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|  | | | | | **Engineering Specification** | | | | | | | | | | | | | | | | | |
| PART NAME: SPEC – Cockpit Illum. | | | | | | | | | | | | | PART NUMBER | | | | | | | | | | | | | |
| **Cockpit Illumination System Specification** | | | | | | | | | | | | | **ES H1BT-1A278-AA** | | | | | | | | | | | | | |
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| 21.Sept. 2016 | | |  | |  | | 4.0 Initial Core Release | | | | | | | |  | |  | |  | | | | | | | |
| 19 June 2016 | | |  | |  | | 4.1 | | | | | | | |  | |  | | PREPARED/APPROVED BY | | | | | | | |
| 24 July 2017 | | |  | |  | | 4.1.1 | | | | | | | |  | |  | | H. Boehm / I. Gupta | | | | | | | |
| 11 Jan 2018 | | |  | |  | | 4.1.2 | | | | | | | |  | |  | | CHECKED BY | | | | | DETAILED BY | | |
| 05 Feb 2018 | | |  | |  | | 4.1.3 | | | | | | | |  | |  | | T. Stein | | | | |  | | |
| 08 Mar 2018 | | |  | |  | | 4.1.4 | | | | | | | | |  | |  | | APPROVAL SIGNATURES ON FILE | | | | | | |
| 03 May 2018 | | |  | |  | | 4.1.5 | | | | | | | | |  | |  | | IN WERS CONCERN | | | | | | |
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| 20 Sept 2018 | | |  | |  | | 6 | | | | | | | | |  | |  | |  | | | | | | |
| 7 Jan 2019 | | |  | |  | | 6.1 | | | | | | | | |  | |  | |  | | | | | | |
| 02 Oct 2019 | | |  | |  | | 6.2 DRAFT | | | | | | | | |  | |  | |  | | | | | | |
| 14 Oct 2019 | | |  | |  | | 6.2.1 DRAFT | | | | | | | | |  | |  | |  | | | | | | |
| 06.Nov 2019 | | |  | |  | | 6.2.2 DRAFT | | | | | | | | |  | |  | |  | | | | | | |
| 06.Dec.2019 | | |  | |  | | 6.3 | | | | | | | | |  | |  | |  | | | | | | |
| 24 Jan 2020 | | |  | |  | | 6.4 | | | | | | | | |  | |  | |  | | | | | | |
| 14 Feb 2020 | | |  | |  | | 6.4.1 DRAFT | | | | | | | | |  | |  | |  | | | | | | |
| 01 April 2020 | | |  | |  | | 6.5 | | | | | | | | |  | |  | |  | | | | | | |
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**Core Document**

**Cockpit Illumination System Specification**

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**Revision History**



|  |  |  |  |
| --- | --- | --- | --- |
| **Revision** | **Date** | **Author** | **Description** |
| 4.0 | 21.Sept. 2016 | Farhan Ehsan | Initial Release as “ES-H1BT-1A278-AA-V4” | |
| 4.1 | 16 June 2016 | Farhan Ehsan | Chapter 1.1.2 “twilight 1-5” updated to “twilight 1-4”  Chapter 2.1 “Future Scope” updated from +20MY to +2XMY  Chapter 3.5 “ Expected Dimming Responses for CAN components without Daytime Dimming” table included from previous releases  Chapter 3.6 “Expected Dimming Responses for CAN components with Daytime Dimming” table included from previous releases  Chapter 6.1 “Extended Play” Updated  Chapter 6.2 “Dimming Intensity Offset via Screen Menu” added | |
| 4.1.1 | 24 July 2017 | Farhan Ehsan | Chapter 3.5 “Expected Dimming Responses for Components without Daytime Dimming”, added and updated police dark car behavior  Chapter 3.6 “Expected Dimming Responses for Components with Daytime Dimming” added and updated police dark car behavior  Updated DID\_TransTime\_Amb\_Down\_BL from 9 to 8  Chapter 6.7.1 “DSPLSendSignals” updated to include “Chrome switches”  Chapter 6.7.1.1 “Illumination Zones vs. Litval” created. | |
| 4.1.2 | 11 January 2018 | Farhan Ehsan | Chapter 2.4 “Illumination Information Flow”  Chapter 3.1.2 “Interpolation Function” added row for 12 bits  Chapter 3.5 “Expected Dimming Responses for Components without Daytime Dimming”, deleted  Chapter 3.6 “Expected Dimming Responses for Components with Daytime Dimming” deleted  Chapter 5 “Ambient Light Sensing” updated threshold table  Chapter 6.2 “Dimming Intensity via Offset Screen Menu” updated  Chapter 6.7.1.1 “Illumination Zones vs. Litval” updated to “Illumination Zones vs. Dimming\_lvl”  Chapter 8 “IPC” updated to include Cluster variants section  Chapter 16.1.3.3 “Internal Indicator Dimming Signal Processing, updated missing signal table  Chapter 16.3 “LIN Communication of Front Door Module to DDS” updated  Chapter 18 “Software Voltage Compensation (SVC) for Illumination” deleted (renumbered to “CHUD – Combiner Head Up Display” chapter)  Chapter 17 “Power Sliding Door” added (renumbered) | |
| 4.1.3 | 12 January 2018 | Farhan Ehsan/Heiner Boehm | References updated  Chapter 8.2.1 10 and 12 Bit description added.  Chapter 3.1.1 updated  Chapter 3.1.4 cd/m² calculation added, percentage calculation removed  Chapter 3.1.5 cd/m² calculation added, percentage calculation removed  Chapter 3.1.6 cd/m² calculation added, percentage calculation removed  Chapter 3.1.4 Updated  Chapter 3.1.1 Wording Updated  Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** added  Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** Reference to DID\_BatterySaveTimer removed / title renamed  Chapter 6.2 Litval removed, Dimming\_Lvl added  Chapter 6.2 Table updated with CAN signal values (Litval)  Chapter 6.7.1 DSPLSendSignals table updated  Chapter 17 updated  Chapter 12.2 DIDs Updated | |
| 4.1.4 | March 7th 2018 | Farhan Ehsan | Chapter 3.1.3 “Seamless/Smooth Transition on Intensity Change” updated to further specify transition type criteria and updated DID\_TransTime\_Amb\_Up from 5 to 6  Chapter 3.7 “CAN Error Handling for Illumination Specific Signals” created  Chapter 6.2.2 "Smooth dimming calibration for Enhanced Dimming Algorithm" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 8.1.2 "Smooth dimming calibration for Enhanced Dimming Algorithm" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 9.1.2 "Smooth dimming calibration for Enhanced Dimming Algorithm" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 9.2.2 "Smooth dimming calibration for Enhanced Dimming Algorithm" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 11.2 "End of Line Programmable DIDs" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 13.1 Configuration updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 15.1.2 "Smooth dimming calibration for Enhanced Dimming Algorithm" updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 16: All instances of Backlit\_LED\_Status replaced with Dimming\_lvl  Chapter 16.1.1 Front Door Module Programmable DIDs updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6  Chapter 16.1.2.3 Backlight Strategy Selection updated with “unused”/”invalid” logic.  Chapter 16.2.1 Rear Door Module End Of Line Programmable DIDs updated DID\_TransTime\_Amb\_Up\_BL from 5 to 6 | |
| 4.1.5 | August 9th 2018 | Farhan Ehsan/Heiner Boehm | Chapter 3.1.3 “Subroutine for hardwired backlight PWM”: Replaced text with flow charts  Chapter 3.2.1.2 “Two-step Dimming Qualifications” deleted  Chapter 3.3 “PWM Signals”: Intro section verbiage updated  Chapter 3.3.1 “PWN Signals at Vehicle Harness” PWM output frequency 1/P max value updated from 300hz to 400hz  Chapter 3.3.3: “Internal 8-bit PWM signals” PWM output frequency 1.P max value deleted  Chapter 3.3.4: “Internal 10-bit PWM signals” PWM output frequency 1.P max value deleted and note 6 added  Chapter 3.3.5: “Internal 12-bit PWM signals” Created  Chapter 16.1.2.4.2 "Subroutine for hardwired backlight PWM", updated c code with change from backlit\_led\_status to dimming\_lvl  Chapter 16.1.2.4.3 "Backlight Subroutine for Components connected via LIN" updated c code with change from backlit\_led\_status to dimming\_lvl | |
| V5 | XXX | Farhan Ehsan | Increment skipped due to previous erroneous increment/release | |
| V6 | September 9th 2018 | Farhan Ehsan | Chapter 3.7 “CAN Error Handling for Illumination specific signals” updated to include table for HMI\_HMIMode\_St vs. Dimming\_lvl vs. Ignition\_Status logic  Chapter 7.1 “Extended Play” relabeled to Chapter 5 since it applies to more than just displays. References to Chapter 7.1 updated to Chapter 5 for all impacted modules  Chapter 8 “FCIMB” modified to “FCIMB and RACM”. | |
| V6.1 | January 1st 2019 | Farhan Ehsan | Section 3.7: “CAN Error Handling for Illumination specific signals” updated to correct error (conflicting requirements between tables) | |
| V6.2 DRAFT | October 9th 2019 | Heiner Boehm | Section 3.1.4 8 / 10 Bit PWM Backlight updated to include 10 bit button backlite  Section 7.6.2 Interface for SYNC 4.0 and beyond added  Section 8.2 Protocol for SYNC Gen 4.0 added  Section 8 ICP added to Chapter Headline | |
| V6.2.1 DRAFT | October 14th 2019 | Heiner Boehm | Section 7.6.2 LIN signal names adopted to be in-line with the LDF name assignment (‘DSPL’ instead of ‘DSP’) | |
| V6.2.2 DRAFT | October 22th 2019 | Ishan Gupta / Heiner Boehm | Section 3.1.9 Calculation time extended for specific executions  Section 2.1.1.8.2 External Switches/Indicators without Own Controller (Illumination Circuit) clarification added regarding brightness compensation.  Section 8.2.1 Indicator added  Section 7.8 Definition of Weight Factors for 10 Bit SDM displays SDM 12 / 13 added  Section 3.8 Soft Dimmer via Onscreen Menu added | |
| V6.3 | December 06th 2019 | Ishan Gupta / Heiner Boehm | Sections Revision History, 3.1.3, 3.1.8, 3.2, 3.7 spelling corrections  Section 17.4 sub chapter heading numbers corrected  Official release | |
| V6.4 | January 24th 2020 | Ishan Gupta / Heiner Boehm | Section 7.6.2 additional zones for backlighting and indicators added  Section 8 revised and subchapter added – clarification of zone handling  Section 7.1 sub chapter with RVC thresholds added and flowchart updated | |
| V6.4.1 DRAFT | February 14rd 2020 | Ishan Gupta / Heiner Boehm | Section 8.2.1 Schematic and lower intensity limit added  Section 5 revised. Sub sections added. Table replaced by flowchart. OTA added.  Section 3.8 revised. Signal name changed.  Section 3.4.11 Revised | |
| V6.5 DRAFT | April 1st 2020 | Ishan Gupta / Heiner Boehm | Section 3.7 revised  Section 4.1 and 4.2 on Sync Screen and IPC added  Section 4 spelling corrections | |

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# Introduction

## Feature Description

### Purpose and Overview of Feature

#### Introduction

Almost all vehicles within the Ford and Lincoln fleets have either a combination of or all of the following within their cockpits: Hard-switches, Vehicle/Infotainment Displays, and Indicators. The aforementioned elements are required to have illumination tied to them for legibility and findability sake. The following specification’s goal is to ensure that all light emitting elements within the cockpit accept the same set of inputs and respond to those inputs in a similar (or entirely same) manner.

#### Goal

The goal is to have consistent illumination behavior for lighting / display elements that fall under the same category (or classification). Any changes in illumination levels not directly requested by the Driver must transition smoothly and seamlessly.

#### Objectives

Utilize the output of existing Ambient Light sensing system(s) as an input to control the illumination levels of cockpit lighting elements/displays, where changes in ambient light levels will drive “smooth” transitions between illumination levels.

Allow the driver to utilize hard switches (i.e. dimmer switch, headlamp switch) or vehicle display soft buttons to change the illumination level of cockpit lighting elements/displays.

All transitions in illumination levels should happen seamlessly, in-phase and without flickering.

All lighting elements within the cockpit should respond to the same inputs (user input or ambient light level change) in lock step and appear homogeneous in intensity and chromaticity – no noticeable delays or noticeable intensity differences between illumination zones, lighting elements or vehicles displays.

The illumination levels for each illumination zone and the transition times between illumination levels should be configurable.

|  |  |
| --- | --- |
| ACM | Audio (Front) Control Module |
| AHU | Audio Head Unit (Connected HMI Radio) |
| ALS | Ambient Light Sensor |
| APIM | Accessory Protocol Interface Module (SYNC) |
| ARL | Attribute Requirement Lists (ARL). Documents vehicle-level characteristics, using RQMTs and DVMs. |
| BCM | Body Control Module |
| DACMC | Digital Audio Control Module C |
| DM | Door Module |
| DDM | Driver Door Module |
| DDS | Driver Door Switchpack |
| DDLS | Driver Door Lock Switch |
| DRDM | Driver Rear Door Module |
| DRWS | Driver Rear Window Switch |
| ECM | Engine Control Module |
| ECU | Electronic Control Unit |
| FCIMB | Front Controls Interface Module B (radio switches) |
| HLS | Head Lamp Switch |
| HVAC | Heating Ventilating and Air Conditioning (climate control module) |
| IPC | Instrument Panel Cluster Control Module |
| PAM | Parking Assist Control Module |
| PADI | Passenger Airbag Deactivation Indicator |
| PCB | Printed Circuit Board |
| PDLS | Passenger Door Lock Switch |
| PDM | Passenger Door Module |
| PRDM | Passenger Rear Door Module |
| PRNDL | PRNDL (indicator of automatic gear switch) |
| PRWS | Passenger Rear Window Switch |
| PSD | Power-sliding door |
| PWS | Passenger Window Switch |
| RCM | Restraints Control Module |
| RHVAC | Rear HVAC |
| SDM | Slim Display Module |
| SOP | Start of Production |
| SVC | Software Voltage Compensation |
| SYNC | see APIM |
| TAC | Tachograph |
| TCU | Telematics Control Unit |
| VQM | Voltage Quality Module |
| GSM | Gear Shift Module |
| OTA | Over The Air |

## Abbreviations

# Cockpit Illumination Dimming System Operation

## Quality Requirements

### Performance Requirements

#### General Illumination Requirements

Cockpit illumination shall meet the Vehicle Harmony attribute level requirements listed in the latest versions of the following specifications:

* ARL: RQT-002004-021873 General Illumination Dimming Rev. XX
* ARL: RQT-002004-021874 Illumination Quality Rev. XX
* ARL: RQT-002004-021875 General Illumination Color Rev. XX

#### Lincoln Embrace / Ford Welcome Farewell

Cockpit illumination shall meet the Lincoln Embrace and Ford Welcome Farewell illumination specific requirements listed within the latest versions of the following documents:

* ARL (Ford Only) RQT-002004-021878 DNA Welcome-Farewell Strategy Rev.XX
* ARL (Lincoln Only): RQT-002004-022094 Lincoln Embrace Welcome and Farewell Behavior Rev. XX
* Both: RQT-000600-022315/1: Lincoln Embrace/ Ford Welcome Farewell compliance with Feature Specification (specification: “WelcomeFarewell\_Spec\_vXX”)

#### LED-Bin Compensation

LEDs are delivered in preselected bins, which describe the brightness class of the LEDs. If LED bin compensation is done via PWM, the PWM generator must be increased with further 2 bits. This compensation should be before the voltage compensation. It is only applicable for modules, which contain an own micro controller. This compensation will be programmed at the supplier. It should have no influence on the protocol data.

#### Cockpit illumination shall not flicker while ramping and/or steadily illuminated

The lighting elements controlled by this feature while it is active shall be steadily illuminated (no flickering) when illuminated.

A flicker, as defined by the Vehicle Harmony Group, is an unintended >=2% change in illumination level which will be confirmed by the Vehicle Harmony group through visual review.

Any corrective actions taken to suppress flickering will require their signoff (re-review) after implementation.

#### Handling subsequent illumination level change requests

This feature does not require that the target illumination be enabled (forced) if any ramping request is interrupted with a new ramping request, and any new ramping requests made mid operation start at the illumination level at which it was received.

#### Performance Latency Requirements

The end to end latency, defined as from user input to beginning of user perceivable response shall be within 200ms. This requirement only applies after the associated modules (including gateway module if applicable) and networks have completed their sleep to awake transitions.

#### Preventing inadvertent illumination of Indicators and Backlighting LEDs

Indicators and Backlighting LEDs shall not inadvertently illuminate in response to leakage currents, diagnostic current for open line detection or any instance where the system is not requesting illumination.

It is left to the supplier’s discretion on how to meet this requirement. One proposal is to have a resistor (specific value defined in conjunction with D&R engineer of driving module) in parallel with the LED.

#### Compensation of Supply Voltage Variation

New vehicles (20MY and beyond) will not come equipped with a voltage quality module (VQM).

Going forward, modules that receive an un-stabilized voltage The components, which have their own controller and supplied via not stabilized voltage, must have compensation, that battery voltage variation had no visible flickering influence on illumination.

##### Illumination stabilization For Modules with Own Controller

For module internal illumination full performance is required (stabilized voltage range):

* From 9V-16V
* At voltage drops which are defined in FS-0000-00001-AB Revision 4, Figure 4.3.1-1 lowered by 1V voltage drop at wire harness.

The compensation could be provided by hardware with stabilized supply voltage and/or stabilized current sources. In case a low stabilized supply voltage is used, the supplier should take care, that the part to part variation of the forward voltage of the LEDs causes not different brightness within the control.

The brightness level should be in the specified tolerance for battery voltage in the range of “stabilized voltage range”.

Modules with own controller which are supplied via other modules (like displays units) must take care that the complete chain fulfil the above requirements.

##### External Switches/Indicators without Own Controller (Illumination Circuit)

Brightness compensation for external switches / indicators connected via vehicle wire harness is not mandatory. These illumination parts must have their nominal brightness at 12.5V DC supply. To minimize the brightness variation caused by the part to part forward voltage variation, the following circuit should be used at new designs, if no thermal requirements against this design. Parallel resistor should be parallel to diode and serial resistor.

#### LED specific requirements

All components that are built for illumination harmony appraisals shall be made from data logged LEDs to have the ability to judge on material-based colour shift.

All electronic control units (ECU) that use the new LEDs shall have its own precautions for enough reverse battery protection covered by the generic reverse battery protection requirements out of the ELCOMP SDS.

All non-intelligent / standalone switches or pushbuttons shall be designed to also have their own reverse battery protection.

The exterior light switch is standard equipment. Its general illumination zone shall protect for the PCB population area and PCB layout to carry a shunt resistor parallel to the dimming input line. This is a countermeasure for glowing illumination zone of the cockpit illumination caused by residual voltage at the PWM output drivers for switch illumination. The PWM switch illumination supply drivers shall not exhibit a residual voltage when the PWM driving signal is switches OFF.

### Safety Requirements

#### Legal Requirements

##### NAFTA Requirements to abide by (or not violate)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **RR ID/ Revision** | **Country/ Vehicle area** | **Regulation Number and Title** | **RR Author** |
|  | [CAN-004804/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=SlSVUVgwIJ_leA) | Canada/ Exterior Lighting | SCHEDULE IV Part II (CMVSS 108 and 108.1)/LIGHTING SYSTEM, RETRO-REFLECTIVE DEVICES and HEADLAMP CONCEALMENT DEVICES | Adams-Campos,Kelley-KADAMSCA (kadamsca) |
|  | [CAN-004804/3](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=QHaZihoBIJ_leA) | Canada/ Exterior Lighting | CMVSS 108/LIGHTING SYSTEM, RETRO-REFLECTIVE DEVICES and HEADLAMP CONCEALMENT DEVICES | Adams-Campos,Kelley-KADAMSCA (kadamsca) |
|  | [CAN-004911/3](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=_cbVUp%245IJ_leA) | Canada/ Interior Lighting | CMVSS 101/SCHEDULE IV PART II 101 (CMVSS 101) Controls and Displays | Laesch,Renu-RLAESCH1 (rlaesch1) |
|  | [XCT-011075/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=BhQZnwM8IJ_leA) | Cross Country Topics/ Instrument Cluster | CROSS COUNTRY SPEEDOMETER MATRIX/CROSS COUNTRY MATRIX FOR SPEEDOMETER AND ODOMETER | Laesch,Renu-RLAESCH1 (rlaesch1) |
|  | [MEX-006101/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=rpTVUZYqIJ_leA) | Mexico/ Interior Lighting | MEX SECOFI-18/HAZARD WARNING SYSTEM | Arellano-Belloc,Hector-HARELLAN (harellan) |
|  | [MEX-006134/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=r2aVUZYqIJ_leA) | Mexico/ Vehicle Display | MEX SECOFI-25/INSTRUMENT CLUSTER. | Arellano-Belloc,Hector-HARELLAN (harellan) |
|  | [USA-004890/4](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=ZHQVUp%245IJ_leA) | US / Vehicle Display | Voluntary Agreements/Mandatory/Voluntary Agreement /Mandatory Commitment - Driver Focus-Telematics Guidelines | Overbeck,Thomas-TOVERBEC (toverbec) |
|  | [USA-006675/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=9zSVUZJ_IJ_leA) | US / Vehicle Display | USA - STATE - SEVERAL/ODOMETER | Laesch,Renu-RLAESCH1 (rlaesch1) |
|  | [USA-006739/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=S9WVUZqBIJ_leA) | US / Interior Lighting | USA - STATE - SEVERAL/CARGO LAMPS | Adams-Campos,Kelley-KADAMSCA (kadamsca) |
|  | [USA-008716/3](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=iRZZdqG9IJ_leA) | US / Interior Lighting & Vehicle Displays | FMVSS 101/FMVSS 101 Controls and Displays | Laesch,Renu-RLAESCH1 (rlaesch1) |
|  | [USA-008732/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=_YfVUliiIJ_leA) | US / Interior Lighting & Vehicle Displays | /NHTSA Visual-Manual Guidelines for In-Vehicle Electronic Devices | Leigh,Michael-MLEIGH (mleigh) |
|  | [USA-011127/2](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=xcaZOgKzIJ_leA) | US / Interior Lighting & Vehicle Display | /2019MY U.S. NHTSA New Car Assessment Program (NCAP) | Buckman,Jennifer-JBARNARD (jbarnard) |

##### ECE Requirements to abide by (or not violate)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **RR ID/ Revision** | **Country/ Vehicle area** | **Regulation Number and Title** | **RR Author** |
|  | [ECE-008757/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=QaeVUlz8IJ_leA) | ECE / Vehicle Displays & Interior Lighting | RE3 ANNEX 16./ON-BOARD COMMUNICATION AND INFORMATION SYSTEMS. | Abraham,James-JABRAH11 (jabrah11) |
|  | [ECE-008647/3](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=5beZ08E2IJ_leA) | ECE / Interior Lighting | ECE-128.00 Supp 2/LIGHT EMITTING DIODE (LED) LIGHT SOURCES | Sanchez,Greg-GSANCHE1 (gsanche1) |
|  | [ECE-004951/10](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=B4Qdj7VGIJ_leA) | ECE / Vehicle Display | ECE-39/SPEEDOMETER | Sanchez,Greg-GSANCHE1 (gsanche1) |
|  | [ECE-005073/16](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=VtddUL_BIJ_leA) | ECE / Interior Lighting & Vehicle Displays | ECE-121.01/Identification of Hand Controls, Tell-Tales and Indicators | Mueller,Joachim-JMUELLE6 (jmuelle6) |

##### China Requirements to abide by (or not violate)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **RR ID/Revision** | **Country** | **Regulation Number and Title** | **RR Author** |
|  | [CHN-004539/19](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=xIVZUEfdIJ_leA) | China / Interior Lighting & Vehicle Display | CNCA CCC rules-component/CHINA: CCC COMPONENT CERTIFICATION | Zhang,Yue-YZHAN256 (yzhan256) |
|  | [XCT-011075/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=BhQZnwM8IJ_leA) | Cross Country Topics / Vehicle Display | CROSS COUNTRY SPEEDOMETER MATRIX/CROSS COUNTRY MATRIX FOR SPEEDOMETER AND ODOMETER | Laesch,Renu-RLAESCH1 (rlaesch1) |
|  | [CHN-005444/1](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=UtUVUZnjIJ_leA) | China / Interior Lighting | GB 17509-2008/CHINA: DIRECTION INDOCATORS | Zhang,Yue-YZHAN256 (yzhan256) |
|  | [CHN-010709/2](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=xQfZz9zNIJ_leA) | China / Vehicle Display | GB/T 19836/CHINA: INSTRUMENTATION FOR ELECTRIC VEHICLES | Peng,Quanping-QPENG4 (qpeng4) |
|  | [CHN-004436/16](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=xgdZ5mJXIJ_leA) | China / Interior Lighting & Vehicle Display | GB 7258/CHINA: CCC VEHICLE APPROVAL | Zhang,Yue-YZHAN256 (yzhan256) |
|  | [CHN-004481/6](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=TrYZpbirIJ_leA) | China / Interior Lighting | GB 20182/CHINA: EXTERNAL RPOJECTIONS - COMMERCIAL VEHICLE CABIN | Zhang,Yue-YZHAN256 (yzhan256) |
|  | [CHN-004329/5](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=h4aZ2P6hIJ_leA) | China / Interior Lighting & Vehicle Displays | GB 4094/CHINA: SYMBOLS FOR CONTROLS, INDICATORS, AND TELL-TALES | Zhang,Yue-YZHAN256 (yzhan256) |
|  | [CHN-004330/5](http://www.fsms-portal.ford.com/regulationRecordReportAction.do?actionId=generateRRText&uid=iWeZpbirIJ_leA) | China / Interior Lighting & Vehicle Display | GB 15082/CHINA: SPEEDOMETERS FOR MOTOR VEHICLE | Zhang,Yue-YZHAN256 (yzhan256) |

## Illumination Information Flow - System Layout C519

BCM

GWM

CHR / CTR

Display

IIC

LIN

HLS

HS3

LIN

FCIMB

HW

ALS

variants

FCIMB

LIN

HS3

IIC

APIM

(SYNC G3)

Display

HS1

ECM

Door Switches

HS3

1 DIN Radio

4)

HW

PRWS

Key

HW

PWS

MS1

HW

PDM

PDLS 5)

LIN

DDS

HS1

Keyless Start/Stop SW

HWW

HW

HW

HW

Auto Hold

HVAC

MS1

HW

Hazard Switch

Sunroof

Switch

Sunblind

Switch

Switch

Bank

HS3

HW

HW

TCU

HS2

HW

HW

PADI

RCM

ECO

Button

GLONASS

/ eCall

PAM

HS1

HW

HS3

IPC

HS2

GSM

PSD 4)

Power Window Switches 3)

Transmission Switches

Steering wheel Switches

HW

PSD Switch

HW

HW

HW

HW

HW

HW

HW

HW

HW

HW

Rear HVAC 4)

MS1

HW

HW

Notes:

1. Russia market only
2. High power switches in some markets instead of door modules
3. C519 / V36xMCA option
4. V36xMCA

HW

MS1

HW

DDLS

DRWS

DDM

MS1

Start Stop

Button

# General Functions

## Overall Dimming

There are three basic types of illumination zones.

* Day time dimmable zones with high brightness levels, e.g. displays and gauge pointers.
* Backlight for search illumination
* Indicators and telltales

Day time dimmable zones need at least 10 / 12 bit resolution. Backlight and indicators need at least 8 / 10 bit resolution.

To adjust the brightness to a harmonic dimming over all components inside the vehicle, it is necessary to define for each customer selected dimming level and every ambient light level a specific PWM intensity value. This is done via weight factor table which should be access able via DIDs. Each weight factor is a two byte value. These weight factor table need to be end of line programmable. It will be calibrated during development phase.

For each illumination zone two end of line programmable DIDs should be available. These two DIDs define the brightness of the lowest and highest ON value. For day time dimmable zones these two DIDs are two byte values, for back light they are two one byte values. The actual value for a defined zone is then interpolated with method described in chapter “Interpolation Function”.

For telltales two one byte values are stored. One for day time brightness and one for night time brightness.

### Illumination Calibration via DID

All DID values are subject to change based on the interior harmonisation process and might be adjusted several times during the development process. Diagnostic service 0x22 (read) and service 0x2E (write) access is preferred during the development phase and allows quick adjustments. All DIDs must be accessible via diagnostic method 3 calibration file. M3 calibration access is not limited to the development phase and must be maintained throughout the vehicle lifetime. Service 0x22 read access should be maintained to enable a quick read of current settings. End of line calibration should be conducted via M3 file and not via service 0x2E write. To enable quick calibration adjustments, it is recommended to maintain service 0x2E write access to support calibration trials, this access must be restricted (security access limitation).

### Interpolation Function

The interpolated value is between the low value and the high value. A weight factor determines the interpolation point on the line from LowValue to HighValue.

ResultValue = LowValue + ((HighValue – LowValue) \* WeightFactor + RoundingOffset) / Divisor

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| PWM Resolution | Range LowValue | Range HighValue | Range WeightFactor | Rounding  Offset | Divisor | | Range Result Value |
| Dec | Shift |
| 8 bit | 0-255 | 0-255 | 0-1024 | 512 | 1024 | 10 | 0-255 |
| 10 bit | 0-1023 | 0-1023 | 0-1024 | 512 | 1024 | 10 | 0-1023 |
| 12 bit | 0-4095 | 0-4095 | 0-4096 | 2048 | 4096 | 12 | 0-4095 |

Sample code:

unsigned int TableInterpolation( unsigned int LowValue, unsigned int HighValue,

unsigned int WeightFactor )

{

return LowValue + (((HighValue - LowValue) \* WeightFactor + RoudingOffset) >> Shift);

}

Note: Take care that the interim variable for the multiplication has at least 20 bit.

### Seamless / Smooth Transition on Intensity Change

On change of Backlit\_LED\_Status (applicable to carry-over components), Dimming\_lvl (preferred over Backlit\_LED\_Status for updated components) or the Litval (applicable to both carry-over and updated components) signal, a new intensity level value is calculated. The change from one intensity value to another intensity value should be a smooth transition. The intensity value (PWM value) shall be updated / transmitted every 40 ms, a value that is derived from our understanding of the most common application loop time. The transition time from start to target intensity is adjustable via method 3 diagnostic parameter. . Furthermore, the transition time is dependent on the system input. The following explains the different types of transitions times and their activation criteria:

1. **DID\_TransTime\_Usr**

Intensity transition time that should be used for user inputs

1. **DID\_TransTime\_OnOff**

Intensity transition time that should be used when going from a nonOFF illumination level to an OFF level or vice versa

1. **DID\_TransTime\_Amb\_Up**

Intensity transition time that should be used in response to a change in the environment’s ambient light level. The target illumination intensity (PWM duty cycle) is higher than the actual illumination intensity.

