Engineering Specification

PART NAME: SPEC – Cockpit Illum.	PART NUMBER
Global CGEA1.3 Enhanced Illumination System Specification	**ES H1BT-1A278-AA**

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14. Jan. 2015			0.1 initial		
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CHECKED T. Stein	DETAILED BY
APPROVAL SIGNATURES ON IN WERS CONCERN	

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(Previous editions may **NOT** be used)

2017MY B479 / C519
Cockpit Illumination System Specification

Revision History

Revision	Date	Author	Description
0.1	14. Jan..2015	Walter Mayer	Initial
0.2	12. Mar. 2015	Walter Mayer	Change Chapter: 3.1.2.2 External Switches/Indicators Without On Controller (Illumination Circuit) Change Chapter 3.6.1 and 3.6.2 (remove line 3 from table) Change Chapter 4.3 (add possible zone combinations) Change Chapter 3.4.3 (typo LIN/ICC => LIN/IIC) Change Chapter 3.3.2.1 (table and figure changed) Change Chapter 3.3.2.3 (Dimming_Lvl => Backlit_LED_Status, sample code) Change Chapter 2.2 (update system layout) Change Chapter 1.3 (abbreviations added) Change Chapter 3.10.1-3.10.22 (message ID removed – CAN-DB is master) Change Chapter 8.1 (DIDs updated) Change Chapter 6.1 (DIDs update) Add Chapter 10.x (PAM) Change Chapter 8.3 and 8.3.1 (change protocol to new LIN.ldf and calibration) Change Chapter 8.1 (table changed) Change Chapter 3.4 (text and default values changed) Add Chapter 11.x (HLS) Add Chapter 12.x (TCU) Add Chapter 5.4.x (Dimming_Lvl HMI Pop Up) Change Chapter 4.3.1 (table reworked, clarification invalid bit, missing msg) Change Chapter 4.4.1 (table reworked, clarification invalid bit, missing msg) Change Chapter 4.4.2 (table reworked, clarification invalid bit, missing msg) Change Chapter 4.3 (brightness target at max. PWM) Change Chapter 4.4 (brightness target at max. PWM) Change Chapter 3.1.1 (voltage supply via other modules added) Add Chapter 13.x (DDM) Add Chapter 14.x (PDM) Add Chapter 15.x (DDS) Add Chapter 16.x (DRDM) Add Chapter 17.x (PRDM)
0.3	20. Mar. 2015	Walter Mayer	Change Chapter 3.1.7 (add note) Change Chapter 3.3 (tables also EOL programmable, method 3) Change Chapter 3.3.2.1 (EOL programmable) Change Chapter 3.3.3.1 (EOL programmable) Change Chapter 3.4 (introduce fixed table size, clarification algorithm up/down) Change Chapter 3.6.2, 3.6.3 (values for SVC remove, clarification, PWM frequ.) Change Chapter 3.1.3 (frequency and accuracy of AD converter added) Change Chapter 11.3 (smooth dimming) Change Chapter 4.1, 5.1, 6.1, 8.1, 13.1, 14.1 (add DID_TransitionTimeMS) Change Chapter 4.2, 5.2, 6.2, 8.2, 13.2, 14.2 (change to EOL programmable, add DID_MoveUpTable and DID_MoveDownTable, correct byte numbers) Change Chapter 8.3.1 (table updated) Change Chapter 11.2 (splited in 12.2.1 and 12.2.2, signal processing added) Add Chapter 11.4 (HLS Dimming_Lvl processing)
0.4	26. Mar. 2015	Walter Mayer	Change Chapter 8.1 (add DID_Backlit_at_Day) Change Chapter 8.3.1 (update signals) Change Chapter 11.2.1 (HLS Low/High Brightness For Indicators) Change Chapter 11.2.2 (table updated) Change Chapter 11.4 (HLS Dimming_Lvl processing) Add Chapter 11.5 (HLS Backlight Error Handling) Add Chapter 18 (Day / Night Selection For Indicators) Change Chapter 1.1, 3.7, 3.8, 3.14 (Specs: Welcome/Farwell, Interior Harmony SDS) Change Chapter 3.1.2.2 (addition for thermal behavior)

Revision	Date	Author	Description
0.5	29. April 2015	Walter Mayer	Change Spec Name to "Global CGEA1.3 Enhanced Illumination System Specification" Change Chapter 1.1 (first 3 paragraph added/changed) Change Chapter 3.3 (last sentence added – readable DID) Change Chapter 11.2.2, 11.4 (table corrected) Change Chapter 11.5 (Day_1 .. Day_6 removed) Change Chapter 3.3.2.3 (sample code => DID_WeightFactorBL [13][6]) Add Chapter 3.15 (Behavior After Reset) Change Chapter 4.3, 4.4, 15.1, 16.1, 17.1 (add reset behaviour) Change Chapter 11.4 (change reset behavior) Change Chapter 3.4.3 (table item 5: typo CAN => LIN/IIC) Change Chapter 18 (table resorted to make processing more obviours) Change Chapter 4.4.1, 4.4.2 (name of IIC/LVDS protocol spec. updated) Add Chapters 19. 19.1 19.2 20. 20.1 20.2 20.3 20.4 Change Chapter 8.3.1 (Litval coding update)
0.6	12. June 2015	Walter Mayer	Change Chapter 11.1 (table change to Backlit_LED_Status) Change Chapter 11.5 (reworked) Add Chapter 11.6 Add Chapter 11.7 Change of Chapter numbers (4.1, 4.2 => radio => 4.2.1, 4.2.2 – no content change) (4.1., 4.2 => SYNC => 4.1.1, 4.1.2, 4.1.3, 4.1.4 – content splitted for VMCU, CCP) Change Chapter 3.15 (sentence corrected "immediately **switch** to") Change of Chapter numbers (6.1, 6.2, 6.3 => manual HVAC => 6.1, 6.1.1, 6.1.2, 6.1.3 => automatic HVAC => 6.2, 6.2.1, 6.2.2, 6.2.3) Change Chapter 6.1.3 (Illumination Zones of manual HVAC) Change Chapter 6.2.3 (Illumination Zones of automatic HVAC)
0.7	23. June 2015	Walter Mayer	Chapter 2.2 splited in chapter 2.2 and 2.3 (B479 and C519) due to different door modules. Chapter 3.4 Remark added (how to calibrate stepped behaviour)
0.8	14. July 2015	Walter Mayer	Change chapters 4.3, 4.3.1, 4.4, 4.4.1, 4.4.2 (remove reset and invalid handling) Add chapter 4.5 new wording for reset and invalid handling for better understanding Change chapters 4.1.1, 4.1.2, 4.1.3, 4.1.4 (text replaced with spec reference) Change chapter 4.3 (add not below table where to find the on/off criteria for zone bits) Change chapter 4.4 (add not below picture, where to find the on/off criteria for display and button backlight)
0.9	22. July 2015	Walter Mayer	Change chapter 4.3 (add info when "Invalid" bit have to be set) Change chapter 4.4 (remove "See also chapter 4.5 Behaviour After Reset And Invalid Bit Handling") Change chapter 4.4.1 and 4.4.2 (remove invalid bit and detailed data, because it is in LVDS spec.) Change chapter 4.5 (remove default value for 10bit) Change chapter 4.1 (insert affected chapters for B479)
0.10	28. Oct. 2015	Walter Mayer / Heiner Boehm	Chapter 4.5 moved to 4.3.2 (only valid for LIN interface) Combine two-step dimming requirements for indicators in chapter 3.5 Combine and re-structure chapter 3.1 Clarification of FCIMB zone control setting Added separate chapter for FCIMB APIM signal overview B479 added Chapter re-arrangement

Table of Contents

1 Introduction

1.1 Purpose and Scope

This document describes the enhanced CGEA1.3 illumination features, applied to B479 / C519 and all future programs.

These enhanced features are:

- Calibrateable illumination brightness and timing is mandatory
- Two step dimming for indicators and telltales is mandatory
- Automatic ambient based dimming using the Litval signal mandatory
- Smooth transition from one brightness level to the next is mandatory
- Additional illumination requirements if voltage quality module is not available

It also handles specific items at the B479 and C519 application specific electrical architecture for the cockpit illumination system.

The generic specification for CGEA1.3 illumination is specified in following documents:

- ES-DS7T-1A278-AD (basic dimming strategy)
- ES-DS7T-1A278-BE (brightness and color, welcome / farewell)
- ES-DS7T-1A278-CB (welcome / farewell)
- Interior Harmony SDS from 3rd of March 2015 or newer (overall targets)
- FS-0000-00001-AB Revision 4 (voltage drop during restart at start/stop vehicles)

In case of double definition, the definition in ES-H1BT-1A278-Ax is prior for B479 and C519 applications and derived vehicle programs.

This specification defines more detailed requirements for a vehicle cockpit illumination dimming system for all Ford B479 and C519 applications based on CGEA1.3 electronic architecture. It covers several possible component designs and defines the common requirements for these differing applications like B515MCA.

However, this specification is subject to change and should not prevent the cockpit component manufacturers from suggesting alternate approaches that would result in an improved or more cost-effective system. The cockpit component manufacturers are encouraged to pursue such changes with Ford Motor Company and the EESE Upper Body Electronics, Cockpit Illumination System Engineering Group.

1.2 Document Intent

This specification is intended as a generic binding guideline for all new 2017 model year Ford carlines based on B479 and C519 global vehicle program derivatives require a dimming control subsystem and it supersedes all previous specifications.
The illumination colour is IceBlue™ and made the use of an ambient light level sensing device, called ambient light sensor (ALS) mandatory.
The specification shall describe the integration of the ambient light level sensor in to the existing electronic architecture whilst leaving all existing dimming output (backend) relevant functions and signals untouched in order to minimise the change impact for the affected backlit components and electronic control units within the cockpit.
The ambient light level sensor offered the possibility to detect a third use case besides

- night time driving with exterior lights on and
- daytime driving with exterior lights off

that could previously not be detected.

This is

- driving with exterior light on during day time conditions.

The B479/C519 architecture provides following improvements:

- dimming calibration over dimming level and ambient light level
- battery voltage compensation for all illumination components
- two step dimming for all indicators

The intention of this document is to describe the three use cases and especially the countermeasures on poor legibility of displays that can be taken in case of daytime driving with lights on.

The architecture is scalable, so it can take into account reduced content as

without dimmer HMI
without ambient light level sensor.

However it is not recommended to reduce the proposed functional content, as this will compromise legibility of backlit ice blue displays and pushbuttons.
At some chapters are code samples. These samples are as a reference. The supplier is responsible, that the real implementation uses the right size of variables, to avoid overflow and mismatch with the sign bit if signed variables are used. Also the supplier is responsible that the real implementation meets the requested timing. The sample code was written with “Microsoft Visual C++ 2010” at a PC. It delivers the right data for reference purpose.

1.3 Abbreviations

ACM	Audio (Front) Control Module
AHU	Audio Head Unit (Connected HMI Radio)
ALS	Ambient Light Sensor
APIM	Accessory Protocol Interface Module (SYNC)
BCM	Body Control Module
DACMC	Digital Audio Control Module C
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
PWS	Passenger Window Switch
RCM	Restraints Control Module
SVC	Software Voltage Compensation
SYNC	see APIM
TCU	Telematics Control Unit
VQM	Voltage Quality Module (not available in B479, C519)

2 Cockpit Illumination Dimming System Operation

2.1 System Operation Overview

The main components of this system include the exterior light switch, dimmer switch, ambient light sensor, body control module and the illuminated components including but not limit to:

- instrument panel cluster
- multimedia system with integrated control panel and display
- heating ventilating and air conditioning module
- automatic transmission shifter
- family entertainment system
- clock
- door trim switches
- steering wheel switches
- IP switches
- overhead console and floor console components

The cockpit illumination contains a front end that is the input section to the system.
The input section has got an HMI (Human Machine Interface) to create the following signal triggers:

- exterior light switch position changing from Off to at least in the state of Position lamps (park lamps) ON or higher
- dimmer switch or soft HMI capable of controlling desired cockpit component backlighting intensity
- ambient light level known to the system to produce best legibility performance of the backlit cockpit components

Ice Blue™ need an ambient light level sensing. The reason for this is manifold:

- Ice Blue is a very light and non saturated colour
- The vehicle interior design very often uses very light and bright silver/grey surfaces that shall be backlit
- There are customer use cases of daytime driving with exterior lights on.
- There are wash out effects of the push button backlighting with the silver surfaces in the daytime light ON use case
- There are wash out effects, if the display brightness would not be adjusted dependant on the ambient light level

However, despite these facts tbd programs have chosen not to use an ambient light sensor or at least not to use it as standard installation for cost reasons, taking into account the compromises in legibility.

The input signals are created and distributed to the Dimming Master ECU. The dimming Master ECU in CGEA1.3 is the body control module.
The functional details are given in chapter Functional System Description.

The dimming master ECU houses an algorithm and lookup tables to distribute signals with the actual dimming level, actual ambient brightness level and day or night state via CAN to other main illumination units. Main illumination units are but not limited to:

- body control module
- instrument panel cluster
- multimedia module
- heating ventilating and air conditioning module

From these signals the main illumination units determine the brightness level for each illumination zone by interpolating the data from a calibrateable table. The illumination zones are backlights, pointers and/or telltales which have similar illumination behaviour. Zones with different illumination behaviour due to different physical light trace will have their own calibration data. The backlight of a rotary knob and a push button has is different dimensions and should have their own zones. Illumination of different colored symbols should have their own zones. Displays and other backlight need different zones. The same is valid for pointers and telltales.

