Development of Frontlighting

Sealed Beam
(div.US) 1960-1990

Halogen (H4/H7)
(div.EU, Japan) 1970’s

Xenon / BiXenon
Xenon: 1991 (BMW); BiXenon: 1994 (Audi)

Adaptive Frontlighting
AFS - Xenon-Technology 2003

LED DRL
(Audi) 2004

Full LED Head Lamp
(Audi) R8 - 2006

New LED Functions
(Audi) 201x

Adaptive Driving beam
(Audi) 2009

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Development of Lighting Technologies

2003 – 2005

2008

2009

2010

2011

2012

Future: OLED
Daytime running light
Adaptive Lighting System
Automatic adaptation of lighting to environmental and traffic conditions

- Urban light
- Country road light
- Highway light
- Intersection light
- Automatic switchover to right hand driving
Future LED Adaptive Frontlighting System

- A combination of
  - Vehicle sensor data
  - Digital navigation data
  - Camera system

- Implementation
  - Highlighting of road traffic signs
  - „Recommended path of travel“ in MMI
  - Projection of turn information

- Advantages
  - Perfect illumination of road in every situation
  - Enhanced safety and comfort
AFS – ECE Regulations

- ECE regulation for AFS:

- ECE 123 – Uniform provisions concerning the approval of adaptive front-lighting systems (AFS) for motor vehicles

Definition:

§ 1.2 „Adaptive front-lighting system“ (or „system“) means a lighting device, providing beams with differing characteristics for automatic adaptation to varying conditions of use of the dipped-beam (passing beam) and, if it applies, the main-beam (driving beam) with a minimum functional content as indicated in paragraph 6.1.1.; such systems consist of the „system control“, one or more „supply and operating device(s)“, if any, and the „installation units“ of the right and of the left side of the vehicle.
Different modes of the passing beam and, where applicable, of the main-beam (ECE R48):

- Class C = neutral state (country light)
- Class V = urban light
- Class E = highway light
- Class W = adverse weather light

Proposal for SAE recommended practice J2838 - Full Adaptive Forward Lighting Systems on the basis of ECE regulations
Highlighting of detected pedestrians
Night Vision Assistant

Detected pedestrians are marked yellow in the display.

During a German study for AUDI 67% of the participants noted, that a marking of dangerous objects is very useful!

Because of the marking a driver has got 1.7 seconds more to react (at a speed of 70 km/h).

are highlighted in red, a warning signal also sounds.
Adaptive Driving Beam

Driving with gliding cut off line, without glaring each other

- Adapt the headlight range for oncoming or preceding vehicles, which are detected by a camera
- If no car is detected, the system runs in main beam

NHTSA Publication
Investigation of Safety-Based Advanced Forward Lighting Concepts to reduce Glare
- DOT HS 811 033
- September 2007
LED MatrixBeam (ADB)

High beam assistant MatrixBeam

- Dividing up the LED main beam into a large number of individual segments
- A camera detects other vehicles, the innovative headlights fade out the appropriate area
- Avoidance of glaring oncoming traffic
- More efficient use of the high beam
Different solutions of ADBs

- AUDI (as shown before)
  - Variable beam angle adjustment (ADB)
  - MatrixBeam (ADB)

- BMW
  - Main-beam assistent (ADB):
    "A camera sensor in the rear-view mirror holder registers the position of other road users and a mechanism on the inside of the headlight selectively produces blind spots for them within the headlight beam. Drivers benefit from the higher luminous power and greater range of the permanently activated high beam – oncoming traffic and any vehicles ahead are not dazzled. Hazards can be recognised earlier, without endangering others. “
Different solutions of ADBs

- Volkswagen
  - Dynamic Light Assist (ADB)
    This camera-based continuous main beam headlight actually “sees” oncoming traffic and automatically adjusts – via the curve lighting module and individually for each headlight - the main beam to eliminate undesired glare.
Different solutions of ADBs

- **Mercedes**
  - **Adaptive main-beam assistent (ADB)**
    A camera is used to control headlamp range adjustment and the main beams in such a way that the road receives the best possible illumination in line with the current driving scenario and with any vehicles travelling ahead with their lights on. The main beams are automatically switched on if no other road users with their lights on are detected.
  
  - **Future technology:**
    The Adaptive Highbeam Assist PLUS allows the high-beam headlamps to be kept on permanently while driving by masking out other road user detected in the beams' cone of light. Adaptive Highbeam Assist PLUS likewise makes use of the new stereo camera also employed by other assistance systems. If its image recognition algorithm picks up a vehicle that is oncoming or driving ahead, it actuates a mechanism in the headlamp module. This then masks the portion of the LED headlamp's high-beam cone of light where there are other vehicles to prevent their drivers being dazzled.
Different solutions of ADBs

- **Opel**
  - **LED Matrix Light (ADB)**

  The matrix light embodies a new philosophy in lighting technology. Rather than using the low beam as the default setting, the high beam is always the standard mode in the new matrix lighting concept. By taking this new approach, the high beam is always kept glare free and is automatically adapted according to the traffic situation. In that sense the matrix light assists the driver in an intelligent way, giving him a stress free driving experience, while maintaining the highest possible level of safety. The light is adjusted more rapidly to the current traffic situation than any solution which relies on the driver or is based on mechanically moved elements.
Results of different test studies

- Drivers are using the main beam in only 42% of the potential time. [Sullivan]

- About 21% of all driving situations are at night.