1. **DID\_TransTime\_Amb\_Down**

Intensity transition time that should be used in response to a change in the environment’s ambient

light level. The target illumination intensity (PWM duty cycle) is lower than the actual illumination intensity.

Each of the fours transition times should be adjustable via method 3 diagnostic parameter.

The DIDs provided below assume that the application time for the ECU containing these DIDs runs at 40ms. ECUs that run at 20ms or 10ms will need to increase their range (0 to 10 for 20ms, 0 to 11 for 10ms) and adjust the following DIDs accordingly (default value +1 for 20ms, default value +2 for 10ms).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Size**  **(Byte)** | **Range** | **Comment / Description** |
| DID\_TransTime\_Usr | 0 | 1 | 0 to 9 | Transition time from start to target intensity on user request (see A.). The transition time is dependent on the number of shifts. This amount is the selectable value. Transition time calculation: (40\*2^x) ms. x is the selectable shift. |
| DID\_TransTime\_Amb\_Up | 6 | 1 | 0 to 9 | Transition time from start to target intensity if increased intensity is requested (see C.). The transition time is dependent on the number of shifts. This amount is the selectable value. Transition time calculation: (40\*2^x) ms. x is the selectable shift. |
| DID\_TransTime\_Amb\_Down | 8 | 1 | 0 to 9 | Transition time from start to target intensity if decreased intensity is requested (See D.). The transition time is dependent on the number of shifts. This amount is the selectable value. Transition time calculation: (40\*2^x) ms. x is the selectable shift. |
| DID\_TransTime\_OnOff | 0 | 1 | 0 to 9 | Transition time from start to target intensity if start or target is 0FF (see B.). The transition time is dependent on the number of shifts. This amount is the selectable value. Transition time calculation: (40\*2^x) ms. x is the selectable shift. |

**Determining type of transition using Dimming\_Lvl & Litval (Preferred):**



**Determining type of transition using Backlit\_LED\_Status & Litval (Alternative, requires buy-off from program vehicle harmony engineer to use):**



#### Seamless / Smooth Dimming Algorithm

Start Intensity Value

**Smooth Dimming Algorithm**

Actual Intensity Value

Target Intensity Value

Amount of Shifts

The start and target intensity values are dependent on the input signals and the weight factor calibration table of the individual module, explained in chapter 3.1. The transition time is adjustable via method 3 diagnostic DIDs. The transition time and amount of intermediate dimming steps is always dependent on the number of shifts selected. The table below shows the possible settings and dependencies.

#### Time Coding by Number of Shifts

40ms, 20ms and 10ms are the only allowed shift times.

Time Coding based off 40ms application times:

|  |  |  |  |
| --- | --- | --- | --- |
| Update Rate [ms] | Number of Shifts | Amount of Dimming steps | Transition Time [ms] |
| 40 | 0 | 1 | 40 |
| 40 | 1 | 2 | 80 |
| 40 | 2 | 4 | 160 |
| 40 | 3 | 8 | 320 |
| 40 | 4 | 16 | 640 |
| 40 | 5 | 32 | 1280 |
| 40 | 6 | 64 | 2560 |
| 40 | 7 | 128 | 5120 |
| 40 | 8 | 256 | 10240 |
| 40 | 9 | 512 | 20480 |

Time Coding based off 20ms application times:

|  |  |  |  |
| --- | --- | --- | --- |
| Update Rate [ms] | Number of Shifts | Amount of Dimming steps | Transition Time [ms] |
| 20 | 1 | 2 | 40 |
| 20 | 2 | 4 | 80 |
| 20 | 3 | 8 | 160 |
| 20 | 4 | 16 | 320 |
| 20 | 5 | 32 | 640 |
| 20 | 6 | 64 | 1280 |
| 20 | 7 | 128 | 2560 |
| 20 | 8 | 256 | 5120 |
| 20 | 9 | 512 | 10240 |
| 20 | 10 | 1024 | 20480 |

Time Coding based off 10ms application times

|  |  |  |  |
| --- | --- | --- | --- |
| Update Rate [ms] | Number of Shifts | Amount of Dimming steps | Transition Time [ms] |
| 10 | 2 | 4 | 40 |
| 10 | 3 | 8 | 80 |
| 10 | 4 | 16 | 160 |
| 10 | 5 | 32 | 320 |
| 10 | 6 | 64 | 640 |
| 10 | 7 | 128 | 1280 |
| 10 | 8 | 256 | 2560 |
| 10 | 9 | 512 | 5120 |
| 10 | 10 | 1024 | 10240 |
| 10 | 11 | 2048 | 20480 |

The following example shows how to calculate a smooth intensity change from start to target value.

Start intensity value = 5; Target intensity value = 100; Transition time = 320 ms / 3 shifts / 8 steps;



#### Seamless Dimming Examples for Backlight Illumination

The following graphic shows seamless dimming examples for backlight illumination.

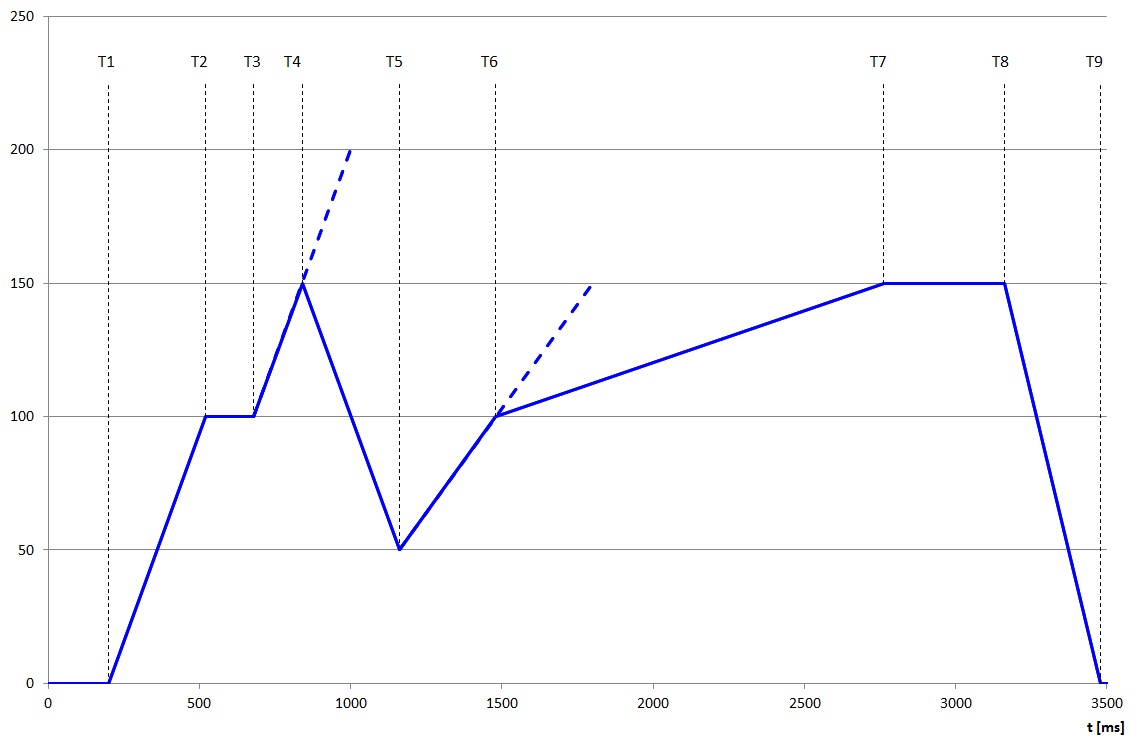


Figure 1

|  |  |
| --- | --- |
| Time | Action |
| T1 | Start new transition with target=100, shift=3 (8x40ms) |
| T2 | Ramping complete, target value reached, no further intensity change until new target is received |
| T3 | Start new transition with target =200, shift=3 (8x40ms) |
| T4 | During ramping up a new transition is started with target=50, shift=3 (8x40ms) |
| T5 | Ramping complete and immediately a new transition is started with Target=150, shift=4 (16x40ms) |
| T6 | During ramping up a new transition is started with target=150, shift=5 (32x40ms) |
| T7 | Ramping complete (stops further change) |
| T8 | Start new transition with Target=0, shift=3 (8x40ms) |
| T9 | Ramping complete (stops further change) |

See 3.1.5 for the seamless / smooth dimming sample code.

### 8 / 10 Bit PWM Backlight

#### Brightness Calibration of 8 Bit Backlight

The following 2 calibratable parameters should be stored as DIDs. Each value is a 1 byte value. For every 8-bit backlight zone a separate parameter block must be stored:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM | 5 | 1 | 0 - 255 | PWM value for lowest brightness  e.g.: Dimming\_Lvl "Night\_1", Litval "Night"  0 refers to 0% PWM duty cycle (off),  255 refers to 100 % PWM duty cycle (max intensity) |
| DID\_High\_PWM | 255 | 1 | 0 - 255 | PWM value for highest brightness  e.g.: Dimming\_Lvl "Night\_12", Litval “Day"  0 refers to 0% PWM duty cycle (off),  255 refers to 100 % PWM duty cycle (max intensity) |

#### Brightness Calibration of 10 Bit Backlight

The following 2 calibratable parameters should be stored as DIDs. Each value is a 2 byte value. For every 10-bit backlight zone a separate parameter block must be stored:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM | 20 | 2 | 0 - 1023 | PWM value for lowest brightness  e.g.: Dimming\_Lvl "Night\_1", Litval "Night"  0 refers to 0% PWM duty cycle (off),  1023 refers to 100 % PWM duty cycle (max intensity) |
| DID\_High\_PWM | 1023 | 2 | 0 - 1023 | PWM value for highest brightness  e.g.: Dimming\_Lvl "Day\_6", Litval “Day"  0 refers to 0% PWM duty cycle (off),  1023 refers to 100 % PWM duty cycle (max intensity) |

#### Definition of Weight Factors for 8 /10 Bit PWM Backlight

The DID\_WeightFactorBL is a calibratable parameter with 108 values. The table below is for reference only. The final values will be evaluated during measurements and distributed to the component teams. The Interaction & Ergonomics team will provide the target luminance values. The ECU supplier must calculate and store the resulting DID values based on the following description.

DID\_WeightFactorBL:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_lvl | Night\_1 | 0 | 11 | 27 | 52 | 88 | 1024 |
| Night\_2 | 8 | 22 | 41 | 70 | 113 | 1024 |
| Night\_3 | 18 | 35 | 59 | 94 | 144 | 1024 |
| Night\_4 | 32 | 53 | 83 | 124 | 181 | 1024 |
| Night\_5 | 52 | 78 | 113 | 161 | 227 | 1024 |
| Night\_6 | 78 | 110 | 152 | 209 | 284 | 1024 |
| Night\_7 | 113 | 152 | 203 | 269 | 353 | 1024 |
| Night\_8 | 162 | 209 | 269 | 344 | 438 | 1024 |
| Night\_9 | 228 | 284 | 354 | 439 | 543 | 1024 |
| Night\_10 | 317 | 384 | 463 | 558 | 672 | 1024 |
| Night\_11 | 440 | 516 | 605 | 709 | 830 | 1024 |
| Night\_12 | 607 | 692 | 789 | 899 | 1024 | 1024 |
| Day\_1 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_2 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_3 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_4 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_5 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_6 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |

Table 1 Example 8 Bit WeightFactor Table

#### Determine the PWM Value for 8 / 10 Bit PWM Backlight

Note: If Dimming\_lvl = 0x0(Off), PWM\_TargetValueBL is 0x0.

Dimming\_lvl

DID\_High\_PWM

WeightFactorBL

DID\_Low\_PWM

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL

#### Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

SAMPLE: Luminance table from ARL (values expressed as cd/m²)

**Note: THESE ARE EXAMPLE VALUES. PROGRAM SPECIFC VALUES MUST BE ALIGNED BETWEEN THE RESPECTIVE COMPONENT OWNER AND THE PROGRAM RESPONSIBLE INTERACTION & ERGONOMICS ENGINEER. ALL VALUES ARE SUBJECT TO CHANGE BASED ON THE INTERIOR HARMONIZATION PROCESS!**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_lvl | Night\_1 | 0.12 | 0.18 | 0.27 | 0.41 | 0.62 | 6.00 |
| Night\_2 | 0.16 | 0.24 | 0.35 | 0.52 | 0.77 | 6.00 |
| Night\_3 | 0.22 | 0.32 | 0.46 | 0.66 | 0.94 | 6.00 |
| Night\_4 | 0.30 | 0.42 | 0.59 | 0.83 | 1.16 | 6.00 |
| Night\_5 | 0.41 | 0.56 | 0.77 | 1.04 | 1.42 | 6.00 |
| Night\_6 | 0.56 | 0.75 | 0.99 | 1.32 | 1.75 | 6.00 |
| Night\_7 | 0.77 | 0.99 | 1.28 | 1.66 | 2.15 | 6.00 |
| Night\_8 | 1.05 | 1.32 | 1.66 | 2.09 | 2.64 | 6.00 |
| Night\_9 | 1.42 | 1.75 | 2.15 | 2.64 | 3.24 | 6.00 |
| Night\_10 | 1.94 | 2.32 | 2.78 | 3.32 | 3.98 | 6.00 |
| Night\_11 | 2.64 | 3.08 | 3.59 | 4.19 | 4.88 | 6.00 |
| Night\_12 | 3.60 | 4.09 | 4.65 | 5.28 | 6.00 | 6.00 |
| Day\_1 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Day\_2 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Day\_3 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Day\_4 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Day\_5 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |
| Day\_6 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 |

Table 2 ARL Example Luminance Table [cd/m²]

Calculation of intensity offset DIDs out of ARL luminance table

DID\_Low\_PWM =round(255\*(L\_min)/( L\_max))

Example calculation based on Table 2 ARL Example Luminance Table [cd/m²]:

DID\_Low\_PWM = round(255\*0.12/6.00) = 5

DID\_High\_PWM = round(255\*(L\_max)/( L\_max))

Example calculation based on Table 2 ARL Example Luminance Table [cd/m²]

DID\_High\_PWM = round(255\*6.00/6.00) = 255

Round: choose the next higher integer if first decimal digit is equal or higher than 5.

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Night\_12 and Day.

Formula to calculate 8 bit WeightFactor table out of ARL luminance table:

Weightfactor[Dimming\_lvl, Litval] =

roundup (1024\*(luminance[Dimming\_lvl, Litval] - L\_min))/( L\_max - L\_min)

Luminance [Dimming\_lvl, Litval] = Luminance value at the table intersection point Dimming\_lvl and Litval

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Night\_12 and Day.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | Litval | | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_lvl | Night\_1 | 0 | 11 | 27 | 52 | 88 | 1024 |
| Night\_2 | 8 | 22 | 41 | 70 | 113 | 1024 |
| Night\_3 | 18 | 35 | 59 | 94 | 144 | 1024 |
| Night\_4 | 32 | 53 | 83 | 124 | 181 | 1024 |
| Night\_5 | 52 | 78 | 113 | 161 | 227 | 1024 |
| Night\_6 | 78 | 110 | 152 | 209 | 284 | 1024 |
| Night\_7 | 113 | 152 | 203 | 269 | 353 | 1024 |
| Night\_8 | 162 | 209 | 269 | 344 | 438 | 1024 |
| Night\_9 | 228 | 284 | 354 | 439 | 543 | 1024 |
| Night\_10 | 317 | 384 | 463 | 558 | 672 | 1024 |
| Night\_11 | 440 | 516 | 605 | 709 | 830 | 1024 |
| Night\_12 | 607 | 692 | 789 | 899 | 1024 | 1024 |
| Day\_1 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_2 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_3 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_4 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_5 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_6 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |

Table 3 Example Weight Factor Table

SAMPLE: Resulting 8 bit PWM output using DID\_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See 3.1.2 for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in 3.1.3.

255 equals 100% PWM duty cycle, 0 equals OFF, all intermediate values are linearly interpolated:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_lvl | Night\_1 | 5 | 8 | 12 | 18 | 26 | 255 |
| Night\_2 | 7 | 10 | 15 | 22 | 33 | 255 |
| Night\_3 | 9 | 14 | 19 | 28 | 40 | 255 |
| Night\_4 | 13 | 18 | 25 | 35 | 49 | 255 |
| Night\_5 | 18 | 24 | 33 | 44 | 60 | 255 |
| Night\_6 | 24 | 32 | 42 | 56 | 74 | 255 |
| Night\_7 | 33 | 42 | 55 | 71 | 91 | 255 |
| Night\_8 | 45 | 56 | 71 | 89 | 112 | 255 |
| Night\_9 | 61 | 74 | 91 | 112 | 138 | 255 |
| Night\_10 | 82 | 99 | 118 | 141 | 169 | 255 |
| Night\_11 | 112 | 131 | 153 | 178 | 208 | 255 |
| Night\_12 | 153 | 174 | 198 | 224 | 255 | 255 |
| Day\_1 | 255 | 255 | 255 | 255 | 255 | 255 |
| Day\_2 | 255 | 255 | 255 | 255 | 255 | 255 |
| Day\_3 | 255 | 255 | 255 | 255 | 255 | 255 |
| Day\_4 | 255 | 255 | 255 | 255 | 255 | 255 |
| Day\_5 | 255 | 255 | 255 | 255 | 255 | 255 |
| Day\_6 | 255 | 255 | 255 | 255 | 255 | 255 |

Table 4 Resulting 8 Bit PWM Table

### 10 Bit PWM Display Backlight

#### Brightness Calibration of Display Backlight and Gauge Pointer

The following 2 calibratable parameters should be stored as DIDs. Each value is a 2 byte value. For every 10-bit backlight zone a separate parameter block must be stored:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM | 4 | 2 | 0 - 1023 | PWM value for lowest brightness  e.g.: Dimming\_Lvl "Night\_1", Litval "Night"  0 refers to 0% PWM duty cycle (off),  1023 refers to 100 % PWM duty cycle (max intensity) |
| DID\_High\_PWM | 1023 | 2 | 0 - 1023 | PWM value for highest brightness  e.g.: Dimming\_Lvl "Day\_6", Litval “Day"  0 refers to 0% PWM duty cycle (off),  1023 refers to 100 % PWM duty cycle (max intensity) |

#### Definition of Weight Factors for 10 Bit PWM (Displays, Gauge Dials and Pointers)

The DID\_WeightFactorDP is a calibratable parameter with 108 values. The table below is for reference only. The final values will be evaluated during measurements and distributed to the component teams. The Interaction & Ergonomics team will provide the target luminance values. The ECU supplier must calculate and store the resulting DID values based on the following description.

DID\_WeightFactorDP:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 2 | 4 | 6 | 9 | 211 |
| Night\_2 | 2 | 3 | 6 | 9 | 12 | 211 |
| Night\_3 | 4 | 6 | 8 | 12 | 17 | 211 |
| Night\_4 | 6 | 9 | 12 | 17 | 23 | 211 |
| Night\_5 | 9 | 12 | 17 | 22 | 30 | 211 |
| Night\_6 | 13 | 17 | 23 | 30 | 39 | 211 |
| Night\_7 | 18 | 23 | 31 | 40 | 51 | 211 |
| Night\_8 | 25 | 32 | 41 | 52 | 66 | 211 |
| Night\_9 | 33 | 43 | 54 | 68 | 85 | 211 |
| Night\_10 | 45 | 57 | 71 | 88 | 110 | 211 |
| Night\_11 | 61 | 75 | 93 | 115 | 141 | 211 |
| Night\_12 | 81 | 99 | 121 | 149 | 181 | 211 |
| Day\_1 | 211 | 227 | 245 | 263 | 283 | 305 |
| Day\_2 | 242 | 266 | 292 | 322 | 354 | 389 |
| Day\_3 | 276 | 311 | 349 | 393 | 441 | 496 |
| Day\_4 | 316 | 363 | 417 | 479 | 550 | 632 |
| Day\_5 | 361 | 424 | 498 | 584 | 686 | 804 |
| Day\_6 | 413 | 495 | 594 | 713 | 854 | 1024 |

Table 5 Example 10 Bit Weightfactor Table

#### Determine the PWM Value for 10 Bit PWM Display Backlight and Pointer PWM

Note: If Dimming\_Lvl = 0x0(Off), PWM\_TargetValueDP is 0x0.

DID\_High\_PWM

WeightFactorDP

DID\_Low\_PWM

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 5

DID\_WeightFactorDP

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP

#### Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

SAMPLE: Luminance table from ARL (values expressed as cd/m²)

**Note: THESE ARE EXAMPLE VALUES. PROGRAM SPECIFC VALUES MUST BE ALIGNED BETWEEN THE RESPECTIVE COMPONENT OWNER AND THE PROGRAM RESPONSIBLE INTERACTION & ERGONOMICS ENGINEER. ALL VALUES ARE SUBJECT TO CHANGE BASED ON THE INTERIOR HARMONIZATION PROCESS!**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 4.00 | 5.29 | 6.99 | 9.25 | 12.23 | 209.00 |
| Night\_2 | 5.27 | 6.91 | 9.07 | 11.90 | 15.62 | 209.00 |
| Night\_3 | 6.93 | 9.03 | 11.76 | 15.31 | 19.94 | 209.00 |
| Night\_4 | 9.12 | 11.79 | 15.24 | 19.70 | 25.46 | 209.00 |
| Night\_5 | 12.01 | 15.41 | 19.76 | 25.35 | 32.52 | 209.00 |
| Night\_6 | 15.81 | 20.13 | 25.62 | 32.62 | 41.52 | 209.00 |
| Night\_7 | 20.81 | 26.29 | 33.22 | 41.97 | 53.02 | 209.00 |
| Night\_8 | 27.39 | 34.35 | 43.07 | 54.00 | 67.70 | 209.00 |
| Night\_9 | 36.06 | 44.87 | 55.83 | 69.48 | 86.45 | 209.00 |
| Night\_10 | 47.47 | 58.62 | 72.39 | 89.39 | 110.39 | 209.00 |
| Night\_11 | 62.48 | 76.58 | 93.85 | 115.02 | 140.96 | 209.00 |
| Night\_12 | 82.25 | 100.04 | 121.68 | 147.99 | 180.00 | 209.00 |
| Day\_1 | 209.00 | 224.67 | 241.51 | 259.62 | 279.08 | 300.00 |
| Day\_2 | 238.57 | 262.08 | 287.90 | 316.27 | 347.44 | 381.68 |
| Day\_3 | 272.31 | 305.71 | 343.20 | 385.29 | 432.55 | 485.59 |
| Day\_4 | 310.84 | 356.61 | 409.13 | 469.38 | 538.50 | 617.80 |
| Day\_5 | 354.81 | 415.99 | 487.71 | 571.81 | 670.41 | 786.00 |
| Day\_6 | 405.00 | 485.25 | 581.40 | 696.60 | 834.62 | 1000.00 |

Table 6 ARL Example Luminance Table [cd/m²]

Calculation of intensity offset DIDs out of ARL luminance table

DID\_Low\_PWM =round(1023\*(L\_min)/( L\_max))

Example calculation based on Table 6 ARL Example Luminance Table [cd/m²]:

DID\_Low\_PWM = round(1023\*4/1000) = 4

DID\_High\_PWM = round(1023\*(L\_max)/( L\_max))

Example calculation based on Table 6 ARL Example Luminance Table [cd/m²]:

DID\_High\_PWM = round(1023\*1000/1000) = 1023

Round: choose the next higher integer if first decimal digit is equal or higher than 5.

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Day\_6 and Day.

Formula to calculate 10 bit WeightFactor table out of ARL luminance table:

Weightfactor[Dimming\_lvl, Litval] =

roundup (1024\*(luminance[Dimming\_lvl, Litval] - L\_min))/( L\_max - L\_min)

Luminance [Dimming\_lvl, Litval] = Luminance value at the table intersection point Dimming\_Lvl and Litval

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Day\_6 and Day.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 2 | 4 | 6 | 9 | 211 |
| Night\_2 | 2 | 3 | 6 | 9 | 12 | 211 |
| Night\_3 | 4 | 6 | 8 | 12 | 17 | 211 |
| Night\_4 | 6 | 9 | 12 | 17 | 23 | 211 |
| Night\_5 | 9 | 12 | 17 | 22 | 30 | 211 |
| Night\_6 | 13 | 17 | 23 | 30 | 39 | 211 |
| Night\_7 | 18 | 23 | 31 | 40 | 51 | 211 |
| Night\_8 | 25 | 32 | 41 | 52 | 66 | 211 |
| Night\_9 | 33 | 43 | 54 | 68 | 85 | 211 |
| Night\_10 | 45 | 57 | 71 | 88 | 110 | 211 |
| Night\_11 | 61 | 75 | 93 | 115 | 141 | 211 |
| Night\_12 | 81 | 99 | 121 | 149 | 181 | 211 |
| Day\_1 | 211 | 227 | 245 | 263 | 283 | 305 |
| Day\_2 | 242 | 266 | 292 | 322 | 354 | 389 |
| Day\_3 | 276 | 311 | 349 | 393 | 441 | 496 |
| Day\_4 | 316 | 363 | 417 | 479 | 550 | 632 |
| Day\_5 | 361 | 424 | 498 | 584 | 686 | 804 |
| Day\_6 | 413 | 495 | 594 | 713 | 854 | 1024 |

Table 7 Weightfactor Table 10 Bit

SAMPLE: Resulting 10 bit PWM output using DID\_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See 3.1.2 for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in 3.1.3.

1023 equals 100% PWM duty cycle, 0 equals OFF, all intermediate values are linearly interpolated:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 4 | 6 | 8 | 10 | 13 | 214 |
| Night\_2 | 6 | 7 | 10 | 13 | 16 | 214 |
| Night\_3 | 8 | 10 | 12 | 16 | 21 | 214 |
| Night\_4 | 10 | 13 | 16 | 21 | 27 | 214 |
| Night\_5 | 13 | 16 | 21 | 26 | 34 | 214 |
| Night\_6 | 17 | 21 | 27 | 34 | 43 | 214 |
| Night\_7 | 22 | 27 | 35 | 44 | 55 | 214 |
| Night\_8 | 29 | 36 | 45 | 56 | 70 | 214 |
| Night\_9 | 37 | 47 | 58 | 72 | 89 | 214 |
| Night\_10 | 49 | 61 | 75 | 92 | 113 | 214 |
| Night\_11 | 65 | 79 | 97 | 118 | 144 | 214 |
| Night\_12 | 85 | 103 | 124 | 152 | 184 | 214 |
| Day\_1 | 214 | 230 | 248 | 266 | 286 | 308 |
| Day\_2 | 245 | 269 | 295 | 324 | 356 | 391 |
| Day\_3 | 279 | 313 | 351 | 395 | 443 | 498 |
| Day\_4 | 318 | 365 | 419 | 481 | 551 | 633 |
| Day\_5 | 363 | 426 | 500 | 585 | 687 | 804 |
| Day\_6 | 415 | 497 | 595 | 714 | 854 | 1023 |

Table 8 Resulting PWM Table 10 Bit

### 12 Bit PWM Display Backlight

#### Brightness Calibration of 12 Bit Illumination Zones

The following 2 calibratable parameters should be stored as DIDs. Each value is a 2 byte value. For every 12-bit backlight zone a separate parameter block must be stored:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM | 16 | 2 | 0 - 4095 | PWM value for lowest brightness  e.g.: Dimming\_Lvl "Night\_1", Litval "Night"  0 refers to 0% PWM duty cycle (off),  4095 refers to 100 % PWM duty cycle (max intensity) |
| DID\_High\_PWM | 4095 | 2 | 0 - 4095 | PWM value for highest brightness  e.g.: Dimming\_Lvl "Day\_6", Litval “Day"  0 refers to 0% PWM duty cycle (off),  4095 refers to 100 % PWM duty cycle (max intensity) |

#### Definition of Weight Factors for 12 Bit PWM (Displays, Gauge Dials and Pointers)

The DID\_WeightFactorDP is a calibratable parameter with 108 values. The table below is for reference only. The final values will be evaluated during measurements and distributed to the component teams. The Interaction & Ergonomics team will provide the target luminance values. The ECU supplier must calculate and store the resulting DID values based on the following description.

DID\_WeightFactorDP:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 5 | 11 | 21 | 35 | 649 |
| Night\_2 | 4 | 9 | 17 | 29 | 47 | 649 |
| Night\_3 | 8 | 15 | 25 | 40 | 62 | 649 |
| Night\_4 | 14 | 23 | 36 | 54 | 81 | 649 |
| Night\_5 | 22 | 34 | 50 | 73 | 105 | 649 |
| Night\_6 | 34 | 49 | 69 | 97 | 136 | 649 |
| Night\_7 | 49 | 69 | 94 | 129 | 175 | 649 |
| Night\_8 | 71 | 96 | 128 | 170 | 226 | 649 |
| Night\_9 | 101 | 132 | 172 | 224 | 290 | 649 |
| Night\_10 | 143 | 182 | 231 | 293 | 371 | 649 |
| Night\_11 | 200 | 249 | 309 | 384 | 475 | 649 |
| Night\_12 | 280 | 340 | 413 | 501 | 608 | 649 |
| Day\_1 | 649 | 679 | 710 | 743 | 777 | 813 |
| Day\_2 | 721 | 789 | 862 | 942 | 1029 | 1125 |
| Day\_3 | 802 | 916 | 1045 | 1193 | 1362 | 1555 |
| Day\_4 | 891 | 1063 | 1268 | 1512 | 1802 | 2148 |
| Day\_5 | 990 | 1234 | 1537 | 1914 | 2383 | 2967 |
| Day\_6 | 1100 | 1432 | 1863 | 2423 | 3151 | 4096 |

Table 9 Example Weightfactor Table 12 Bit

Figure 2

#### Determine the PWM Value for 12 Bit PWM Display Backlight and Pointer PWM

Note: If Dimming\_Lvl = 0x0(Off), PWM\_TargetValueDP is 0x0.