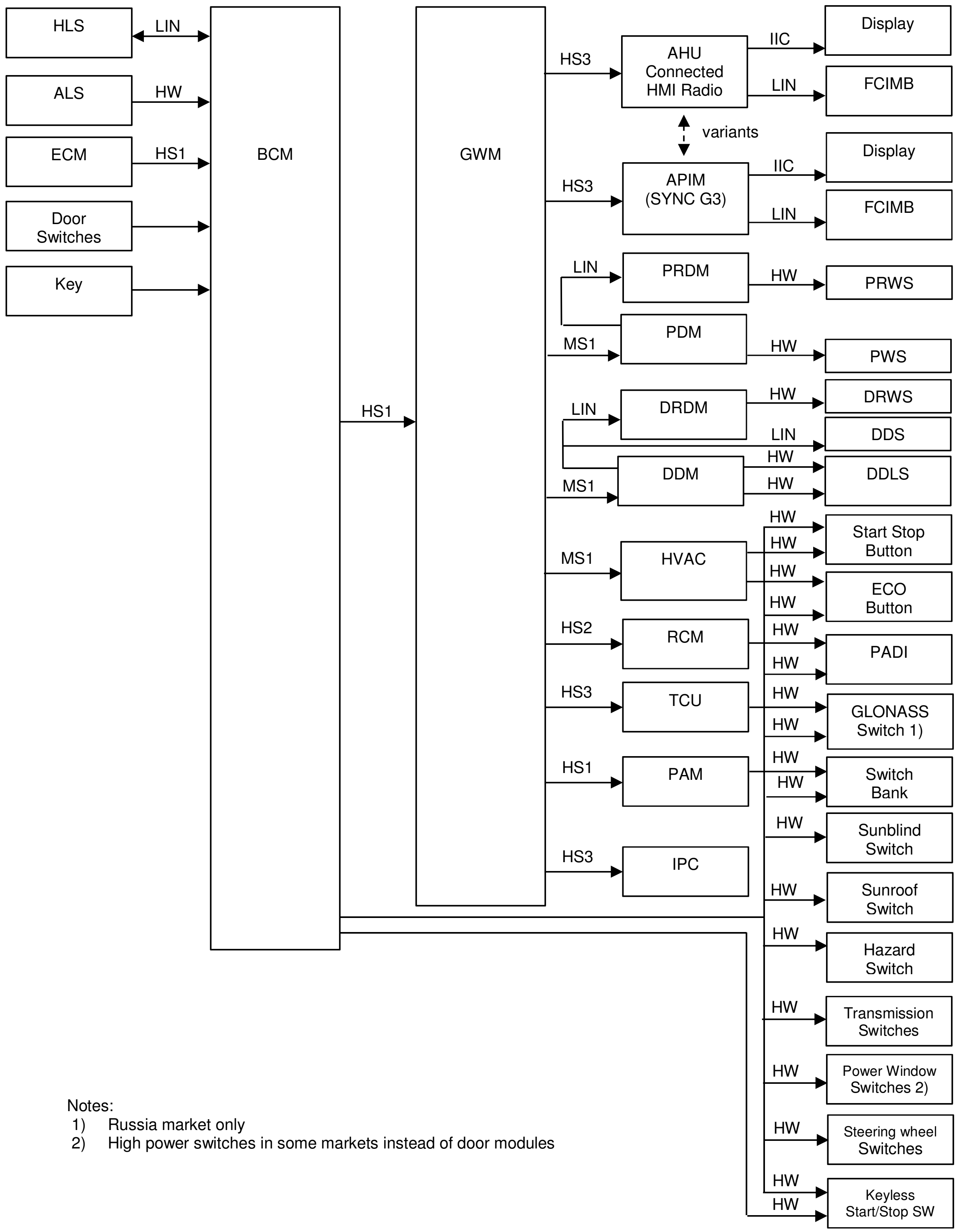
To calibrate the illumination by end of line programming, every zone should have an own PWM generator. Depending on the required dynamic of the brightness the resolution of the PWM generator is different for the zones.

If the illuminated component is not at the main board of the main illumination unit, the illumination signal will be transferred to other boards or components via LIN, IIC or hard wired. For standalone switches and push buttons typically the body control module is the main illumination unit.

The main illumination units will also have a welcome / farewell algorithm to generate the welcome and farewell scenario with the interior light.

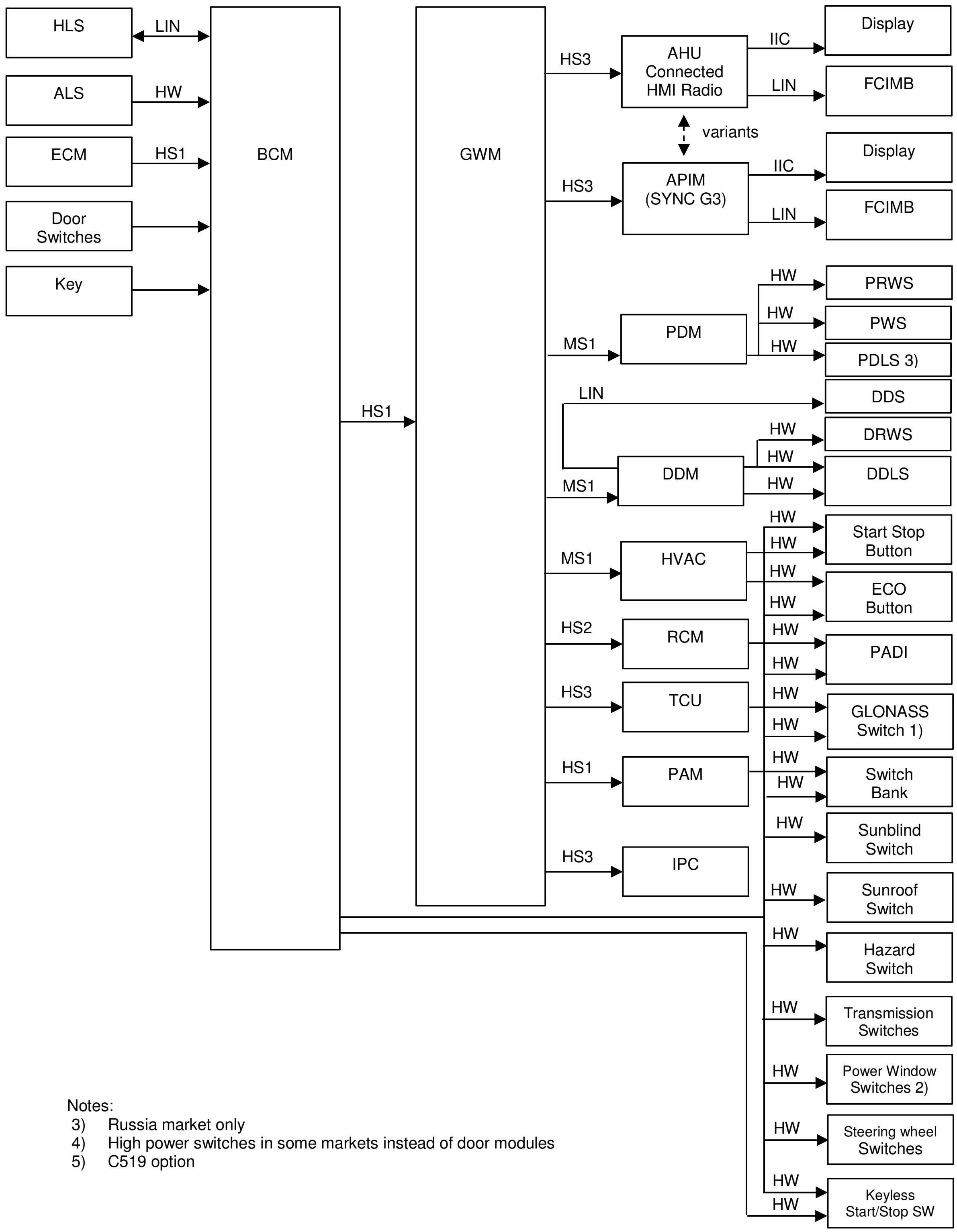
To avoid flickering caused by battery voltage variation, the illumination must have an illumination stabilizing feature.

2.2 Illumination Information Flow - System Layout B479



Notes:
1) Russia market only
2) High power switches in some markets instead of door modules

2.3 Illumination Information Flow - System Layout C519



Notes:
3) Russia market only
4) High power switches in some markets instead of door modules
5) C519 option

3 General Functions

3.1 Compensation Of Supply Voltage Variation

The new vehicles will not have any longer a voltage quality module (VQM). The components, which have an own controller and supplied via not stabilized voltage, must have compensation, that battery voltage variation had no visible flickering influence to illumination.

3.1.1 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.

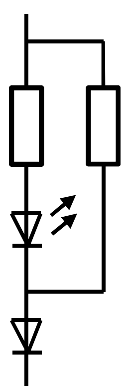
The compensation could be provided by hardware with stabilized supply voltage and/or stabilized current sources. In case a low stabilized supply voltage is used, the supplier should take care, that the part to part variation of the forward voltage of the LEDs causes not different brightness within the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

3.1.2 External Switches/Indicators Without Own Controller (Illumination Circuit)

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. See also chapter 3.7 for hardware requirements.



3.1.3 Definition Of Flickering

Flickering is defined, if the brightness level exceeds the specified values for “delta brightness level A” to “delta brightness level B”.

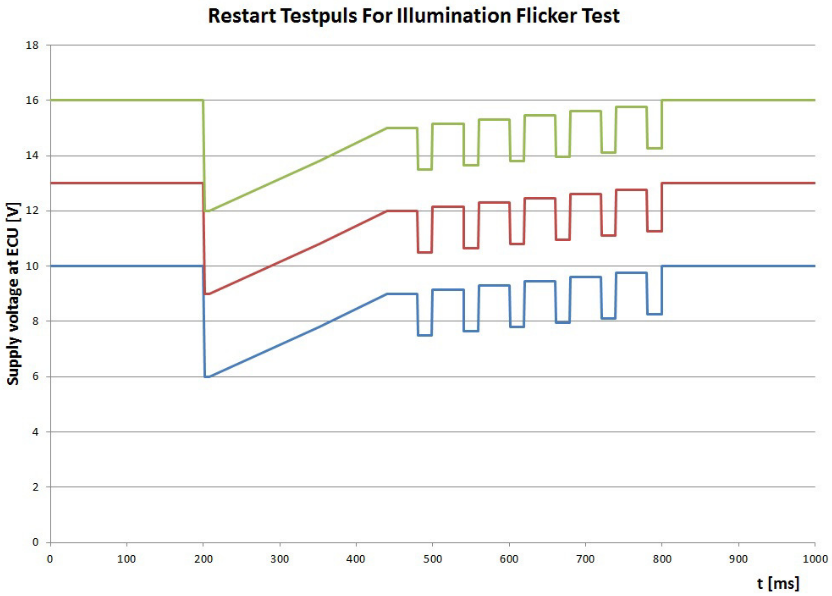
No	Requirement	Test Condition	Min	Max	Unit
1	Operating voltage		9	16	V
2	Restart Puls	Puls according FS-0000-00001-AB Revision 4, Figure 4.3.1-1 (minus 1V for voltage drop at wire harness)	6	16	V
3	delta brightness level A (high voltage jump) test for voltage/current sources only [1]	Single voltage jump - see “Restart Test Pulse” Testproc. steps -/+4V from 10V to 16V PWM ratio 2-100%		2	%
4	delta brightness level B (low voltage jump) Test for SVC output only [1]	Low voltage jump - see “Voltage Noise Test” Testproc. steps +/- 100mV from 9-16V PWM ratio 2-100%		2	%

Note: 1) The delta of brightness evaluation is done via current measurement of LED current.

Table 1

3.1.4 Restart Test Pulse

The restart test pulse for illumination flicker test has to be performed with a starting voltage of 10V, 13V and 16V. Each restart test pulse should be performed with 2%, 50% and 100% PWM.

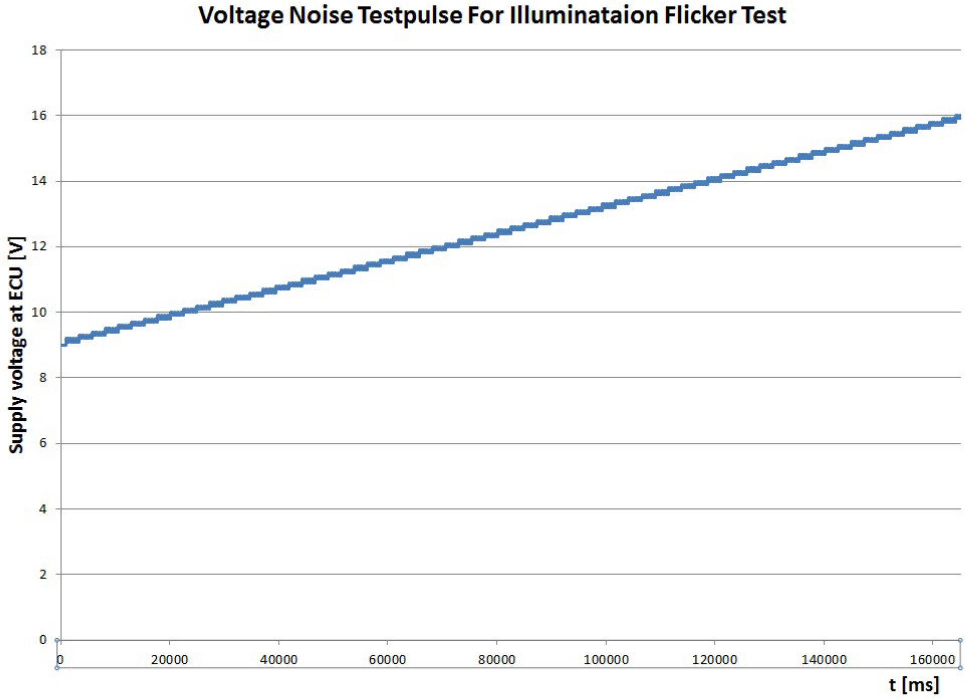


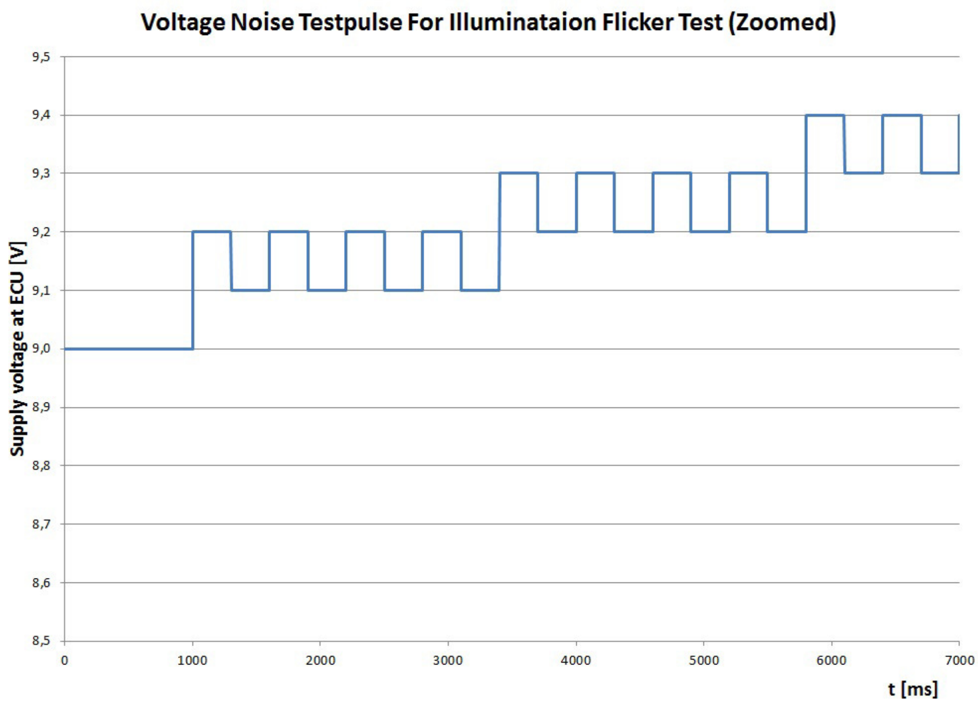
Data for testpuls:

t[ms]	U1 [V]	U2 [V]	U3 [V]
0	10,00	13,00	16,00
100	10,00	13,00	16,00
200	10,00	13,00	16,00
202	6,00	9,00	12,00
207	6,00	9,00	12,00
351	7,80	10,80	13,80
440	9,00	12,00	15,00
480	9,00	12,00	15,00
481	7,50	10,50	13,50
499	7,50	10,50	13,50
500	9,15	12,15	15,15
540	9,15	12,15	15,15
541	7,65	10,65	13,65
559	7,65	10,65	13,65
560	9,30	12,30	15,30
600	9,30	12,30	15,30
601	7,80	10,80	13,80
619	7,80	10,80	13,80
620	9,45	12,45	15,45
660	9,45	12,45	15,45
661	7,95	10,95	13,95
679	7,95	10,95	13,95
680	9,60	12,60	15,60
720	9,60	12,60	15,60
721	8,10	11,10	14,10
739	8,10	11,10	14,10
740	9,75	12,75	15,75
780	9,75	12,75	15,75
781	8,25	11,25	14,25
799	8,25	11,25	14,25
800	10,00	13,00	16,00
1000	10,00	13,00	16,00

3.1.5 Voltage Noise Test

The voltage noise test pulse for illumination flicker test has to be performed in the range of 9V to 16V. The voltage noise test pulse should be performed with 2%, 50% and 100% PWM.





