win!

Semiconductors enabling consumer acceptance

‘Connected Mobility’

- Digital consumer and mobile technologies for new services
- Mastering range anxiety
- Ensuring security in the grid
- Enhancing driver experience

Electromobility driving new semiconductor technology

‘More than Moore’

- High power ICs for the electric drivetrain (including safety isolation)
- Maximize energy efficiency of the conventional electronic system
Connected Mobility
Enabling new services

802.11p
LF, UHF

Cellular
NFC

Cellular

NFC

802.11p
Connected Mobility
Telematics to master range anxiety

- EVs want to be charged whenever they are parked
- Knowing infrastructure locations (Charge Spots) is not enough
- Important is to know the next available Charge Spot
- Connectivity is required for online checks
- ...and reservation
- ......authentication
- ............metering and billing
- ............roaming
Critical mass market factors for telematics:
- enabler of new business models
- small form factor and low cost
- automotive grade
- easy programmability
- privacy protection / security

NXP ATOP ramped up to mass production in 2011
Connected Mobility
Security in the grid

- Enabled by security against hacking and fraud:
  - localizing the charging station,
  - booking,
  - battery swapping
  - (pre-)paying / billing
Connected Mobility
Enhancing driver experience ... examples

- Uninterrupted entertainment in hybrid cars for start-stop systems – NXP first to supply complete portfolio of 6V capable amplifiers

- Driver information vs. driver distraction?
  Need advice on most economical driving and not excessive data (learn from Smart Phone)
Semiconductors & Electromobility … win - win!

Semiconductors enabling consumer acceptance

• 'Connected Mobility'
  - Digital consumer and mobile technologies for new services
  - Mastering range anxiety
  - Ensuring security in the grid
  - Enhancing driver experience

Electromobility driving new semiconductor technology

• 'More than Moore'
  - High power ICs for the electric drivetrain (including safety isolation)
  - Maximize energy efficiency of the conventional electronic system
The (Hybrid) Electrical Vehicle … driving new semiconductors technology

1) **High power** ICs (including safety isolation)

2) **Maximize energy efficiency** of the conventional electronic system
From ‘Moore’ . . .

Baseline CMOS: CPU, Memory, Logic

Transistors Per Die

10^10
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^-1

1K 4K 16K 64K 256K 1M 4M 16M 64M 256M 128M 1G 2G 4G

Moore: Miniaturization

130nm
90nm
65nm
45nm
32nm
22nm

Information Processing
From ‘Moore’ to ‘More-than-Moore’ … a new trajectory in Semiconductor technology

Baseline CMOS: CPU, Memory, Logic

More than Moore: Enrichment
- Analog/RF
- High Voltage
- Power
- Sensors
- Actuators

Sense, Interact, Power-up

Information Processing

Moore: Miniaturization

Information
Processing

Transistors Per Die

10^10

1965 Actual Data
MOS Arrays
MOS Logic 1975 Actual Data
1975 Projection
Memory
Microprocessor
Application map for power devices

Drain to Source Voltage $V_{DS}$ (V)

Low voltage  Medium voltage  High voltage

Drain Current $I_D$ (A)

Low current  Medium current  High current

NEW POWER technologies: GaN, SiC, ...

Computing

Automotive

Hybrid & EV

Consumer

Industrial

- Start-stop systems
- EPS
- ABS
- Solenoids
- Pump relays
- VRM
- PM IC switches
- DC/DC converters
- RF-PA basestations
- Engine control
- Solenoid drive
- Lamps
- Relay switching
- Wiper motor
- Transmission
- Water pump
- Airbags
- Inverter drive
- Ignition systems
- Auxiliary systems in HEV
  (heating, fans)
- Engine cooling
- EPS, step-down DC/DC
- Discharge lamp
- Discharge/Boosting
- Inverters
  full HEV & EV
- Inverters
  mild HEV
- Charger
  HEV
- Solar inverters
  Industrial appl
  UPS
- Servers
  PC
  Power PFC
- Power supply
  PFC
  notebook
  mobiles
- Power supply
  lighting
The (Hybrid) Electrical Vehicle … driving new semiconductor technology
Electric drivetrain requires high power and safety isolation

- All HV components need to be fully isolated from the car body network

TJA1052i
Isolated CAN Transceiver

- High Voltage Safety and Signal integrity
  - 3.75 kV (RMS) rated Galvanic Isolation
  - IEC61010-1 CAT II, 5kV rated voltage
  - IEC60950, CAT II, 6kV rated voltage
  - ± 8kV (IEC) ESD handling on the bus pins

- 3-chip Multi-Chip Module
  - Integrates TJA1049 CAN transceiver with 2 Capacitive Isolator chips
  - High transient immunity
  - Low EM emission and high EM immunity
  - Very fast isolator
  - Loop Delay < 220ns

- NXP Automotive Quality
  - AEC-Q100
The (Hybrid) Electrical Vehicle ... driving new semiconductor technology
Maximize energy efficiency of the existing conventional electronic system

- **Partial Networking** *(Audi, BMW, Daimler, Porsche, VW - Auto Electronics Conference in LB, June 2011)*

Ricky Hudi, managing E/E director at Audi:

“Audi and Volkswagen corporations have started to introduce Partial Networking into the next generation of car models.”
The (Hybrid) Electrical Vehicle … driving new semiconductor technology
Maximize energy efficiency of the existing conventional electronic system

- **Partial Networking:** Aug. 2011 NXP launches industry first ISO compliant ICs (NWP ISO 11898-6)

**With Partial Networking:**
- ECU on
- ECU off
- Only selected ECUs are 'on'

**Power savings ~ 100 W**
**Emission savings 2.6g CO₂/km ≡ 247 € in 2015**
The (Hybrid) Electrical Vehicle … driving new semiconductor technology
Maximize energy efficiency of the existing conventional electronic system

- Complement 12V boardnet with 48V: Audi, BMW, Daimler, Porsche, VW
  (Auto Electronics Conference in LB, June 2011)

- The higher the voltage, the lower the cable diameters and the smaller the actuators
- Beyond 60V DC special measures protecting humans have to be taken
- The optimum compromise between system cost and maximum power per weight is 48V

Expected reduction in fuel consumption: up to 6%
The (Hybrid) Electrical Vehicle … driving new semiconductor technology
Maximize energy efficiency of the existing conventional electronic system

- Complement 12V board net with 48V: NXP’s high-voltage mixed-signal technology available!

• Voltage robustness beyond +/- 100V in combination with high logic density

NXP’s technology ready for 48V in-car networks!
(including +/- 60V bus robustness)
Conclusion
Semiconductors & Electromobility

- Semiconductors enable Electromobility through 'Connected Mobility'
  - Consumer acceptance
  - New business models

- Electromobility drives new semiconductor technology
  - High voltage, high power
  - Energy efficiency

What it takes

- Blend technology from different domains … create new user experiences!
- Open industry standards … international … and beyond automotive!
- New business models … more complex than traditional automotive value-chain