DID\_High\_PWM

WeightFactorDP

DID\_Low\_PWM

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 9

DID\_WeightFactorDP

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP

#### Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

SAMPLE: Luminance table from ARL (values expressed as cd/m²)

**Note: THESE ARE EXAMPLE VALUES. PROGRAM SPECIFC VALUES MUST BE ALIGNED BETWEEN THE RESPECTIVE COMPONENT OWNER AND THE PROGRAM RESPONSIBLE INTERACTION & ERGONOMICS ENGINEER. ALL VALUES ARE SUBJECT TO CHANGE BASED ON THE INTERIOR HARMONIZATION PROCESS!**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 4.00 | 5.29 | 6.99 | 9.25 | 12.23 | 209.00 |
| Night\_2 | 5.27 | 6.91 | 9.07 | 11.90 | 15.62 | 209.00 |
| Night\_3 | 6.93 | 9.03 | 11.76 | 15.31 | 19.94 | 209.00 |
| Night\_4 | 9.12 | 11.79 | 15.24 | 19.70 | 25.46 | 209.00 |
| Night\_5 | 12.01 | 15.41 | 19.76 | 25.35 | 32.52 | 209.00 |
| Night\_6 | 15.81 | 20.13 | 25.62 | 32.62 | 41.52 | 209.00 |
| Night\_7 | 20.81 | 26.29 | 33.22 | 41.97 | 53.02 | 209.00 |
| Night\_8 | 27.39 | 34.35 | 43.07 | 54.00 | 67.70 | 209.00 |
| Night\_9 | 36.06 | 44.87 | 55.83 | 69.48 | 86.45 | 209.00 |
| Night\_10 | 47.47 | 58.62 | 72.39 | 89.39 | 110.39 | 209.00 |
| Night\_11 | 62.48 | 76.58 | 93.85 | 115.02 | 140.96 | 209.00 |
| Night\_12 | 82.25 | 100.04 | 121.68 | 147.99 | 180.00 | 209.00 |
| Day\_1 | 209.00 | 224.67 | 241.51 | 259.62 | 279.08 | 300.00 |
| Day\_2 | 238.57 | 262.08 | 287.90 | 316.27 | 347.44 | 381.68 |
| Day\_3 | 272.31 | 305.71 | 343.20 | 385.29 | 432.55 | 485.59 |
| Day\_4 | 310.84 | 356.61 | 409.13 | 469.38 | 538.50 | 617.80 |
| Day\_5 | 354.81 | 415.99 | 487.71 | 571.81 | 670.41 | 786.00 |
| Day\_6 | 405.00 | 485.25 | 581.40 | 696.60 | 834.62 | 1000.00 |

Table 10 ARL Example Luminance Table [cd/m²] 12 Bit

Calculation of intensity offset DIDs out of ARL luminance table

DID\_Low\_PWM =round(4095\*(L\_min)/( L\_max))

Example calculation based on Table 10:

DID\_Low\_PWM = round(4095\*4/1000) = 16

DID\_High\_PWM = round(4095\*(L\_max)/( L\_max))

Example calculation based on Table 10:

DID\_High\_PWM = round(4095\*1000/1000) = 4095

Round: choose the next higher integer if first decimal digit is equal or higher than 5.

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Day\_6 and Day.

Formula to calculate 12 bit WeightFactor table out of ARL luminance table:

Weightfactor[Dimming\_lvl, Litval] =

roundup (4096\*(luminance[Dimming\_lvl, Litval] - L\_min))/( L\_max - L\_min)

Luminance [Dimming\_lvl, Litval] = Luminance value at the table intersection point Dimming\_Lvl and Litval

L\_min = ARL table field with lowest luminance. Usually the intersection point of Night\_1 and Night.

L\_max = ARL table field with highest luminance. Usually the intersection point of Day\_6 and Day.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 6 | 13 | 22 | 34 | 844 |
| Night\_2 | 6 | 12 | 21 | 33 | 48 | 844 |
| Night\_3 | 13 | 21 | 32 | 47 | 66 | 844 |
| Night\_4 | 22 | 33 | 47 | 65 | 89 | 844 |
| Night\_5 | 33 | 47 | 65 | 88 | 118 | 844 |
| Night\_6 | 49 | 67 | 89 | 118 | 155 | 844 |
| Night\_7 | 70 | 92 | 121 | 157 | 202 | 844 |
| Night\_8 | 97 | 125 | 161 | 206 | 262 | 844 |
| Night\_9 | 132 | 169 | 214 | 270 | 340 | 844 |
| Night\_10 | 179 | 225 | 282 | 352 | 438 | 844 |
| Night\_11 | 241 | 299 | 370 | 457 | 564 | 844 |
| Night\_12 | 322 | 395 | 484 | 593 | 724 | 844 |
| Day\_1 | 844 | 908 | 977 | 1052 | 1132 | 1218 |
| Day\_2 | 965 | 1062 | 1168 | 1285 | 1413 | 1554 |
| Day\_3 | 1104 | 1241 | 1395 | 1569 | 1763 | 1981 |
| Day\_4 | 1262 | 1451 | 1667 | 1914 | 2199 | 2525 |
| Day\_5 | 1443 | 1695 | 1990 | 2336 | 2741 | 3216 |
| Day\_6 | 1650 | 1980 | 2375 | 2849 | 3416 | 4096 |

Table 11 Weightfactor Table 12 Bit

SAMPLE: Resulting 12 bit PWM output using DID\_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See 3.1.2 for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in 3.1.3.

4095 equals 100% PWM duty cycle, 0 equals OFF, all intermediate values are linearly interpolated:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 16 | 22 | 29 | 38 | 50 | 856 |
| Night\_2 | 22 | 28 | 37 | 49 | 64 | 856 |
| Night\_3 | 29 | 37 | 48 | 63 | 82 | 856 |
| Night\_4 | 38 | 49 | 63 | 81 | 105 | 856 |
| Night\_5 | 49 | 63 | 81 | 104 | 134 | 856 |
| Night\_6 | 65 | 83 | 105 | 134 | 170 | 856 |
| Night\_7 | 86 | 108 | 136 | 172 | 217 | 856 |
| Night\_8 | 113 | 140 | 176 | 221 | 277 | 856 |
| Night\_9 | 147 | 184 | 229 | 285 | 355 | 856 |
| Night\_10 | 194 | 240 | 297 | 367 | 452 | 856 |
| Night\_11 | 256 | 314 | 384 | 471 | 578 | 856 |
| Night\_12 | 337 | 409 | 498 | 607 | 737 | 856 |
| Day\_1 | 856 | 920 | 989 | 1064 | 1143 | 1229 |
| Day\_2 | 977 | 1074 | 1179 | 1296 | 1423 | 1564 |
| Day\_3 | 1115 | 1252 | 1405 | 1578 | 1772 | 1989 |
| Day\_4 | 1273 | 1461 | 1676 | 1922 | 2206 | 2531 |
| Day\_5 | 1453 | 1704 | 1998 | 2342 | 2746 | 3219 |
| Day\_6 | 1659 | 1988 | 2381 | 2853 | 3418 | 4095 |

Table 12 Resulting PWM Table 12 Bit

### Maximum Delay from CAN Message to LIN/IIC Message

If the signal is transferred via LIN or IIC bus and the PWM target value has changed, at each frame a new value with the function SmoothTransitionNextValue should be calculated until the new PWM target value is reached. If the PWM value has reached his new PWM target value, the frame cycle time could be reduced.

The function SmoothTransitionNextValue should be called with the output from the function PWM\_TargetValueBL or PWM\_TargetValueDP. Every call with the same target value deliver a new value according the interpolation table. If the target value change, the interpolation automatic restarts from the actual point.

t

…

T1

t

PWM value at LIN/IIC

T2

t

CAN message

LIN/IIC message

T6

CAN messages value A

CAN messages B

LIN/IIC PWM values B

LIN/IIC PWM values A

LIN/IIC PWM values A to B

zoom

calculation

T3

T4

T5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Abbreviation** | **Description** | **Max** | **Unit** |
| 1 | T1 | LIN/IIC cycle time, while no change of PWM value | 500 | ms |
| 2 | T2 | LIN/IIC cycle time, while PWM value change | 40 | ms |
| 3 | T3 | Calculation time to get new PWM value | 5 | ms |
| 4 | T4 | Max time to begin of next LIN/IIC frame | T2 | ms |
| 5 | T5 | Max time to complete a LIN/IIC frame | 10 | ms |
| 6 | T6 | Max reaction time from CAN to LIN/IIC frame 1 | T3+T4+T5 | ms |
| 7 | FJ | Frame time jitter | +/- 10 | % |

Note 1: Start measure time after the 3rd interframe bit of CAN message with new PWM value

Stop measure time after first stop bit of check sum at LIN message with new PWM value

Stop measure time after stop signal at IIC bus with new PWM value

Note 2: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

### Maximum Delay from CAN Message to PWM Output

If the signal is transferred to the PWM generator and the PWM target value has changed, at each PWM update time (T2) a new value with the function SmoothTransitionNextValue should be calculated until the new PWM target value is reached. If the PWM value has reached his PWM new target value, the PWM update time could be reduced (T1).

The function SmoothTransitionNextValue should be called with the output from the function PWM\_TargetValueBL or PWM\_TargetValueDP. Every call with the same target value delivers a new value according the interpolation table. If the target value changes, the interpolation automatically restarts from the actual point. After this, if necessary, the value must be LED bin adjusted and/or adjusted to the supply voltage.

t

…

T1

t

PWM value at output

T2

t

CAN message

PWM output

T5

CAN messages value A

CAN messages B

PWM values B

PWM values A

PWM values A to B

zoom

calculation

T3

T4

T4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Abbreviation** | **Description** | **Max** | **Unit** |
| 1 | T1 | PWM update time, while no change of PWM value | 500 | ms |
| 2 | T2 | PWM update time, while PWM value change | 40 | ms |
| 3 | T3 | Calculation time to get new PWM value | 5 | ms |
| 4 | T4 | PWM cycle Time 2 | 1 / fP | ms |
| 5 | T5 | Max reaction time from CAN to PWM output 1 | T3+2\*T4 | ms |
| 6 | PJ | PWM update time jitter | +/- 10 | % |

Note 1: Start measure time after the 3rd interframe bit of CAN message with new PWM value

Stop measure at raising edge of new PWM value

Note 2: fP = PWM output frequency

Note 3: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

### Maximum Delay from LIN/IIC Message to PWM Output

The PWM value at LIN/IIC message is transferred to the next possible PWM square wave. If necessary, the value must be LED bin adjusted and/or adjusted to the supply voltage.

t

…

T1

t

PWM value at output

T2

t

LIN/IIC message

PWM output

T5

LIN/IIC messages value A

LIN/IIC messages B

PWM values B

PWM values A

PWM values A to B

zoom

calculation

T3

T4

T4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Abbreviation** | **Description** | **Max** | **Unit** |
| 1 | T1 | PWM update time, while no change of PWM value | 500 | ms |
| 2 | T2 | PWM update time, while PWM value change | 40 | ms |
| 3 | T3 | Calculation time to get new PWM value 4 | 1 | ms |
| 4 | T4 | PWM cycle Time 2 | 1 / fP | ms |
| 5 | T5 | Max reaction time from LIN/IIC to PWM output 1 | T3+2\*T4 | ms |
| 6 | PJ | PWM update time jitter | +/- 10 | % |

Note 1: Start measure time after first stop bit of check sum at LIN message with new PWM value

Start measure time after stop signal at IIC bus with new PWM value

Stop measure at raising edge of new PWM value

Note 2: fP = PWM output frequency

Note 3: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

Note 4: The maximum calculation time is extended to 5 ms if the dimming algorithm is within the receiving module.

## Telltale and Indicator Dimming

This sub-chapter is applicable for indicator and telltale dimming, even if only the word indicator is mentioned. Indicators must be able to support at least two step dimming. For indicators at least 8-bit PWM generators should be available. This specification only defines the indicator intensity. The indicator on / off request is always controlled by the related function.

### Two-step Dimming

IndicationBrightness

Indicator Function

(on / off)

DID\_Night\_PWM

PWM Generator and LED

DID\_Day\_PWM

0

Each indicator, or indicator set, must support intensity calibration via diagnostic tools. A component that contains an indicator set with two or more indicators with equal luminance and chromaticity requirements may share one illumination parameter. All other indicators must support a separate calibration parameter. Every external indicator / telltale, which is connected to the wire harness, is assumed to be a separate zone. The calibratable DID must support a day and a night setting with 8 bit resolution as shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Range** | **Comment, Description** |
| DID\_Night\_PWM | 231) | 0 - 255 | PWM value for night time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle | |
| DID\_Day\_PWM | 255 | 0 - 255 | PWM value for day time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle | |

1) If ALS is not present (not recommended), DID\_Night\_PWM must be adjusted to ensure legibility in all conditions, e.g. bright daytime conditions. The adjustment must be approved by a FORD representative responsible for legibility.

See chapter 3.1.1 for DID calibration details.

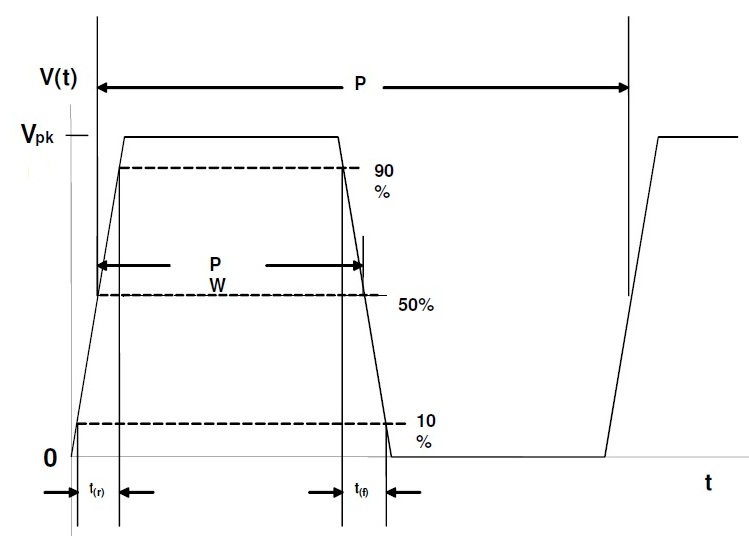
#### Telltale and Indicator Day / Night Selection

The signals for the Day/Night selection for indicator / telltale brightness should immediately transition based on changes in the following signals.

|  |  |  |  |
| --- | --- | --- | --- |
| **Inputs** | | | **Output** |
| **Dimming\_Lvl** | **Day\_Night\_Status** | **Parklamp\_Status** | **IndicationBrightness** |
| Day\_1 .. Day\_6 | Don’t care | Don’t care | Day |
| Night\_1 .. Night\_12 | Don’t care | Don’t care | Night |
| Off, (Unknown, Invalid)1 | Day | Don’t care | Day |
| Off, (Unknown, Invalid)1 | Night | On | Night |
| Off, (Unknown, Invalid)1 | Night | Off | Day |
| Off, (Unknown, Invalid)1 | Null, NotUsed | On | Night |
| Off, (Unknown, Invalid)1 | Null, NotUsed | Off, (Unknown, Invalid)1 | Day |

## PWM Signals

Definition of PWM values:



During updating the PWM generator no unexpected PWM ratios are allowed. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio. Care must be taken, that such side effects are avoided when loading a new value in the PWM generator.

Example: If the actual PWM ratio is 25% and new target ratio is 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%.

### PWM Signals at Vehicle Wire harness

Some modules need to power external indicators or backlight via the vehicle wire harness. E.g. standalone switches and / or indicators. Following requirements are valid for PWM signals which are sent via vehicle wire harness to other components.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operating Conditions: 1,2 System Voltage: 9.5 < Vsys < 16.0 volts  Ambient Temperature: -40oC < Tamb < 85oC | | | | | | |
| **No** | **Characteristic** | **Comment** | **Min** | **Typ** | **Max** | **Unit** |
| 1 | PWM Output frequency 1/P 3 | Configurable in the ECU | 100 | 220 | 400 | Hz |
| 2 | PWM Output frequency 1/P 4 | Configurable in the ECU | 200 | 220 | 400 | Hz |
| 3 | Frequency jitter | Measured via 1 second sliding window |  |  | 0.1 | Δ % |
| 4 | PWM rise t(r) / fall time t(f) |  | 8 |  | 50 | µs |
| 5 | PWM output duty cycle Pw/P7 |  | 0 |  | 100 | % |
| 6 | PWM output duty cycle jitter | Measured via 1 second sliding window |  |  | 0.1 | Δ % |
| 7 | PWM output duty cycle tolerance total |  |  |  | 0.2 | Δ % |
| 8 | PWM resolution | 8 bit or better |  |  | 1/255 |  |
| 9 | PWM response time message 5 |  |  |  | 21 | ms |
| 10 | PWM response time voltage 6 |  |  |  | 18 | ms |
| 11 | Shortage to GND detection | Duty cycle while error detection active | 10 |  | 100 | % |
| 12 | Shortage to Ubat or open line detection | Duty cycle while error detection active | 0 |  | 90 | % |
| 13 | PWM output voltage (Vpk) | Short circuit & reverse battery protected | Vsys-1.5 |  |  | V |
| 14 | Ground Offset | See ELCOMP requirement RQT-191001-009976 & 009989 | | | | V |

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.

Note 2: Output values are measured at the ECU with the PWM output and related to ECU GND.

Note 3: For zones without software voltage compensation

Note 4: For zones with software voltage compensation

Note 5: Time when message is complete at bus to PWM response is measured at ECU PWM output.

Note 6: Time when voltage jump is applied to PWM response is measured at ECU PWM output.

This value is only applicable if software voltage compensation is used.

Note7: Any received PWM duty cycle shall be mapped to the closed available (considering

resolution) duty cycle in the receiving ECU.

### PWM Input Handling at Controls with Micro Controller

Each module with an internal micro controller and an external PWM illumination input must follow the PWM signal with the following requirements:

PWM duty cycle = 0% -> Illumination OFF

PWM duty cycle = 100% -> Maximum brightness intensity

PWM duty cycle >= 3% and PWM duty cycle <= 99% shall follow in a [monotonically](http://www.dict.cc/englisch-deutsch/monotonically.html) [increasing](http://www.dict.cc/englisch-deutsch/nondecreasing.html) function.

(PWM duty cycle >0 and PWM duty cycle < 3%) shall either follow the [monotonically](http://www.dict.cc/englisch-deutsch/monotonically.html) [increasing](http://www.dict.cc/englisch-deutsch/nondecreasing.html) function or stay OFF.

(PWM duty cycle >99 and PWM duty cycle < 100%) shall either follow the [monotonically](http://www.dict.cc/englisch-deutsch/monotonically.html) [increasing](http://www.dict.cc/englisch-deutsch/nondecreasing.html) function or stay at maximum brightness.

All PWM duty cycles between 0% and 100% are valid and shall be mapped to the nearest capability of the monitoring hardware.

### Internal 8-bit PWM Signals

Illumination zones with night time dimmable back light only or telltales should have at least 8-bit resolution. Following requirements are valid for internal 8-bit PWM signals.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operating Conditions: 1,2, 3 System Voltage: 9.5 < Vsys < 16.0 volts  Ambient Temperature: -40oC < Tamb < 85oC | | | | | | |
| **No** | **Characteristic** | **Comment** | **Min** | **Typ** | **Max** | **Unit** |
| 1 | PWM Output frequency 1/P |  | 200 | 300 |  | Hz |
| 2 | Frequency jitter | Measured via 1 second sliding window |  |  | 0.1 | Δ % |
| 3 | PWM output duty cycle jitter | Measured via 1 second sliding window |  |  | 0.1 | Δ % |
| 4 | PWM output duty cycle tolerance total |  |  |  | 0.2 | Δ % |
| 5 | PWM resolution | 8 bit or better |  |  | 1/255 |  |
| 6 | PWM response time message 4 |  |  |  | 21 | ms |
| 7 | PWM response time voltage 5 |  |  |  | 18 | ms |

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.

Note 2: Output values are measured at the related LED(s) related to ECU GND.

Note 3: Vsys is related to control module pins

Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).

Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).

This value is only applicable if software voltage compensation is used.

### Internal 10-bit PWM Signals

Illumination zones with day time dimmable back light like displays or pointer should have at least 10-bit resolution. Following requirements are valid for internal 10-bit PWM signals.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operating Conditions: 1,2, 3 System Voltage: 9.5 < Vsys < 16.0 volts  Ambient Temperature: -40oC < Tamb < 85oC | | | | | | |
| **No** | **Characteristic** | **Comment** | **Min** | **Typ** | **Max** | **Unit** |
| 1 | PWM Output frequency 1/P |  | 200 | 3006 |  | Hz |
| 2 | Frequency jitter | Measured via 1 second sliding window |  |  | 0.02 | Δ % |
| 3 | PWM output duty cycle jitter | Measured via 1 second sliding window |  |  | 0.02 | Δ % |
| 4 | PWM output duty cycle tolerance total |  |  |  | 0.04 | Δ % |
| 5 | PWM resolution | 10 bit or better |  |  | 1/1023 |  |
| 6 | PWM response time message 4 |  |  |  | 21 | ms |
| 7 | PWM response time voltage 5 |  |  |  | 18 | ms |

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.

Note 2: Output values are measured at the related LED(s) related to ECU GND.

Note 3: Vsys is related to control module pins

Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).

Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).

This value is only applicable if software voltage compensation is used.

Note 6: The PWM update frequency and the display screen update frequency must be chosen in a manner that the differential frequency does not produce visible flicker or other interferences on the screen.

### Internal 12-bit PWM Signals

Illumination zones with day time dimmable back light like displays or pointer should have at least 10-bit resolution. Following requirements are valid for internal 12-bit PWM signals.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operating Conditions: 1,2, 3 System Voltage: 9.5 < Vsys < 16.0 volts  Ambient Temperature: -40oC < Tamb < 85oC | | | | | | |
| **No** | **Characteristic** | **Comment** | **Min** | **Typ** | **Max** | **Unit** |
| 1 | PWM Output frequency 1/P |  | 200 | 3006 |  | Hz |
| 2 | Frequency jitter | Measured via 1 second sliding window |  |  | 0.02 | Δ % |
| 3 | PWM output duty cycle jitter | Measured via 1 second sliding window |  |  | 0.02 | Δ % |
| 4 | PWM output duty cycle tolerance total |  |  |  | 0.04 | Δ % |
| 5 | PWM resolution | 12 bit or better |  |  | 1/4095 |  |
| 6 | PWM response time message 4 |  |  |  | 21 | ms |
| 7 | PWM response time voltage 5 |  |  |  | 18 | ms |

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.

Note 2: Output values are measured at the related LED(s) related to ECU GND.

Note 3: Vsys is related to control module pins

Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).

Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).

This value is only applicable if software voltage compensation is used.

Note 6: The PWM update frequency and the display screen update frequency must be chosen in a manner that the differential frequency does not produce visible flicker or other interferences on the screen.

## CAN Signals

This chapter describe all illumination relevant CAN signals.

### Dimming\_Lvl

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Dimming\_Lvl |
| Send Type | OnChange | 500ms |
| Length (bit) | 8 |  |
| Coding | 0x00  0x01  0x02  0x03  0x04  0x05  0x06  0x07  0x08  0x09  0x0A  0x0B  0x0C  0x0D  0x0E  0x0F  0x10  0x11  0x12  0xFE  0xFF | Off Illumination Off  Night\_1 Barely Discernible  Night\_2  Night\_3  Night\_4  Night\_5  Night\_6  Night\_7  Night\_8  Night\_9  Night\_10  Night\_11  Night\_12 Max Nighttime Brightness  Day\_1 Min Daytime Brightness  Day\_2  Day\_3  Day\_4  Day\_5  Day\_6 Max Daytime Brightness  Unknown  Invalid |
| Description / Remarks |  | Driver selected illumination level |

### Parklamp\_Status

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Parklamp\_Status |
| Send Type | OnChange | 500ms |
| Length (bit) | 2 |  |
| Coding | 0x0  0x1  0x2  0x3 | Off  On  Unknown  Invalid |
| Description / Remarks |  | State of the park lamp |

### Litval

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Litval |
| Send Type | OnChange | 500ms |
| Length (bit) | 8 |  |
| Coding | 0x0  0x1  0x2  0x3  0x4  0x5  0xFE  0xFF | Night  Twilight\_1  Twilight\_2  Twilight\_3  Twilight\_4  Day  Unknown  Invalid |
| Description / Remarks |  | ALS driven ambient light level |

### Backlit\_LED\_Status

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Backlit\_LED\_Status |
| Send Type | OnChange | 500ms |
| Length (bit) | 4 |  |
| Coding | 0x0  0x1  0x2  0x3  0x4  0x5  0x6  0x7  0x8  0x9  0xA  0xB  0xC  0xD  0xE  0xF | Off  Night\_1  Night\_2  Night\_3  Night\_4  Night\_5  Night\_6  Night\_7  Night\_8  Night\_9  Night\_10  Night\_11  Night\_12  Unused1  Unused2  Unused3 |
| Description / Remarks |  | Driver selected illumination level |

### Ignition\_Status

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Ignition\_Status |
| Send Type | OnChange | 500ms |
| Length (bit) | 4 |  |
| Coding | 0x0  0x1  0x2  0x4  0x8  0xF | Unknown  Off  Accessory  Run  Start  Invalid |
| Description / Remarks |  | Vehicle ignition state |

### Delay\_Accy

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Delay\_Accy |
| Send Type | OnChange | 500ms |
| Length (bit) | 1 |  |
| Coding | 0x0  0x1 | Off  On |
| Description / Remarks |  | Delayed accessory |

### Day\_Night\_Status

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | BodyInfo\_3 |
| HS2 Message |  | BodyInfo\_3\_HS2 |
| HS3 Message |  | BodyInfo\_HS3 |
| MS1 Message |  | BodyInfo\_3\_MS1 |
| Signal Name |  | Day\_Night\_Status |
| Send Type | OnChange | 500ms |
| Length (bit) | 2 |  |
| Coding | 0x0  0x1  0x2  0x3 | Null (sensor not present)  Day  Night  NotUsed |
| Description / Remarks |  | Day night state form ALS |

### HMI\_HMIMode\_St

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  |  |
| HS2 Message |  |  |
| HS3 Message |  | HMI\_Send\_Signals\_7 |
| MS1 Message |  |  |
| Signal Name |  | HMI\_HMIMode\_St |
| Send Type | Event Periodic | 1000ms |
| Length (bit) | 1 |  |
| Coding | 0x0  0x1  0x2  0x3  0x4  0x5 | Invalid  OffMode  On  Phone  Climate  Load\_Shed\_Active |
| Description / Remarks |  | Multimedia system state  (Mapped to Multimedia\_System Signal) |

### Multimedia\_System

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | Cluster\_Info4\_HS1 |
| HS2 Message |  | Cluster\_Info1\_HS2 |
| HS3 Message |  |  |
| MS1 Message |  | HS3\_GatewayData\_MS1 |
| Signal Name |  | Multimedia\_System |
| Send Type | Event Periodic | 100ms |
| Length (bit) | 1 |  |
| Coding | 0x0  0x1 | Off  On |
| Description / Remarks |  | Multimedia system state  (Derived from HMI\_HMIMode\_St Signal) |

### Multimedia\_System\_UB

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | Cluster\_Info4\_HS1 |
| HS2 Message |  | Cluster\_Info1\_HS2 |
| HS3 Message |  |  |
| MS1 Message |  | HS3\_GatewayData\_MS1 |
| Signal Name |  | Multimedia\_System\_UB |
| Send Type | Event Periodic | 100ms |
| Length (bit) | 1 |  |
| Coding | 0x0  0x1 | Unchanged\_data  Fresh\_data |
| Description / Remarks |  | Multimedia system state update bit |

### Dimming\_Lvl\_RqMnu

|  |  |  |
| --- | --- | --- |
| **Item** | **Code** | **Name / Description** |
| HS1 Message |  | TBD – Received by BCM |
| HS2 Message |  |  |
| HS3 Message |  | TBD – Send by APIM |
| MS1 Message |  |  |
| Signal Name |  | Dimming\_Lvl\_RqMnu |
| Send Type | Event Periodic | 500ms |
| Length (bit) | 5 |  |
| Coding | 0x00  0x01  0x02  0x03  0x04  0x05  0x06  0x07  0x08  0x09  0x0A  0x0B  0x0C  0x0D  0x0E  0x0F  0x10  0x11  0x12  0x13  0x14 | Not Pressed  Night\_1 Barely Discernible  Night\_2  Night\_3  Night\_4  Night\_5  Night\_6  Night\_7  Night\_8  Night\_9  Night\_10  Night\_11  Night\_12 Max Nighttime Brightness  Day\_1 Min Daytime Brightness  Day\_2  Day\_3  Day\_4  Day\_5  Day\_6 Max Daytime Brightness  Down  Up |
| Description / Remarks |  | Request to set the interior dimming level |

## Warnings

Every module that needs to indicate / display a warning shall display the warning with the normal calculated illumination intensity if a valid illumination signal is available. A warning shall be displayed with the maximum illumination intensity (Day\_6 / Day or Night\_12 / Day) if the illumination input is received as OFF or invalid / missing.

## Network Sleep with Active Illumination

The illumination master ECU (BCM) might initiate a network sleep in low power modes (Ignition\_Status < (Run and Start) to minimize battery drainage. At the same time, it might be necessary to keep the illumination active ( > OFF) in some cases. All components receiving illumination signals shall maintain the last valid illumination signal value > OFF if a valid network sleep is initiated and the last received illumination signal is != OFF. The dimming master (BCM) shall wake-up and distribute the illumination signals = OFF if the condition, which requires illumination, does not exist anymore. Otherwise, illumination is required to stay ON indefinitely.