Data for testpulse:

t[ms]	U1 [V]		t[ms]	U1 [V]
0	9,0		:	:
1000	9,0		160900	15,8
1001	9,2		160901	15,7
1300	9,2		161200	15,7
1301	9,1		161201	15,8
1600	9,1		161500	15,8
1601	9,2		161501	15,7
1900	9,2		161800	15,7
1901	9,1		161801	15,9
2200	9,1		162100	15,9
2201	9,2		162101	15,8
2500	9,2		162400	15,8
2501	9,1		162401	15,9
2800	9,1		162700	15,9
2801	9,2		162701	15,8
3100	9,2		163000	15,8
3101	9,1		163001	15,9
3400	9,1		163300	15,9
3401	9,3		163301	15,8
3700	9,3		163600	15,8
3701	9,2		163601	15,9
4000	9,2		163900	15,9
4001	9,3		163901	15,8
4300	9,3		164200	15,8
4301	9,2		164201	16,0
4600	9,2		164500	16,0
4601	9,3		164501	15,9
4900	9,3		164800	15,9
4901	9,2		164801	16,0
5200	9,2		165100	16,0
5201	9,3		165101	15,9
5500	9,3		165400	15,9
5501	9,2		165401	16,0
5800	9,2		165700	16,0
5801	9,4		165701	15,9
6100	9,4		166000	15,9
6101	9,3		166001	16,0
6400	9,3		166300	16,0
6401	9,4		166301	15,9
6700	9,4		166600	15,9
6701	9,3		166601	16,0
:	:		167600	16,0

3.2 Definition Of Calibrateable Transfertable

There are three basic types of illumination zones.

- Day time dimmable with high brightness level like displays and gauge pointers.
- Back light for search illumination
- Indicators or telltales

Day time dimmable zones need at least 10 bit resolution. Back light and indicators need at least 8 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 value. This is done with a 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.

All end of line programmable DIDs have to be in a calibration file and method 3 calibrateable. They have to be at least readable via supplier DIDs.

3.2.1 Interpolation Function

The interpolated value is between the low value and the high value. A weight factor determine 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
8 bit	0-255	0-255	0-1024	512	1024	0-255
10 bit	0-1023	0-1023	0-1024	512	1024	0-1023

Table 2

Sample code:

```
unsigned int TableInterpolation( unsigned int LowValue, unsigned int HighValue,
                                 unsigned int WeightFactor )
{
  return LowValue + (((HighValue - LowValue) * WeightFactor + 512) >> 10);
}
```

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

3.2.2 8 Bit PWM Backlight

3.2.2.1 Definition Of Weight Factors For 8 Bit PWM Backlight

The following 108 calibrateable parameters should be stored as DIDs. They should be end of line programmable. The final values will be evaluated during measurements and distributed to the supplier.

DID_WeightFactorBL:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Backlit_LED_Status	Night_1	0	65	135	222	376	800
	Night_2	27	92	162	248	400	808
	Night_3	53	119	189	275	424	817
	Night_4	81	146	216	302	449	825
	Night_5	110	175	245	330	475	834
	Night_6	141	206	276	360	503	844
	Night_7	175	241	310	394	534	854
	Night_8	217	283	353	436	572	868
	Night_9	274	340	410	492	623	885
	Night_10	358	424	493	574	698	911
	Night_11	491	558	627	705	818	953
	Night_12	720	787	856	930	1024	1024

Table 3

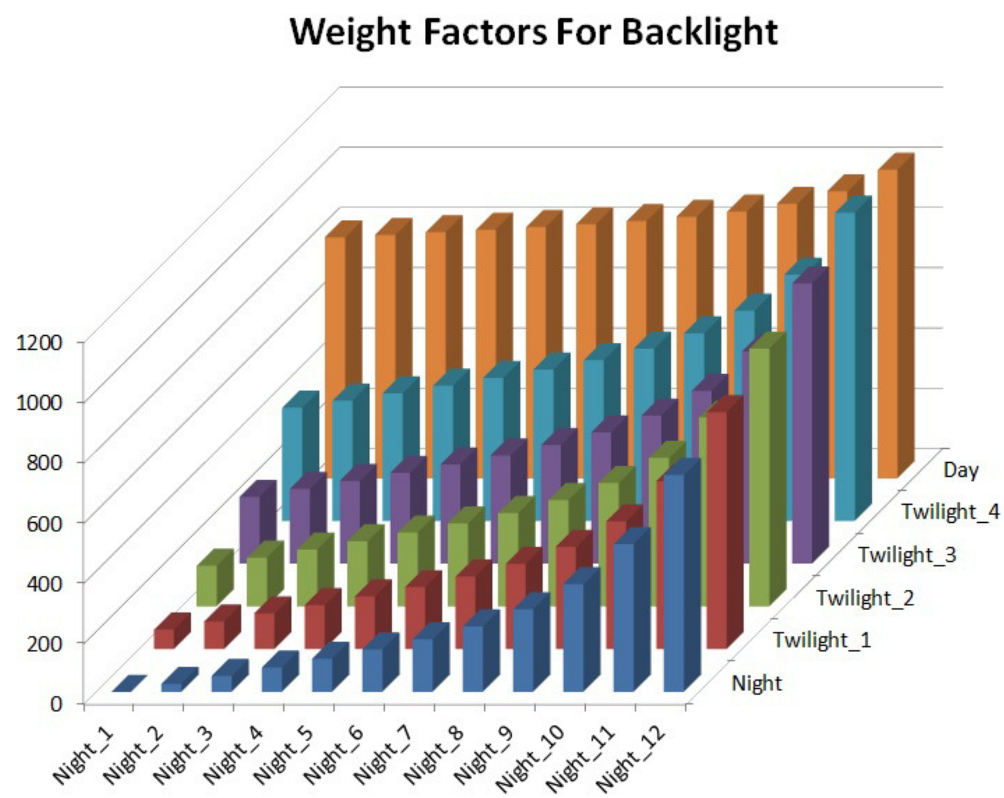


Figure 1

3.2.2.2 Brightness Calibration Of Backlight

The following 2 calibrateable parameters should be stored as end of line programmable DIDs. Each value should be stored in 1 byte. For every 8-bit backlight zone a separate parameter block must be stored:

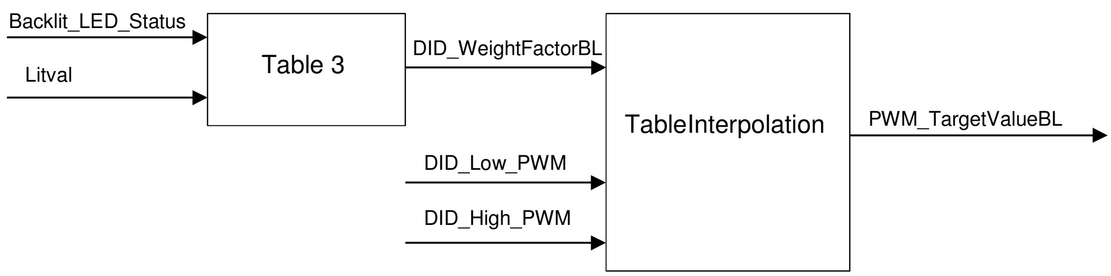
Identifier	**Value**	**Comment, Description**
DID_Low_PWM [1]	5	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night"
DID_High_PWM	255	PWM value for highest brightness e.g.: Dimming_Lvl "Night_12", Litval "Twilight_4"

Table 4

Note 1: If SVC is used for this zone, do not calibrate a value lower than 5. Otherwise the flickering requirement could not be reached.

3.2.2.3 Determine The PWM Value For 8 Bit PWM Backlight

For Backlit_LED_Status = Off the PWM value is zero. For all other Backlit_LED_Status the following calculation flow should be applied:



Sample code:

```
unsigned int DID_WeightFactorBL [13][6] = {
                       {    0,    0,    0,    0,    0,    0 },  // see note
                       {    0,   65,  135,  222,  376,  800 },
                       {   27,   92,  162,  248,  400,  808 },
                       {   53,  119,  189,  275,  424,  817 },
                       {   81,  146,  216,  302,  449,  825 },
                       {  110,  175,  245,  330,  475,  834 },
                       {  141,  206,  276,  360,  503,  844 },
                       {  175,  241,  310,  394,  534,  854 },
                       {  217,  283,  353,  436,  572,  868 },
                       {  274,  340,  410,  492,  623,  885 },
                       {  358,  424,  493,  574,  698,  911 },
                       {  491,  558,  627,  705,  818,  953 },
                       {  720,  787,  856,  930, 1024, 1024 } };


unsigned int PWM_TargetValueBL( unsigned char Backlit_LED_Status,
                                unsigned char Litval,
                                unsigned int DID_Low_PWM, unsigned int DID_High_PWM )
// determin PWM target value for one symbol backlight illumination zone
{
  if (Backlit_LED_Status == Off )
  {
    return 0;
  }
  else
  {
    return TableInterpolation( DID_Low_PWM, DID_High_PWM,
                               DID_WeightFactorBL[Backlit_LED_Status][Litval] );
  }
}
```

Note: This line was only filled to make the code more easy to read. Of course it is possible to eliminate this line from the array and adjust all index values accordingly.

3.2.3 10 Bit PWM Display Backlight

3.2.3.1 Definition Of Weight Factors For 10 Bit PWM (Display and Gauge Pointer)

The following 108 calibrateable parameters should be stored as DIDs. They should be end of line programmable. The final values will be evaluated during measurements and distributed to the supplier.

DID_WeightFactorDP:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	25	51	83	141	300
	Night_2	11	36	61	93	149	304
	Night_3	22	46	72	102	157	307
	Night_4	34	57	82	112	166	311
	Night_5	46	69	93	123	175	315
	Night_6	59	81	105	134	184	320
	Night_7	73	95	118	146	195	324
	Night_8	91	112	135	162	208	330
	Night_9	114	135	156	182	226	338
	Night_10	149	169	189	213	251	350
	Night_11	205	222	240	261	293	368
	Night_12	300	314	328	344	363	400
	Day_1	320	338	357	380	414	500
	Day_2	407	426	445	469	505	595
	Day_3	493	513	534	558	596	689
	Day_4	582	603	624	650	689	786
	Day_5	678	699	721	748	790	890
	Day_6	800	823	846	874	918	1024

Table 5

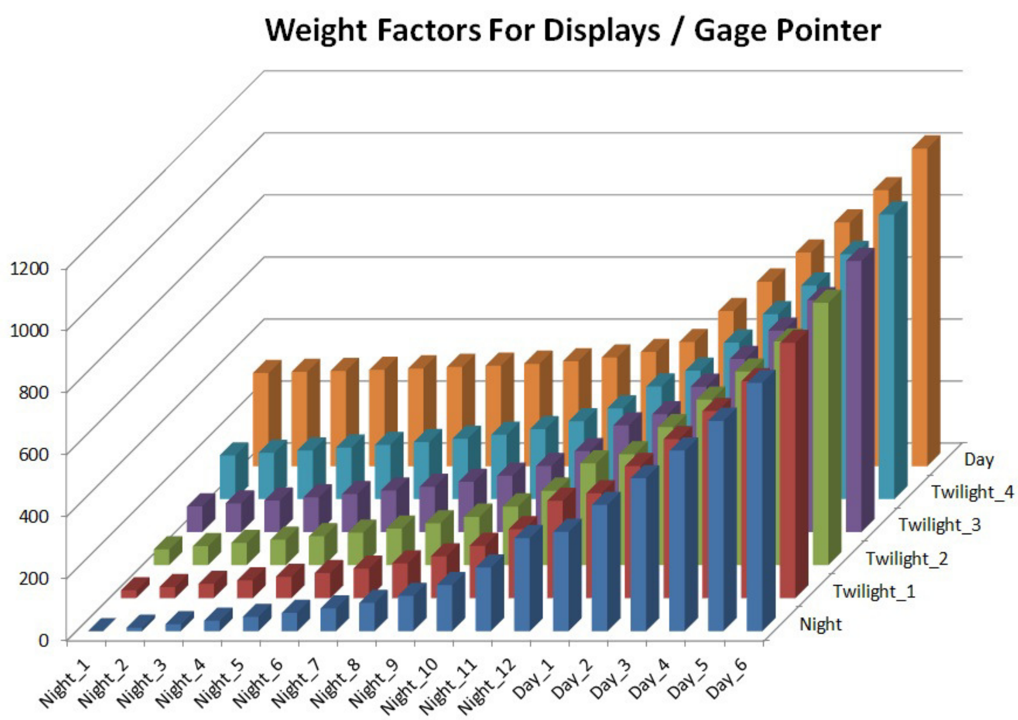


Figure 2

3.2.3.2 Brightness Calibration Of Display Backlight And Gauge Pointer

The following 2 calibrateable parameters should be stored as end of line programmable DIDs. Each value should be stored in 2 bytes. For every 10-bit backlight zone a separate parameter block must be stored:

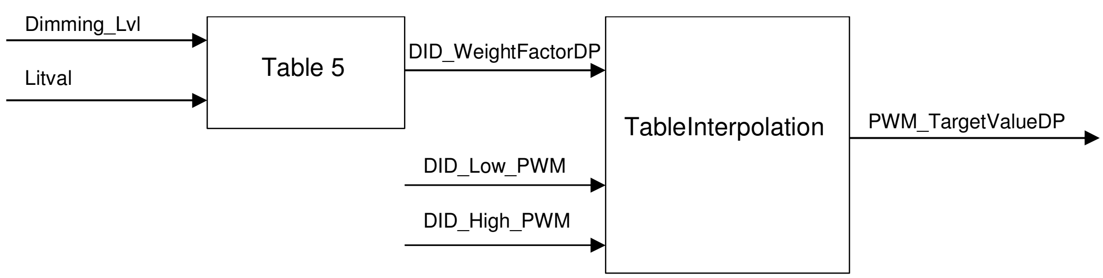
Identifier	Value	Comment, Description
DID_Low_PWM [1]	5	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night"
DID_High_PWM	1023	PWM value for highest brightness e.g.: Dimming_Lvl "Day_6", Litval "Day"

Table 6

Note 1: If SVC is used for this zone, do not calibrate a value lower than 5. Otherwise the flickering requirement could not be reached.