- Use of the main beam: 3.1% [UMTRI]

- According to a test study by Sprute the use of the main beam is too rare.

- Analysing of two test drives, blind and non-blind.

- Non-blind test drive: use of the main beam could be increased up to more than 50%. [Sprute]
Matrix beam – test study with ADBs

<table>
<thead>
<tr>
<th>relative position to racks</th>
<th>Matrix-Beam</th>
<th>aVCOL</th>
<th>aCOL</th>
<th>Conventional 1</th>
<th>Conventional 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 m after</td>
<td>86.6 m</td>
<td>94.4 m</td>
<td>75.0 m</td>
<td>51.1</td>
<td>76.4 m</td>
</tr>
</tbody>
</table>

- High sight distances with conventional system 2 → relational comparison
- Benefits with aCOL can’t be shown (test design)
- Potential on the left side: + 54.8 m
- Potential on the right side: + 23 m (not significant)

<table>
<thead>
<tr>
<th>Significant improvement</th>
<th>Matrix-Beam</th>
<th>aVCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>43.6 m</td>
<td>54.8 m</td>
</tr>
</tbody>
</table>

- 15.8 m (no. 6)
- 18.0 m
Matrix beam – safety enhancement vs. Risk compensation

- Risk compensation leads to
  - Increasing speed by 5 km/h [sprute] because of better sight and safety feeling
  - Longer stopping distance of about 6.5 m at 100 km/h

- Net safety enhancement of about 68%
Design Concept for LED ADB headlights
Adaptive Driving Beam

Current North American regulatory situation:

- F/CMVSS108 does not allow an ADB
  (note in Proposal for SAE Recommended Practice J2838 – AFS: Requirements concerning Adaptive Driving Beam are not included in this standard at this time, but will likely be added at a later date.)

- Difference to ECE regulation:
  - Field of light distribution
Adaptive Driving Beam

- Difference to ECE regulation:
  - F/CMVSS 108: maximum value for upper beam is 75,000 cd (H-V),
    max. value as per ECE R48:
    6.1.9.1. The aggregate maximum intensity of the main-beam headlamps
    which can be switched on simultaneously shall not exceed 430,000 cd,
    which corresponds to a reference value of 100.
  - ADB is mentioned in ECE R48 (Rev. 06) „Adaptive main-beam“ means a
    main-beam of the AFS that adapts its beam pattern to the presence of
    oncoming and preceding vehicles in order to improve the long-range
    visibility for the driver without causing discomfort, distraction or glare to
    other road users.
Sweeping turn indicator
Sweeping turn indicator
Sweeping turn indicator

- At the moment, the sweeping turn indicator is not practicable in the US because of the minimum requirements of the effective projected luminous lens area:

<table>
<thead>
<tr>
<th>Lighting device</th>
<th>Single compartment lamp</th>
<th>Multiple compartment lamp or multiple lamps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Each compartment or lamp</td>
</tr>
<tr>
<td>Front turn signal lamp ...</td>
<td>2200</td>
<td>2200</td>
</tr>
<tr>
<td>Rear turn signal lamp ...</td>
<td>5000</td>
<td>2200</td>
</tr>
<tr>
<td>Stop lamp ................</td>
<td>5000</td>
<td>2200</td>
</tr>
</tbody>
</table>

- ECE Regulations:
  - No requirements on effective projected luminous lens area
  - Amber direction indicators in the rear
In comparison with a conventional bulb direction indicator:
- Fully activated after 250 ms
- Sweeping turn indicator is fully activated after 160 ms and gives a more intuitive signal to other road users
- Photometric requirements are measured with full intensity
Future Technology: **Laser Light**

**Laser based white light**
White illumination with Laser, based on the same functional principle as white LEDs.

- Blue (450 nm) laser light source
- Laser exposes a fluorescence material (Phosphor)
- Phosphor layer converts the blue light into white spectrum
Future Technology: Laser Light

Many possibilities to use laser light in vehicles

- Daytime running light
- Direction indicator
- Highlighting of detected pedestrians

Definition of LED in ECE regulation:
"Light-emitting diode (LED) light source" means a light source where the element for visible radiation is one or more solid state junctions producing injection luminescence/fluorescence.

Interpretation of laser light as „light emitting diode“ as well?
Laser rear lamp for bad weather conditions

- Laser rear lamp
  - Is generated by a laser diode
  - Provides drivers behind with a bright, clear signal
  - Red line on the road prompts to maintain sufficient distance
  - In fog or spray, the laser beam strikes the water droplets and makes them visible
  - The beam pattern is then seen as a huge triangle
Thank you for your attention