## CAN Error Handling for Illumination specific signals

If a Signal gateway message or Frame gateway message containing either Dimming\_Lvl, Backlit\_LED\_Status or HMI\_HMIMode\_St signal has an update bit which shows “not updated” for greater than a period of time as per “Diagnostic Fault Coverage and DTC Numbers Design Consideration” (typically 5 seconds) then the subscriber shall follow the following logic:

|  |  |  |
| --- | --- | --- |
| **CAN Input Signals** | | **Output for Dimming Algorithm** |
| **Backlit\_LED\_Status** | **Ignition\_Status** | **Backlit\_LED\_Status** |
| Missing / unused / invalid | Run, Start | Keep last valid received non-Off value |
| Off / Night\_1 ... Night\_12 | Run, Start | OFF / Night\_1 ... Night\_12 |
| Off / unused / invalid | Not (Run, Start) | OFF |
| Night\_1 ... Night\_12 | Not (Run, Start) | Night\_1 ... Night\_12 |
| Off, Night\_1 ... Night\_12 -> Missing | Not (Run, Start) | Keep last valid received value |
| **Dimming\_lvl** | **Ignition\_Status** | **Dimming\_lvl** |
| Missing / unused / invalid | Run, Start | Keep last valid received non-Off value |
| Off / Night\_1 ... Night\_12, Day\_1 … Day\_6 | Run, Start | Night\_1 ... Night\_12, Day\_1 … Day\_6 |
| Off/ unused / invalid | Not (Run, Start) | OFF |
| Night\_1 ... Night\_12, Day\_1 … Day\_6 | Not (Run, Start) | Night\_1 ... Night\_12, Day\_1 … Day\_6 |
| Off, Night\_1 ... Night\_12, Day\_1 … Day\_6 -> Missing | Not (Run, Start) | Keep last valid received value |

**Individual ECUs may require a specific CAN-error / extended illumination handling. The individual CAN-error / extended illumination handling overrides this general section if defined in the respecitive ECU relevant section.**

## Soft Dimmer via Onscreen Menu

The overall cockpit illumination intensity is adjustable via the following dimmer inputs:

* Physical dimmer buttons, typically housed in the head lamp switch.
* Soft HMI dimmer via onscreen menu

The following executions are possible:

* Physical dimmer buttons only
* Soft HMI dimmer via screen menu only
* Physical dimmer buttons and soft HMI dimmer
* No user selectable dimmer input (not recommended)

The soft HMI dimmer via

**The Carline specifc execution needs to be agreed with the Core and Appliction Function Owner for Cockpit Illumiantion!**

### Soft HMI Dimmer Interface

HW

HLS

BCM

SYNC

ECG

LIN

CAN

CAN

#### BCM



#### SYNC / Infotainment

##### Soft HMI Slider Indication

#### Soft HMI Slider Operation



Remarks:

* Dimmin\_Lvl2 cannot be set to OFF by the user. Valid range is Night\_1 to Night12 and Day\_1 to Day\_6
* The default setting is defined by BCM and received via CAN signal Dimming\_Lvl
* The dimming slider does not have a reset. Dimming\_Lvl signal is the default
* The HMI soft dimmer is configurable present / not-present via DID in the Infotainment ECU.
* The soft HMI dimmer is not selectable / greyed-out if Dimming\_Lvl is missing
* Long press dynamic timing behavior is defined by HMI /SYNC in accordance with other HMI elements of the same kind

#### ECG

The ECG shall receive the CAN signal Dimmin\_Lvl2 on HS3 and distribute the signal on HS1.

See 3.4.11 Dimming\_Lvl

# Display Day / Night Color Palette Selection

Displays may have different color palettes for daytime and nighttime. If two different color palettes are available the following color palette switching logic must be implemented. The color palette selection is dependent on the ambient light condition and user selection in SYNC screen. If palette selection is set to Auto by the user, the night color set shall be displayed in low ambient brightness scenarios, the day color palette shall be displayed in high ambient brightn ess scenarios.

The color palette switching logic is filtered via a time and value hysteresis to avoid frequent color palette switching and customer annoyance.

**Important note:** Any component with a day / night color palette switch is only applicable to vehicles equipped with an ambient light sensor. The ambient light sensor is the main input for the color palette switching. The related CAN signal Litval must support all signal values Night, Twilight\_1, Twilight\_2, Twilight\_3; Twilight\_4 and Day.

The Day\_Night\_Status signal is used for initialisation of the logic and missing sensor input detection.

The Litval signal contains the ambient light information. It is the main input to switch between the color sets.

The DID DID\_Threshold\_to\_Night defines the value based lower threshold for the night color set trigger.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Identifier** | **Default Value FNA** | **Default Value ROW** | **Resolution** | **Min Value** | **Max Value** | **Range** |
| DID\_Threshold\_to\_Night | Twilight\_1 | Twilight\_1 | 1 | Night | Twilight 4 | Night to Twilight\_4 (0x0 to 0x4) |

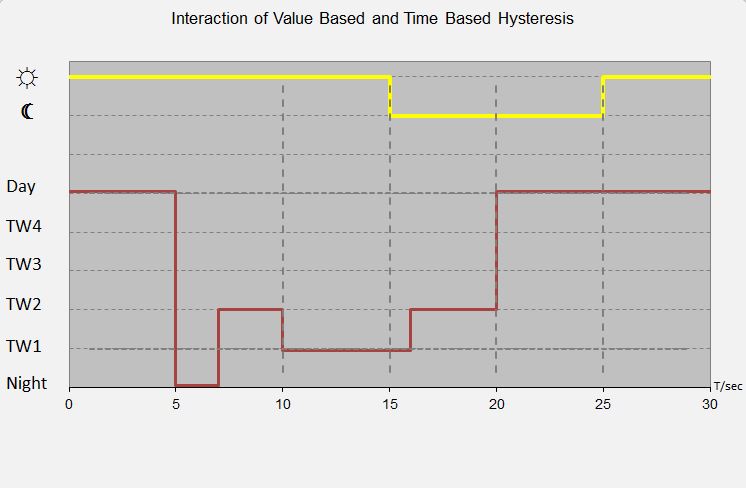
The DID DID\_DayToNightTime defines the time based hysteresis to switch from day to night color set.

The DID DID\_NightToDayTime defines the time based hysteresis to switch from night to night day set.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Identifier** | **Default Config Value FNA** | **Default Value Config ROW** | **Resolution** | **Min Value** | **Max Value** | **Unit** |
| DID\_DayToNightTime | 10 | 10 | 1 | 0 | 255 | Sec |
| DID\_NightToDayTime | 5 | 5 | 1 | 0 | 255 | Sec |

See chapter 3.1.1 for DID calibration details.

See below for detailed description



Precondition for this example use case visualisation: DID\_Threshold\_to\_Night = Twilight\_1; DID\_DayToNightTime = 5 sec; DID\_NightToDayTime = 5 sec;

T=0sec: Day color set displayed

T=5sec: Value threshold for night color set reached / undershot; hysteresis timer DayToNightTime start; Day color set still displayed

T=7sec: Value threshold for night color set exceeded again; Hysteresis timer DayToNightTime stopped and reset; Day color set still displayed

T=10sec: Value threshold for night color set reached; hysteresis timer DayToNightTime start; Day color set still displayed

T=15sec: Hysteresis timer DayToNightTime elapsed; change from Day to Night color set displayed

T=16sec: No threshold relevant event; No change

T=20sec: Value threshold for day color set reached; hysteresis timer NightToDayTime start; Night color set still displayed

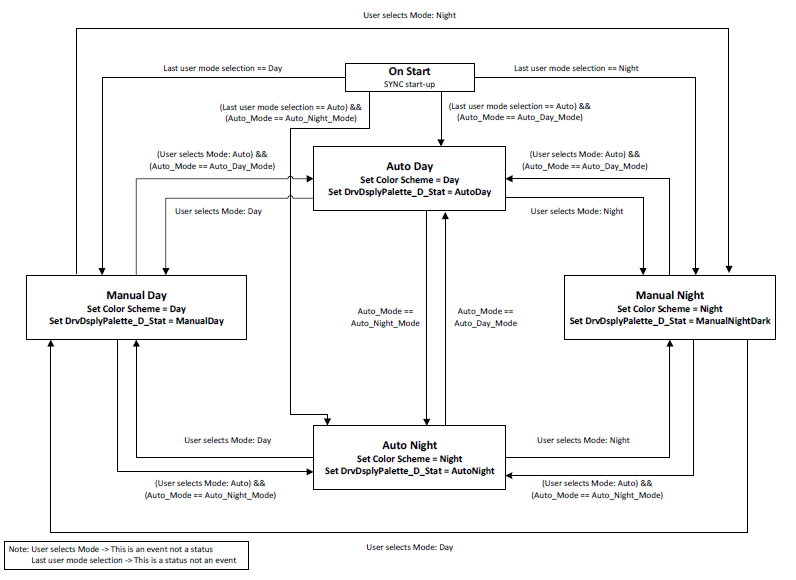
T=25 sec: Hysteresis timer NightToDayTime elapsed; change from Night to Day color set displayed

## SYNC Screen Display:

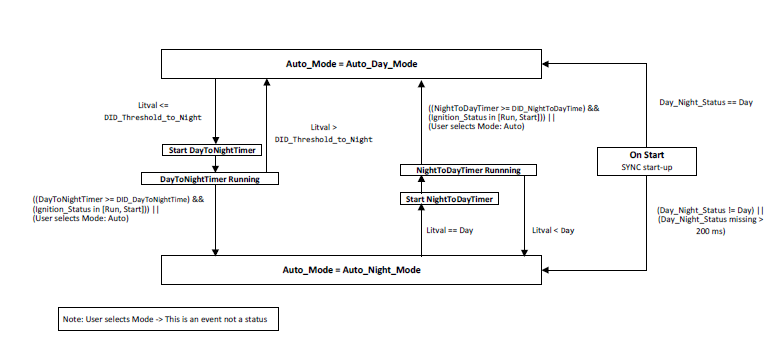
Sync screen supports 4 states, which are ManualDay, ManualNight, AutoDay and AutoNight. If the user selects auto mode and Litval signal is equal to Day, AutoDay is selected and similarly if user selects auto mode and Litval signal is anything except day mode, Auto Night is selected.

Further, if user selects Day, ManualDay is selected and if user selects Night, ManualNight is selected. These transitions happen regardless of Litval signal.

The flowchart below shows the transitions between the four states and the conditions that lead to those transitions.



The flowchart below shows the state machine for determining the state of  Auto\_Mode (between Auto\_Day\_Mode and Auto\_Night\_Mode). The auto color palette selection is based on Litval, which represents the ambient brightness. The other major conditions include ignition status and user selection of auto mode. This state machine should always run in parallel to the previous flow chart and acts as an input to it.



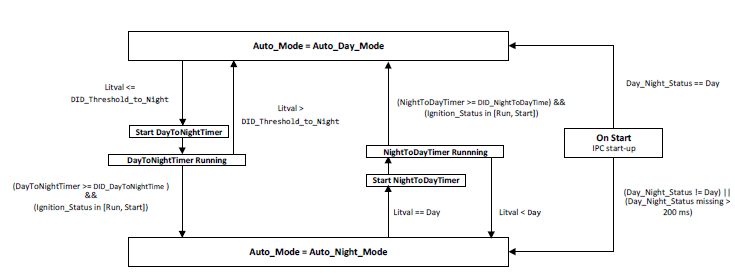
## Digital Instrument Panel Cluster

This section has been drafted specifically to support MY 21 U725 Program, namely the 2021 Ford Bronco. This program is supposed to have a digital cluster with a day and a night palette. Hence, a new signal is required from the APIM to the IPC to change the color palette. This section would be applicable to any future program in which the cluster color palette is expected to match the SYNC color palette at all times without any independent control.

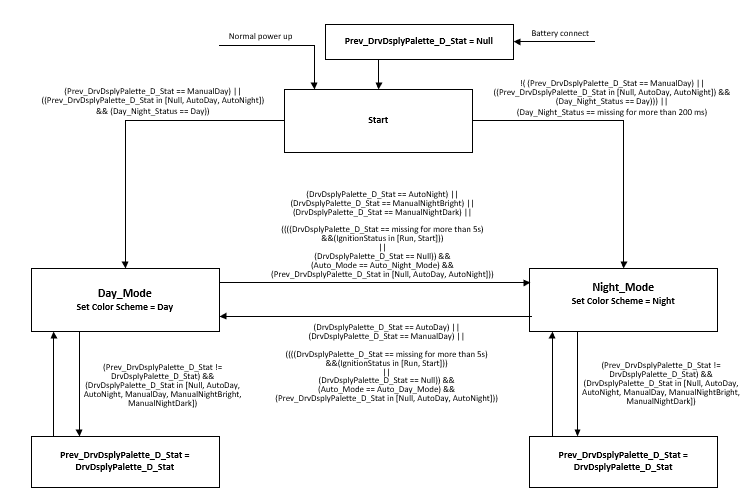
The CAN Signal being transmitted is called DrvDsplyPalette\_D\_Stat and it consists of 4 independent states: ManualNight (ManualNightBright and ManualNightDark), ManualDay, AutoDay and AutoNight. If the Litval signal is equal to day and user selects Auto Mode, we switch to AutoDay and similary if Litval signal is less than or equal to DID\_Threshold\_to\_Night (which is Twilight\_1) and user selects Auto Mode, we switch to AutoNight. If the user selects Day Mode, we switch to ManualDay and similary if the user selects Night Mode, we switch to ManualNight, regardless of litval.

An addition to this control logic, this ManualNight mode is essentially ManualNightDark mode. This color palette has been implemented from another program, MY21 CX727. CX727 is supposed to have two manual night modes, ManualNightBright and ManualNightDark. However for U725 we have only one night mode, ManualNightDark mode. So essentially the terms ManualNight and ManualNightDark mean the same thing. And in case Sync is sending the ManualNightBright signal, that would constitute to be ManualNightDark signal.

The flowchart below shows the state machine for determining the state of  Auto\_Mode (between Auto\_Day\_Mode and Auto\_Night\_Mode). The auto color palette selection is based on Litval, which represents the ambient brightness. The other major conditions include ignition status. The difference in this flowchart from the SYNC state machine is, that in this case the user is not able to make a selection of auto mode.



The flow chart below shows the generic transition between Night (all night options/modes) and Day (all day options/modes).



# Extended Illumination

The infotainment system and related subsystems have conditions which require illumination while the illumination master is in Off or sleep mode. This extended illumination condition is defined below.

## OTA Specific Requirements

The OTA feature may request extended illumination. The OTA feature must ensure that:

1. BCM is awake to transmit CAN signal Litval until 3. Is completed.
2. The gateway module transmits CAN signal Litval to the infotainment module (APIM)
3. The infotainment module (APIM) is awake and CAN signal Litval is received and processed.
4. APIM sets internal signal OTA\_Illum\_Rq
   1. OTA\_Illum\_Rq = 0x1 (On) if illumination is requested by the OTA feature.
   2. OTA\_Illum\_Rq = 0x0 (Off) if illumination is not requested by the OTA feature

## Infotainment (APIM) Specific Requirements

The infotainment module (APIM) shall set signal HMI\_HMIMode\_St = 0x2 (On) whenever illumination of the display or control (FCIM / FCIMB / RACM / SIMA etc.) is needed.

infotainment module (APIM) internal signal OTA\_Illum\_Rq is supported. See 5.1 for details.

This logic is applicable in all color sets (day / night / auto).

### Initialisation

The following variables are created to ensure proper initialisation after battery connect. The variables are always in defined states even when the input signals are missing or undefined.



### Extended Illumination Variable Definition

The variable Int\_HMI\_HMIMode\_St is derived from CAN signal HMI\_HMIMode\_St.

The variable Int\_OTA\_Illum\_Rq is derived from the internal signal OTA\_Illum\_Rq

The variable Extended\_Illumiantion is calculated and defines the Extended Illumination status.



\*) Execute when signal is received or changed



\*) Execute when signal is received or changed

### Int\_Litval Variable Definition

The variable Int\_Litval is derived from CAN signal Litval



\*) Execute when signal is received or changed

### Int\_Dimming\_Lvl Variable Definition

The variables Int\_Dimming\_Lvl, Int\_Day\_Dimming\_Lvl and Int\_Night\_Dimming\_Lvl are derived from CAN signal Dimming\_Lvl



\*) Execute when signal is received or changed

### Update Illumination – Dimming Algorithm Input Definition

All flowcharts defined in section 5.2.1 to 5.2.4 trigger an illumination update (Update Illumination). The flowchart below defines the Update Illumination execution and the Input to the dimming algorithm.

#### Update Illumination – For Displays



\*) The dimming algorithm defined in section 3.1 assumes Dimming\_Lvl and Litval as inputs. Dimming\_Lvl is substituted by Execute\_Dimming\_Lvl and Litval is substituted by Int\_Litval.

#### Update Illumination – For ICP / FCIM



\*) The dimming algorithm defined in section 3.1 assumes Dimming\_Lvl and Litval as inputs. Dimming\_Lvl is substituted by Execute\_Dimming\_Lvl and Litval is substituted by Int\_Litval.

# Ambient Light Sensing

The ambient light sensor measures the ambient light intensity (Lux). The following principle shall be used. Further electronic elements may be applied, e.g. for proper ESD protection. The formula for I(Ev) must be adopted accordingly.

BCM

5V

R1

U1

ALS

I(Ev)

R3

R2

U2

The light induced current *I(Ev)* needs to be determined. The BCM sensor calibration table is based on I(Ev) only. The additional measurement of U1 shall compensate the transistor variations and the bypass current through R1 and (R2 || R3).

**Determine I(Ev) based on U1 and U2**

The Lux to I (Ev) transfer characteristic and the R3 pull-down resistance can be determined from the ambient light sensor specification ESH1BT-14A597-Ax.

**Calculation of R3 and I(Ev) based on ambient light sensor specification**

**Calculation details of I(Ev) based on U1 and U2:**

Superposition principle, U2 is a function of U1 and a function of I(Ev)

(Substitution)

(Replace substitution)

## Light Sensing Range

The ambient light sensor (ALS) should measure the Lux value in the range from nominal 0...3600 Lux for cockpit illumination applications. The minimum A/D converter resolution is 10bit (12 bit converter is recommended).

## Sensor Calibration / Translation Table Configuration

The light induced current *I(Ev)* must be mapped to a BCM internal signal for further processing. This mapping must be calibratable to adopt on changes of the ALS characteristic or changes of internal thresholds. The mapping table shall provide the full resolution of the A/D converters.

High level software [counts] = 10000 [counts] – 2\*I(Ev) [counts /µA]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Standard Windscreen Glass Type** | | | | |
| Ambient\_Light\_Level\_Cfg | Light Induced Current I(Ev) [µA] | High Level Software  [Counts] | Illuminance  [Lux] | Comment |
| *Zero ambient light* | 0,0 | 10000 | 0 | Not configurable |
| Dusk0 | 58,0 | 9884 | 75 |  |
| Dusk1 | 108,5 | 9783 | 140 |  |
| Dusk2 | 201,0 | 9598 | 260 |  |
| Dusk3 | 371,0 | 9258 | 480 |  |
| Dusk4 | 696,0 | 8608 | 900 |  |
| Day | 1391,0 | 7218 | 1800 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tinted Windscreen Glass Type** | | | | |
| Ambient\_Light\_Level\_Cfg | Light Induced Current I(Ev) [µA] | High Level Software  [Counts] | Illuminance  [Lux] | Comment |
| *Zero ambient light* | 0,0 | 10000 | 0 | Not configurable |
| Dusk0 | TBD | TBD | TBD | TBD data to be replaced with real default data after test with physical windscreen types. |
| Dusk1 | TBD | TBD | TBD |
| Dusk2 | TBD | TBD | TBD |
| Dusk3 | TBD | TBD | TBD |
| Dusk4 | TBD | TBD | TBD |
| Day | TBD | TBD | TBD |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **IR Windscreen Glass Type** | | | | |
| Ambient\_Light\_Level\_Cfg | Light Induced Current I(Ev) [µA] | High Level Software  [Counts] | Illuminance  [Lux] | Comment |
| *Zero ambient light* | 0,0 | 10000 | 0 | Not configurable |
| Dusk0 | TBD | TBD | TBD | TBD data to be replaced with real default data after test with physical windscreen types. |
| Dusk1 | TBD | TBD | TBD |
| Dusk2 | TBD | TBD | TBD |
| Dusk3 | TBD | TBD | TBD |
| Dusk4 | TBD | TBD | TBD |
| Day | TBD | TBD | TBD |

See 3.1.1 for DID calibration details

|  |  |  |  |
| --- | --- | --- | --- |
| Illuminance threshold [Lux] | | BCM Internal Variable  (Threshold) | Litval CAN-Signal  (Range) |
| Increasing illuminance | Decreasing illuminance |  |  |
|  |  |  | Night |
| 75 | 75 | Dusk0 |  |
|  |  |  | Twilight\_1 |
| 140 | 140 | Dusk1 |  |
|  |  |  | Twilight\_2 |
| 260 | 260 | Dusk2 |  |
|  |  |  | Twilight\_3 |
| 480 | 480 | Dusk3 |  |
|  |  |  | Twilight\_4 |
|  | 900 | Dusk4 |  |
| 1800 |  | Day |  |
|  |  |  | Day |

\*Time hysteresis between thresholds shall be calibratable.

\* Illuminance thresholds calibratable between 0 and 3600 Lux

## Open Line and Shortage Detection

The supplier must provide a tolerance calculation and must determine the thresholds for open line, shortage to U\_Batt and shortage to GND. These thresholds must be outside of the sensor operational + tolerance range.

## Sliding Threshold Hysteresis

The ambient light level is mapped to certain thresholds (Litval). The transition from one to another threshold should be damped / filtered via a sliding hysteresis to avoid frequent switching between thresholds.

The hysteresis shall be adjustable.

Sliding hysteresis definition:

* If the new value is below the actual output value, then use then new value as actual output value.
* If the new value plus hysteresis is above the actual output value, then use the new value minus hysteresis as new actual output value.
* In all other cases don’t change the actual output value.

Sample code:

unsigned char DID\_Sliding\_Hysteresis = 1;

int SlidingHysteresis( int TargetValue, int LastValue )

{

int NewValue;

if (TargetValue < LastValue)

{

NewValue = TargetValue;

}

else

{

if (TargetValue > (LastValue + DID\_Sliding\_Hysteresis))

{

NewValue = TargetValue - DID\_Sliding\_Hysteresis;

}

else

{

NewValue = LastValue;

}

}

return NewValue;

}

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Resolution** | **Min Value** | **Max Value** | **Unit** |
| DID\_Sliding\_Hysteresis | 10 | 1 | 0 | 255 | Count |

All DID values are subject to change based on the interior harmonisation process and might be adjusted several times during the development process. Method 2 read and write access is preferred during the development phase. From the launch of the carline onwards, all DIDs must be accessible via diagnostic method 3. Method 2 read access should be maintained to enable quick analysis of current settings. Method 2 write access should not be conducted at EOL. To enable quick calibration adjustments, it is recommended to maintain the method 2 write access to support calibration trials, this access must be restricted (e.g. L3 security access limitation).

# APIM / AHU / LCIS

General Chapters 1 until 6 (including section [5](#extended) Extended Illumination), 7.1, 7.6 until 7.7.2 are to be implemented / considered for all components if applicable.

## Dimming Intensity Offset

The display intensity may be optimized by offsets.

**Night-mode:** The standard dimming system offers a 12 step customer selectable dimming adjustment in night mode. Offsets are added to the actual dimming system step within the given range of Night\_1 to Night\_12. Offsets resulting in dimming intensities below Night\_1 or above Night\_12 are clipped to these borders.

**Day-mode:** The standard dimming system offers a 6 step customer selectable dimming adjustment in day mode. Offsets are added to the actual dimming system step within the given range of Day\_1 to Day\_6. Offsets resulting in dimming intensities below Day\_1 or above Day\_6 are clipped to these borders.

The offset logic is applied after all the logical treatments of extended illumination logic as a kind of post processing.

Execute any offset change applied to Dimming\_Lvl with the transition time DID\_TransTime\_Usr.

The Rear View Camera (RVC) offers additional thresholds. See chapter 7.1.2



### Dimming Intensity Offset via Screen Menu

Components may choose to offer an on screen menu to offset the local display illumination intensity from the vehicle level intensity. The display intensity is still dependant on the dimming system inputs, but a further user adjustable offset allows local intensity adjustment within the given system borders.

The variables *Offset\_Position\_Day* and *Offset\_Position\_Night* are set to zero in case the Dimming Intensity Offset via Screen Menu is not implemented.

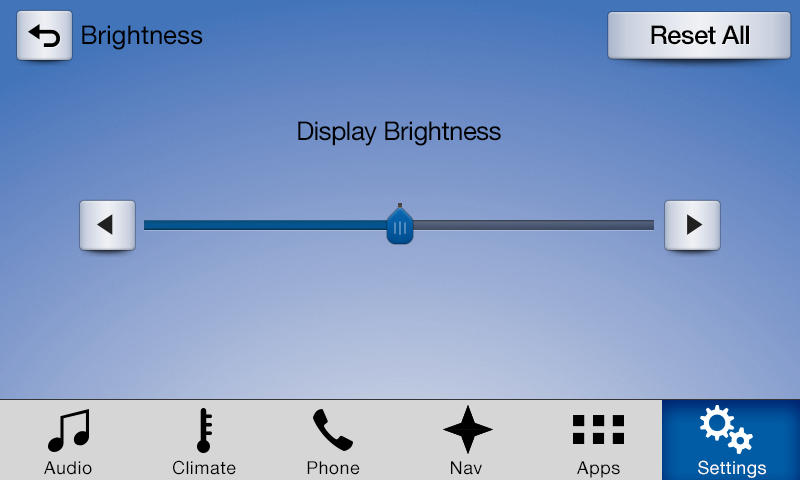


Figure 3 - Intensity Offset Slider

Up to 9 discrete intensity settings on the HMI slider are offered. The slider centre position does not offset the dimming system input. The slider offers up to 4 steps towards lower and 4 steps towards higher intensity (-4 to +4).

### Dimming Intensity Offset via Rear View Camera Calibration Parameters

Vehicles may choose to offer a rear view camera (RVC). A calibratable threshold shall be applied to the received diming level while the rear view camera is active (rear view camera picture is shown on the screen). This threshold allows a dedicated RVC screen intensity minimum tuning possibility. The RVC threshold is compared to the Dimming\_Lvl + HMI offset position via slider and only the greater of the two is applied. The calibration parameter DID\_RVC\_MinThreshold is set to zero in case the rear view camera is not installed. See chapter 7.1 for details.

The target illumination intensity is applied immediately on RVC screen activation / deactivation. Smooth / seamless dimming is resumed as soon as the target intensity is reached.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_RVC\_MinThreshold\_Night | 6 | 1 | 1 to 12 | Threshold (Night 1..Night12) applied while rear view camera is active, for night mode. The threshold value is defined by the RVC Function Owner |
| DID\_RVC\_MinThreshold\_Day | 3 | 1 | 1 to 6 | Threshold (Day1..Day6) applied while rear view camera is active, for night mode. The threshold value is defined by the RVC Function Owner |

See chapter 3.1.1 for DID details.

## Mechless radio (sub entry 1 DIN radio)

General Chapters 1 until 6 are to be implemented / considered for all components if applicable.

A mechless radio with internal display shall use an 8 bit intensity table for search illumination zones and 10 bit intensity table for the display. See chapter 3.1.4 and 3.1.5 respectively. A radio w/o display does not need the 10 bit display table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_BL\_Radio | 5 | 1 | 0 to 255 | PWM value for lowest brightness backlight (ice blue) Use it with DID\_WeightFactorBL. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_BL\_Radio | 255 | 1 | 0 to 255 | PWM value for highest brightness backlight (ice blue) Use it with DID\_WeightFactorBL. This value defines the highest PWM intensity for the DDS. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_Low\_PWM\_DisplayBL | 5 | 2 | 0 to 1023 | PWM value for lowest display intensity. Use it with DID\_WeightFactorDP. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_DisplayBL | 1023 | 2 | 0 to 1023 | PWM value for highest display intensity. Use it with DID\_WeightFactorDP. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorBL | See 3.1.4 | See 3.1.4 | See 3.1.4 | Weight factor table for backlight. |
| DID\_WeightFactorDP | See 3.1.5 | See 3.1.5 | See 3.1.5 | Weight factor table for display. |
| DID\_Night\_Ind\_PWM | See 0 | 1 | 0 to 255 | Used for Indicators / telltales if applicable |
| DID\_Day\_Ind\_PWM | See 0 | 1 | 0 to 255 | Used for Indicators / telltales if applicable |
| DID\_TransTime\_Usr | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Up | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Down | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_OnOff | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |

See chapter 3.1.1 for DID details.

The mechless radio might be used in other carlines which do not support seamless and advanced ambient based dimming. The supplier must adjust the 8 bit backlight and 10 bit display table columns for day and night to achieve the desired 12 night steps and 6 day step brightness intensities. The intensity targets are defined in the latest interior harmony SDS.

## SYNC – APIM

### SYNC – APIM

General Chapters 1 until 6 (including section [5](#extended) Extended Illumination), 7.1, 7.6 until 7.7.2 are to be implemented / considered for all components if applicable.

The SDM display backlight intensity control is independent from day / night palette set.

#### SDM4 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM4

WeightFactorDP

DID\_Low\_PWM\_SDM4

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 13

DID\_WeightFactorDP\_SDM4

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### SDM6 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM6

WeightFactorDP

DID\_Low\_PWM\_SDM6

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 14

DID\_WeightFactorDP\_SDM6

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### SDM8 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM8

WeightFactorDP

DID\_Low\_PWM\_SDM8

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 15

DID\_WeightFactorDP\_SDM8

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### Display Button Backlight Intensity Control

See chapter 3.1.4 for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Rotary Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Button Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### General DIDs for Intensity Calibration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_WeightFactorDP\_SDM4 | See 7.7.2  Table 13 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM4 display. |
| DID\_Low\_PWM\_SDM4 | 15 | 2 | 0 to 1023 | PWM value for lowest SDM4 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM4 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM4 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorDP\_SDM6 | See 7.7.2  Table 14 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM6 display. |
| DID\_Low\_PWM\_SDM6 | 9 | 2 | 0 to 1023 | PWM value for lowest SDM6 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM6 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM6 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorDP\_SDM8 | See 7.7.2  Table 15 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM8 display. |
| DID\_Low\_PWM\_SDM8 | 8 | 2 | 0 to 1023 | PWM value for lowest SDM8 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM8 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM8 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorBL | See 3.1.4 | See 3.1.4 | See 3.1.4 | Weight factor table for backlight. |
| DID\_Low\_PWM\_ DisplayButtonBL | 5 | 1 | 0 to 255 | PWM value for lowest display button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_ DisplayButtonBL | 255 | 1 | 0 to 255 | PWM value for highest display button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_Low\_PWM\_RotoryBL | 5 | 1 | 0 to 255 | PWM value for lowest FCIMB rotary intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_RotoryBL | 255 | 1 | 0 to 255 | PWM value for highest FCIMB rotary intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_Low\_PWM\_ButtonBL | 5 | 1 | 0 to 255 | PWM value for lowest FCIMB button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_ButtonBL | 255 | 1 | 0 to 255 | PWM value for highest FCIMB button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_TransTime\_Usr | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Up | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Down | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_OnOff | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |

See chapter 3.1.1 for DID calibration details.

## Low Cost Infotainment System (CTR)

General Chapters 1 until 6 (including section [5](#extended) Extended Illumination), 7.1, 7.6 until 7.7.2 are to be implemented / considered for all components if applicable.

The SDM display backlight intensity control is independent from day / night color palette set.