3.2.3.3 Determine the PWM Value for 10 Bit PWM Display Backlight And Pointer PWM

For Dimming_Lvl = Off the PWM value is zero. For all other Dimming_Lvl the following calculation flow should be applied:



Sample code:

```c
unsigned int DID_WeightFactorDP [19][6] = {
                       {    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 },
                       {  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 } };


unsigned int PWM_TargetValueDP( unsigned char Dimming_Lvl, unsigned char Litval,
                                unsigned int DID_Low_PWM, unsigned int DID_High_PWM )
// determin PWM target value for one display backlight or gauge pointer illumination
// zone
{
  if ( Dimming_Lvl == Off )
  {
    return 0;
  }
  else
  {
    return TableInterpolation( DID_Low_PWM, DID_High_PWM,
                               DID_WeightFactorDP[Dimming_Lvl][Litval] );
  }
}
```

Note: This line was only filled to make the code more easy to read. Of course it is possible to eliminate this line from the array and adjust all index values accordingly.

3.3 Smooth Transition While Changing The Dimming PWM Values

When the Dimming_Lvl, Backlit_LED_Status, BacklitLEDCmd or the Litval Signal change, a new PWM values is calculated. The change from one PWM value to another PWM value should be a smooth transition. The transition time DID_TransitionTimeMS and the tables DID_MoveUpTable and DID_MoveDownTable should be calibrateable DIDs. It is important, that the unused values at the end of DID_MoveUpTable and DID_MoveDownTable are filled with 255. During the transition at least every 30ms a new PWM value has to be calculated. The transition tables and DID_TransitionTimeMS should be end of line programmable.

To get the transition table independent of the sampling time, the sampling time could be in the range of (MaxSampleTimeMS/2) to (MaxSampleTimeMS). If the real sampling at the bus, the protocol speed is faster than (MaxSampelTimeMS/2), then the same value is repeated, to get a sampling time in the above range. E.g. if bus cycle time is 12ms, then each value is transmitted 2 times, and the calculation is done ever 24ms like the example below.

The following algorithm should be use to calculate the transition values:

```
const signed int    MaxSampleTimeMS      = 30;   // max possible sample time is 30ms
const signed int    MinSampleTimeMS      = MaxSampleTimeMS / 2;   // 15ms = 30ms div 2
const signed int    SampelTimeMS         = 24;   // real sample time
const signed int    DID_TransitionTimeMS = 1104; // calibrateable from 500 to 1500 ms
const signed int    MaxTransitionTimeMS  = 1500; // max. possible transition time
const unsigned char TransitionSampels    = DID_TransitionTimeMS / SampelTimeMS;
const unsigned char MaxTransitionSampels = MaxTransitionTimeMS / MinSampleTimeMS;

unsigned char DID_MoveUpTable [MaxTransitionSampels] =
                                  {    1,   2,   4,   5,   6,   8,   9,  11,  12,  14,
                                      16,  17,  19,  21,  23,  25,  27,  29,  32,  34,
                                      37,  40,  43,  47,  50,  55,  59,  64,  70,  76,
                                      83,  91, 100, 110, 121, 134, 149, 165, 183, 205,
                                     225, 237, 245, 250, 253, 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, 255, 255,
                                     255, 255, 255, 255, 255, 255, 255, 255, 255, 255
                                  };
unsigned char DID_MoveDownTable [MaxTransitionSampels] =
                                  {    1,  29,  54,  76,  95, 112, 127, 140, 152, 162,
                                     171, 179, 186, 192, 198, 203, 208, 212, 216, 219,
                                     222, 225, 227, 230, 232, 234, 236, 237, 239, 241,
                                     242, 243, 245, 246, 247, 248, 250, 251, 252, 253,
                                     254, 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, 255, 255, 255, 255, 255, 255,
                                     255, 255, 255, 255, 255, 255, 255, 255, 255, 255
                                  };
```

```c
signed int LastInValue = 0;
signed int LastOutValue = 0;
signed int LastBaseValue = 0;
unsigned char Index = 0;
signed int Delta;

unsigned int SmoothTransitionNextValue( unsigned char Table[], unsigned int NewValue )
{

  if (NewValue != LastInValue)
  {
    Index = 0;
        LastBaseValue = LastOutValue;
        LastInValue = NewValue;
        Delta = NewValue - LastOutValue;
  }

  if (Index < TransitionSampels)
  {
        LastOutValue = LastBaseValue + (( Delta * Table[Index] + 128 ) >> 8);
        Index++;
  }
  else
  {
    LastOutValue = NewValue;
  }
  return LastOutValue;
}



unsigned int SmoothTransitionNextValueUpDown( unsigned int NewValue )
{
  if (NewValue > LastOutValue )
  {
    return SmoothTransitionNextValue( MoveUpTable, NewValue );
  }
  else
  {
    return SmoothTransitionNextValue( MoveDownTable, NewValue );
  }
}
```

Remark:

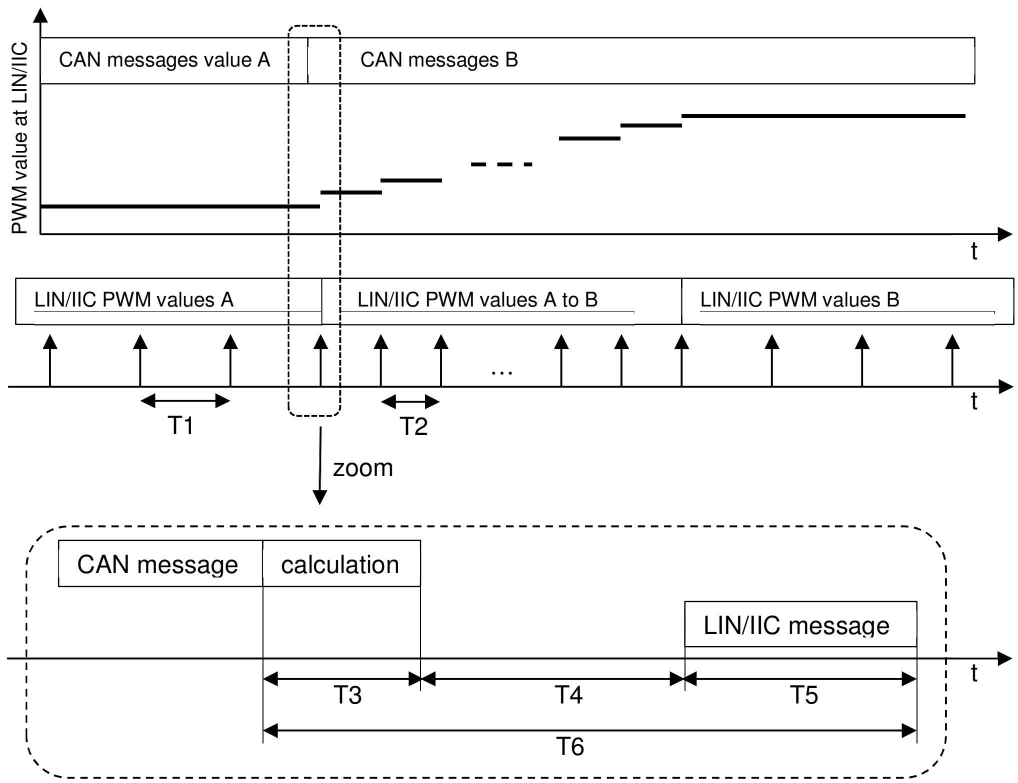
To get stepped behaviour like CGEA1.3 base architecture, the value DID_TransitionTimeMS has to be set 0.

DID_TransitionTimeMS = 0 => stepped transition to next target value
DID_TransitionTimeMS > 0 => smooth transition to next target value within specified milliseconds

3.3.1 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.



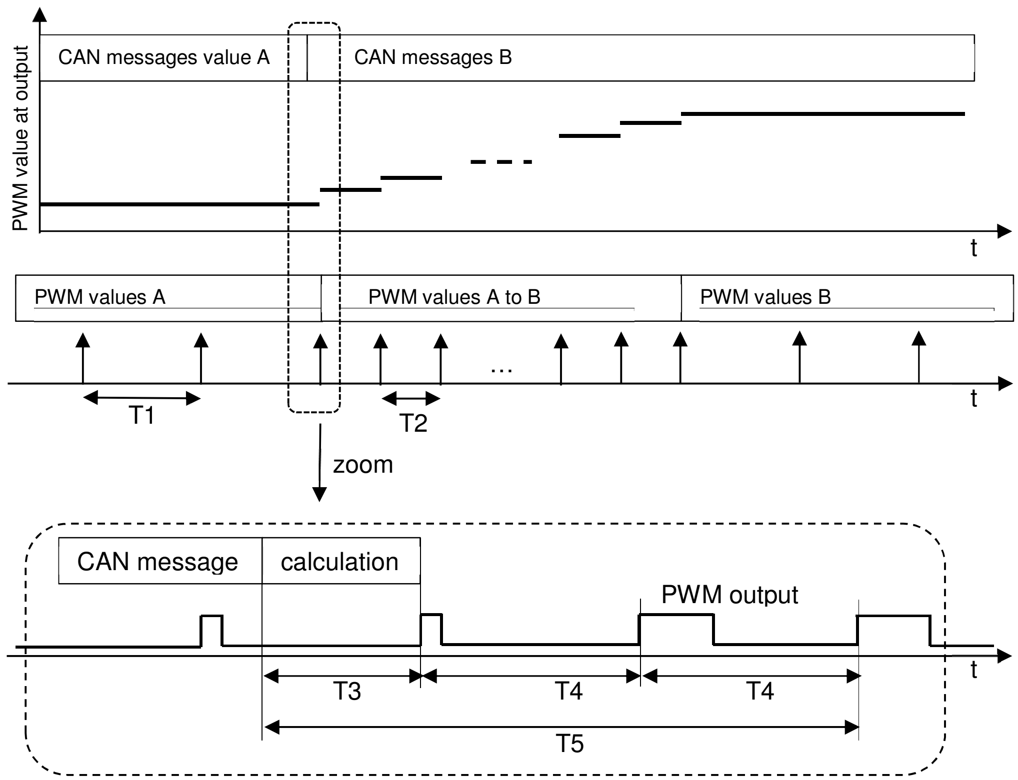
Item	Abbreviation	Description	Max	Unit
1	T1	LIN/IIC cycle time, while no change of PWM value	500	ms
2	T2	LIN/IIC cycle time, while PWM value change	30	ms
3	T3	Calculation time to get new PWM value	5	ms
4	T4	Max time to begin of next LIN/IIC frame	T2	ms
5	T5	Max time to complete a LIN/IIC frame	10	ms
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

3.3.2 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 deliver a new value according the interpolation table. If the target value change, the interpolation automatic restarts from the actual point. After this, if necessary, the value has to be LED bin adjusted and/or adjusted to the supply voltage.



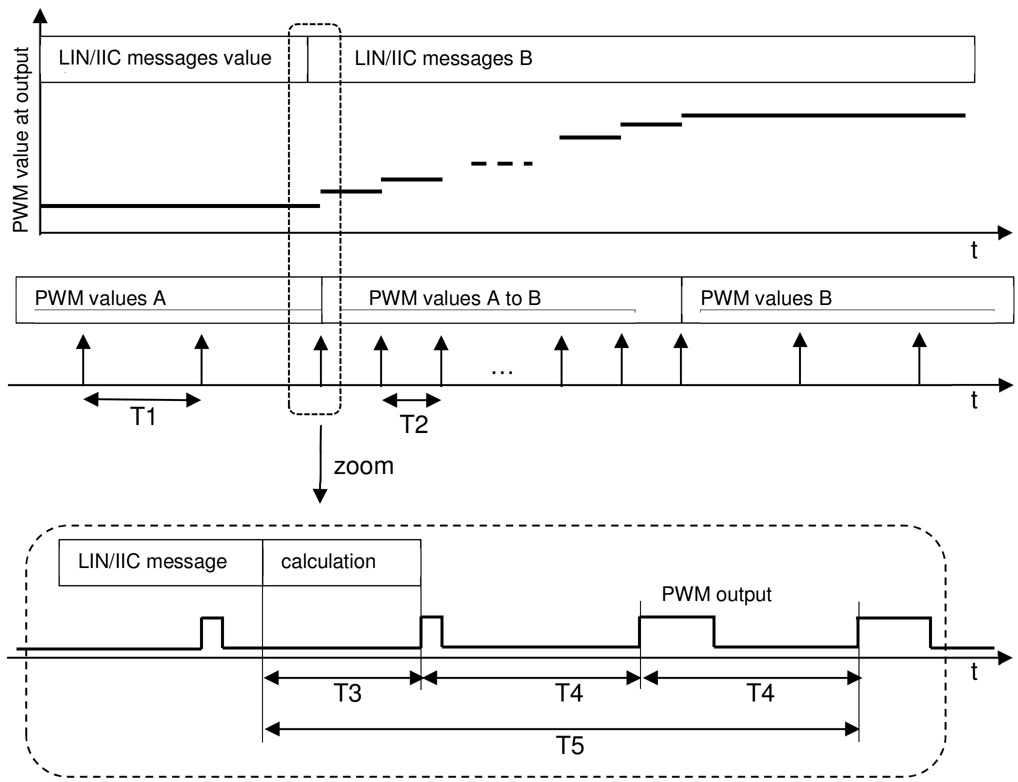
Item	Abbreviation	Description	Max	Unit
1	T1	PWM update time, while no change of PWM value	500	ms
2	T2	PWM update time, while PWM value change	30	ms
3	T3	Calculation time to get new PWM value	5	ms
4	T4	PWM cycle Time [2]	$1 / f_P$	ms
5	T5	Max reaction time from CAN to PWM output [1]	T3+2*T4	ms
6	PJ	PWM 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: f_P = PWM output frequency

3.3.3 Maximum Delay From LIN/IIC Message To PWM Output

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



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	30	ms
3	T3	Calculation time to get new PWM value	1	ms
4	T4	PWM cycle Time [2]	$1 / f_P$	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: f_P = PWM output frequency

3.4 Telltale and Indicator Two-step Dimming

Indicators must be able two have two step dimming. For indicators an 8-bit PWM generator should be available. To calibrate indicators, for each zone two one byte end of line calibrateable values should be available. Every external indicator / telltale, which is connected to via the wire harness is assumed to be a separate zone.

Identifier	Value	Comment, Description
DID_Night_PWM	127	PWM value for night time telltale brightness
DID_Day_PWM	255	PWM value for day time telltale brightness

3.4.1 Telltale and Indicator Day / Night Selection

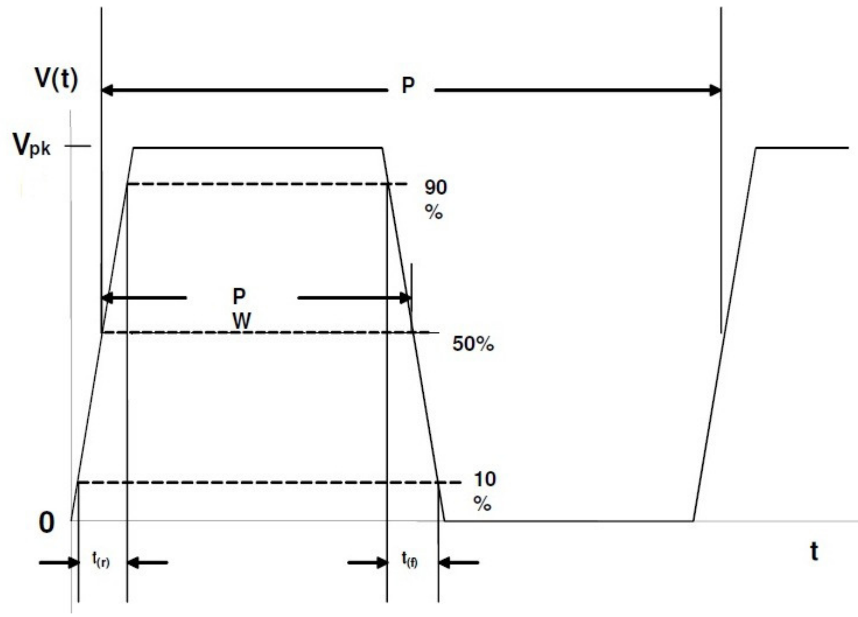
The signals for the Day/Night selection for indicator / telltale brightness should be selected based on the following signals.

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	Day	Don't care	Day
Off, Unknown, Invalid	Night	Don't care	Night
Off, Unknown, Invalid	Null, NotUsed	On	Night
Off, Unknown, Invalid	Null, NotUsed	Off, Unknown, Invalid	Day

Note: When the module powers up and had not received the signals at least one time, Night should be used as default. This is to avoid bright flickering during a re-crank if a reset happens.

3.5 PWM Signals

Definition of PWM values:



3.5.1 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	300	Hz
2	PWM output frequency 1/P [4]	Configurable in the ECU	200	220	300	Hz
3	Frequency jitter				0.1	Δ %
4	PWM rise t(r) / fall time t(f)		8		50	µs
5	PWM output duty cycle Pw/P		0		100	%
6	PWM output duty cycle jitter				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.

3.5.2 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 increasing function.
(PWM duty cycle >0 and PWM duty cycle < 3%) shall either follow the monotonically increasing function or stay OFF.
(PWM duty cycle >99 and PWM duty cycle < 100%) shall either follow the monotonically increasing 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.

3.5.3 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	400	Hz
2	Frequency jitter				0.1	Δ %
3	PWM output duty cycle jitter				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.

3.5.4 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	300	400	Hz
2	Frequency jitter				0.02	Δ %
3	PWM output duty cycle jitter				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.

3.6 Appearance of cockpit components

3.6.1 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 have to 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.

3.6.2 Daytime / Nighttime appearance of cockpit components

The daytime / nighttime appearance of cockpit components is defined within:

- ES-DS7T-1A278-AD (basic dimming strategy)
- ES-DS7T-1A278-BE (brightness and color, welcome / farewell)
- ES-DS7T-1A278-CB (welcome / farewell)
- Interior Harmony SDS from 3rd of March 2015 or newer (overall targets)

Each supplier shall note that the Ice Blue^{TM} is a non saturated illumination colour. Hence every material that interacts with the light of the LED source, will cause a resulting colour shift to the human eye.
The magnitude of the colour shift is influenced by but not necessarily limited to the following:

- Base material selection (transparent, 'milky' white, smoked, powder ingredient; type of plastics)
- Wall thickness (the thicker, the more shift)
- Viewing angle (especially in combination with LCDs)
- Smoke level of transparent materials (the more smoke level, the more shift)
- Backlighting concept (light box vs. Light duct / Light guide)
- Operating point of the LEDs (colour shift caused by current / thermal dependencies)

The supplier shall tune the colour shift imposed by any of the above as good as possible to achieve best matching of all LED colour bins to the Ford Ice Blue^{TM} colour coordinate tolerance box (wright box).

$x_{\text{LED bin centre}} + \Delta x_{\text{material}} = x_{\text{target}} = 0{,}1870$
$y_{\text{LED bin centre}} + \Delta y_{\text{material}} = y_{\text{target}} = 0{,}2750$

The tolerance box and its centre/target are defined in Interior Harmony SDS requirement IH-0004 and its associated details.
The Illumination Harmony Engineering signoff is subject of Jury Appraisals and optical performance testing.

B479 and C519 will have daytime illumination for the instrument cluster and all components with displays. All switch backlighting can be calibrated to be ON during day time, too.

3.6.3 LED specific requirements

The colour target shall be tested at 25°C ambient temperature.
Suppliers are requested to operate their LEDs as close as possible at the binning current to minimize resulting colour shift.
Precautions shall be taken in the printed circuit board layout of the LED to minimize the junction temperature rise by sufficient copper pad cooling.
Only LEDs shall be considered for colour coordinate appraisals that fall inside the total theoretical LED binning range definition.
LEDs that actually fall outside the total range due to LED manufacturers binning measurements afflicted with tolerances shall not be considered.

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.

Currently Osram LED data sheets have foot notes that call for the following test tolerances:

1a. Brightness groups are tested at current pulse durations of 25 ms and a tolerance of ± 11%.
2a. Chromaticity coordinate groups are tested at current pulse durations of 25 ms and a tolerance of ±0.01.

For the Ford Ice Blue LEDs, Ford aims to have Osram sign off to the Ford LED drawings that shall contain tighter wordings of the above:

1b. Brightness groups are tested at current pulse durations of 25 ms and a tolerance of ± 5%.
2b. Chromaticity coordinate groups are tested at current pulse durations of 25 ms and a tolerance of ±0.002.

According the Ford Drawing ES-8L8T-13D775-AC (Ford Ice Blue LED spec) and the Osram LED data sheets the maximum reverse voltage rating of the LED is only 5V instead of the 12V that LEDs out of alternative technologies do have.
All electronic control units (ECU) that use the new LEDs shall have its own precautions for sufficient 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.

Approved suppliers for Ice Blue general backlighting of new designed components are Osram and Nichia only.

3.7 Hardware for Indicator and Backlight

3.7.1 Indicators

For indicators, a resistor parallel to the LED is necessary. The resistance value must be defined in conjunction with D&R engineer of the driving module.

The purpose of this parallel resistor is:

- To ensure, that no leakage current drive enough current through the LED to illuminate it during off state.
- To ensure, that the diagnostic current for open line detection will not illuminate the LED.

3.7.2 Backlight

For backlight, a resistor parallel to all backlight LED must be design protected. The responsible D&R engineer will decide together with the D&R engineer of the driving module, whether this resistor must be populated.

The purpose of this parallel resistor is:

- To ensure, that no leakage current drive enough current through the LEDs to illuminate the LEDs during off state.
- To ensure, that the diagnostic current for open line detection will not illuminate the LEDs.

Typically more than one component backlight are driven with one control module output. At all components for one output only one component need the backlight parallel resistor.

3.8 CAN Signals

This chapter describe all illumination relevant CAN signals.

3.8.1 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

3.8.2 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

3.8.3 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

3.8.4 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

3.8.5 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

3.8.6 Key_In_Ignition_Stat

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		Key_In_Ignition_Stat
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Out In
Description / Remarks		Key in / out state

3.8.7 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

3.8.8 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

3.8.9 DrStatDrv_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatDrv_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Door state driver

3.8.10 DrStatPsngr_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatPsngr_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Door state passenger

3.8.11 DrStatRr_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatRr_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Door state rear right

3.8.12 DrStatRl_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatRl_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Door state rear left

3.8.13 DrStatTgate_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatTgate_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Indicates trunk AJAR if the vehicle has a trunk. Otherwise the signal is always CLOSED

3.8.14 DrStatInnrTgate_B_Actl

Item	Code	Name / Description
HS1 Message		BodyInfo_3
HS2 Message		BodyInfo_3_HS2
HS3 Message		BodyInfo_HS3
MS1 Message		BodyInfo_3_MS1
Signal Name		DrStatInnrTgate_B_Actl
Send Type	OnChange	500ms
Length (bit)	1	
Coding	0x0 0x1	Closed Ajar
Description / Remarks		Indicates tailgate AJAR if the vehicle has a tailgate. Otherwise the signal is always CLOSED

3.8.15 Veh_Lock_Status

Item	Code	Name / Description
HS1 Message		Locking_Systems_2
HS2 Message		BodyEngGateway_2_HS2
HS3 Message		
MS1 Message		Locking_Systems_2_MS1
Signal Name		Veh_Lock_Status
Send Type	Event Periodic	
Length (bit)	2	
Coding	0x0 0x1 0x2 0x3	LOCK_DBL (Double Lock all vehicle doors, disable the interior and exterior door lock handles) LOCK_ALL (lock all doors disable the exterior door lock handles only) UNLOCK_ALL (unlock all doors) UNLOCK_DRV (unlock the driver's door)
Description / Remarks		

3.8.16 Veh_Lock_Status_UB

Item	Code	Name / Description
HS1 Message		Locking_Systems_2 (signal not in CAN DB)
HS2 Message		BodyEngGateway_2_HS2
HS3 Message		
MS1 Message		Locking_Systems_2_MS1 (signal not in CAN DB)
Signal Name		Veh_Lock_Status_UB
Send Type	Event Periodic	
Length (bit)	1	
Coding	0x0 0x1	Unchanged_data Fresh_data
Description / Remarks		

3.8.17 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)

3.8.18 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)

3.8.19 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

3.9 Preprocessing Of CAN Signals

Some signals could have error states. To avoid uncontrolled conditions, these signals should be handled as described in this chapter.

3.9.1 Preprocessing Of CAN Signal Dimming_Lvl

If (CAN.Dimming_Lvl signal is missing) or (CAN.Dimming_Lvl > Day_6)
then hold the last value which was lower or equal Day_6.

If this error state occur longer than 5 seconds
then
if (Ignition_Status >= Run)
Dimming_Lvl = Night_12
Else
Dimming_Lvl = Off

Note: Due to an issue with the CAN.Dimming_Lvl, the following filtering should be implemented. In some conditions the CAN.Dimming_Lvl have a short period with drops to 0x00 (Off). To avoid flickering these drops must be removed with the following filter:

If (CAN.Dimming_Lvl == Off)
then hold the last value which was greater than Off

If (CAN.Dimming_Lvl == Off) for longer than DID_Dimming_Lvl_Timer
then
Dimming_Lvl = Off

3.9.2 Preprocessing Of CAN Signal Parklamp_Status

If (CAN.Parklamp_Status signal is missing) or (CAN.Parklamp_Status > On)
then hold the last value which was lower or equal On.

If this error state occur longer than 5 seconds
then
if (Ignition_Status >= Run)
Parklamp_Status = On
Else
Parklamp_Status = Off

3.9.3 Preprocessing Of CAN Signal Litval

If (CAN.Litval signal is missing) or (CAN.Litval > Day)
then hold the last value which was lower or equal Day.

If this error state occur longer than 5 seconds
then Litval = Twilight_4

3.9.4 Preprocessing Of CAN Signal Ignition_Status

If (CAN.Ignition_Status signal is missing) or (CAN.Ignition_Status > Start)
then hold the last value which was lower or equal Start.

If this error state occur longer than 5 seconds
then Ignition_Status = Run
If this error state occur longer than 10 minutes
then Ignition_Status = Off

3.9.5 Preprocessing Of CAN Signal Courtesy_Delay_Status

If (CAN.Courtesy_Delay_Status signal is missing) or (CAN.Courtesy_Delay_Status > On)
then hold the last value which was lower or equal On.

If this error state occur longer than 5 seconds
then Courtesy_Delay_Status = Off

3.9.6 Preprocessing Of CAN Signal Dr_Courtesy_Light_Stat

If (CAN.Dr_Courtesy_Light_Stat signal is missing) or (CAN.Dr_Courtesy_Light_Stat > On)
then hold the last value which was lower or equal On.

If this error state occur longer than 5 seconds
then Dr_Courtesy_Light_Stat = Off

3.9.7 Preprocessing Of CAN Signal Illuminated_Entry_Stat

If (CAN.Illuminated_Entry_Stat signal is missing) or (CAN.Illuminated_Entry_Stat > On)
then hold the last value which was lower or equal On.

If this error state occur longer than 5 seconds
then Illuminated_Entry_Stat = Off

3.9.8 Preprocessing Of CAN Signals With Update Bits (…_UB)

If a signal has an additional signal with the ending _UB, than the value of the signal should only be updated, if the corresponding update bit signal indicates “Fresh Data”. Otherwise use the last valid value.

3.10 Timer DIDs

The following DIDs should be non end of line programmable DIDs for calibration of the timing.

Identifier	Value	Comment, Description	Min	Max	Res.	Unit
DID_Dimming_Lvl_Timer	1100	PWM value for lowest brightness Display backlight Use it with DID_WeightFactorDP	0	2550	10	ms
DID_Stage_2_Timer	25	PWM value for highest brightness Display backlight Use it with DID_WeightFactorDP	0	255	1	s
DID_Stage_3_Delay_Timer	800	PWM value for lowest brightness Display button backlight Use it with DID_WeightFactorBL	0	2550	10	ms
DID_Stage_4_Timer	25	PWM value for highest brightness Display button backlight Use it with DID_WeightFactorBL	0	255	1	s
DID_BatterySave_Timer	10	PWM value for highest brightness Display button backlight Use it with DID_WeightFactorBL	0	255	1	min

3.11 Signal Processing

The signal processing is done with the following steps:

- Preprocessing of signals
    - Handle error states of the signals

- Calculating WelcomeFarewellControl from:
    - Ignition_Status
    - Key_In_Ignition_Stat
    - Delay_Accy
    - DrStatDrv_B_Actl
    - DrStatPsngr_B_Actl
    - DrStatRr_B_Actl
    - DrStatRl_B_Actl
    - DrStatInnrTgate_B_Actl
    - Veh_Lock_Status
    - Multimedia_System

- Calculating ActualDimmingLvl and ActualDimmingLvlBL the PWM brightness value from:
    - WelcomeFarewellState
    - Litval
    - Dimming_Lvl
    - Backlit_LED_Status

- Calculation TellTaleDimmingLvl
    - Parklamp_Status
    - Day_Night_Status
    - Dimming_Lvl
    - Litval

3.12 Welcome / Farewell Strategy

The generic welcome / farewell strategy for CGEA1.3 illumination is specified in following documents:

- ES-DS7T-1A278-BE (brightness and color, welcome / farewell)
- ES-DS7T-1A278-CB (welcome / farewell)
- Interior Harmony SDS from 3rd of March 2015 or newer (overall targets)

The following section describes in more detail, how to process the different CAN signals to handle the welcome and farewell strategy.