### Overview

#### SDM4 Display Intensity Control (optional – not used at SOP)

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM4

WeightFactorDP

DID\_Low\_PWM\_SDM4

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 13

DID\_WeightFactorDP\_SDM4

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### SDM6 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM6

WeightFactorDP

DID\_Low\_PWM\_SDM6

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 14

DID\_WeightFactorDP\_SDM6

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### SDM8 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM8

WeightFactorDP

DID\_Low\_PWM\_SDM8

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 15

DID\_WeightFactorDP\_SDM8

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### Display Button Backlight Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Rotary Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Button Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Backlit\_LED\_Status

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 1

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### General DIDs for Intensity Calibration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_WeightFactorDP\_SDM4 | See 7.7.2  Table 13 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM4 display. |
| DID\_Low\_PWM\_SDM4 | 15 | 2 | 0 to 1023 | PWM value for lowest SDM4 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM4 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM4 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorDP\_SDM6 | See 7.7.2  Table 14 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM6 display. |
| DID\_Low\_PWM\_SDM6 | 9 | 2 | 0 to 1023 | PWM value for lowest SDM6 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM6 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM6 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorDP\_SDM8 | See 7.7.2  Table 15 | See 3.1.5 | See 3.1.5 | Weight factor table for SDM8 display. |
| DID\_Low\_PWM\_SDM8 | 8 | 2 | 0 to 1023 | PWM value for lowest SDM8 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_SDM8 | 1023 | 2 | 0 to 1023 | PWM value for highest SDM8 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_WeightFactorBL | See 3.1.4 | See 3.1.4 | See 3.1.4 | Weight factor table for backlight. |
| DID\_Low\_PWM\_ DisplayButtonBL | 5 | 1 | 0 to 255 | PWM value for lowest display button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_ DisplayButtonBL | 255 | 1 | 0 to 255 | PWM value for highest display button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_Low\_PWM\_RotoryBL | 5 | 1 | 0 to 255 | PWM value for lowest FCIMB rotary intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_RotoryBL | 255 | 1 | 0 to 255 | PWM value for highest FCIMB rotary intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_Low\_PWM\_ButtonBL | 5 | 1 | 0 to 255 | PWM value for lowest FCIMB button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_High\_PWM\_ButtonBL | 255 | 1 | 0 to 255 | PWM value for highest FCIMB button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle |
| DID\_TransTime\_Usr | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Up | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_Amb\_Down | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |
| DID\_TransTime\_OnOff | See 3.1.3 | 1 | 0 to 9 | See 3.1.3 |

See chapter 3.1.1 for DID calibration details.

## AHU/CHR – Radio

General Chapters 1 until 6 (including section [5](#extended) Extended Illumination), 7.1, 7.6 until 7.7.2 are to be implemented / considered for all components if applicable.

### General DIDs for Intensity Calibration

See chapter 3.1.1 for DID calibration details.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_DisplayBL | 5 | 2 | 0 - 1023 | PWM value for lowest brightness Display backlight.  0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_DisplayBL | 1023 | 2 | 0 - 1023 | PWM value for highest brightness Display backlight.  0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle |
| DID\_Low\_PWM\_DisplayButtonBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness Display button backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_DisplayButtonBL | 255 | 1 | 0 - 255 | PWM value for highest brightness  Display button backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_Low\_PWM\_RotoryBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness  Rotary backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_RotoryBL | 255 | 1 | 0 - 255 | PWM value for highest brightness  Rotary backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_Low\_PWM\_ButtonBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness  Button backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_High\_PWM\_ButtonBL | 255 | 1 | 0 - 255 | PWM value for highest brightness  Button backlight. 0 refers to 0% PWM duty cycle and 255 refers to 100% PWM duty cycle |
| DID\_WeightFactorDP | See 3.1.5 | 108\*2 | See 3.1.5 | See 3.1.5 |
| DID\_WeightFactorBL | See 3.1.4 | 72\*2 | See 3.1.4 | See 3.1.4 |

### Smooth Dimming Calibration for Enhanced Dimming Algorithm

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

\*Backlight includes all AHU illumination zones, except indicators and telltales.

See 3.1.1 for DID details

#### SDM4 Display Intensity Control

See chapter 3.1.5 10 Bit PWM Display Backlight for detailed general information

Display\_BL\_PWM\_low

Display\_BL\_PWM\_high

DID\_High\_PWM\_SDM4

WeightFactorDP

DID\_Low\_PWM\_SDM4

Dimming\_Lvl

3.1.2

Interpolation Function

Litval

Table 13

DID\_WeightFactorDP\_SDM4

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueDP

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_DP:

#### Display Button Backlight Intensity Control

See chapter 3.1.4

8 / 10 Bit PWM Backlight for detailed general information

Button\_BL\_PWM

Dimming\_lvl

DID\_High\_PWM\_ DisplayButtonBL

WeightFactorBL

DID\_Low\_PWM\_ DisplayButtonBL

3.1.2

Interpolation Function

Litval

Table 6

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Rotary Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

DSPLDimmLvl2

Dimming\_lvl

DID\_High\_PWM\_RotoryBL

WeightFactorBL

DID\_Low\_PWM\_RotoryBL

3.1.2

Interpolation Function

Litval

Table 6

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

#### FCIMB Backlight Button Intensity Control

See chapter 3.1.4 8 Bit PWM Backlight for detailed general information

DSPLDimmLvl1

Dimming\_lvl

DID\_High\_PWM\_ButtonBL

WeightFactorBL

DID\_Low\_PWM\_ButtonBL

3.1.2

Interpolation Function

Litval

Table 6

DID\_WeightFactorBL

3.1.3

Seamless / Smooth Transition on Intensity Change

PWM\_TargetValueBL

DID\_TransTime\_Usr

DID\_TransTime\_Amb\_Up

DID\_TransTime\_Amb\_Down\_Up

DID\_TransTime\_OnOff\_Up

PWM\_Output\_BL:

## LIN communication (APIM / CTR / CHR) – FCIMB

The protocol must be able to send the illumination message every 40ms or faster, while the PWM values need to be changed. This is every time a new brightness level is selected by the passenger, day light sensor or the welcome / farewell sequence. If no change of the PWM signal is necessary, the back light messages should be transmitted at least all 500ms. Every message with a valid PWM value must update the PWM generator.

During updating the PWM generator no unexpected PWM ratios are allowed. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio.

Example: If the actual PWM ratio is 25% and switched to 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%. Care must be taken, that during loading a new value in the PWM generator no such side effects are generated.

### Heritage Protocol

The PWM generators should use the complete range and resolution of 256 steps with 0x00 = off and 0xFF = 100% on.

The invalid bit has no effect on the zone bits. They are always used as the newest message hast transmitted this zone bits.

At PWM value 255 the maximum brightness requirement should be fulfilled. Lower PWM values should dim the brightness proportional.

See also chapter 7.6.1.2 Behaviour after Reset and Invalid Bit Handling

The signals of the DSPLSendSignals message are used with the following button and knobs:

DSPLDimmLvl1

DSPLDimmLvl2

DSPLIlluZone

Zone2

DSPLIlluZone

VolumeKnob

DSPLIlluZone

Zone1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DSPLIlluZone  VolumeKnob | DSPLIlluZone  Zone1 | VolumeKnob LED | Zone1  LED | Remark |
| 0 | 0 | Off | Off | Both knobs off |
| 1 | 0 | On | Off | Only ON/OFF knob illuminated |
| 1 | 1 | On | On | Both knobs illuminated |
| 0 | 1 | Not defined | Not defined | Not allowed state |

The controlling device should to turn on and off all 3 zone bits simultaneously.

The controlling device should set the “Invalid” bit, when LIN message must be send and brightness information is still not available via CAN (e.g. during power up situations).

#### DSPLSendSignals

The DSPLSendSignals contains the bits for the active zones, an invalid bit and two PWM values for the brightness of the knob and button backlight. The zone bits turn the related zone on and off. The dimming level signals control two 8-bit PWM generators. One PWM output for the two knobs and the other for the buttons. There is also an LDF file with the data description. The LDF file is the master in case of a mismatch to this description. Missing messages are handled like Invalid bit is set.

|  |  |  |
| --- | --- | --- |
| Name | Definition | Description |
| DSPLIlluZone | BIT{0}  BIT{1}  BIT{2}  BIT{3}  BIT{4}  BIT{5}  BIT{6}  BIT{7} | Bit 0 .. 4 are zone bits to turn on and off the zones independent of the PWM value:  VolumeKnob:  0: – backlight off  1: – backlight on  HazardWarning\_DoorLock: (not used)  0: – backlight off  1: – backlight on  CD\_Slot: (not used)  0: – backlight off  1: – backlight on  Zone2: (buttons)  0: – backlight off  1: – backlight on  Zone1: (OK knob)  0: – backlight off  1: – backlight on  Chrome: (buttons)  0: – backlight off  1: – backlight on  Reserved  Invalid:  0: – valid PWM value   * See chapter 7.6.1.2   1: – invalid PWM value   * See chapter 7.6.1.2 |
| DSPLDimmLvl1 | BIT{7:0} | 0x00 – 0xFF:  Value for the 8-bit button backlight PWM generator. |
| DSPLDimmLvl2 | BIT{7:0} | 0x00 – 0xFF:  Value for the 8-bit knob backlight PWM generator. |

##### Illumination Zones vs. Dimming\_lvl.

Bits 0,1,2,3,4, and 6 of signal DSPLIlluZone are set to 1 permanently to adhere to the current CGEA 1.3 implementation and are dimmable via signal DSPLDimmLvl1 or DSPLDimmLvl2 including the OFF state.

Bit 5 of signal DSPLIlluZone is specific to Chrome buttons which are expected to be “OFF” when Dimming\_lvl = Day\_1 to Day\_6 or OFF, and “ON” when Dimming\_lvl = Night\_1 to Night\_12

The zone control may be changed in the future. Therefore, the individual zone control function shall be implemented.

|  |  |  |
| --- | --- | --- |
| **Dimming\_Lvl** | **DSPLIlluZone (bits)** | **Comments** |
| Night\_1 to Night\_12 | 0x7F | Bits 0 to 6 are ON, and these Illumination Zones can follow signal DSPLDimmLvl1 or DSPLDimmLvl2 including the OFF state. |
| Day\_1 to Day\_6 | 0x5F | Bit 5 should transition to OFF, while all remaining bits from 0 to 6 remain ON. |
| Off | keep last valid value | Keep last valid value for DSPLIlluZone (0x7F / 0x5F) |

#### Behaviour after Reset and Invalid Bit Handling

- After RESET or Battery ON the last valid PWM should be set to zero and the InvalidTimeout timer should be reset and run.

- Every time a new valid PWM is received, the last valid PWM should be updated with the new PWM value and the InvalidTimeout timer should be reset and run.

- If InvalidTimeout timer finish and last valid PWM is zero, set last valid PWM to Default\_BL\_PWM

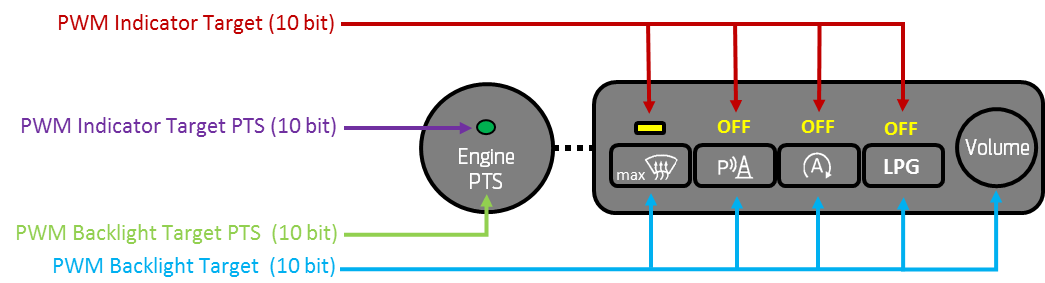
- Use the last valid PWM for updating the PWM generator.

- Update the PWM generator every time the last valid PWM value changes.

- Default\_BL\_PWM is 0xFF (for 8 bit values)

- The InvalidTimeout value is 5 sec.

### Interface for SYNC 4.0 and beyond



#### Intensity control

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **PWM Channels [LIN]** | **Resolution [Bit]** | **Sender** | **Receiver** | **Description** |
| DSPLIlluPWMIndicatorTargetPTS | 10 | APIM / CTR / CHR | ICP | PWM Indicator Target PTS |
| DSPLIlluPWMBacklightTargetPTS | 10 | APIM / CTR / CHR | ICP | PWM Backlight Target PTS |
| DSPLIlluPWMBacklightTarget | 10 | APIM / CTR / CHR | ICP | PWM Backlight Target |
| DSPLIlluPWMIndicatorTarget | 10 | APIM / CTR / CHR | ICP | PWM Indicator Target |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_Ind\_PTS | 102 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_High\_PWM\_Ind\_PTS | 1023 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_Low\_PWM\_Indicator | 102 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_High\_PWM\_Indicator | 1023 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_Low\_PWM\_BL\_PTS | 4 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_High\_PWM\_BL\_PTS | 1023 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_Low\_PWM\_BL | 4 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_High\_PWM\_BL | 1023 | 2 | 0 - 1023 | See 3.1.5.1 |
| DID\_WeightFactor\_Ind\_PTS | See  Table 18 | 216 | 0 - 1024 | See 7.9 |
| DID\_WeightFactor\_Ind | See  Table 18 | 216 | 0 - 1024 | See 7.9 |
| DID\_WeightFactor\_BL\_PTS | See  Table 5 | 216 | 0 - 1024 | See 3.1.4 |
| DID\_WeightFactor\_BL | See  Table 5 | 216 | 0 - 1024 | See 3.1.4 |

DSPLIlluPWMIndicatorTargetPTSPTS

DID\_High\_PWM\_Ind\_PTS

WeightFactorInd

DID\_Low\_PWM\_Ind\_PTS

Dimming\_Lvl

Interpolation Function 3.1.2

Litval

Table 18

DID\_WeightFactor\_Ind\_PTS

DSPLIlluPWMIndicatorTargetPTS PTS

DID\_High\_PWM\_Ind

WeightFactorInd

DID\_Low\_PWM\_Ind

Dimming\_Lvl

Interpolation Function 3.1.2

Litval

Table 18

DID\_WeightFactor\_Ind

DSPLIlluPWMBacklightTargetPTS PTS

DID\_High\_PWM\_BL\_PTS

WeightFactor

DID\_Low\_PWM\_BL\_PTS

Dimming\_Lvl

Interpolation Function 3.1.2

Litval

Table 5

DID\_WeightFactor\_BL\_PTS

DSPLIlluPWMBacklightTarget PTS PTS

DID\_High\_PWM\_BL

WeightFactor

DID\_Low\_PWM\_BL

Dimming\_Lvl

Interpolation Function 3.1.2

Litval

Table 5

DID\_WeightFactor\_BL

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Zones [LIN]** | **Function** | **Resolution [Bit]** | **Sender** | **Receiver** | **Description** |
| DSPLIlluIndPTS | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR, CHR | ICP | PTS Indicator |
| DSPLIlluInd1 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_1 |
| DSPLIlluInd2 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_2 |
| DSPLIlluInd3 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_3 |
| DSPLIlluInd4 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_4 |
| DSPLIlluInd5 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_5 |
| DSPLIlluInd6 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_6 |
| DSPLIlluInd7 | 0 =Off,  1 = On,  2 = Blinking | 2 | APIM,  CTR,  CHR | ICP | Generic Indicator\_7 |
| DSPLIlluBtnPTS | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | PTS Button Backlight |
| DSPLllluBtn1 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_1 Backlight |
| DSPLllluBtn2 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_2 Backlight |
| DSPLllluBtn3 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_3  Backlight |
| DSPLllluBtn4 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_4  Backlight |
| DSPLllluBtn5 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_5  Backlight |
| DSPLllluBtn6 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_6  Backlight |
| DSPLllluBtn7 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_7  Backlight |
| DSPLllluBtn8 | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Generic Button\_8  Backlight |
| DSPLIlluVolKnob | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | On / Off pushbutton on the volume rotary |
| DSPLIlluBtnChrome | 0 =Off,  1 = On | 1 | APIM,  CTR,CHR | ICP | Chrome Buttons  Backlight |

#### Illumination zone signal control

All button illumination zones are set to On (0x1) permanently by default. Individual zone control handling may be added separately. Indicator zones are controlled by the driving function / ECU. The Chrome button zone logic is handled in section 7.6.2.2.1.1

###### Chrome Button Zone Handling

|  |  |  |
| --- | --- | --- |
| **Dimming\_Lvl** | **DSPLIlluBtnChrome** | **Comments** |
| Night\_1 to Night\_12 | 0x1 (On) | Chrome buttons zone is active |
| Day\_1 to Day\_6 | 0x0 (OFF) | Chrome button zone is disabled |
| Off / Missing | keep last valid value | Keep last valid value |

#### Smooth dimming timer signals

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Timer [LIN]** | **Resolution [Bit]** | **Sender** | **Receiver** | **Description** |
| DSPLIlluPWMTimerUp | 4 | APIM / CTR / CHR | ICP | Timer Up |
| DSPLIlluPWMTimerDown | 4 | APIM / CTR / CHR | ICP | Timer Down |

Dimming\_Lvl

Figure 4

Litval

DSPLIlluPWMTimerUp

DID\_TransTime\_Usr\_ICP

DID\_TransTime\_Amb\_Up\_ICP

DSPLIlluPWMTimerDown

DID\_TransTime\_Amb\_Down\_ICP

DID\_TransTime\_Usr\_ICP

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_ICP | 5 | 1 | 0 - 9 | See 3.1.5.1 |
| DID\_TransTime\_Amb\_Up\_ICP | 6 | 1 | 0 - 9 | See 3.1.5.1 |
| DID\_TransTime\_Amb\_Down\_ICP | 8 | 1 | 0 - 9 | See 3.1.5.1 |
| DID\_TransTime\_Usr\_ICP | 5 | 1 | 0 - 9 | See 3.1.5.1 |



Figure 4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Dimming\_Curve [LIN]** | **Resolution [Bit]** | **Sender** | **Receiver** | **Description** |
| DSPLIlluDimmingCurveType | 1 | APIM / CTR / CHR | ICP | Dimming curve type:  0 = linear  1= exponential |

#### Dimming curve type signals

## IIC communication (APIM / CHR / CTR) – Display

The protocol must be able to send both backlight messages every 40ms or faster, while the PWM values need to be changed. This is every time a new brightness level is selected by the passenger, day light sensor or the welcome / farewell sequence. If no change of the PWM signal is necessary, the back light messages should be transmitted at least all 500ms. Every message with a valid PWM value must update the PWM generator.

During updating the PWM generator no unexpected PWM ratios are allowed. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio.

Example: If the actual PWM ratio is 25% and switched to 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%. Care must be taken, that during loading a new value in the PWM generator no such side effects are generated.

At Button\_BL\_PWM value 255 the maximum brightness requirement for buttons backlight should be fulfilled. Lower PWM values should dim the brightness proportional.

At Display\_BL\_PWM value 1023 the maximum brightness requirement for display backlight should be fulfilled. Lower PWM values should dim the brightness proportional.

DSPLDimmLvl1

DSPLDimmLvl2

DSPLIlluZone

Zone2

DSPLIlluZone

VolumeKnob

DSPLIlluZone

Zone1

The backlight messages are used for the following zones:

Display Backlight PWM Message

Button Backlight PWM Message

#### Display Button Backlight PWM

The Display Button Backlight PWM Message contains the brightness information for an 8-bit display backlight PWM generator. The PWM generator should use the complete range and resolution of 256 steps with 0x00 = off and 0xFF = 100% on. There is also an “I2C over LVDS Communication Protocol” spec. with the data description. The signal name for Display Button Backlight is **Button\_BL\_PWM**.

#### Display Backlight PW

The Display Backlight PWM Message contains the brightness information for a 10 bit display backlight PWM generator. The PWM generator should use the complete range and resolution of 1024 steps with 0x000 = off and 0x3FF = 100% on. There is also an “I2C over LVDS Communication Protocol” spec. with the data description. The signal names for Display Backlight are **Display\_BL\_PWM\_low** for the low byte and **Display\_BL\_PWM\_high** for the upper two bits.

### 

## Definition of Weight Factors for 10 Bit SDM displays

DID\_WeightFactorDP\_SDM4:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 2 | 6 | 12 | 20 | 375 |
| Night\_2 | 2 | 5 | 10 | 17 | 27 | 375 |
| Night\_3 | 4 | 8 | 14 | 23 | 36 | 375 |
| Night\_4 | 8 | 13 | 21 | 31 | 47 | 375 |
| Night\_5 | 13 | 19 | 29 | 42 | 61 | 375 |
| Night\_6 | 19 | 28 | 40 | 57 | 79 | 375 |
| Night\_7 | 28 | 40 | 55 | 75 | 102 | 375 |
| Night\_8 | 41 | 55 | 74 | 99 | 132 | 375 |
| Night\_9 | 58 | 77 | 100 | 131 | 170 | 375 |
| Night\_10 | 82 | 106 | 135 | 172 | 219 | 375 |
| Night\_11 | 116 | 145 | 181 | 225 | 281 | 375 |
| Night\_12 | 162 | 198 | 241 | 295 | 360 | 375 |
| Day\_1 | 375 | 392 | 410 | 429 | 449 | 470 |
| Day\_2 | 417 | 441 | 466 | 492 | 520 | 549 |
| Day\_3 | 463 | 495 | 528 | 564 | 601 | 642 |
| Day\_4 | 515 | 555 | 599 | 645 | 696 | 750 |
| Day\_5 | 572 | 623 | 679 | 739 | 805 | 876 |
| Day\_6 | 636 | 700 | 770 | 846 | 931 | 1024 |

Table 13

DID\_WeightFactorDP\_SDM6:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 1 | 3 | 6 | 10 | 211 |
| Night\_2 | 1 | 3 | 6 | 9 | 14 | 211 |
| Night\_3 | 3 | 6 | 9 | 13 | 19 | 211 |
| Night\_4 | 6 | 9 | 13 | 18 | 25 | 211 |
| Night\_5 | 9 | 13 | 18 | 24 | 33 | 211 |
| Night\_6 | 13 | 18 | 24 | 33 | 43 | 211 |
| Night\_7 | 19 | 25 | 33 | 43 | 56 | 211 |
| Night\_8 | 26 | 34 | 44 | 57 | 73 | 211 |
| Night\_9 | 36 | 46 | 59 | 75 | 95 | 211 |
| Night\_10 | 49 | 62 | 78 | 98 | 122 | 211 |
| Night\_11 | 67 | 83 | 103 | 127 | 157 | 211 |
| Night\_12 | 90 | 110 | 135 | 165 | 202 | 211 |
| Day\_1 | 211 | 227 | 244 | 263 | 283 | 304 |
| Day\_2 | 241 | 265 | 292 | 321 | 353 | 388 |
| Day\_3 | 276 | 310 | 349 | 392 | 441 | 495 |
| Day\_4 | 316 | 363 | 417 | 479 | 550 | 631 |
| Day\_5 | 361 | 424 | 497 | 584 | 685 | 804 |
| Day\_6 | 412 | 495 | 594 | 712 | 854 | 1024 |

**Table 14**

DID\_WeightFactorDP\_SDM8:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 1 | 3 | 5 | 8 | 211 |
| Night\_2 | 1 | 3 | 5 | 8 | 12 | 211 |
| Night\_3 | 3 | 5 | 8 | 12 | 16 | 211 |
| Night\_4 | 5 | 8 | 12 | 16 | 22 | 211 |
| Night\_5 | 8 | 12 | 16 | 22 | 29 | 211 |
| Night\_6 | 12 | 17 | 22 | 29 | 39 | 211 |
| Night\_7 | 17 | 23 | 30 | 39 | 50 | 211 |
| Night\_8 | 24 | 31 | 40 | 51 | 66 | 211 |
| Night\_9 | 33 | 42 | 53 | 67 | 85 | 211 |
| Night\_10 | 45 | 56 | 70 | 88 | 109 | 211 |
| Night\_11 | 60 | 75 | 92 | 114 | 141 | 211 |
| Night\_12 | 81 | 99 | 121 | 148 | 181 | 211 |
| Day\_1 | 211 | 227 | 244 | 263 | 283 | 304 |
| Day\_2 | 241 | 265 | 292 | 321 | 353 | 388 |
| Day\_3 | 276 | 310 | 349 | 392 | 441 | 495 |
| Day\_4 | 316 | 363 | 417 | 479 | 550 | 631 |
| Day\_5 | 361 | 424 | 497 | 584 | 685 | 804 |
| Day\_6 | 412 | 495 | 594 | 712 | 854 | 1024 |

**Table 15**

DID\_WeightFactorDP\_SDM 12 / 13:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 2 | 4 | 6 | 10 | 146 |
| Night\_2 | 1 | 3 | 5 | 9 | 13 | 146 |
| Night\_3 | 3 | 5 | 8 | 12 | 17 | 146 |
| Night\_4 | 4 | 7 | 11 | 16 | 22 | 146 |
| Night\_5 | 7 | 10 | 14 | 20 | 29 | 146 |
| Night\_6 | 9 | 14 | 19 | 27 | 37 | 146 |
| Night\_7 | 13 | 18 | 25 | 34 | 46 | 146 |
| Night\_8 | 18 | 25 | 33 | 44 | 58 | 146 |
| Night\_9 | 25 | 33 | 43 | 56 | 74 | 146 |
| Night\_10 | 33 | 43 | 56 | 72 | 93 | 146 |
| Night\_11 | 44 | 57 | 72 | 92 | 117 | 146 |
| Night\_12 | 59 | 74 | 93 | 117 | 146 | 146 |
| Day\_1 | 146 | 156 | 167 | 178 | 190 | 203 |
| Day\_2 | 188 | 204 | 221 | 239 | 259 | 281 |
| Day\_3 | 242 | 266 | 292 | 321 | 353 | 388 |
| Day\_4 | 310 | 346 | 387 | 431 | 481 | 537 |
| Day\_5 | 398 | 451 | 511 | 579 | 655 | 742 |
| Day\_6 | 511 | 587 | 675 | 776 | 892 | 1024 |

**Table 16**

DID\_WeightFactorDP\_SDM15:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 2 | 3 | 6 | 10 | 126 |
| Night\_2 | 1 | 3 | 5 | 8 | 13 | 126 |
| Night\_3 | 2 | 4 | 7 | 11 | 16 | 126 |
| Night\_4 | 3 | 6 | 9 | 14 | 21 | 126 |
| Night\_5 | 5 | 8 | 12 | 18 | 26 | 126 |
| Night\_6 | 7 | 11 | 16 | 23 | 33 | 126 |
| Night\_7 | 10 | 14 | 20 | 29 | 41 | 126 |
| Night\_8 | 13 | 19 | 26 | 37 | 52 | 126 |
| Night\_9 | 17 | 24 | 34 | 47 | 65 | 126 |
| Night\_10 | 23 | 31 | 43 | 59 | 81 | 126 |
| Night\_11 | 30 | 41 | 55 | 75 | 101 | 126 |
| Night\_12 | 39 | 53 | 71 | 94 | 126 | 126 |
| Day\_1 | 126 | 139 | 153 | 168 | 185 | 203 |
| Day\_2 | 167 | 186 | 206 | 229 | 254 | 281 |
| Day\_3 | 221 | 248 | 277 | 310 | 347 | 389 |
| Day\_4 | 293 | 331 | 373 | 421 | 476 | 537 |
| Day\_5 | 387 | 441 | 502 | 572 | 651 | 742 |
| Day\_6 | 511 | 588 | 675 | 776 | 892 | 1024 |

**Table 17**

## Definition of Weight Factors for ICP Indicator Illumination

DID\_WeightFactor\_IndTarPTS:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Litval | | | | | |
|  |  | Night | Twilight\_1 | Twilight\_2 | Twilight\_3 | Twilight\_4 | Day |
| Dimming\_Lvl | Night\_1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_8 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_11 | 0 | 0 | 0 | 0 | 0 | 0 |
| Night\_12 | 0 | 0 | 0 | 0 | 0 | 0 |
| Day\_1 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_2 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_3 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_4 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_5 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |
| Day\_6 | 1024 | 1024 | 1024 | 1024 | 1024 | 1024 |

Table 18

# ICP / FCIMB / RACM

General Chapters 1 until 6 (including section [5](#extended) Extended Illumination), and 7.6are to be implemented / considered if applicable.

## Protocol for SYNC Gen 3

DSPLDimmLvl1

DSPLDimmLvl2

DSPLIlluZone

Zone2

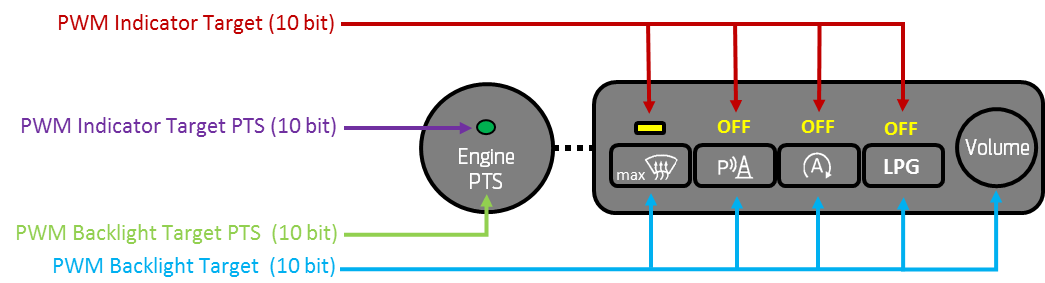
DSPLIlluZone

VolumeKnob

DSPLIlluZone

Zone1

## Protocol for SYNC Gen 4.0



### Dimming Algorithm / Flow Chart

#### Variable Structure



#### Dimming Step Calculation

The following flowcharts are to be implemented in 4 instances. Each signal handles it’s illumination zones parallel to the others.



#### Indicator Blinking State

Indicators may request a blinking state. The blinking frequency is dependent on the requesting function. The ICP shall support different blinking frequencies for the indicators. Each indicator frequency shall be calibratable.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Identifier** | **Min Value** | **Max Value** | **Resolution [Hz]** | **Default Value [Hz]** | **Unit** |
| Indicator\_1 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_2 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_3 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_4 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_5 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_6 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_7 | 0.1 | 5 | 0.1 | See function specification | Hz |
| Indicator\_PTS | 0.1 | 5 | 0.1 | See function specification | Hz |

#### Interrupt Routine



### Indicators

The signals with prefix Int\_ are generated ICP internally and dirived from the respective LIN input signal





#### Hardwired Indicators

The indicator driver ECU (e.g. ICP) shall read the function driver ECU signal. The function driver ECU controls the indicator ON/OFF/ blinking state. The illumination day / night intensity is controlled by the indicator driver ECU to ensure that:

* all indicators are illuminated with the same intensity
* all indicators are dimming synchronously



Figure 5 - Example Illustration (High Side Driver )

The function driver ECU must ensure that the day and night intensity values are set to 100% PWM duty cycle whenever the indicator request is ON. The day / night PWM intensity will be controlled by the Indicator driver ECU.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Operating Conditions: 1,2 System Voltage: 9.5 < Vsys < 16.0 volts  Ambient Temperature: -40oC < Tamb < 85oC | | | | | | |
| **No** | **Characteristic** | **Comment** | **Min** | **Typ** | **Max** | **Unit** |
| 1 | Indicator ON detection time |  |  |  | 5 | ms |
| 2 | Indicator OFF detection time |  |  |  | 5 | ms |
| 3 | PWM input voltage | See device transmittal | | | | V |
| 4 | Ground Offset | See ELCOMP requirement RQT-191001-009976 & 009989 | | | | V |
| 5 | Rload | See device transmittal 3 | | | | R |

Note: Interface partners of function driver ECU, Indicator Driver ECU, External Indicator shall align their assumptions regarding interface compatibility via the known tool chain of GDT and interface control sheets

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.

Note 2: Output values are measured at the ECU with the PWM output and related to ECU GND.

Note 3: The open line detection of the transmitting ECU needs to be considered

**Behavior on missing CAN / LIN signal or sleep request (Indicators only):**

|  |  |  |  |
| --- | --- | --- | --- |
| **State** | **CAN / LIN Indicator PWM Intensity** | **Indicator Request** | **Indicator Intensity Output** |
| 1 | Available | ON | Follow CAN / LIN intensity |
| 2 | Available | OFF | OFF |
| 3 | Missing / sleep request | ON | Maintain last CAN / LIN intensity level |
| 4 | Missing / sleep request | OFF | OFF\* |

\*) Memorize the last received non-OFF CAN / LIN intensity level. Apply the memorized value if Indicator is requested on while CAN / LIN signal is missing. Assume maximum intensity level if last received non-OFF value cannot be retrieved (only on ECU reset / battery re-connect).

### Dimming Algorithm / Sample Code

The dimming algorithm in the following code example is adjusted for an Arduino Uno. This code shall illustrate the desired algorithm behavior. Coding language and implementation details remain at the supplier’s discretion.

Data for backlight zones (0.1 - 6.0 cd/m²)\*:

\*) See RQT-002004-021873 for confirmed cd/m² values

const PROGMEM unsigned int E\_Curve\_Data\_Backlight[1024] = // used for 6 cd/m² backlight

{ 0, 1092, 1097, 1101, 1105, 1110, 1114, 1119,

1123, 1128, 1132, 1137, 1141, 1146, 1151, 1155,

1160, 1165, 1169, 1174, 1179, 1183, 1188, 1193,

1198, 1202, 1207, 1212, 1217, 1222, 1227, 1232,

1237, 1242, 1247, 1252, 1257, 1262, 1267, 1272,

1277, 1282, 1287, 1292, 1298, 1303, 1308, 1313,

1319, 1324, 1329, 1334, 1340, 1345, 1351, 1356,

1361, 1367, 1372, 1378, 1383, 1389, 1395, 1400,

1406, 1411, 1417, 1423, 1429, 1434, 1440, 1446,

1452, 1457, 1463, 1469, 1475, 1481, 1487, 1493,

1499, 1505, 1511, 1517, 1523, 1529, 1535, 1542,

1548, 1554, 1560, 1566, 1573, 1579, 1585, 1592,

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Data for deadfront backlight zones (0.1-500.0 cd/m²)\*:

\*) See RQT-002004-021873 for confirmed cd/m² values

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Data for indicators (19.5 - 800 cd/m²)\* or (13,8 – 565 cd/m²)\*:

\*) See RQT-002004-021873 for confirmed cd/m² values

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16732, 16795, 16857, 16920, 16983, 17046, 17110, 17174,

17238, 17302, 17366, 17431, 17496, 17561, 17627, 17692,

17758, 17825, 17891, 17958, 18025, 18092, 18159, 18227,

18295, 18363, 18431, 18500, 18569, 18638, 18708, 18777,

18847, 18918, 18988, 19059, 19130, 19201, 19273, 19345,

19417, 19489, 19562, 19635, 19708, 19781, 19855, 19929,

20003, 20078, 20153, 20228, 20303, 20379, 20455, 20531,

20608, 20684, 20761, 20839, 20916, 20994, 21073, 21151,

21230, 21309, 21389, 21468, 21548, 21629, 21709, 21790,

21871, 21953, 22035, 22117, 22199, 22282, 22365, 22448,

22532, 22616, 22700, 22785, 22870, 22955, 23041, 23126,

23213, 23299, 23386, 23473, 23561, 23648, 23737, 23825,

23914, 24003, 24092, 24182, 24272, 24363, 24454, 24545,

24636, 24728, 24820, 24913, 25006, 25099, 25192, 25286,

25380, 25475, 25570, 25665, 25761, 25857, 25953, 26050,

26147, 26245, 26342, 26441, 26539, 26638, 26737, 26837,

26937, 27037, 27138, 27239, 27341, 27443, 27545, 27648,

27751, 27854, 27958, 28062, 28167, 28272, 28377, 28483,

28589, 28695, 28802, 28910, 29018, 29126, 29234, 29343,

29453, 29562, 29672, 29783, 29894, 30005, 30117, 30230,

30342, 30455, 30569, 30683, 30797, 30912, 31027, 31143,

31259, 31375, 31492, 31610, 31727, 31846, 31964, 32083,

32203, 32323, 32444, 32564, 32686, 32808, 32930, 33053,

33176, 33299, 33424, 33548, 33673, 33799, 33925, 34051,

34178, 34305, 34433, 34562, 34690, 34820, 34949, 35080,

35210, 35342, 35473, 35606, 35738, 35871, 36005, 36139,

36274, 36409, 36545, 36681, 36818, 36955, 37093, 37231,

37370, 37509, 37649, 37789, 37930, 38071, 38213, 38356,

38499, 38642, 38786, 38931, 39076, 39221, 39368, 39514,

39662, 39809, 39958, 40107, 40256, 40406, 40557, 40708,

40860, 41012, 41165, 41318, 41472, 41627, 41782, 41938,

42094, 42251, 42408, 42566, 42725, 42884, 43044, 43204,

43365, 43527, 43689, 43852, 44016, 44180, 44344, 44509,

44675, 44842, 45009, 45177, 45345, 45514, 45684, 45854,

46025, 46196, 46369, 46541, 46715, 46889, 47064, 47239,

47415, 47592, 47769, 47947, 48126, 48305, 48485, 48666,

48847, 49030, 49212, 49396, 49580, 49765, 49950, 50136,

50323, 50511, 50699, 50888, 51077, 51268, 51459, 51651,

51843, 52036, 52230, 52425, 52620, 52816, 53013, 53211,

53409, 53608, 53808, 54009, 54210, 54412, 54615, 54818,

55023, 55228, 55433, 55640, 55847, 56056, 56264, 56474,

56685, 56896, 57108, 57321, 57534, 57749, 57964, 58180,

58397, 58615, 58833, 59052, 59272, 59493, 59715, 59938,

60161, 60385, 60610, 60836, 61063, 61290, 61519, 61748,

61978, 62209, 62441, 62674, 62907, 63142, 63377, 63613,

63850, 64088, 64327, 64567, 64808, 65049, 65292, 65535};

typedef union

{

struct

{

// IMPORTANT!!! High / low order of bytes depended on uC architecture

// This is for Arduino Uno board

unsigned int LowUnsignedInt;

signed int HighInt;

} HiLow;

struct

{

signed long HighResValue;

} LongValue;

} HighResType;

HighResType Actual; // actual Value

int Target; // new Target

signed long DeltaStep; // actual delta to add

void SetNewTarget( int up, int down, int NewTarget )

{

signed int ActualValue;

signed long NewDelta;

noInterrupts();

ActualValue = Actual.HiLow.HighInt;

interrupts();

if (Target != NewTarget)

{

noInterrupts();

Target = NewTarget;

interrupts();

if (Target > ActualValue)

{

NewDelta = ( Target - ActualValue ) << (14 - up) );

}

else if (Target < ActualValue)

{

NewDelta = ( Target - ActualValue ) << (14 - down) );

}

else

{

NewDelta = 0;

}

noInterrupts();

DeltaStep = NewDelta;

interrupts();

}

} // SetNewTarget

void InterruptRoutine10ms()

// executed every 10ms

{

int Index;

Actual.LongValue.HighResValue = Actual.LongValue.HighResValue + DeltaStep;

if ((DeltaStep>0) && (Actual.HiLow.HighInt>=Target))

{ // stop dimming up

Actual.HiLow.HighInt = Target;

Actual.HiLow.LowUnsignedInt = 0;

DeltaStep = 0;

}

if ((DeltaStep<0) && (Actual.HiLow.HighInt<=Target))

{ // stop dimming down

Actual.HiLow.HighInt = Target;

Actual.HiLow.LowUnsignedInt = 0;

DeltaStep = 0;

}

// update PWM generator (or output control)

Index = Actual.HiLow.HighInt;

if (DSPLIlluDimmingCurveType == Linear)

{ // linear behavior

SetNewPWM(Actual.LongValue.HighResValue >> 10);

}

else

{ // exponential behavior

SetNewPWM(E\_Curve\_Data\_Backlight[Index]);

}

} // InterruptRoutine10ms

// to set a new target to index 500 with dimming up time 2.5s and dimming down time 10s use following call

SetNewTarget( 10, 21, 500 );

### Zone Handling

The zone handling is applicable for each backlight zone. Indicators are not affected. Xxx is a synonym for the different backlight zones defined within section 7.6.2.2



# IPC

General chapters 1 until 4 are to be implemented / considered if applicable.

## Diagnostic DIDs for Intensity Calibration

See chapter 3.1.1 for DID calibration details.

### General DIDs for Intensity Calibration

#### Diagnostic DIDs for Zones with an own PWM Generator

Each illumination zone should have an own PWM generator to tune the intensity independently

The following DIDs control a separate PWM generator and must fulfil the following:

* 12 bit size zones (0 = OFF, translates to 0% PWM duty cycle; 4095 = max intensity translates to 100% PWM duty cycle).
* 10 bit size zones (0 = OFF, translates to 0% PWM duty cycle; 1023 = max intensity, translates to 100% PWM duty cycle).
* Any value between 0 and 1023 (4095) is valid and shall result in a linearly interpolated intensity output. The resolution of 1024 (10 bit) / 4096 (12 bit) steps must be provided.
* The IPC must meet all intensity targets (as per Interior Harmony SDS) when calibration is set to default.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_WeightFactorDP\_10Bit  (standard resolution variant) | See 3.1.5 | 108\*2 | See 3.1.5 | See 3.1.5 (used for displays) |
| DID\_WeightFactorDP\_12Bit  (high resolution variant) | See 3.1.6 | 108\*2 | See 3.1.6 | See 3.1.6 (used for displays) |
| DID\_WeightFactor\_Gauge | See 3.1.5 | 108\*2 | See 3.1.5 | See 3.1.5 (used for gauge, pointer and ring) |
| DID\_Low\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 20 | 2 | 0 - 4095 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 4095 | 2 | 0 –4095 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_Low\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Low\_PWM\_Gauge\_BL | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the gauge. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Gauge\_BL | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the gauge. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Low\_PWM\_Gauge\_Pointer | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the gauge pointer. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Gauge\_Pointer | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the gauge pointer. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Low\_PWM\_Gauge\_Ring | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the gauge Ring. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Gauge\_Ring | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the gauge Ring. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Low\_PWM\_PRNDL\_BL | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the PRNDL backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_PRNDL\_BL | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the PRNDL backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Blue | 408 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (blue). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_Blue | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (blue). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Green | 508 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (green). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_Green | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (green). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Turn | 508 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (turn indicator). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_Turn | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (turn indicator). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Amber | 508 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (amber). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_Amber | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (amber). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Orange | 304 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (orange). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_Orange | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (orange). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Night\_PWM\_Red | 508 | 2 | 0 - 1023 | PWM value for nighttime telltale / indicator brightness (red). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Day\_PWM\_ Red | 1023 | 2 | 0 - 1023 | PWM value for daytime telltale / indicator brightness (red). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |

### Smooth Dimming Calibration for Enhanced Dimming Algorithm

See 3.1.3 for detailed DID information

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

\*Backlight includes all IPC illumination zones, except indicators and telltales.

### IPC variants

The calibration parameters in chapter 9.1.1 are generic. Only a subset of the generic parameters must be assigned to the related IPC variant. The applicability is dependent on the IPC design and the available illumination zones. The DIDs defined in chapter 9.1.2 are applicable to every IPC variant.

#### Full Screen IPC (SX Cluster)

Any displayed information (e.g. gauge, pointer, telltale, scale, indicator) which is integrated into the IPC Display does not require a dedicated calibration zone as it is part of the display calibration zone. Full (TFT) instrument clusters without any further physical illumination zone does only require the following illumination zones listed in chapter 9.1.1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_WeightFactorDP\_10Bit  (standard resolution variant) | See 3.1.5 | 108\*2 | See 3.1.5 | See 3.1.5 (used for displays) |
| DID\_Low\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_WeightFactorDP\_12Bit  (high resolution variant) | See 3.1.6 | 108\*2 | See 3.1.6 | See 3.1.6 (used for displays) |
| DID\_Low\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 20 | 2 | 0 - 4095 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 4095 | 2 | 0 - 4095 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_WeightFactorDP\_Additional\_Color | TBD | TBD | TBD | TO BE ASSESSED |

A high PWM dimming resolution is one of the key elements to achieve a seamless and high quality dimming impression. It is recommended to use the 12 bit (high resolution variant) dimming resolution for displays with higher luminance, bigger size or light color schemes. Lower resolution might lead to stepped instead of seamless dimming response, especially towards lower intensities.

#### IPC with Display and further Physical Illumination Zones (S0 / S1 / S2)

Any displayed information within a separate physical zone (e.g. gauge, pointer, telltale, scale, and indicator) does require a dedicated calibration. Instrument clusters with separate physical zones require the illumination zones listed in chapter 9.1.1.

Any Display integrated zone does not require a dedicated calibration parameter.

A high PWM dimming resolution is one of the key elements to achieve a seamless and high quality dimming impression. It is recommended to use (12 bit) dimming resolution for displays with higher luminance, bigger size or light color schemes. Lower resolution might lead to stepped instead of seamless dimming response, especially towards lower intensities. The DIDs listed below are variants, it is recommended to use the (high resolution variant (12 bit)).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DID\_WeightFactorDP\_12Bit  (high resolution variant) | See 3.1.6 | 108\*2 | See 3.1.6 | See 3.1.6 (used for displays) |
| DID\_Low\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 20 | 2 | 0 - 4095 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_12Bit  (high resolution variant) | 4095 | 2 | 0 - 4095 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle |
| DID\_WeightFactorDP\_10Bit  (standard resolution variant) | See 3.1.5 | 108\*2 | See 3.1.5 | See 3.1.5 (used for displays) |
| DID\_Low\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_Display\_BL\_10Bit  (standard resolution variant) | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |

## IPC Illumination Zones:



## Dimming\_Lvl HMI Pop Up

In Dimming Day Mode, the pop up shall have 6 incremental steps, whereas in Dimming Night Mode the HMI shall have 12+1 bar graph increments.

 Day mode representation of bar graph

 Night mode representation of bar graph.

Operation:

If configured, whenever the Dimming\_Lvl changes by a user input to the HLS or the dimming HMI menu, the IPC shall show a dimming level HMI pop up window as shown in the example above.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Show\_Dimming\_Lvl\_Repeater | 1 | 1 | 0 - 1 | 0 -> dimming HMI repeater off / not shown  1 -> dimming HMI repeater on / shown |

The duration of the dimming level repeater needs to be aligned with the HMI team.

### Dimming\_Lvl HMI Pop Up Coding

In Dimming Day Mode, the pop up shall have 6 incremental steps, whereas in Dimming Night Mode the HMI shall have 12+1 bar graph increments.

| Dimming\_Lvl | | Meaning | Output |
| --- | --- | --- | --- |
| hex | dec | Displayed bar graph pattern |
| 0x00 | 0 | Off |  |
| 0x01 | 1 | Night 1 (min night) |  |
| 0x02 | 2 | Night 2 |  |
| 0x03 | 3 | Night 3 |  |
| 0x04 | 4 | Night 4 |  |
| 0x05 | 5 | Night 5 |  |
| 0x06 | 6 | Night 6 |  |
| 0x07 | 7 | Night 7 |  |
| 0x08 | 8 | Night 8 |  |
| 0x09 | 9 | Night 9 |  |
| 0x0A | 10 | Night 10 |  |
| 0x0B | 11 | Night 11 |  |
| 0x0C | 12 | Night 12 (max night) |  |
| 0x0D | 13 | Day 1 (min day) |  |
| 0x0E | 14 | Day 2 |  |
| 0x0F | 15 | Day 3 |  |
| 0x10 | 16 | Day 4 |  |
| 0x11 | 17 | Day 5 |  |
| 0x12 | 18 | Day 6 (max day) |  |
| 0x13 – 0xFD | 19-253 | Not used | none |
| 0xFE | 254 | Unknown | none |
| 0xFF | 255 | Invalid | none |

# HVAC

General chapters 1 until 4 are to be implemented / considered if applicable.

## Manual HVAC

### Diagnostic DIDs for Intensity Calibration

See chapter 3.1.1 for DID calibration details.

#### General DIDs for Intensity Calibration

The following DIDs are applicable for both dimming algorithms:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_DisplayBL | 5 | 2 | 0 - 1023 | N/A (no display) |
| DID\_High\_PWM\_DisplayBL | 1023 | 2 | 0 - 1023 | N/A (no display) |
| DID\_Low\_PWM\_KnobLeftBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness of left rotary  (blower symbol). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_KnobLeftBL | 255 | 1 | 0 - 255 | PWM value for highest brightness of left rotary.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_KnobRightBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness of right rotary backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_KnobRightBL | 255 | 1 | 0 - 255 | PWM value for highest brightness of right rotary backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_ButtonBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Button backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_ButtonBL | 255 | 1 | 0 - 255 | PWM value for highest brightness of Button backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempRed | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Temperature backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempRed | 255 | 1 | 0 - 255 | PWM value for highest brightness of Temperature backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempBlue | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Temperature backlight (blue). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempBlue | 255 | 1 | 0 - 255 | PWM value for highest brightness of Temperature backlight (blue). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_SeatRed | 5 | 1 | 0 - 255 | PWM value for lowest brightness of  Seat backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_SeatRed | 255 | 1 | 0 - 255 | PWM value for highest brightness of Seat backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_SeatBlue | 5 | 1 | 0 - 255 | n/a |
| DID\_High\_PWM\_SeatBlue | 255 | 1 | 0 - 255 | n/a |
| DID\_Night\_PWM\_SeatRed | 23 | 1 | 0 - 255 | PWM value for nighttime telltale / indicator brightness (seat red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_SeatRed | 255 | 1 | 0 – 255 | PWM value for daytime telltale / indicator brightness (seat red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_SeatBlue | 23 | 1 | 0 – 255 | n/a |
| DID\_Day\_PWM\_SeatBlue | 255 | 1 | 0 – 255 | n/a |
| DID\_Night\_PWM\_KnobYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale /indicator brightness located at the rotary yellow (amber). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_KnobYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale /indicator brightness located at the rotary yellow (amber). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_ButtonYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale /indicator brightness located on Buttons yellow (amber).  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ButtonYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale /indicator brightness located on Buttons yellow (amber).  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_BlowerYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness Blower bar yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_BlowerYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness. Blower bar yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_ECO | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External ECO button yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ECO | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External ECO button yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_StartStop | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External Start-Stop button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_StartStop | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External Start-Stop button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_AUTOHOLD | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External AUTOHOLD button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ AUTOHOLD | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External AUTOHOLD button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempIndexBL | 5 | 1 | 0 – 255 | PWM value for lowest brightness  temperature knob index. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempIndexBL | 255 | 1 | 0 – 255 | PWM value for highest brightness  temperature knob index. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_WeightFactorDP | See 3.1.5 | 108\*2 | See 3.1.5 | N/A (no display) |
| DID\_WeightFactorBL | See 3.1.4 | 72\*2 | See 3.1.4 | Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight” |

### Smooth Dimming Calibration for Enhanced Dimming Algorithm

The following DIDs are applicable in combination with the enhanced dimming algorithm (3.1.3)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

\*Backlight includes all HVAC illumination zones, except indicators and telltales.

### Example Illumination Zones of manual HVAC



## Automatic HVAC

### Diagnostic DIDs for Intensity Calibration

See chapter 3.1.1 for DID calibration details.

#### General DIDs for Intensity Calibration

The following DIDs are applicable for both dimming algorithms:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_DisplayBL | 5 | 2 | 0 - 1023 | PWM value for lowest brightness of Display backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_High\_PWM\_DisplayBL | 1023 | 2 | 0 - 1023 | PWM value for highest brightness of Display backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle |
| DID\_Low\_PWM\_KnobLeftBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness of left rotary  (blower symbol). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_KnobLeftBL | 255 | 1 | 0 - 255 | PWM value for highest brightness of left rotary.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_KnobRightBL1 | 5 | 1 | 0 - 255 | PWM value for lowest brightness of right rotary backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_KnobRightBL1 | 255 | 1 | 0 - 255 | PWM value for highest brightness of right rotary backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_ButtonBL | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Button backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_ButtonBL | 255 | 1 | 0 - 255 | PWM value for highest brightness of Button backlight. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempRed | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Temperature backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempRed | 255 | 1 | 0 - 255 | PWM value for highest brightness of Temperature backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempBlue2 | 5 | 1 | 0 - 255 | PWM value for lowest brightness of Temperature backlight (blue). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempBlue2 | 255 | 1 | 0 - 255 | PWM value for highest brightness of Temperature backlight (blue). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_SeatRed | 5 | 1 | 0 - 255 | PWM value for lowest brightness of  Seat backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_SeatRed | 255 | 1 | 0 - 255 | PWM value for highest brightness of Seat backlight (red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_SeatBlue | 5 | 1 | 0 - 255 | n/a |
| DID\_High\_PWM\_SeatBlue | 255 | 1 | 0 - 255 | n/a |
| DID\_Night\_PWM\_SeatRed | 23 | 1 | 0 - 255 | PWM value for nighttime telltale / indicator brightness (seat red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_SeatRed | 255 | 1 | 0 – 255 | PWM value for daytime telltale / indicator brightness (seat red). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_SeatBlue | 23 | 1 | 0 – 255 | n/a |
| DID\_Day\_PWM\_SeatBlue | 255 | 1 | 0 – 255 | n/a |
| DID\_Night\_PWM\_KnobYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale /indicator brightness located at the rotary yellow (amber). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_KnobYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale /indicator brightness located at the rotary yellow (amber). 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_ButtonYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale /indicator brightness located on Buttons yellow (amber).  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ButtonYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale /indicator brightness located on Buttons yellow (amber).  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_BlowerYellow | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness Blower bar yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_BlowerYellow | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness. Blower bar yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_ECO3 | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External ECO button yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ECO3 | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External ECO button yellow (amber) telltales.  0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_StartStop | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External Start-Stop button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_StartStop | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External Start-Stop button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Night\_PWM\_AUTOHOLD3 | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness External AUTOHOLD button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Day\_PWM\_ AUTOHOLD3 | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness External AUTOHOLD button yellow (amber) telltales. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_Low\_PWM\_TempIndexBL | 5 | 1 | 0 – 255 | PWM value for lowest brightness  temperature knob index. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_High\_PWM\_TempIndexBL | 255 | 1 | 0 – 255 | PWM value for highest brightness  temperature knob index. 0 = 0% PWM duty cycle; 255 = 100% PWM duty< cycle |
| DID\_WeightFactorDP | See 3.1.5 | 108\*2 | See 3.1.5 | Default values see “Definition Of Weight Factors For 10 Bit PWM (Display and Gauge Pointer)” |
| DID\_WeightFactorBL | See 3.1.4 | 72\*2 | See 3.1.4 | Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight” |

Note 1: This zone might be combined with the zone for PWM\_KnobLeftBL and is not used during calibration. To be approved by the responsible FORD illumination engineer.

Note 2: This zone might be combined with the zone for TempRed and is not used during calibration. To be approved by the responsible FORD illumination engineer.

Note 3: This zone might be combined with the indicator zone of the PWM\_StartStop indicator and is not used during calibration. To be approved by the responsible FORD illumination engineer.

### Smooth Dimming Calibration for Enhanced Dimming Algorithm

The following DIDs are applicable in combination with the enhanced dimming algorithm (3.1.3)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

\*Backlight includes all HVAC illumination zones, except indicators and telltales.

### Example Illumination Zones of automatic HVAC



# RCM

General Chapters 1 until 4 are to be implemented / considered if applicable.

## Calibratable Intensity DIDs

See chapter 3.1.1 for DID calibration details.

|  |  |  |  |
| --- | --- | --- | --- |
| **Identifier** | **Value** | **Bytes** | **Comment, Description** |
| DID\_Low\_PWM\_PADI\_Ind | 23 | 1 | PWM value for night time telltale brightness  PADI Indicator |
| DID\_High\_PWM\_PADI\_Ind | 255 | 1 | PWM value for day time telltale brightness  PADI Indicator |

# BCM

General Chapters 1 until 6 are to be implemented / considered if applicable.

## Extended Search Illumination

The BCM is one of the main components driving identifications of controls explained in chapter 3.1. Even if these identifications of controls are not directly connected to the BCM, it might control the illumination via the main illumination signals indirectly (e.g. Dimming\_Lvl, Backlit\_LED\_Status,…).

Hence the BCM and components containing these identifications must align on how to fulfil the requirement explained in 3.1. This alignment should be supported by the respective illumination program representative.

## End of Line Programmable DIDs

See chapter 3.1.1 for DID calibration details.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_PWM\_HW\_BL | See sample code | 72 | 0 - 255 | PWM table for hardwired connected backlight |
| DID\_Night\_PWM\_Ind 1 | 23 | 1 | 0 – 255 | PWM value for night time indicator / telltale brightness |
| DID\_Day\_PWM\_Ind 1 | 255 | 1 | 0 – 255 | PWM value for day time indicator / telltale brightness |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

Note 1: Each indicator PWM generator must have a separate DID to adjust the indicator day and night PWM value

## Overview Backlight for Hardwired Connected Components

Backlit\_LED\_Status

PWM\_TargetValueBL

DID\_PWM\_HW\_BL

Subroutine for hardwired backlight PWM

See 12.3.1

Litval

DID\_TransTime\_Usr\_BL

DID\_TransTime\_Amb\_Up\_BL

DID\_TransTime\_Amb\_Down\_BL

DID\_TransTime\_OnOff\_BL

CAN

Backlit\_LED\_Status\_Int

DID\_Backlit\_Ctrl

### Definition of the subroutines for backlight PWM

Note: All code is only an example to define the function more detailed. Implementation language and implementation code can be different but should have the same function.

#### On Update of Illumination Signals

Whenever Backlit\_LED\_Status or Litval is updated execute the following routines:

SetLitval\_HW ( Litval );

SetBacklit\_LED\_Status\_HW ( Backlit\_LED\_Status );

#### Subroutine for Hardwired Backlight PWM

// Variable definition. The following 7 variables should be initialized after reset/power-up

unsigned long ActualPWM\_HW;

unsigned long ActualPWMxShift\_HW;

unsigned long LastPWM\_HW;

unsigned long TargetPWM\_HW;

unsigned char Shift\_HW;

unsigned char Last\_Litval;

unsigned char Last\_Backlit\_LED\_Status;

unsigned char DID\_TransTime\_Usr\_BL = 0;

unsigned char DID\_TransTime\_Amb\_Up\_BL = 5;

unsigned char DID\_TransTime\_Amb\_Down\_BL = 8;

unsigned char DID\_TransTime\_OnOff\_BL = 0;

unsigned char DID\_PWM\_HW\_BL[13][6] = { // <----Litval--->

{ 0, 0, 0, 0, 0, 0 }, // ^

{ 5, 16, 30, 52, 102, 255 }, // |

{ 11, 22, 36, 58, 108, 255 }, // |

{ 17, 28, 42, 64, 114, 255 }, // |

{ 23, 34, 48, 71, 121, 255 }, // |

{ 30, 41, 55, 78, 128, 255 }, // |

{ 38, 49, 63, 86, 136, 255 }, //Backlit\_LED\_Status

{ 47, 58, 72, 95, 146, 255 }, // |

{ 58, 70, 84, 107, 157, 255 }, // |

{ 73, 84, 98, 121, 172, 255 }, // |

{ 91, 103, 117, 140, 191, 255 }, // |

{ 117, 128, 142, 166, 218, 255 }, // |

{ 153, 164, 179, 203, 255, 255 }, // v

};

// Initialization during power-up

ActualPWM\_HW = 0;

ActualPWMxShift\_HW = 0;

LastPWM\_HW = 0;

TargetPWM\_HW = 0;

Shift\_HW = 0;

Last\_Litval = 0;

Last\_Backlit\_LED\_Status = 0;

// Routine definition

void SetNewTarget( unsigned long NewTargetPWM, unsigned char NewShift )

{

Shift\_HW = NewShift;

TargetPWM\_HW = NewTargetPWM;

LastPWM\_HW = ActualPWM\_HW;

ActualPWMxShift\_HW = ActualPWM\_HW << Shift\_HW;

}

void SetLitval\_HW( unsigned char New\_Litval)

{

unsigned int PWM\_TargetValueBL;

if ( Last\_Litval != New\_Litval )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[Last\_Backlit\_LED\_Status][New\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

Last\_Litval = New\_Litval;

}

}

void SetBacklit\_LED\_Status\_HW( unsigned char New\_Backlit\_LED\_Status)

{

unsigned int PWM\_TargetValueBL;

if ( Last\_Backlit\_LED\_Status != New\_Backlit\_LED\_Status )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[New\_Backlit\_LED\_Status][Last\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

if ( PWM\_TargetValueBL == 0 )

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

}

else

{

if (ActualPWM\_HW == 0)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

}

Last\_Backlit\_LED\_Status = New\_Backlit\_LED\_Status;

}

}

// This timer interrupt must be called every 40ms:

Void Interrupt40ms()

{

ActualPWMxShift\_HW = ActualPWMxShift\_HW - LastPWM\_HW + TargetPWM\_HW;

ActualPWM\_HW = ActualPWMxShift\_HW >> Shift\_HW;

Update\_PWM\_Generator( ActualPWM\_HW);

if ((LastPWM\_HW < TargetPWM\_HW) && ( ActualPWM\_HW >= TargetPWM\_HW ))

{

LastPWM\_HW = TargetPWM\_HW;

}

if ((LastPWM\_HW > TargetPWM\_HW) && ( ActualPWM\_HW <= TargetPWM\_HW))

{

LastPWM\_HW = TargetPWM\_HW;

}

}

## LIN communication BCM - Head Lamp Switch

The BCM transmits several illumination signals to the HLS. The HLS will select via internal tables the right brightness for indicators and backlight.