3.13 Behavior After Reset

To avoid a bright flickering, in case the voltage drops below the definded recrank voltage puls and the module perform a reset, the module should set all backlight and indicators to OFF state (dark) after reset. After the right signals are received via CAN, LIN or ICC bus, the module should immediately switch to the right brightness level.

If not otherwise specified, the following should be used in case for longer signal missing:
If the CAN, LIN or IIC bus signal is missing longer than InvalidTimeout, the following conditions should be assumed:

- Backlit_LED_Status = Night_12
- Dimming_Lvl = Day_6
- Day_Night_Status = Null
- Parklamp_Status = Off
- IndicationBrightness = Day

If not otherwise specified InvalidTimeout = 5 seconds.

4 Ambient Light Sensing

The ambient light sensor should measure the Lux value from ambient light. The following features should be supported:

4.1 Light Sensing Range

The ambient light sensor should measure the Lux value in a range from 0..2000 Lux. The A/D converter must have a resolution of at least 10bit.

4.2 Wind Screen Adjustment

To adjust different windscreens, the sensor should have have a method 2 configuration DID. This should be one byte with the range of 16/64 to 255/64. The measured value should be multiplied with this factor to adjust different transmission values of the windscreen.

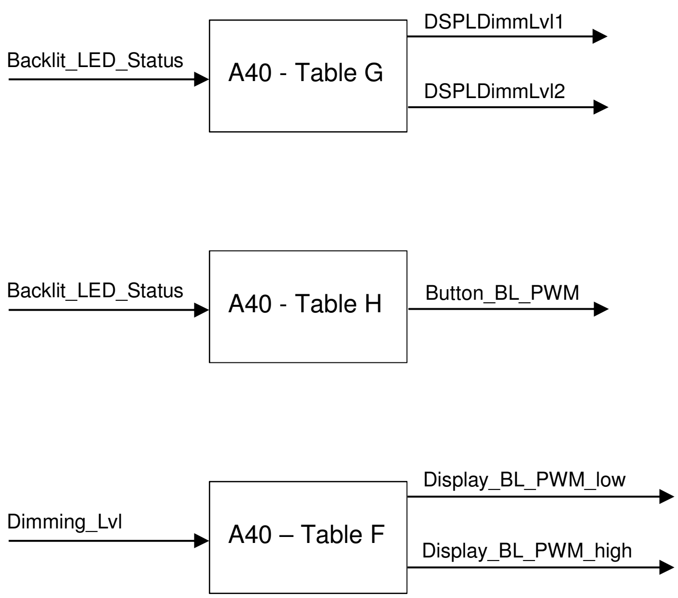
5 APIM / AHU

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

5.1 End Of Line Programmable DIDs (SYNC)

For B479 only following chapters are applicable:
Chapter 1 to chapter 3.1.1
Chapter 3.3.1 to chapter 3.3.3
Chapter 3.5.2 to chapter 3.5.4 (for info)
Chapter 3.6 to chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** (for info)
Chapter 3.7.1 to chapter 3.8.19 (for reference all CAN signals – not all used by SYNC)
Chapter 3.9 to chapter 3.9.8
Chapter 3.12 to 3.13
Chapter 4 to 5.2.4
Chapter 5.4 to 5.4.2

5.2 Signal overview in B479 environment (SYNC)



5.2.1 End Of Line Programmable DIDs (SYNC-VMCU)

See “A40_Display_Illumination_Behavior_Table_RELEASED_vxx.xlsx”.

5.2.2 End Of Line Programmable Table DIDs (SYNC-VMCU)

See “A40_Display_Illumination_Behavior_Table_RELEASED_vxx.xlsx”.

5.2.3 End Of Line Programmable DIDs (SYNC-CCP)

See “A40_Display_Illumination_Behavior_Table_RELEASED_vxx.xlsx”.

5.2.4 End Of Line Programmable Table DIDs (SYNC-CCP)

See “A40_Display_Illumination_Behavior_Table_RELEASED_vxx.xlsx”.

5.3 End Of Line Programmable DIDs (radio)

5.3.1 End Of Line Programmable DIDs (radio)

The APIM / AHU should have the following end of line programmable DIDs for the 4 dimming zones:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_DisplayBL	5	2	PWM value for lowest brightness Display backlight Use it with DID_WeightFactorDP
DID_High_PWM_DisplayBL	1023	2	PWM value for highest brightness Display backlight Use it with DID_WeightFactorDP
DID_Low_PWM_DisplayButtonBL	5	1	PWM value for lowest brightness Display button backlight Use it with DID_WeightFactorBL
DID_High_PWM_DisplayButtonBL	255	1	PWM value for highest brightness Display button backlight Use it with DID_WeightFactorBL
DID_Low_PWM_RotoryBL	5	1	PWM value for lowest brightness Rotory backlight Use it with DID_WeightFactorBL
DID_High_PWM_RotoryBL	255	1	PWM value for highest brightness Rotory backlight Use it with DID_WeightFactorBL
DID_Low_PWM_ButtonBL	5	1	PWM value for lowest brightness Button backlight Use it with DID_WeightFactorBL
DID_High_PWM_ButtonBL	255	1	PWM value for highest brightness Button backlight Use it with DID_WeightFactorBL
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

5.3.2 End Of Line Programmable Table DIDs (radio)

The APIM / AHU should have the following 4 DIDs which are end of line programmable tables:

Identifier	Value	Bytes	Comment, Description
DID_WeightFactorDP		108*2	Default values see “Definition Of Weight Factors For 10 Bit PWM (Display and Gauge Pointer)”
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

The DIDs are used to generate the following signals:

- DID_WeightFactorDP, DID_Low_PWM_DisplayBL, DID_High_PWM_DisplayBL
  ==> Display_BL_PWM_low, Display_BL_PWM_high
- DID_WeightFactorBL, DID_Low_PWM_DisplayButtonBL, DID_High_PWM_DisplayButtonBL
  ==> Button_BL_PWM
- DID_WeightFactorBL, DID_Low_PWM_RotoryBL, DID_High_PWM_RotoryBL
  ==> DSPLDimmLvl2
- DID_WeightFactorBL, DID_Low_PWM_ButtonBL, DID_High_PWM_ButtonBL
  ==> DSPLDimmLvl1

5.4 LIN communication (APIM / Radio) – FCIMB

The protocol must be able to send the illumination message every 30ms 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.

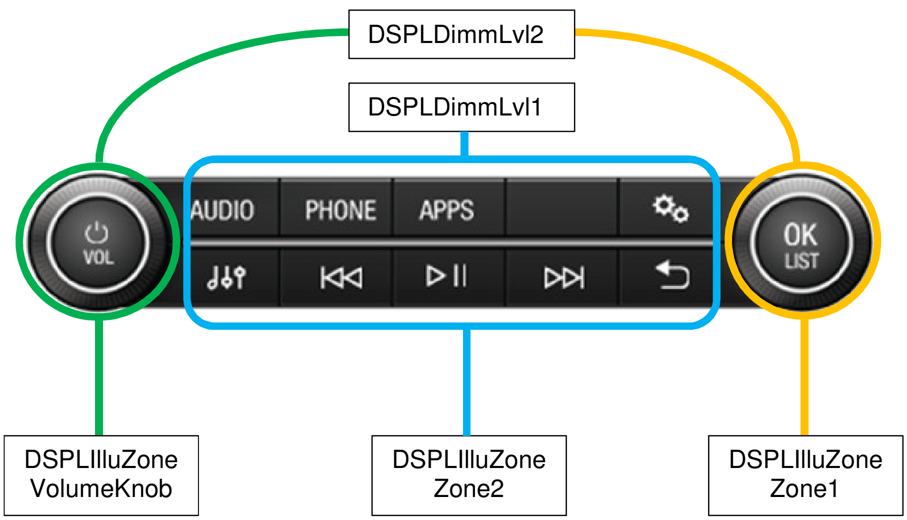
The PWM generators should use the complete range and resolution of 256 steps with 0x00 = off and 0xFF = 100% on.

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 5.4.2 Behaviour after Reset And Invalid Bit Handling

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



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. Timing is defined by “ES-DS7T-1A278-BE” table 6. See also the related foot notes.
The controlling device should set the “Invalid” bit, when LIN message have to be send and brightness information is still not available via CAN (e.g. during power up situations).

5.4.1 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 for the two knobs and the other for the buttons. There is also a 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 .. 4 are zone bits to turn on and off the zones independent of the PWM value:
	BIT{0}	VolumeKnob: 0: – backlight off 1: – backlight on
	BIT{1}	HazardWarning_DoorLock: (not used) 0: – backlight off 1: – backlight on
	BIT{2}	CD_Slot: (not used) 0: – backlight off 1: – backlight on
	BIT{3}	Zone2: (buttons) 0: – backlight off 1: – backlight on
	BIT{4}	Zone1: (OK knob) 0: – backlight off 1: – backlight on
	BIT{5:6}	Reserved
	BIT{7}	Invalid: 0: – valid PWM value ⇨ See chapter 5.4.2 1: – invalid PWM value ⇨ See chapter 5.4.2
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.

Bit 0 until bit 4 of signal DSPLIlluZone is set to 1 permanently to adhere to the current CGEA 1.3 implementation. This means that all the FCIMB zones are always dimmable via signal DSPLDimmLvl1 or DSPLDimmLvl2 including the OFF state. The zone control may be changed in the future. Therefore the individual zone control function shall be implemented.

5.4.2 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 change.
- Default_BL_PWM is 0xFF (for 8 bit values)
- The InvalidTimeout value is 5 sec.

5.5 IIC communication APIM – Display

The protocol must be able to send both backlight messages every 30ms 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.

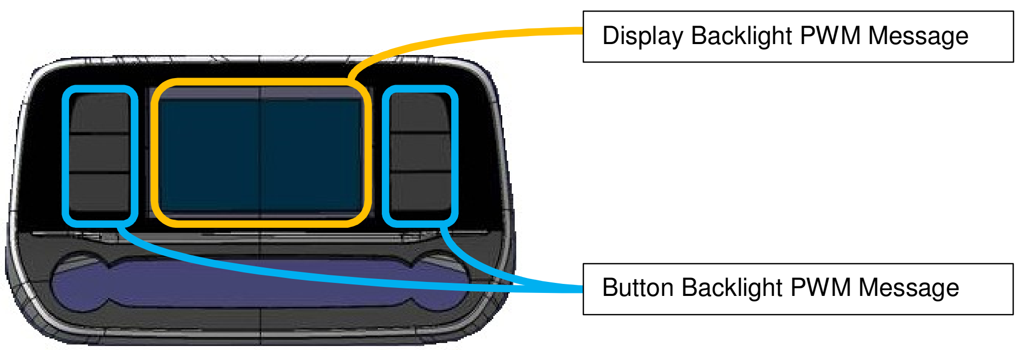
During updating the PWM generator no unexpected PWM ratios are allowed. The ratio of the PWM output signal is not allowed to exceed the range from the actual PWM ratio and the target PWM ratio.

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.

The backlight messages are used for the following zones:



The controlling device should to turn on and off the button backlight with the timing is defined by “ES-DS7T-1A278-BE” table 6. See also the related foot notes.

The controlling device should to turn on and off the display with the timing is defined by “ES-DS7T-1A278-BE” table 11. See also the related foot notes.

5.5.1 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 a “I2C over LVDS Communication Protocol” spec. with the data description. The signal name for Display Button Backlight is **Button_BL_PWM**.

5.5.2 Display Backlight PWM

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 a “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.

6 FCIMB

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

See chapter 3 and 5.4.

7 IPC

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

7.1 End Of Line Programmable DIDs

The IPC should have the following end of line programmable DIDs for the various dimming zones:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_DisplayBL	5	2	PWM value for lowest brightness Display backlight Use it with DID_WeightFactorDP
DID_High_PWM_DisplayBL	1023	2	PWM value for highest brightness Display backlight Use it with DID_WeightFactorDP
DID_Low_PWM_GaugePointer	5	2	PWM value for lowest brightness Gauge pointer Use it with DID_WeightFactorDP
DID_High_PWM_GaugePointer	1023	2	PWM value for highest brightness Gauge pointer Use it with DID_WeightFactorDP
DID_Low_PWM_GaugeRing	5	2	PWM value for lowest brightness Gauge ring Use it with DID_WeightFactorDP
DID_High_PWM_GaugeRing	1023	2	PWM value for highest brightness Gauge ring Use it with DID_WeightFactorDP
DID_Low_PWM_GaugeBL	5	1	PWM value for lowest brightness Gauge backlight left Use it with DID_WeightFactorBL
DID_High_PWM_GaugeBL	255	1	PWM value for highest brightness Gauge backlight left Use it with DID_WeightFactorBL
DID_Low_PWM_PRNDL_BL	5	1	PWM value for lowest brightness PRNDL backlight Use it with DID_WeightFactorBL
DID_High_PWM_PRNDL_BL	255	1	PWM value for highest brightness PRNDL backlight Use it with DID_WeightFactorBL
DID_Night_PWM_Blue	102	1	PWM value for night time telltale brightness Blue telltales
DID_Day_PWM_Blue	255	1	PWM value for day time telltale brightness Blue telltales
DID_Night_PWM_Green	127	1	PWM value for night time telltale brightness Green telltales (not turn telltales)
DID_Day_PWM_Green	255	1	PWM value for day time telltale brightness Green telltales (not turn telltales)
DID_Night_PWM_Turn	127	1	PWM value for night time telltale brightness Green turn telltales
DID_Day_PWM_Turn	255	1	PWM value for day time telltale brightness Green turn telltales
DID_Night_PWM_Yellow	127	1	PWM value for night time telltale brightness Yellow (amber) telltales
DID_Day_PWM_Yellow	255	1	PWM value for day time telltale brightness Yellow (amber) telltales
DID_Night_PWM_Orange	76	1	PWM value for night time telltale brightness Red telltales

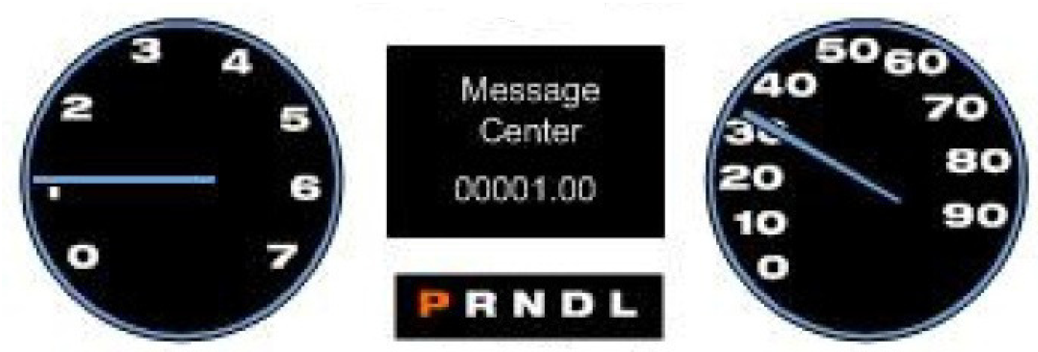
DID_Day_PWM_Orange	255	1	PWM value for day time telltale brightness Red telltales
DID_Night_PWM_Red	127	1	PWM value for night time telltale brightness Red telltales
DID_Day_PWM_Red	255	1	PWM value for day time telltale brightness Red telltales
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

7.2 End Of Line Programmable Table DIDs

The IPC should have the following 4 DIDs which are end of line programmable tables:

Identifier	Value	Bytes	Comment, Description
DID_WeightFactorDP		108*2	Default values see “Definition Of Weight Factors For 10 Bit PWM (Display and Gauge Pointer)”
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

7.3 IPC Illumination Zones:



7.4 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

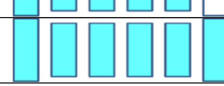
night mode representation of bar graph.