### HLS\_Illumination\_Signals

The following signals are transmitted from BCM to HLS. There is also and LDF file with the data description. The LDF file is the master in case of a mismatch to this description.

|  |  |  |
| --- | --- | --- |
| Name | Size | Description |
| Day\_Night\_Status | 2 bit | Ambient light sensor state:  0x0: Null (sensor not present)  0x1: Day (day time brightness for indicator)  0x2: Night (night time brightness for indicator)  0x3: NotUsed |
| Parklamp\_Status | 2 bit | Head lamp status:  0x0: Off  0x1: On  0x2: Unknown  0x3: Invalid |
| Litval | 8 bit | Ambient light level:  0x0: Night  0x1: Twilight\_1  0x2: Twilight\_2  0x3: Twilight\_3  0x4: Twilight\_4  0x5: Day  0xFE: Unknown  0xFF: Invalid |
| Ignition\_Status | 4 bit | Ignition state:  0x0: Unknown  0x1: Off  0x2: Accessory  0x4: Run  0x8: Start  0xF: Invalid |

|  |  |  |
| --- | --- | --- |
| Name | Size | Description |
| Dimming\_Lvl | 8 bit | Display and Pointer illumination:  0x00: Off Illumination Off  0x01: Night\_1 Barely Discernible  0x02: Night\_2  0x03: Night\_3  0x04: Night\_4  0x05: Night\_5  0x06: Night\_6  0x07: Night\_7  0x08: Night\_8  0x09: Night\_9  0x0A: Night\_10  0x0B: Night\_11  0x0C: Night\_12 Max Nighttime Brightness  0x0D: Day\_1 Min Daytime Brightness  0x0E: Day\_2  0x0F: Day\_3  0x10: Day\_4  0x11: Day\_5  0x12: Day\_6 Max Daytime Brightness  0xFE: Unknown  0xFF: Invalid |
| Backlit\_LED\_Status | 4 bit | Search illumination:  0x00: Off Illumination Off  0x01: Night\_1 Barely Discernible  0x02: Night\_2  0x03: Night\_3  0x04: Night\_4  0x05: Night\_5  0x06: Night\_6  0x07: Night\_7  0x08: Night\_8  0x09: Night\_9  0x0A: Night\_10  0x0B: Night\_11  0x0C: Night\_12 Max Nighttime Brightness  0x0D: Unused1  0x0E: Unused2  0x0F: Unused3 |

# PAM

General Chapters 1 until 4 are to be implemented / considered if applicable.

## Indicator Intensity Calibration DIDs

See chapter 3.1.1 for DID calibration details.

|  |  |  |  |
| --- | --- | --- | --- |
| **Identifier** | **Value** | **Bytes** | **Comment, Description** |
| DID\_Low\_PWM\_PAM\_Ind | 23 | 1 | PWM value for night time telltale brightness  Parking Assistant Indicator |
| DID\_High\_PWM\_PAM\_Ind | 255 | 1 | PWM value for day time telltale brightness  Parking Assistant Indicator |

# HLS

General Chapters 1 until 4 are to be implemented / considered if applicable.

## Configuration

See 3.1.1 for configuration DID details

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_PWM\_HW\_BL | See sample code 14.4.2.2 | 72 | 0 - 255 | PWM table for hardwired connected backlight |
| DID\_Night\_PWM\_Ind | 23 | 1 | 0 – 255 | PWM value for night time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle |
| DID\_Day\_PWM\_Ind | 255 | 1 | 0 – 255 | PWM value for day time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

## HLS Day/Night Brightness for Indicators

See 3.2

## HLS Smooth Dimming

The smooth dimming algorithm is described in chapter 3.1.3. (General description).

See 14.4.2 for a HLS specific description.

During updating the PWM generator no unexpected PWM ratios are allowed. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio.

Example: If the actual PWM ratio is 25% and switched to 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%. Care must be taken, that during loading a new value in the PWM generator no such side effects are generated.

## HLS Dimming\_lvl processing

The signal Dimming\_lvl should be processed in the following way.

|  |  |  |
| --- | --- | --- |
| **Dimming\_lvl** | **Ignition\_Status** | **BacklitLEDCmd** |
| Off | Not( Run, Start) | Off |
| Off | Run, Start | Last “non off” value (Night\_1 ... Night\_12, Day\_1 … Day\_6) – see note |
| Night\_1 ... Night\_12  Day\_1 … Day\_6 | Don’t care | Night\_1 ... Night\_12  Day\_1 … Day\_6 |
| All others | Don’t care | see HLS Backlight Error Handling |

Note: If last value is unknown (e.g. reset), use off

### Overview Backlight

PWM\_TargetValueBL

DID\_PWM\_HW\_BL

Subroutine for hardwired backlight PWM

See 14.4.2

Dimming\_lvl

Litval

DID\_TransTime\_Usr\_BL

DID\_TransTime\_Amb\_Up\_BL

DID\_TransTime\_Amb\_Down\_BL

DID\_TransTime\_OnOff\_BL

### Definition of the subroutines for backlight PWM

Note: All code is only an example to define the function more detailed. Implementation language and implementation code can be different but should have the same function.

#### On Update of Illumination Signals

Whenever Dimming\_lvl or Litval is updated execute the following routines:

SetLitval\_HW ( Litval );

SetDimming\_lvl\_HW ( Dimming\_lvl );

#### Subroutine for Hardwired Backlight PWM

// Variable definition. The following 7 variables should be initialized after reset/power-up

unsigned long ActualPWM\_HW;

unsigned long ActualPWMxShift\_HW;

unsigned long LastPWM\_HW;

unsigned long TargetPWM\_HW;

unsigned char Shift\_HW;

unsigned char Last\_Litval;

unsigned char Last\_Dimming\_lvl;

unsigned char DID\_TransTime\_Usr\_BL = 0;

unsigned char DID\_TransTime\_Amb\_Up\_BL = 5;

unsigned char DID\_TransTime\_Amb\_Down\_BL = 8;

unsigned char DID\_TransTime\_OnOff\_BL = 0;

unsigned char DID\_PWM\_HW\_BL[19][6] = { // <----Litval--->

{ 0, 0, 0, 0, 0, 0 }, // ^

{ 5, 8, 12, 18, 26, 255 }, // |

{ 7, 10, 15, 22, 33, 255 }, // |

{ 9, 14, 19, 28, 40, 255 }, // |

{ 13, 18, 25, 35, 49, 255 }, // |

{ 18, 24, 33, 44, 60, 255 }, // |

{ 24, 32, 42, 56, 74, 255 }, // Dimming\_lvl

{ 33, 42, 55, 70, 91, 255 }, // |

{ 45, 56, 71, 89, 112, 255 }, // |

{ 61, 74, 91, 112, 138, 255 }, // |

{ 82, 99, 118, 141, 169, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // v

};

// Initialization during power-up

ActualPWM\_HW = 0;

ActualPWMxShift\_HW = 0;

LastPWM\_HW = 0;

TargetPWM\_HW = 0;

Shift\_HW = 0;

Last\_Litval = 0;

Last\_Dimming\_lvl = 0;

// Routine definition

void SetNewTarget( unsigned long NewTargetPWM, unsigned char NewShift )

{

Shift\_HW = NewShift;

TargetPWM\_HW = NewTargetPWM;

LastPWM\_HW = ActualPWM\_HW;

ActualPWMxShift\_HW = ActualPWM\_HW << Shift\_HW;

}

void SetLitval\_HW( unsigned char New\_Litval)

{

unsigned int PWM\_TargetValueBL;

if ( Last\_Litval != New\_Litval )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[Last\_Dimming\_lvl][New\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

Last\_Litval = New\_Litval;

}

}

void SetDimming\_lvl\_HW( unsigned char New\_Dimming\_lvl)

{

unsigned int PWM\_TargetValueBL;

if ( Last\_Dimming\_lvl != New\_Dimming\_lvl )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[New\_Dimming\_lvl][Last\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

if ( PWM\_TargetValueBL == 0 )

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

}

else

{

if (ActualPWM\_HW == 0)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

}

Last\_Dimming\_lvl = New\_Dimming\_lvl;

}

}

// This timer interrupt must be called every 40ms:

Void Interrupt40ms()

{

ActualPWMxShift\_HW = ActualPWMxShift\_HW - LastPWM\_HW + TargetPWM\_HW;

ActualPWM\_HW = ActualPWMxShift\_HW >> Shift\_HW;

Update\_PWM\_Generator( ActualPWM\_HW);

if ((LastPWM\_HW < TargetPWM\_HW) && ( ActualPWM\_HW >= TargetPWM\_HW ))

{

LastPWM\_HW = TargetPWM\_HW;

}

if ((LastPWM\_HW > TargetPWM\_HW) && ( ActualPWM\_HW <= TargetPWM\_HW))

{

LastPWM\_HW = TargetPWM\_HW;

}

}

## HLS Dimming\_lvl Error Handling

If (signal == valid signal)

Then

Use new value

Else

If (last valid signal == Off) AND (error time > 5 seconds)

Then

set signal to Night\_12

Else

set signal to last valid signal

Note:

1. Valid signals for Dimming\_lvl are Off, Night\_1 ... Night\_12
2. Error is invalid signal or missing signal
3. Missing signal is LIN active, but illumination frame not transmitted

## HLS Litval Error Handling

If (signal == valid signal)

Then

Use new value

Else

If (last valid signal <> Day) AND (error time > 5 seconds)

Then

set signal to Day

Else

set signal to last valid signal

Note:

1. Valid signals for Litval are Night, Twilight\_1 ... Twilight\_4, Day
2. Error is invalid signal or missing signal
3. Missing signal is LIN active, but illumination frame not transmitted

## HLS Ignition Handling

In order to allow the customer to find the headlamp switch in dim light if the backlighting is in the off position turn it on while Ignition\_Status is in RUN or START. If last Dimming\_lvl was off or unknown use Night\_12. If last Dimming\_lvl was <> off use this value.

Last\_Dimming\_lvl is the last user selected Dimming\_lvl which is not OFF. Init values after reset should be OFF.

Dimming\_lvl\_Table is the value for selecting Dimming\_lvl at the PWM table.

Dimming\_lvl\_Table = Dimming\_lvl

If (Dimming\_lvl <> Off)

Then

Last\_Dimming\_lvl = Dimming\_lvl

Else

If (Ignition\_Status == Run) OR (Ignition\_Status == Start)

Then

If (Last\_Dimming\_lvl == Off)

Then

Last\_Dimming\_lvl = Night\_12

EndIf

Dimming\_lvl\_Table = Last\_Dimming\_lvl

EndIf

# TCU

General Chapters 1 until 4 are to be implemented / considered if applicable.

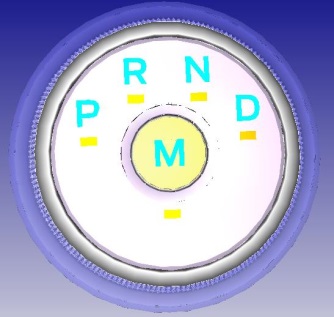
## Indicator Intensity DIDs

See chapter 3.1.1 for DID calibration details.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_TCU\_Ind | 23 | 1 | 0 - 255 | PWM value for ERA Glonass / eCall Indicator night time brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |
| DID\_High\_PWM\_TCU\_Ind | 255 | 1 | 0 - 255 | PWM value for ERA Glonass / eCall Indicator day time brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |

# GSM – Gear Shift Module

General chapters 1 until 4 are to be implemented / considered if applicable.



## Diagnostic DIDs for Intensity Calibration

See chapter 3.1.1 for DID calibration details.

### General DIDs for Intensity Calibration

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_Low\_PWM\_BL | 5 | 1 | 0 - 255 | PWM value for lowest backlight intensity  Use it with DID\_WeightFactorBL |
| DID\_High\_PWM\_BL | 255 | 1 | 0 - 255 | PWM value for highest backlight intensity  Use it with DID\_WeightFactorBL |
| DID\_Night\_PWM\_Indicator | 23 | 1 | 0 - 255 | PWM value for night time indicator / telltale brightness |
| DID\_Day\_PWM\_Indicator | 255 | 1 | 0 - 255 | PWM value for day time indicator / telltale brightness |
| DID\_WeightFactorBL | See 3.1.4 | 72\*2 | See 3.1.4 | Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight” |

### Smooth Dimming Calibration for Enhanced Dimming Algorithm

The following DIDs are applicable in combination with the enhanced dimming algorithm (3.1.3)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

\*Backlight includes all GSM backlit illumination zones, except indicators and telltales.

# Door Trim Illumination

The figure below shows the illumination signal flow for components contributing to the door trim illumination. The figure below shows the **4 door module** configuration (B479 example).

DDM

PDM

DRDM

PRDM

PWM

PWM

LIN

PWM

PWM

Figure 6 – Signal Flow Door Trim Illumination for 4 Door Module Configuration

Driver Door Switchpack (LIN)

Door Trim Switches (PWM)

Door Trim Switches (PWM)

Rear Door Trim Switches (PWM)

Rear Door Trim Switches (PWM)

BCM

GWM

CAN

CAN

LIN

The **2 door module** configuration is shown in the figure below (C519 example). The rear door trim switches are controlled via front door control unit.

CAN

BCM

DDM

GWM

CAN

PWM

PWM

Door Trim Switches (PWM)

Rear Door Trim Switches (PWM)

LIN

PWM

PDM

Driver Door Switchpack (LIN)

Door Trim Switches (PWM)

Rear Door Trim Switches (PWM)

PWM

Figure 7 - Signal Flow Door Trim Illumination for 2 Door Modules

To enable the usage of initial CGEA 1.3 and enhanced CGEA 1.3 DCU dimming functionality, it was necessary to handle both protocols in the DDS. See. 17.5 for the initial CGEA 1.3 specification reference. The enhanced CGEA 1.3 dimming functionality is explained within this specification. The DDS distinguishes between these two functionalities via RheostatPositionCmd signal value.

|  |  |  |
| --- | --- | --- |
| **Functionality** | **RheostatPositionCmd** | **Description** |
| Standard CGEA 1.3 dimming\* | 0x0 – 0xC | OFF, Night\_1 … Night\_12 |
| Enhanced CGEA 1.3 dimming | 0xF | New Illumination Strategy |

\*The initial CGEA 1.3 configuration shall only be used to ensure backwards compatibility.

The related LDF file is the master in case of a mismatch to the table above.

The DCU must ensure that on transmission of the first LIN frame, the correct signal value range is transmitted.

The DDS must receive 3 successive valid samples of signal RheostatPositionCmd to switch between the functionalities. All 3 samples must contain values from the same functionality (e.g. 0x0 -0xC). The number of samples used to switch the functionality should be calibratable.

## Front Door Modules

General Chapters 1 until 6 are to be implemented / considered if applicable.

This chapter describes a DCU specific dimming algorithm which might differ from the generic algorithm as it is based on PWM target values.

### Front Door Module Programmable DIDs

The front door modules should have the following DIDs. See

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_DCU\_Input\_Selector | 2 | 1 | 0 - 3 | Defines which illumination input signal is processed. See 17.1.2.3 |
| DID\_PWM\_LIN\_BL | See sample Code | 72 | 0 - 255 | PWM table for backlight of LIN connected components |
| DID\_PWM\_HW\_BL | See sample Code | 72 | 0 - 255 | PWM table for hardwired DCU connected backlight |
| DID\_Night\_LIN\_Ind | 23 | 1 | 0 - 255 | PWM value for night time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. LIN |
| DID\_Day\_LIN\_Ind | 255 | 1 | 0 - 255 | PWM value for day time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. LIN |
| DID\_Night\_HW\_Ind | 23 | 1 | 0 - 255 | PWM value for night time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. Hardwired |
| DID\_Day\_HW\_Ind | 255 | 1 | 0 - 255 | PWM value for day time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. Hardwired |
| DDS\_Tran\_Time\_LIN\_Ind | 4 | 1 | 0 - 9 | Indicator transition time from start to target intensity |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

See chapter 3.1.1 for DID calibration details.

### Backlight Intensity Control

### Overview Backlight for Components connected via LIN

DID\_TransTime\_Usr\_BL

DID\_TransTime\_Amb\_Up\_BL

DID\_TransTime\_Amb\_Down\_BL

DID\_TransTime\_OnOff\_BL

Dimming\_lvl

Litval

Table 19

Dimming\_lvl\_Int

PWM\_TargetValueBL

Dimming\_lvl

DID\_PWM\_LIN\_BL

Delay\_Accy

Litval\_Int

Output on LIN

See 17.1.2.4.3

LIN\_PWM\_BL

(DDS\_PWM\_BL)

LIN\_Tran\_Time\_BL

(DDS\_Tran\_Time\_BL)

Litval

Transition Time

### Overview Backlight for Hardwired connected Components

DID\_TransTime\_Usr\_BL

DID\_TransTime\_Amb\_Up\_BL

DID\_TransTime\_Amb\_Down\_BL

DID\_TransTime\_OnOff\_BL

Dimming\_lvl

Litval

Table 19

Dimming\_lvl\_Int

PWM\_TargetValueBL

Dimming\_lvl

DID\_PWM\_HW\_BL

Delay\_Accy

Litval\_Int

Subroutine for hardwired backlight PWM

See 17.1.2.4

Litval

### Backlight Strategy Selection

DID DCU\_Input\_Selector

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **CAN Input Signals** | | | **Output for Dimming Algorithm** | | **Comment** |
| **DID**  **value** | **Input Selector** | **Dimming\_lvl2** | **Delay\_Accy3** | **Litval4** | **Dimming\_lvl\_Int** | **Litval\_Int** | All door trim illumination components are able to follow Dimming\_lvl and powered via battery or battery saver output.   * This configuration provides the desired welcome / farewell behaviour and seamless dimming |
| 0 | Dimming\_lvl2 | Off / unused / invalid | OFF | don’t care | OFF | don’t care |
| 0 | Dimming\_lvl2 | Off / unused / invalid  -> Missing6 | OFF | don’t care | OFF | don’t care |
| 0 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 | OFF | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 0 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 -> Missing6 | OFF | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 0 | Dimming\_lvl2 | Off / missing 6) / unused / invalid | ON1 | Night  ... Day / missing | Keep last valid  Dimming\_lvl value > OFF 5) | Keep last valid  Litval value |
| 0 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 | ON | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 1 | Delay\_Accy3 | don’t care | OFF | don’t care | OFF | Day | If at least one door trim component is directly powered via delayed accessory relay and no CAN / LIN dimming interface available.   * No dimming (only on / off)  / might differ from welcome and farewell in low power mode (del accy =OFF) |
| 1 | Delay\_Accy3 | don't care | ON1 | don’t care | Night\_12 | Day |
| 2 | Dimming\_lvl2and Delay\_Accy3 | don’t' care | OFF | don’t care | OFF | don’t care | If at least one door trim component is powered via delayed accessory relay and all components are able to follow Dimming\_lvl signal (CAN /LIN).   * Seamless dimming supported / might differ from welcome and farewell in low power mode (del accy =OFF) |
| 2 | Dimming\_lvl2and Delay\_Accy3 | Off / missing 6 / unused / invalid | ON1 | Night  ... Day / missing | Keep last valid  Dimming\_lvl value > OFF 5) | Keep last valid  Litval value |
| 2 | Dimming\_lvl2and Delay\_Accy3 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 | ON | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 3 | Dimming\_lvl2 | Off / unused / invalid | OFF | don’t care | OFF | don’t care | At least one door trim illumination component is hardwired connected to the BCM backlight illumination PWM output   * Seamless dimming supported / OFF during delayed accessory after 25 sec timeout. |
| 3 | Dimming\_lvl2 | Off / unused / invalid -> Missing6 | OFF | don’t care | OFF | don’t care |
| 3 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 | OFF | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 3 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 -> Missing6 | OFF | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 3 | Dimming\_lvl2 | Off / unused / invalid | ON1 | don’t care | OFF | don’t care |
| 3 | Dimming\_lvl2 | Off / unused / invalid -> Missing6 | ON1 | don’t care | OFF | don’t care |
| 3 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 | ON | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |
| 3 | Dimming\_lvl2 | Night\_1 .. Night\_12, Day\_1 .. Day\_6 -> Missing6 | ON | Night  ... Day | Night\_1 .. Night\_12,  Day\_1 .. Day\_6 | Night  ... Day |

Table 19

Note1: If Delay\_Accy is missing and last received value is ON, keep this value and start 10 min timer. Assume Delay\_Accy = OFF after timer has elapsed.

Resume normal operation as per Table 19 if valid signal is available.

Note2: Dimming\_lvl\_LIN in case of rear door module

Note3: Delay\_Accy\_LIN in case of rear door module

Note4: LitVal\_LIN in case of rear door module; every data not equal to Night, T1..4,Day shall be assumed as Day to ensure legibility.

Note5: Assume 0xC, if last received value in range cannot be retrieved (only on battery re-connect or ECU reset)

Note6: The term ‘missing’ means that signal can be absent also during CAN sleep, in which case last valid state has to be kept.

Every Carline should aim to implement configuration 0 to provide the desired dimming performance. Options 1 to 3 are listed to enable backwards compatibility to door trim components with limited performance / interface capabilities.

#### Definition of the subroutines for backlight PWM

Note: All code is only an example to define the function more detailed. Implementation language and implementation code can be different but should have the same function.

##### On Receipt of a New Illumination CAN Message

Assume a new CAN message arrived and the new illumination values are in the following variables:

Dimming\_Lvl, Litval, Delay\_Accy

Execute the following routines:

SetLitval\_HW ( Litval );

SetDimming\_Lvl\_HW ( Dimming\_Lvl );

SetDelay\_Accy\_HW (Delay\_Accy);

SetLitval\_LIN ( Litval );

SetDimming\_Lvl\_LIN ( Dimming\_Lvl );

SetDelay\_Accy\_LIN (Delay\_Accy);

##### Subroutine for Hardwired Backlight PWM

// Variable definition. The following 7 variables should be initialized after reset/power-up

unsigned long ActualPWM\_HW;

unsigned long ActualPWMxShift\_HW;

unsigned long LastPWM\_HW;

unsigned long TargetPWM\_HW;

unsigned char Shift\_HW;

unsigned char Last\_Litval;

unsigned char Last\_Dimming\_Lvl;

unsigned char LastNonOff\_Dimming\_Lvl;

unsigned char DID\_DCU\_Input\_Selector = 2;

unsigned char DID\_TransTime\_Usr\_BL = 0;

unsigned char DID\_TransTime\_Amb\_Up\_BL = 6;

unsigned char DID\_TransTime\_Amb\_Down\_BL = 8;

unsigned char DID\_TransTime\_OnOff\_BL = 0;

unsigned char DID\_PWM\_HW\_BL[19][6] = { // <----Litval--->

{ 0, 0, 0, 0, 0, 0 }, // ^

{ 5, 8, 12, 18, 26, 255 }, // |

{ 7, 10, 15, 22, 33, 255 }, // |

{ 9, 14, 19, 28, 40, 255 }, // |

{ 13, 18, 25, 35, 49, 255 }, // |

{ 18, 24, 33, 44, 60, 255 }, // |

{ 24, 32, 42, 56, 74, 255 }, // Dimming\_Lvl

{ 33, 42, 55, 70, 91, 255 }, // |

{ 45, 56, 71, 89, 112, 255 }, // |

{ 61, 74, 91, 112, 138, 255 }, // |

{ 82, 99, 118, 141, 169, 255 }, // |

**{ 112, 131, 153, 178, 208, 255 }, // |**

**{ 153, 174, 198, 224, 255, 255 }, // |**

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // v

};

// Initialization during power-up

ActualPWM\_HW = 0;

ActualPWMxShift\_HW = 0;

LastPWM\_HW = 0;

TargetPWM\_HW = 0;

Shift\_HW = 0;

Last\_Litval = 0;

Last\_Dimming\_Lvl = 0;

LastNonOff\_Dimming\_Lvl = Night\_12;

// Routine definition

void SetNewTarget( unsigned long NewTargetPWM, unsigned char NewShift )

{

Shift\_HW = NewShift;

TargetPWM\_HW = NewTargetPWM;

LastPWM\_HW = ActualPWM\_HW;

ActualPWMxShift\_HW = ActualPWM\_HW << Shift\_HW;

}

unsigned char Litval\_Int( unsigned char Litval )

{

if (DID\_DCU\_Input\_Selector==1)

return Day;

else

return Litval; // if bus sleep mode use last valid Litval

}

void SetLitval\_HW( unsigned char New\_Litval)

{

unsigned int PWM\_TargetValueBL;

New\_Litval = Litval\_Int( New\_Litval );

if ( Last\_Litval != New\_Litval )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[Last\_Dimming\_Lvl][New\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

Last\_Litval = New\_Litval;

}

}

unsigned char Dimming\_Lvl\_Int( unsigned char Dimming\_Lvl )

{

if ((Dimming\_Lvl >= Night\_1) && (Dimming\_Lvl <= **Day\_6**))

{

LastNonOff\_Dimming\_Lvl = Dimming\_Lvl;

}

if (DID\_DCU\_Input\_Selector==0)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

// (after 10min set Delay\_Accy to Off)

return LastNonOff\_Dimming\_Lvl;

else

return Dimming\_Lvl; // if missing use last valid Dimming\_Lvl

}

else if (DID\_DCU\_Input\_Selector==1)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

//(after 10min set Delay\_Accy to Off)

return Night\_12;

else

return Off;

}

else if (DID\_DCU\_Input\_Selector==2)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

//(after 10min set Delay\_Accy to Off)

return LastNonOff\_Dimming\_Lvl;

else

return Off;

}

else // (DID\_DCU\_Input\_Selector==3)

{

return Dimming\_Lvl; // if missing use last valid Dimming\_Lvl

}

}

int StayInDayOrNightRange (unsigned char New\_Dimming\_Lvl, unsigned char Last\_Dimmimg\_lvl)

{

return

(

((New\_Dimming\_Lvl <= Night\_12) && (Last\_Dimming\_Lvl <= Night\_12)) ||

((New\_Dimming\_Lvl >= Day\_1) && (Last\_Dimming\_Lvl >= Day\_1))

);

}

void SetDimming\_Lvl\_HW( unsigned char New\_Dimming\_Lvl)

{

unsigned int PWM\_TargetValueBL;

New\_Dimming\_Lvl = Dimming\_Lvl\_Int( New\_Dimming\_Lvl );

if ( Last\_Dimming\_Lvl != New\_Dimming\_Lvl )

{

PWM\_TargetValueBL = DID\_PWM\_HW\_BL[New\_Dimming\_Lvl][Last\_Litval];

if (((Last\_Dimming\_Lvl == Off) && (New\_Dimming\_Lvl > Off)) ||

((Last\_Dimming\_Lvl > Off) && (New\_Dimming\_Lvl == Off)))

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

}

if (StayInDayOrNightRange (New\_Dimming\_Lvl, Last\_Dimming\_Lvl))

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

else

{

if (PWM\_TargetValueBL < ActualPWM\_HW)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

}

}

Last\_Dimming\_Lvl = New\_Dimming\_Lvl;

}

}

void SetDelay\_Accy\_HW( unsigned char Delay\_Accy )

{

SetDimming\_Lvl\_HW(Dimming\_Lvl);

}

// This timer interrupt has to be called every 40ms:

Void Interrupt40ms()

{

ActualPWMxShift\_HW = ActualPWMxShift\_HW - LastPWM\_HW + TargetPWM\_HW;

ActualPWM\_HW = ActualPWMxShift\_HW >> Shift\_HW;

Update\_PWM\_Generator( ActualPWM\_HW);

if ((LastPWM\_HW < TargetPWM\_HW) && ( ActualPWM\_HW >= TargetPWM\_HW ))

{

LastPWM\_HW = TargetPWM\_HW;

}

if ((LastPWM\_HW > TargetPWM\_HW) && ( ActualPWM\_HW <= TargetPWM\_HW))

{

LastPWM\_HW = TargetPWM\_HW;

}

}

##### Backlight Subroutine for Components Connected via LIN

// Variable definition. The following 7 variables should be initialized after reset/power-up

unsigned long ActualPWM\_LIN;

unsigned long ActualPWMxShift\_LIN;

unsigned long LastPWM\_LIN;

unsigned long TargetPWM\_LIN;

unsigned char Shift\_LIN;

unsigned char Last\_Litval;

unsigned char Last\_Dimming\_Lvl;

unsigned char LastNonOff\_Dimming\_Lvl;

unsigned char DID\_DCU\_Input\_Selector = 2;

unsigned char DID\_TransTime\_Usr\_BL = 0;

unsigned char DID\_TransTime\_Amb\_Up\_BL = 6;

unsigned char DID\_TransTime\_Amb\_Down\_BL = 8;

unsigned char DID\_TransTime\_OnOff\_BL = 0;

unsigned char DID\_PWM\_LIN\_BL[19][6] = { // <----Litval--->

{ 0, 0, 0, 0, 0, 0 }, // ^

{ 5, 8, 12, 18, 26, 255 }, // |

{ 7, 10, 15, 22, 33, 255 }, // |

{ 9, 14, 19, 28, 40, 255 }, // |

{ 13, 18, 25, 35, 49, 255 }, // |

{ 18, 24, 33, 44, 60, 255 }, // |

{ 24, 32, 42, 56, 74, 255 }, // Dimming\_Lvl

{ 33, 42, 55, 70, 91, 255 }, // |

{ 45, 56, 71, 89, 112, 255 }, // |

{ 61, 74, 91, 112, 138, 255 }, // |

{ 82, 99, 118, 141, 169, 255 }, // |

**{ 112, 131, 153, 178, 208, 255 }, // |**

**{ 153, 174, 198, 224, 255, 255 }, // |**

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // |

{ 255, 255, 255, 255, 255, 255 }, // v

};

// Initialization during power-up

ActualPWM\_LIN = 0;

ActualPWMxShift\_LIN = 0;

LastPWM\_LIN = 0;

TargetPWM\_LIN = 0;

Shift\_LIN = 0;

Last\_Litval = 0;

Last\_Dimming\_Lvl = 0;

LastNonOff\_Dimming\_Lvl = Night\_12;

// Routine definition

void SetNewTarget( unsigned long NewTargetPWM, unsigned char NewShift )

{

Shift\_LIN = NewShift;

TargetPWM\_LIN = NewTargetPWM;

LastPWM\_LIN = ActualPWM\_LIN;

ActualPWMxShift\_LIN = ActualPWM\_LIN << Shift\_LIN;

}

unsigned char Litval\_Int( unsigned char Litval )

{

if (DID\_DCU\_Input\_Selector==1)

return Day;

else

return Litval; // if bus sleep mode use last valid Litval

}

void SetLitval\_LIN( unsigned char New\_Litval)

{

unsigned int PWM\_TargetValueBL;

New\_Litval = Litval\_Int( New\_Litval );

if ( Last\_Litval != New\_Litval )

{

PWM\_TargetValueBL = DID\_PWM\_LIN\_BL[Last\_Dimming\_Lvl][New\_Litval];

if (PWM\_TargetValueBL < ActualPWM\_LIN)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

Last\_Litval = New\_Litval;

}

}

unsigned char Dimming\_Lvl\_Int( unsigned char Dimming\_Lvl )

{

if ((Dimming\_Lvl >= Night\_1) && (Dimming\_Lvl <= **Day\_6**))

{

LastNonOff\_Dimming\_Lvl = Dimming\_Lvl;

}

if (DID\_DCU\_Input\_Selector==0)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

// (after 10min set Delay\_Accy to Off)

return LastNonOff\_Dimming\_Lvl;

else

return Dimming\_Lvl; // if missing use last valid Dimming\_Lvl

}

else if (DID\_DCU\_Input\_Selector==1)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

//(after 10min set Delay\_Accy to Off)

return Night\_12;

else

return Off;

}

else if (DID\_DCU\_Input\_Selector==2)

{

if (Delay\_Accy == On) // or missing with last Delay\_Accy==On

//(after 10min set Delay\_Accy to Off)

return LastNonOff\_Dimming\_Lvl;

else

return Off;

}

else // (DID\_DCU\_Input\_Selector==3)

{

return Dimming\_Lvl; // if missing use last valid Dimming\_Lvl

}

}

int StayInDayOrNightRange (unsigned char New\_Dimming\_Lvl, unsigned char Last\_Dimmimg\_lvl)

{

return

(

((New\_Dimming\_Lvl <= Night\_12) && (Last\_Dimming\_Lvl <= Night\_12)) ||

((New\_Dimming\_Lvl >= Day\_1) && (Last\_Dimming\_Lvl >= Day\_1))

);

}

void SetDimming\_Lvl\_LIN( unsigned char New\_Dimming\_Lvl)

{

unsigned int PWM\_TargetValueBL;

New\_Dimming\_Lvl = Dimming\_Lvl\_Int( New\_Dimming\_Lvl );

if ( Last\_Dimming\_Lvl != New\_Dimming\_Lvl )

{

PWM\_TargetValueBL = DID\_PWM\_LIN\_BL[New\_Dimming\_Lvl][Last\_Litval];

if (((Last\_Dimming\_Lvl == Off) && (New\_Dimming\_Lvl > Off)) ||

((Last\_Dimming\_Lvl > Off) && (New\_Dimming\_Lvl == Off)))

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_OnOff\_BL );

}

else

}

if (StayInDayOrNightRange (New\_Dimming\_Lvl, Last\_Dimming\_Lvl))

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Usr\_BL );

}

else

{

if (PWM\_TargetValueBL < ActualPWM\_LIN)

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Down\_BL );

}

else

{

SetNewTarget( PWM\_TargetValueBL, DID\_TransTime\_Amb\_Up\_BL );

}

}

}

Last\_Dimming\_Lvl = New\_Dimming\_Lvl;

}

}

void SetDelay\_Accy\_LIN( unsigned char Delay\_Accy )

{

SetDimming\_Lvl\_LIN(Dimming\_Lvl);

}

// This timer interrupt has to be called every 40ms:

Void Interrupt40ms()

{

ActualPWMxShift\_LIN = ActualPWMxShift\_LIN - LastPWM\_LIN + TargetPWM\_LIN;

ActualPWM\_LIN = ActualPWMxShift\_LIN >> Shift\_LIN;

Update\_PWM\_Generator( ActualPWM\_LIN);

if ((LastPWM\_LIN < TargetPWM\_LIN) && ( ActualPWM\_LIN >= TargetPWM\_LIN ))

{

LastPWM\_LIN = TargetPWM\_LIN;

}

if ((LastPWM\_LIN > TargetPWM\_LIN) && ( ActualPWM\_LIN <= TargetPWM\_LIN))

{

LastPWM\_LIN = TargetPWM\_LIN;

}

}

### Indicator Intensity Control

The indicator on / off request is always controlled by the related function and not defined within this specification. This specification defines the indicator illumination intensity only.

#### Overview Indicator Intensity for Components Connected via LIN

DID\_Day\_LIN\_Ind

DID\_Night\_LIN\_Ind

**See 3.2**

Output on LIN

LIN\_PWM\_Ind

(DDS\_PWM\_Ind)

LIN\_Tran\_Time\_Ind

(DDS\_Tran\_Time\_Ind)

Dimming\_Lvl

Day\_Night\_Status

PWM\_TargetValueInd

Parklamp\_Status

DDS\_Tran\_Time\_LIN\_Ind

Transition Time

## Rear Door Modules

General Chapters 1 until 4 are to be implemented / considered if applicable.

This chapter describes a DCU specific dimming algorithm which might differ from the generic algorithm as it is based on PWM target values.

### Rear Door Module End of Line Programmable DIDs

The rear door modules should have the following end of line programmable DIDs:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_DCU\_Input\_Selector | 2 | 1 | 0 - 3 | Defines which illumination input signal is processed. See Table 19. |
| DID\_PWM\_HW\_BL | See sample code | 72 | 0 - 255 | PWM table for hardwired DCU connected backlight |
| DID\_Night\_HW\_Ind | 23 | 1 | 0 - 255 | PWM value for night time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. Hardwired |
| DID\_Day\_HW\_Ind | 255 | 1 | 0 - 255 | PWM value for day time telltale / indicator brightness.  0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle. Hardwired |
| DID\_TransTime\_Usr\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity on user request. Used for backlight. |
| DID\_TransTime\_Amb\_Up\_BL | 6 | 1 | 0 - 9 | Transition time from start to target intensity if increased intensity is requested. Used for backlight. |
| DID\_TransTime\_Amb\_Down\_BL | 8 | 1 | 0 - 9 | Transition time from start to target intensity if decreased intensity is requested. Used for backlight. |
| DID\_TransTime\_OnOff\_BL | 0 | 1 | 0 - 9 | Transition time from start to target intensity if start or target is 0FF. Used for backlight. |

See chapter 3.1.1 for DID calibration details.

### Backlight Intensity Control

#### Overview Backlight for Hardwired Connected Components

DID\_TransTime\_Usr\_BL

DID\_TransTime\_Amb\_Up\_BL

DID\_TransTime\_Amb\_Down\_BL

DID\_TransTime\_OnOff\_BL

Dimming\_lvl \_LIN

LitVal\_LIN

Table 19

Dimming\_lvl \_Int

PWM\_TargetValueBL

Dimming\_lvl\_LIN

DID\_PWM\_HW\_BL

Delay\_Accy\_LIN

Litval\_Int

Subroutine for hardwired backlight PWM

See 17.2.2.2

LitVal\_LIN

#### Definition of the subroutines for backlight PWM

Note: All code is only an example to define the function more detailed. Implementation language and implementation code can be different but should have the same function.

##### On Receipt of a New Illumination LIN Message

Assume a new LIN message arrived and the new illumination values are in the following variables:

Dimming\_Lvl\_LIN, LitVal\_LIN, Delay\_Accy\_LIN

Execute the following routines:

SetLitval\_HW ( LitVal\_LIN );

SetDimming\_Lvl\_HW ( Dimming\_Lvl\_LIN );

SetDelay\_Accy\_HW (Delay\_Accy\_LIN);

##### Subroutine for Hardwired Backlight PWM

See 17.1.2.4.2

### Indicator Intensity Control

The indicator on / off request is always controlled by the related function and not defined within this specification. This specification defines the indicator illumination intensity only.

**See 3.2 for indicator dimming details**

## LIN Communication of Front Door Module to DDS

DDS\_Tran\_Time\_Ind

DDS\_PWM\_Ind

DDS\_Tran\_Time\_BL

DDS\_PWM\_BL

DDM

DDS

Backlight

DDS

Indicator

On /Off is controlled by the respective function and is not defined within this illumination specification

The protocol must be able to send the illumination message at least every 80ms. If no change of the PWM signal is necessary, the backlight messages should be transmitted at least all 500ms. Every message with a valid PWM value must update the PWM generator.

During application of one PWM duty cycle it is not allowed to update the applied duty cycle, the received update shall be queued. An update is only allowed after having completed the actual running PWM period. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio.

Example: If the actual PWM ratio is 25% and switched to 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%. Care must be taken, that during loading a new value in the PWM generator no such side effects are generated.

### Missing Message / Signal Handling

If DDS\_PWM\_BL is missing, keep last valid received value. If last valid value cannot be retrieved, assume 0x0.

If DDS\_Tran\_Time\_BL is missing, keep last valid received value. If last valid value cannot be retrieved, assume 0x5.

If DDS\_PWM\_Ind is missing, keep last valid received value. If last valid value cannot be retrieved, assume 0xFF.

If DDS\_Tran\_Time\_Ind is missing, keep last valid received value. If last valid value cannot be retrieved, assume 0x5.

If RheostatPositionCmdis missing, keep last valid received value. If last valid value cannot be retrieved, assume value 0xF.

The missing message strategy shall not inhibit the normal network sleep process during ignition off and shall not keep the illumination active. See chapter 3.6 for more details.

The PWM generators should use the complete range and resolution of 256 steps with 0x00 = off and 0xFF = 100% on. All values in between are valid and shall result in a linearly interpolated intensity output.

At PWM value 255 the maximum brightness requirement should be fulfilled.

The front door module sends the new target PWM values and transition times to the rear door module and DDS via LIN signals. The indicator and backlight signals are independent of each other and may contain different target intensity values and transition times. The backlight and indicator intensity is calibrateable as described in Table 20.The LDF is the master in case of a mismatch to this description

|  |  |  |
| --- | --- | --- |
| Signal Name | Size | Description |
| DDS\_PWM\_BL  *(DDM to DDS only)* | 8 bits | 0x00 – 0xFF:  Target PWM value for the 8-bit DDS backlight PWM generator. |
| DDS\_Tran\_Time\_BL  *(DDM to DDS only)* | 4 bits | 0x0 – 0x9:  Transition time for DDS backlight PWM generator (shifts)  See 3.1.3.2 |
| DDS\_PWM\_Ind  *(DDM to DDS only)* | 8 bits | 0x00 – 0xFF:  Target PWM value for the 8-bit DDS indicator PWM generator. |
| DDS\_Tran\_Time\_Ind  *(DDM to DDS only)* | 4 bits | 0x0 – 0x9:  Transition time for DDS indicator PWM generator (shifts)  See 3.1.3 |
| Rear\_PWM\_BL | 8 bits | 0x00 – 0xFF:  Target PWM value for the 8-bit rear backlight PWM generator. |
| Rear\_Tran\_Time\_BL | 4 bits | 0x0 – 0x9:  Transition time for rear backlight PWM generator (shifts)  See 3.1.3 |

Table 20

## DDS

General Chapters 1 until 6 are to be implemented / considered if applicable.

The LIN interface to the DDM is described in 17.3

The information of target intensity and transition time needs to be transmitted simultaneously by the DDM. The DDS receives a filtered / calibrated target PWM intensity value. The DID table containing the transition time settings / amount of shifts is only available in the DDM and not part of the DDS. The DDM shall transmit the new target value in combination with the value of shifts needed for the transition.

DDS\_Tran\_Time\_Ind

DDS\_PWM\_Ind

DDS\_Tran\_Time\_BL

DDS\_PWM\_BL

DDM

DDS

Backlight

DDS

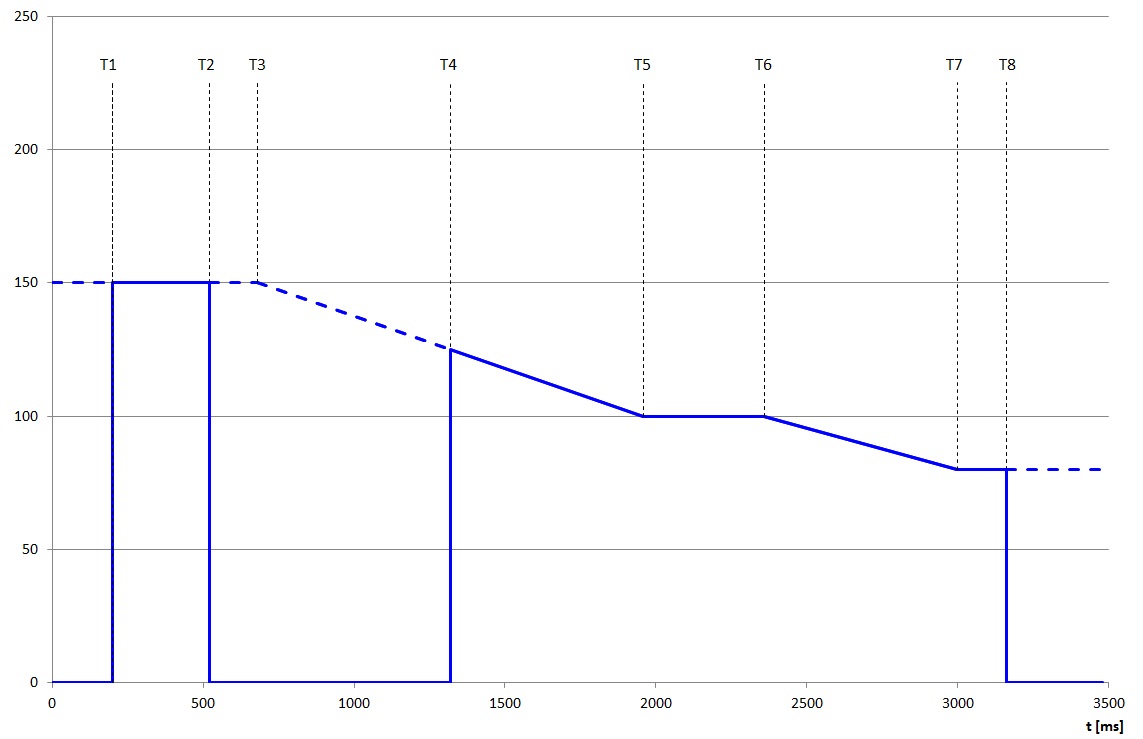
Indicator

On /Off is controlled by the respective function and is not defined within this illumination specification

### Seamless Dimming Algorithm

The seamless dimming algorithm for backlight is described in 17.1.2.4.

The seamless dimming algorithm for indicators is similar to the backlight dimming except on transition to or from OFF. The indicator ON / OFF status is controlled by the related function and not part of this illumination specification. If any Indicator illumination is requested by the function, the target brightness level needs to be set immediately without any ramping or smooth dimming. The smooth dimming is only applied if the indicator is already requested on / illuminated and new target intensity > OFF is received. The graphic below shows some example dimming cases.



|  |  |
| --- | --- |
| Time | Action |
| 0-T1 | Indicator PWM algorithm is at level 150, but indicator is turned off by the function |
| T1 | Indicator is turned on by the function with 150 PWM, the transition from OFF to target intensity is always immediate, even if the shift is set >0. |
| T2 | Indicator is turned off by the function. The transition to OFF is always immediate, even if the shift is set >0. |
| T3 | Start transition for indicator PWM algorithm with Target=100, shift=5 (32x40ms). The illumination is still OFF as per function request |
| T4 | During ramping down indicator is turned on by the function (with PWM=125) .The indicator illuminates with the current intensity calculated by the function and follows the ramping subsequently. |
| T5 | Ramping complete (stops further intensity changes) |
| T6 | Start new transition with Target=80, shift=4 (16x40ms) |
| T7 | Ramping complete (stops further change) |
| T8 | Indicator is turned off by the function. Illumination is switched OFF immediately |

#### Sample code in the DDS

Note: All code is only an example to define the function more detailed. Implementation language and implementation code can be different but should have the same function.

##### Definition of some internal variables:

unsigned char OldTargetPWM\_BL;

unsigned char OldShift\_BL;

unsigned long ActualPWM\_BL;

unsigned long ActualPWMxShift\_BL;

unsigned long LastPWM\_BL;

unsigned long TargetPWM\_BL;

unsigned char Shift\_BL;

unsigned char OldTargetPWM\_Ind;

unsigned char OldShift\_Ind;

unsigned long ActualPWM\_Ind;

unsigned long ActualPWMxShift\_Ind;

unsigned long LastPWM\_Ind;

unsigned long TargetPWM\_Ind;

unsigned char Shift\_Ind;

##### When a new LIN message arrives

The following sample code explains, what should be done when a new illumination LIN message arrives. Assume a new LIN message arrived and the new illumination values are in the following 4 variables:

DDS\_PWM\_BL, DDS\_Tran\_Time\_BL, DDS\_PWM\_Ind, DDS\_Tran\_Time\_Ind

Than call the following routines:

CheckUpdate\_BL( DDS\_PWM\_BL, DDS\_Tran\_Time\_BL );

CheckUpdate\_Ind( DDS\_PWM\_Ind, DDS\_Tran\_Time\_Ind );

With the definition of the routines as follows:

void SetNewTarget\_BL( int NewTargetPWM\_BL, char NewShift\_BL )

{

Shift\_BL = NewShift\_BL;

TargetPWM\_BL = NewTargetPWM\_BL;

LastPWM\_BL = ActualPWM\_BL;

ActualPWMxShift\_BL = ActualPWM\_BL << Shift\_BL;

}

void CheckUpdate\_BL( int NewTargetPWM\_BL, char NewShift\_BL )

{

if (( OldTargetPWM\_BL != NewTargetPWM\_BL ) || ( OldShift\_BL != NewShift\_BL ))

{

OldTargetPWM\_BL = NewTargetPWM\_BL;

OldShift\_BL = NewShift\_BL;

SetNewTarget\_BL( NewTargetPWM\_BL, NewShift\_BL );

}

}

void SetNewTarget\_Ind( int NewTargetPWM\_Ind, char NewShift\_Ind )

{

Shift\_Ind = NewShift\_Ind;

TargetPWM\_Ind = NewTargetPWM\_Ind;

LastPWM\_Ind = ActualPWM\_Ind;

ActualPWMxShift\_Ind = ActualPWM\_Ind << Shift\_Ind;

}

void CheckUpdate\_Ind( int NewTargetPWM\_Ind, char NewShift\_Ind )

{

if (( OldTargetPWM\_Ind != NewTargetPWM\_Ind ) || ( OldShift\_Ind != NewShift\_Ind ))

{

OldTargetPWM\_Ind = NewTargetPWM\_Ind;

OldShift\_Ind = NewShift\_Ind;

SetNewTarget\_Ind( NewTargetPWM\_Ind, NewShift\_Ind );

}

}

##### Calculation at every 40ms to update the PWM generators:

Void Timer40ms()

{ // this should be executed every 40ms

// part for backlight PWM generator

ActualPWMxShift\_BL = ActualPWMxShift\_BL - LastPWM\_BL + TargetPWM\_BL;

ActualPWM\_BL = ActualPWMxShift\_BL >> Shift\_BL;

SetPWM(ActualPWM\_BL); // update the backlight PWM generator

if (( LastPWM\_BL < TargetPWM\_BL ) && ( ActualPWM\_BL >= TargetPWM\_BL ))

{

LastPWM\_BL = TargetPWM\_BL;

}

else if (( LastPWM\_BL > TargetPWM\_BL ) && ( ActualPWM\_BL <= TargetPWM\_BL ))

{

LastPWM\_BL = TargetPWM\_BL;

}

// part for indicator PWM generator

ActualPWMxShift\_Ind = ActualPWMxShift\_Ind - LastPWM\_Ind + TargetPWM\_Ind;

ActualPWM\_Ind = ActualPWMxShift\_Ind >> Shift\_Ind;

SetPWM(ActualPWM\_Ind); // update the indicator PWM generator

if (( LastPWM\_Ind < TargetPWM\_Ind) && ( ActualPWM\_Ind >= TargetPWM\_Ind ))

{

LastPWM\_Ind = TargetPWM\_Ind;

}

else if (( LastPWM\_Ind > TargetPWM\_Ind ) && ( ActualPWM\_Ind <= TargetPWM\_Ind ))

{

LastPWM\_Ind = TargetPWM\_Ind;

}

}

## Initial CGEA 1.3 DCU Illumination Specification

ES-DS7T-1A278-AD (for reference only)

# Power Sliding Door

General Chapters 1 until 4 are to be implemented / considered if applicable.

Chapter 3.2 describes the Indicator / Telltale dimming.

## Calibrateable Intensity DIDs

All DID values are subject to change based on the interior harmonisation process and might be adjusted several times during the development process. Diagnostic service 0x22 (read) and service 0x2E (write) access is preferred during the development phase and allows quick adjustments. All DIDs must be accessible via diagnostic method 3 calibration file. M3 calibration access is not limited to the development phase and must be maintained throughout the vehicle lifetime. Service 0x22 read access should be maintained to enable a quick read of current settings. End of line calibration should be conducted via M3 file and not via service 0x2E write. To enable quick calibration adjustments it is recommended to maintain service 0x2E write access to support calibration trials, this access must be restricted (security access limitation).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Identifier** | **Default**  **Value** | **Bytes** | **Range** | **Comment, Description** |
| DID\_IND\_PSD\_Funct\_NIGHT | 23 | 1 | 0 - 255 | PWM value for Moving Door Indicator nighttime brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |
| DID\_IND\_PSD\_Funct\_DAY | 255 | 1 | 0 - 255 | PWM value for Moving Door Indicator daytime brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |
| DID\_IND\_PSD\_CutOff\_NIGHT | 23 | 1 | 0 - 255 | PWM value for Moving Door Indicator nighttime brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |
| DID\_IND\_PSD\_CutOff\_DAY | 255 | 1 | 0 - 255 | PWM value for Moving Door Indicator daytime brightness. 0 refers to 0% duty cycle, 255 refers to 100% duty cycle. |

# CHUD – Combiner Head-Up-Display

The applicable welcome / farewell behaviour is defined in the Interior Harmony SDS and the CHUD FS.

The CHUD does have an independent dimming strategy which is not linked to the cockpit illumination dimming system described within this document. The CHUD dimming strategy is defined in the CHUD specification. The CHUD has an individual ambient light sensor input and an IPC menu to adjust the brightness.

# Appendix

## Sample code for 10-bit display / backlight PWM:

### Definition of some internal variables and DIDs:

// the following 7 variables should be initialized after reset/power up

unsigned long ActualPWM; // actual PWM value

unsigned long ActualPWMxShift; // actual PWM value x number of transition steps (2^shift)

unsigned long LastPWM; // PWM value at start of transition

unsigned long TargetPWM; // target PWM value

unsigned char Shift; // number of transition steps = 2^shift

unsigned char Last\_Litval;

unsigned char Last\_Dimming\_Lvl;

unsigned char DID\_TransTime\_Usr = 0;

unsigned char DID\_TransTime\_Amb\_Up = 5;

unsigned char DID\_TransTime\_Amb\_Down = 8;

unsigned char DID\_TransTime\_OnOff = 0;

unsigned int DID\_Low\_PWM\_DP = 20; // low calibration value for (display) backlight

unsigned int DID\_High\_PWM\_DP = 1023; // high calibration value for (display) backlight

unsigned int DID\_WeightFactorDP [19][6] = {

// <----Litval--->

{ 0, 0, 0, 0, 0, 0 }, // see note

{ 0, 25, 51, 83, 141, 300 }, // ^

{ 11, 36, 61, 93, 149, 304 }, // |

{ 22, 46, 72, 102, 157, 307 }, // |

{ 34, 57, 82, 112, 166, 311 }, // |

{ 46, 69, 93, 123, 175, 315 }, // |

{ 59, 81, 105, 134, 184, 320 }, // |

{ 73, 95, 118, 146, 195, 324 }, // |

{ 91, 112, 135, 162, 208, 330 }, // |

{ 114, 135, 156, 182, 226, 338 }, // Dimming\_Lvl

{ 149, 169, 189, 213, 251, 350 }, // |

{ 205, 222, 240, 261, 293, 368 }, // |

{ 300, 314, 328, 344, 363, 400 }, // |

{ 320, 338, 357, 380, 414, 500 }, // |

{ 407, 426, 445, 469, 505, 595 }, // |

{ 493, 513, 534, 558, 596, 689 }, // |

{ 582, 603, 624, 650, 689, 786 }, // |

{ 678, 699, 721, 748, 790, 890 }, // |

{ 800, 823, 846, 874, 918, 1024 } }; // v

Note: This line was only filled to make the code easier to read. Of course it is possible to eliminate this line from the array and adjust all index values accordingly.

### Definition of the subroutines for 10-bit backlight PWM:

// subroutine to adjust the Litval signal

void SetLitval( unsigned char New\_Litval)

{

unsigned int NewPWM;

if ( Last\_Litval != New\_Litval )

{

// calculate the new target PWM

NewPWM = PWM\_TargetValueDP( Last\_Dimming\_Lvl, New\_Litval, DID\_Low\_PWM\_DP, DID\_High\_PWM\_DP );

if (NewPWM < ActualPWM) // if transition to lower PWM

{

SetNewTarget( NewPWM, DID\_TransTime\_Amb\_Down );

}

else // transition to higher PWM

{

SetNewTarget( NewPWM, DID\_TransTime\_Amb\_Up );

}

Last\_Litval = New\_Litval;

}

}

// subroutine to adjust the Dimming\_Lvl

void SetDimming\_Lvl( unsigned char New\_Dimming\_Lvl)

{

unsigned int NewPWM;

if ( Last\_Dimming\_Lvl != New\_Dimming\_Lvl )

{

// calculate the new target PWM

NewPWM = PWM\_TargetValueDP( New\_Dimming\_Lvl, Last\_Litval, DID\_Low\_PWM\_DP, DID\_High\_PWM\_DP );

if (NewPWM < ActualPWM) // if transition to lower PWM

{

if (New\_Dimming\_Lvl == Off) // to backlight turn off

{

SetNewTarget( NewPWM, DID\_TransTime\_OnOff );

}

else if (DayNightChange( Last\_Dimming\_Lvl, New\_Dimming\_Lvl )) // if day-night or night-day jump

{

SetNewTarget( NewPWM, DID\_TransTime\_Amb\_Down );

}

else // user input

{

SetNewTarget( NewPWM, DID\_TransTime\_Usr );

}

}

else // if transition to higher PWM

{

if (Last\_Dimming\_Lvl == Off) // if backlight turn on

{

SetNewTarget( NewPWM, DID\_TransTime\_OnOff );

}

else if (DayNightChange( Last\_Dimming\_Lvl, New\_Dimming\_Lvl )) // if day-night or night-day jump

{

SetNewTarget( NewPWM, DID\_TransTime\_Amb\_Up );

}

else // user input

{

SetNewTarget( NewPWM, DID\_TransTime\_Usr );

}

}

Last\_Dimming\_Lvl = New\_Dimming\_Lvl;

}

}

// adjust table weight factors with low and high calibration value

unsigned int TableInterpolation( unsigned int LowValue, unsigned int HighValue,

unsigned int WeightFactor )

{

return LowValue + (((HighValue - LowValue) \* WeightFactor + 512) >> 10);

}

unsigned int PWM\_TargetValueDP( unsigned char Dimming\_Lvl,

unsigned char Litval,

unsigned int DID\_Low\_PWM, unsigned int DID\_High\_PWM )

// determine PWM target value for 10-bit illumination zone

{

if (Dimming\_Lvl == Off )

{

return 0;

}

else

{

return TableInterpolation( DID\_Low\_PWM, DID\_High\_PWM,

DID\_WeightFactorDP[Dimming\_Lvl][Litval] );

}

}

unsigned char DayNightChange( unsigned char LastDimmingLvl, unsigned char NewDimmingLvl )

// return 1 if Dimming\_Lvl change from night setting to day setting or from day setting to night setting

// else retrun 0

{

if ((( LastDimmingLvl >= Night\_1 ) && ( LastDimmingLvl <= Night\_12 ) &&

( NewDimmingLvl >= Day\_1 ) && (NewDimmingLvl <= Day\_6 )) ||

(( LastDimmingLvl >= Day\_1 ) && ( LastDimmingLvl <= Day\_6 ) &&

( NewDimmingLvl >= Night\_1 ) && (NewDimmingLvl <= Night\_12 )))

{

return 1;

}

else

{

return 0;

}

}

// start a new transition

void SetNewTarget( unsigned int NewTargetPWM, unsigned char NewShift )

{

Shift = NewShift; // new number of transition steps (2^shift)

TargetPWM = NewTargetPWM; // set new target PWM value

LastPWM = ActualPWM; // remember actual PWM value

ActualPWMxShift = ActualPWM << Shift; // calculate actual PWM x number of steps (2^shift)

}

### Subroutine for 40ms update of 10-bit PWM generator:

This subroutine must be called every 40ms by a timer routine.

void UpdatePWMevery40ms()

{

ActualPWMxShift = ActualPWMxShift - LastPWM + TargetPWM; // perform one interpolation step

ActualPWM = ActualPWMxShift >> Shift; // divide by the number of transition steps (2^shift)

SetNewPWM\_Value( ActualPWM ); // update here the 10 bit PWM generator or I²C message

if ((LastPWM < TargetPWM) && ( ActualPWM >= TargetPWM ))

{ // if (rising slope) and (actual PWM >= target PWM) then stop

// with LastPWM = TargetPWM, the calculation the interpolation did not change the PWM value

LastPWM = TargetPWM;

}

if ((LastPWM > TargetPWM) && ( ActualPWM <= TargetPWM))

{ // if (falling slope) and (actual PWM <= target PWM) then stop

// with LastPWM = TargetPWM, the calculation the interpolation did not change the PWM value

LastPWM = TargetPWM;

}

}