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.

7.4.1 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

8 HVAC

General Chapters 1 until 4 are to be implemented / considered if applicable.
See chapter 19 if SVC is implemented.

8.1 Manual HVAC

8.1.1 End Of Line Programmable DIDs

The HVAC should have the following end of line programmable DIDs for the various backlighting dimming zones:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_DisplayBL	5	2	n/a
DID_High_PWM_DisplayBL	1023	2	n/a
DID_Low_PWM_KnobLeftBL	5	1	PWM value for lowest brightness Knob left backlight (ice blue) (blower symbol) Use it with DID_WeightFactorBL
DID_High_PWM_KnobLeftBL	255	1	PWM value for highest brightness Knob left backlight (ice blue) (blower symbol) Use it with DID_WeightFactorBL
DID_Low_PWM_KnobRightBL	5	1	PWM value for lowest brightness Knob right backlight (ice blue) (Max AC, Max Def) Use it with DID_WeightFactorBL
DID_High_PWM_KnobRightBL	255	1	PWM value for highest brightness Knob right backlight (ice blue) (Max AC, Max Def) Use it with DID_WeightFactorBL
DID_Low_PWM_ButtonBL	5	1	PWM value for lowest brightness Button backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ButtonBL	255	1	PWM value for highest brightness Button backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_TempRed	5	1	PWM value for lowest brightness Temperature backlight (red) Use it with DID_WeightFactorBL
DID_High_PWM_TempRed	255	1	PWM value for highest brightness Temperature backlight (red) Use it with DID_WeightFactorBL
DID_Low_PWM_TempBlue	5	1	PWM value for lowest brightness Temperature backlight (blue) Use it with DID_WeightFactorBL
DID_High_PWM_TempBlue	255	1	PWM value for highest brightness Temperature backlight (blue) Use it with DID_WeightFactorBL
DID_Low_PWM_SeatRed	5	1	PWM value for lowest brightness Seat backlight (red) Use it with DID_WeightFactorBL
DID_High_PWM_SeatRed	255	1	PWM value for highest brightness Seat backlight (red) Use it with DID_WeightFactorBL
DID_Low_PWM_SeatBlue	5	1	n/a
DID_High_PWM_SeatBlue	255	1	n/a

The HVAC should have the following end of line programmable DIDs for the various telltale dimming zones:

DID_Night_PWM_SeatRed	23	1	PWM value for night time telltale brightness Seat red telltales
DID_Day_PWM_SeatRed	255	1	PWM value for day time telltale brightness Seat red telltales
DID_Night_PWM_SeatBlue	23	1	n/a
DID_Day_PWM_SeatBlue	255	1	n/a
DID_Night_PWM_KnobYellow	23	1	PWM value for night time telltale brightness Knob yellow (amber) telltales (Max AC, Max Def)
DID_Day_PWM_KnobYellow	255	1	PWM value for day time telltale brightness Knob yellow (amber) telltales (Max AC, Max Def)
DID_Night_PWM_ButtonYellow	23	1	PWM value for night time telltale brightness Button yellow (amber) telltales
DID_Day_PWM_ButtonYellow	255	1	PWM value for day time telltale brightness Button yellow (amber) telltales
DID_Night_PWM_BlowerYellow	23	1	PWM value for night time telltale brightness Blower bar yellow (amber) telltales
DID_Day_PWM_BlowerYellow	255	1	PWM value for day time telltale brightness Blower bar yellow (amber) telltales
DID_Night_PWM_ECO	23	1	PWM value for night time telltale brightness External ECO button yellow (amber) telltales
DID_Day_PWM_ECO	255	1	PWM value for day time telltale brightness External ECO button yellow (amber) telltales
DID_Night_PWM_StartStop	23	1	PWM value for night time telltale brightness External Start-Stop button yellow (amber) telltales
DID_Day_PWM_StartStop	255	1	PWM value for day time telltale brightness External Start-Stop button yellow (amber) telltales
DID_Night_PWM_AUTOHOLD	23	1	PWM value for night time telltale brightness External AUTOHOLD button yellow (amber) telltales
DID_Day_PWM_ AUTOHOLD	255	1	PWM value for day time telltale brightness External AUTOHOLD button yellow (amber) telltales
DID_Low_PWM_TempIndexBL	5	1	PWM value for lowest brightness temperature knob index (iceblue) Use it with DID_WeightFactorBL
DID_High_PWM_ TempIndexBL	255	1	PWM value for highest brightness Seat backlight (ice blue) Use it with DID_WeightFactorBL
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

8.1.2 End Of Line Programmable Table DIDs

The HVAC should have the following 4 DIDs which are end of line programmable tables:

Identifier	**Value**	**Bytes**	**Comment, Description**
DID_WeightFactorDP		108*2	n/a
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

8.1.3 Illumination Zones of manual HVAC

8.2 Automatic HVAC

8.2.1 End Of Line Programmable DIDs

The HVAC should have the following end of line programmable DIDs for the various backlighting dimming zones:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_DisplayBL	5	2	PWM value for lowest brightness Display backlight Use it with DID_WeightFactorDP
DID_High_PWM_DisplayBL	1023	2	PWM value for highest brightness Display backlight Use it with DID_WeightFactorDP
DID_Low_PWM_KnobLeftBL	5	1	PWM value for lowest brightness Knob left backlight (ice blue)(left and right) Use it with DID_WeightFactorBL
DID_High_PWM_KnobLeftBL	255	1	PWM value for highest brightness Knob left backlight (ice blue)(left and right) Use it with DID_WeightFactorBL
DID_Low_PWM_KnobRightBL	5	1	PWM value for lowest brightness Knob right backlight (ice blue)(corona, divider bar) Use it with DID_WeightFactorBL
DID_High_PWM_KnobRightBL	255	1	PWM value for highest brightness Knob right backlight (ice blue)(corona, divider bar) Use it with DID_WeightFactorBL
DID_Low_PWM_ButtonBL	5	1	PWM value for lowest brightness Button backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ButtonBL	255	1	PWM value for highest brightness Button backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_TempRed	5	1	PWM value for lowest brightness Temperature backlight (red)(red and blue) Use it with DID_WeightFactorBL
DID_High_PWM_TempRed	255	1	PWM value for highest brightness Temperature backlight (red)(red and blue) Use it with DID_WeightFactorBL
DID_Low_PWM_TempBlue	5	1	n/a
DID_High_PWM_TempBlue	255	1	n/a
DID_Low_PWM_SeatRed	5	1	PWM value for lowest brightness Seat backlight (red) Use it with DID_WeightFactorBL
DID_High_PWM_SeatRed	255	1	PWM value for highest brightness Seat backlight (red) Use it with DID_WeightFactorBL
DID_Low_PWM_SeatBlue	5	1	n/a
DID_High_PWM_SeatBlue	255	1	n/a

The HVAC should have the following end of line programmable DIDs for the various telltale dimming zones:

DID_Night_PWM_SeatRed	23	1	PWM value for night time telltale brightness Seat red telltales
DID_Day_PWM_SeatRed	255	1	PWM value for day time telltale brightness Seat red telltales
DID_Night_PWM_SeatBlue	23	1	n/a
DID_Day_PWM_SeatBlue	255	1	n/a
DID_Night_PWM_KnobYellow	23	1	PWM value for night time telltale brightness Knob yellow (amber) telltales
DID_Day_PWM_KnobYellow	255	1	PWM value for day time telltale brightness Knob yellow (amber) telltales
DID_Night_PWM_ButtonYellow	23	1	PWM value for night time telltale brightness Button yellow (amber) telltales
DID_Day_PWM_ButtonYellow	255	1	PWM value for day time telltale brightness Button yellow (amber) telltales
DID_Night_PWM_BlowerYellow	23	1	PWM value for night time telltale brightness Blower bar yellow (amber) telltales
DID_Day_PWM_BlowerYellow	255	1	PWM value for day time telltale brightness Blower bar yellow (amber) telltales
DID_Night_PWM_ECO	23	1	PWM value for night time telltale brightness External ECO button yellow (amber) telltales (and StartStop)
DID_Day_PWM_ECO	255	1	PWM value for day time telltale brightness External ECO button yellow (amber) telltales (and StartStop)
DID_Night_PWM_StartStop	23	1	n/a
DID_Day_PWM_StartStop	255	1	n/a
DID_Night_PWM_AUTOHOLD	23	1	PWM value for night time telltale brightness External AUTOHOLD button yellow (amber) telltales
DID_Day_PWM_ AUTOHOLD	255	1	PWM value for day time telltale brightness External AUTOHOLD button yellow (amber) telltales
DID_Low_PWM_TempIndexBL	5	1	n/a
DID_High_PWM_ TempIndexBL	255	1	n/a
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

8.2.2 End Of Line Programmable Table DIDs

The HVAC should have the following 4 DIDs which are end of line programmable tables:

Identifier	**Value**	**Bytes**	**Comment, Description**
DID_WeightFactorDP		108*2	Default values see “Definition Of Weight Factors For 10 Bit PWM (Display and Gauge Pointer)”
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

8.2.3 Illumination Zones of automatic HVAC

9 RCM

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

9.1 End Of Line Programmable DIDs

The RCM should have the following end of line programmable DIDs for the PADI:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_PADI_Ind	127	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

10 BCM

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

10.1 End Of Line Programmable DIDs

The BCM should have the following end of line programmable DIDs for the various dimming zones:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_CommonBL	5	1	PWM value for lowest brightness common backlight Use it with DID_WeightFactorBL
DID_High_PWM_CommonBL	255	1	PWM value for highest brightness common backlight Use it with DID_WeightFactorBL
DID_Night_PWM_KSSsw_Ind	127	1	PWM value for night time telltale brightness Keyless Start/Stop Indicator
DID_Day_PWM_KSSsw_Ind	255	1	PWM value for day time telltale brightness Keyless Start/Stop Indicator
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms
DID_Backlit_at_Day	0	1/8	0x0 = process Backlit_LED_Status like CGEA1.3 FNA 0x1 = process Backlit_LED_Status like CGEA1.3 FOE Backlit_LED_Status = Night_12 while Dimming_Lvl in [Day_1 .. Day_6]

10.2 End Of Line Programmable Table DIDs

The BCM should have the following 3 DIDs which are end of line programmable tables:

Identifier	Value	Bytes	Comment, Description
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

10.3 LIN communication BCM - Head Lamp Switch

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

10.3.1 HLS_Illumination_Signals

The following signals are transmited from BCM to HLS. There is also and LDF file with the data description. The LDF file is the master in case of an 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

11 PAM

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

11.1 End Of Line Programmable DIDs

The PAM should have the following end of line programmable DIDs for the indicator:

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

12 HLS

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

12.1 HLS 8 Bit PWM Backlight

The following 78 calibrateable parameter bytes should be stored as parameter field. They need not end of line programmable. The final values will be evaluated during measurements and distributed to the supplier.

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Backlit_LED_Status	Off	0	0	0	0	0	0
	Night_1	12	28	46	69	109	200
	Night_2	19	34	52	75	114	202
	Night_3	25	41	58	80	118	204
	Night_4	32	47	64	86	123	206
	Night_5	39	54	71	92	128	209
	Night_6	47	62	78	99	134	211
	Night_7	56	71	87	107	141	214
	Night_8	68	82	98	117	149	218
	Night_9	82	96	111	130	159	223
	Night_10	104	117	131	148	174	230
	Night_11	134	146	159	174	196	240
	Night_12	180	191	202	214	229	255

Table 7

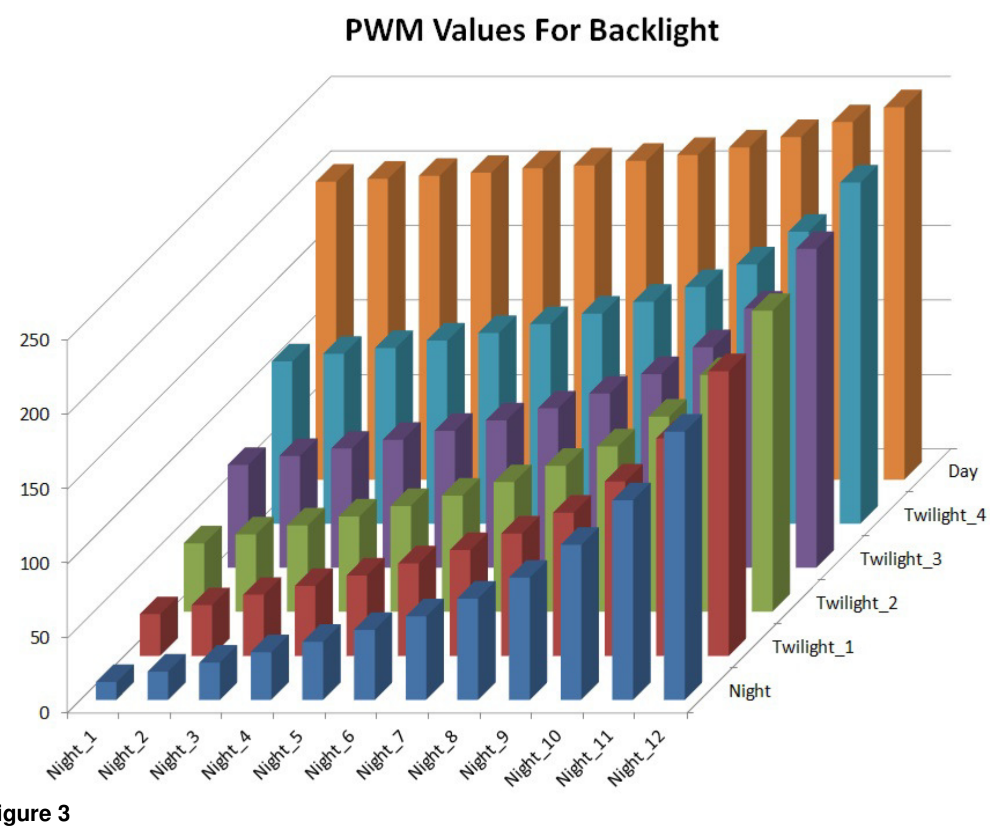


Figure 3

12.2 HLS 8 Bit PWM For Indicators

12.2.1 HLS Day/Night Brightness For Indicators

See chapter 18

12.2.2 HLS 8 Bit PWM Values

The following 2 parameters bytes should be stored as a parameter field. They need not end of line programmable. The final values will be evaluated during measurements and distributed to the supplier.

Identifier	IndicationBrightness	Indicator PWM Value
TwoStepDimmingNightPWM	Night	23
TwoStepDimmingDayPWM	Day	255

12.3 HLS Smooth Dimming

The smooth dimming have to be done according chapter "Smooth Transition While Changing The Dimming PWM Values". The two tables could be optimized for a fixed sampling rate and max. 1500ms transition time.

The DIDs described should be stored in parameter fields. They need not end of line programmable. The final values will be evaluated during measurements and distributed to the supplier.

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.

12.4 HLS Backlit_LED_Status processing

There signal Backlit_LED_Status should be processed in the following way.

Backlit_LED_Status	Ignition_Status	BacklitLEDCmd
Off	Not(Run, Start)	Off
Off	Run, Start	Last "non off" value (Night_1 .. Night_12) – see note
Night_1 .. Night_12	Don't care	Night_1 .. Night_12
All others	Don't care	see HLS Backlight Error Handling

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

12.5 HLS Backlit_LED_Status 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 Backlit_LED_Status 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

12.6 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

12.7 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 Backlit_LED_Status was Off or unknown use Night_12. If last Backlit_LED_Status was <> Off use this value.

Last_Backlit_LED_Status is the last user selected Backlit_LED_Status which is not OFF. Init values after reset should be OFF.

Backlit_LED_Status_Table is the value for selecting Backlit_LED_Status at the PWM table.

```
Backlit_LED_Status_Table = Backlit_LED_Status
If (Backlit_LED_Status <> Off)
Then
  Last_Backlit_LED_Status = Backlit_LED_Status
Else
   If (Ignition_Status == Run) OR (Ignition_Status == Start)
   Then
       If (Last_Backlit_LED_Status == Off)
       Then
           Last_Backlit_LED_Status = Night_12
       EndIf
       Backlit_LED_Status_Table = Last_Backlit_LED_Status
   EndIf
```

13 TCU

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

13.1 End Of Line Programmable DIDs

The TCU should have the following end of line programmable DIDs for the indicator:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_TCU_Ind	23	1	PWM value for night time telltale brightness ERA Glonass Indicator
DID_High_PWM_TCU_Ind	255	1	PWM value for day time telltale brightness ERA Glonass Indicator

14 DDM

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

14.1 End Of Line Programmable DIDs

The DDM should have the following end of line programmable DIDs for the indicator:

Identifier	Value	Bytes	Comment, Description
DID_Low_PWM_DDLS_BL	5	1	PWM value for lowest brightness DDSL backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ DDLS_BL	255	1	PWM value for highest brightness DDSL backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_DRWS_BL	5	1	PWM value for lowest brightness DRWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ DRWS_BL	255	1	PWM value for highest brightness DRWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_DDS_BL	5	1	PWM value for lowest brightness DDS backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ DDS_BL	255	1	PWM value for highest brightness DDS backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_DDLS_Ind	23	1	PWM value for night time telltale brightness DDLS Indicator
DID_High_PWM_DDLS_Ind	255	1	PWM value for day time telltale brightness DDLS Indicator
DID_Low_PWM_DDS_Ind	23	1	PWM value for night time telltale brightness DDS Indicator
DID_High_PWM_DDS_Ind	255	1	PWM value for day time telltale brightness DDS Indicator
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

14.2 End Of Line Programmable Table DIDs

The DDM should have the following 3 DIDs which are end of line programmable tables:

Identifier	Value	Bytes	Comment, Description
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

15 PDM

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

15.1 End Of Line Programmable DIDs

The PDM should have the following end of line programmable DIDs for the indicator:

Identifier	**Value**	**Bytes**	**Comment, Description**
DID_Low_PWM_PDLS_BL	5	1	PWM value for lowest brightness PDSL + PWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ PDLS_BL	255	1	PWM value for highest brightness PDSL + PWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_PRWS_BL	5	1	PWM value for lowest brightness PRWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_High_PWM_ PRWS_BL	255	1	PWM value for highest brightness PRWS backlight (ice blue) Use it with DID_WeightFactorBL
DID_Low_PWM_PDS_BL	5	1	Reserved – not applicable
DID_High_PWM_ PDS_BL	255	1	Reserved – not applicable
DID_Low_PWM_PDLS_Ind	23	1	Reserved – not applicable
DID_High_PWM_PDLS_Ind	255	1	Reserved – not applicable
DID_Low_PWM_PDS_Ind	23	1	Reserved – not applicable
DID_High_PWM_PDS_Ind	255	1	Reserved – not applicable
DID_TransitionTimeMS	1104	2	Transition time for smooth transition in ms

15.2 End Of Line Programmable Table DIDs

The PDM should have the following 3 DIDs which are end of line programmable tables:

Identifier	**Value**	**Bytes**	**Comment, Description**
DID_WeightFactorBL		72*2	Default values see “Definition Of Weight Factors For 8 Bit PWM Backlight”
DID_MoveUpTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"
DID_MoveDownTable		100	Default values see "Smooth Transition While Changing The Dimming PWM Values"

16 DDS

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

16.1 LIN communication DDM – DDS

The protocol must be able to send the illumination message every 30ms 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.

If missing messages occur, the last valid PWM signal should be used for the PWM generator. If (missing message last longer than InvalidTimeout) AND (last valid PWM signal was zero), then use the default value Default_BL_PWM for the new valid PWM signal. In all other cases of missing messages use the last valid PWM signal.

After RESET, the PWM signal should be set to zero and the InvalidTimeout counter should start.

Default_BL_PWM value is 0xFF.
The InvalidTimeout value is 5 sec.

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

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

The DDM sends the PWM values to the DDS. One value is for the backlight PWM generator, the other value for the indicator PWM generator. The LDF file is the master in case of a mismatch to this description.

Name	Definition	Description
DDS_PWM_BL	BIT{7:0}	0x00 – 0xFF: Value for the 8-bit backlight PWM generator.
DDS_PWM_Ind	BIT{7:0}	0x00 – 0xFF: Value for the 8-bit indicator PWM generator.

17 DRDM

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

17.1 LIN communication DDM - DRDM

The protocol must be able to send the illumination message every 30ms 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.

If missing messages occur, the last valid PWM signal should be used for the PWM generator. If (missing message last longer than InvalidTimeout) AND (last valid PWM signal was zero), then use the default value Default_BL_PWM for the new valid PWM signal. In all other cases of missing messages use the last valid PWM signal.

After RESET, the PWM signal should be set to zero and the InvalidTimeout counter should start.

Default_BL_PWM value is 0xFF.
The InvalidTimeout value is 5 sec.

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

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

The DDM sends the PWM values to the DRDM. The value is for the backlight PWM generator. The LDF file is the master in case of a mismatch to this description.

Name	Definition	Description
DRDM_PWM_BL	BIT{7:0}	0x00 – 0xFF: Value for the 8-bit backlight PWM generator.

18 PRDM

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

18.1 LIN communication PDM - PRDM

The protocol must be able to send the illumination message every 30ms 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.

If missing messages occur, the last valid PWM signal should be used for the PWM generator. If (missing message last longer than InvalidTimeout) AND (last valid PWM signal was zero), then use the default value Default_BL_PWM for the new valid PWM signal. In all other cases of missing messages use the last valid PWM signal.

After RESET, the PWM signal should be set to zero and the InvalidTimeout counter should start.

Default_BL_PWM value is 0xFF.
The InvalidTimeout value is 5 sec.

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

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

The PDM sends the PWM values to the PRDM. The value is for the backlight PWM generator. The LDF file is the master in case of a mismatch to this description.

Name	Definition	Description
PRDM_PWM_BL	BIT{7:0}	0x00 – 0xFF: Value for the 8-bit backlight PWM generator.

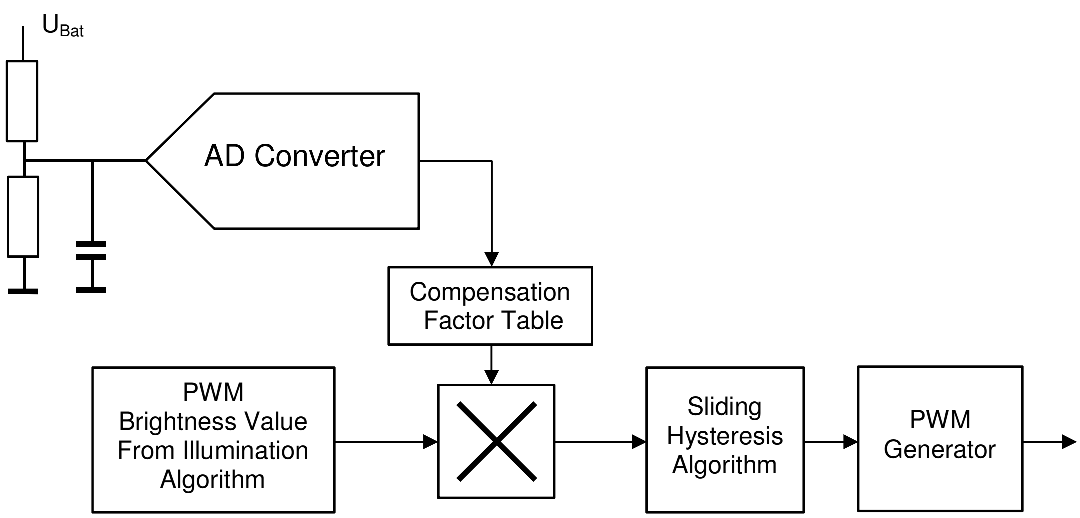
19 Software Voltage Compensation (SVC) For Illumination

For compensation via SVC the following the following is required:

- The PWM generator must have an at least 2 bit increased resolution.
  - 10 bit for tell tales and only night time dimmable backlight instead of 8 bit.
  - 12 bit for displays and pointers and other day time dimmable back light instead of 10 bit.
- Perform the voltage compensation at least every 10ms, preferred with the PWM frequency.
- After the A/D converter a configurable transfer table must be applied with at least 21 calibrateable data points in the range of 6V to 16V. Other values are interpolated between them.
- The resolution of the AD converter must be better than 25 mV battery voltage.
- A sliding hysteresis filter must be applied in front of the PWM generator.
  The hysteresis default value is 1 digit (calibrateable 0-255)
- At the AD converter input an analog filter must be applied.
- The AD converter sampling frequency should be at least 2 times of the PWM output frequency
- The accuracy of the voltage measurement should be better than 10%
- At the AD converter output a digital filter must be applied only for SVC purpose. The filter time constant must be programmable. The default value is no filtering (every sample is unfiltered feed to the lookup table).

19.1 Block Diagram For Software Voltage Compensation

The AD converter output is feed to a compensation factor table. The output of the table is the compensation factor, which must be applied to the PWM brightness value from the illumination algorithm. This product is feed in a sliding hysteresis algorithm, to avoid flickering if the value jumps one digit up and down, caused by noise at the battery voltage. Finally the output value of the sliding hysteresis is feed into the PWM generator who controls the LED(s).



19.2 Compensation Factor Table

The table should have at least 21 data points in the range of 6V to 16V. For each data point a two byte value must be available. 0x800 should be factor 1.0. The system should be calibrated in such a way, that at 9V or lower supply voltage the PWM level is transferred unchanged through the SVC (factor = 1.0). At higher voltage levels the PWM value must be decrease in such a way, that the brightness is constant.

supply voltage	factor	DID value
6,0	1,0	2048
6,5	1,0	2048
7,0	1,0	2048
7,5	1,0	2048
8,0	1,0	2048
8,5	1,0	2048
9,0	1,0	2048
9,5	1,0	2048
10,0	1,0	2048
10,5	1,0	2048
11,0	1,0	2048
11,5	1,0	2048
12,0	1,0	2048
12,5	1,0	2048
13,0	1,0	2048
13,5	1,0	2048
14,0	0,9	1940
14,5	0,9	1843
15,0	0,9	1755
15,5	0,8	1676
16,0	0,8	1603

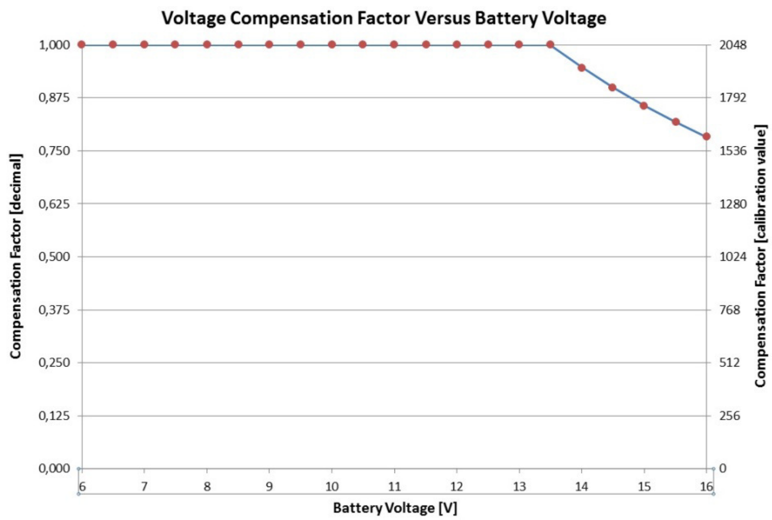


Table 8

19.3 Definition Of Sliding Hysteresis

The sliding hysteresis should have the following behaviour:

- If the new value is smaller than the actual PWM output value, than use then new value as actual PWM output value.
- If the new value plus hysteresis is bigger than the actual PWM output value, than use the new value minus hysteresis as new actual PWM output value.
- In all other cases don't change the actual output value.

Sample code:

```
unsigned char DID_PWM_Hysteresis = 1;

int SlidingHysteresis( int TargetValue, int LastValue )
{
  int NewValue;

     if (TargetValue < LastValue)
     {
       NewValue = TargetValue;
     }
     else
     {
       if (TargetValue > (LastValue + DID_PWM_Hysteresis))
       {
         NewValue = TargetValue - DID_PWM_Hysteresis;
       }
       else
       {
         NewValue = LastValue;
       }
     }
  return NewValue;
}
```

20 Clarification For Referenced Specifications

Here are some clarification to the referenced specification are described to make it more understandable.

20.1 Clarification For ES-DS7T-1A278-BE, Page 13, Table 6, Column= Day_Night_Status or Litval

If Dimming_Lvl = (Night_1 .. Night12, Day_1 .. Day_6) use Litval (not "don't care")
If Backlit_LED_Status = (Night_1 .. Night12) use Litval (not "don't care")

20.2 Clarification For ES-DS7T-1A278-BE, Page 15, Table 11, First Column

Extend "Dimming_Lvl Missing" to "Dimming_Lvl Missing, Unknown or Invalid"

20.3 Clarification For ES-DS7T-1A278-BE, Page 15, Table 11, Column=Litval

If Dimming_Lvl = (Night_1 .. Night12, Day_1 .. Day_6) use Litval (not "don't care)

20.4 Clarification For ES-DS7T-1A278-BE, Page 21, Note 4

If (Dimming_Lvl is Missing, Unknown or Invalid) handle according Page 15 Table 11