Research & Vehicle Technology
"Infotainment Systems Product Development"

Feature –Smooth Dimming / Cockpit Illumination

APIM Phoenix Domain Controller Infotainment Subsystem Part Specific Specification (SPSS)

Version 1.0

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Revision History

Date	Version	Notes	
October 25, 2021	1.0	Initial Release	

Table of Contents

1 Overview

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

1.1 Goal

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

1.2 Objectives

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

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

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

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

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

1.3 Terminology and Abbreviations

The following table lists terminologies that are used in this document along with a brief description.

Term	Description
ACM	Audio (Front) Control Module
ADAS	Advanced Driver Assistance Systems
AHU	Audio Head Unit (Connected HMI Radio)
ALS	Ambient Light Sensor
APIM	Accessory Protocol Interface Module (SYNC)
ARL	Attribute Requirement Lists (ARL). Documents vehicle-level
BCM	Body Control Module
CCH	Climate Control Head
CEA	Clear Exit Assist feature
CHR	Connected HMI Radio
CTR	Connected Touch Radio
DACMC	Digital Audio Control Module C
DCM	Door Control Module
DCU	Door Control Unit
DCMG/H	Door Control Module G/H
DM	Door Module
DDM	Driver Door Module

Term	Description
DDS	Driver Door Switchpack
DDLS	Driver Door Lock Switch
DRDM	Driver Rear Door Module
DRWS	Driver Rear Window Switch
ECM	Engine Control Module
ECG	Enhanced Communication Gateway
ECU	Electronic Control Unit
FCIMB	Front Controls Interface Module B (Radio Switches)
GSM	Gear Shift Module
GWM	GateWay Module
HLS	Head Lamp Switch
HVAC	Heating Ventilating and Air Conditioning (Climate Control Module)
ICP	Integrated Control Panel.
IPC	Instrument Panel Cluster Control Module
LCIS	Low Cost Infotainment System
LSM	Light Switch Module
LVDS	Low Voltage Differential Signal
OTA	Over The Air
PAM	Parking Assist Control Module
PADI	Passenger Airbag Deactivation Indicator
PCB	Printed Circuit Board
PDLS	Passenger Door Lock Switch
PDM	Passenger Door Module
PRDM	Passenger Rear Door Module
PRNDL	PRNDL (Indicator Of Automatic Gear Switch)
PRWS	Passenger Rear Window Switch
PSD	Power-Sliding Door
PTS	Push to Start
PWS	Passenger Window Switch
RACM	Rear Audio Control Module
RCM	Restraints Control Module
RDDM	Rear Driver Door Module
RHVAC	Rear HVAC
RPDM	Rear Passenger Door Module
RSOA	Rear Seat Occupant Alert
SCCM	Steering Column Control Module
SDM	Slim Display Module
SIMA	Switch Interface Module A
SOP	Start of Production
SVC	Software Voltage Compensation
SWS	Steering Wheel Switches
SWS LS	Steering Wheel Switches Left Side
SWS RS	Steering Wheel Switches Right Side
SUNC	see APIM
TAC	Tachograph
TCU	Telematics Control Unit

Term	Description
VQM	Voltage Quality Module

1.4 List of Feature Modules/ECUs

This is a list of all the ECU's interacting with the feature. This is common across all Ford programs / vehicles except for one exception. Some Ford commercial van vehicles like V710 Transit Van program has a PSD module, which is absent from other programs.

SNo	Module
1	IPC
2	APIM
3	ICP
4	DDM
5	PDM
6	RDDM
7	RPDM
8	DDS
9	1-DIN Radio
10	RCCM
11	BCM
12	ECG
13	RCM
14	PAM / ADAS
15	TCU
16	GSM
17	HLS
18	RCCM/HVAC
19	SCCM
20	PSD **(only for van commercial vehicles)**

2 Architectural Design

2.1 IIR-REQ-455557/A-IlluminationClient _Rx

2.1.1 MD-REQ-455558/A-ScanInprogress_B_Stat

Message Type: Status

This signal is used to know the status of AVIS.

Name	Literals	Value	Description
ScanInprogress_B_Stat	-	-	A request to
	Off	0x00	AVIS is not requested and the system continue working normally
	Active	0x01	AVIS is activated and request that center stacks screen goes to minimum brightness level

2.1.2 MD-REQ-283052/A-Dimming_Lvl

Message Type: Status

Used to indicate the Intensity level of dimmable backlighting.

Name	Literals	Value	Description
Dimming_Lvl	-	-	Intensity level of dimmable backlighting
	Off	0x0	Off status
	Night_1	0x1	Night_1 Status
	Night_2	0x2	Night_2 Status
	Night_3	0x3	Night_3 Status
	Night_4	0x4	Night_4 Status
	Night_5	0x5	Night_5 Status
	Night_6	0x6	Night_6 Status
	Night_7	0x7	Night_7 Status
	Night_8	0x8	Night_8 Status
	Night_9	0x9	Night_9 Status
	Night_10	0xA	Night_10 Status
	Night_11	0xB	Night_11 Status
	Night_12	0xC	Night_12 Status
	Day_1	0xD	Day_1 Status
	Day_2	0xE	Day_2 Status
	Day_3	0xF	Day_3 Status
	Day_4	0x10	Day_4 Status
	Day_5	0x11	Day_5 Status
	Day_6	0x12	Day_6 Status
	Unknown	0xFE	Unknown
	Invalid	0xFF	Invalid

2.1.3 MD-REQ-460777/A-Parklamp_Status

Message Type: Status

Used to indicate the status of the park lamp.

Name	Literals	Value	Description
Parklamp_Status	-	-	Current parklamp status
	Off	0x0	Off Status
	On	0x1	On Status
	Unknown	0x2	Unknown
	Invalid	0x3	Invalid

2.1.4 MD-REQ-411352/A-Litval

Message Type: Status

The signal contains the ambient light information.

Name	Literals	Value	Description
Litval_St	-	-	The signal contains the ambient light information
	Night	0x0	
	Twilight_1	0x1	
	Twilight_2	0x2	
	Twilight_3	0x3	
	Twilight_4	0x4	
	Day	0x5	
	Not_Used	0x6	
	….	….	
	Not_Used	0xFD	
	Unknown	0xFE	
	Invalid	0xFF	

2.1.5 MD-REQ-455597/A-Backlit_LED_Status

Message Type: Status

This signal is used to know the status of Backlit_LED.

Name	Literals	Value	Description
Backlit_LED_Status	-	-	Intensity level of dimmable backlighting
	Off	0x0	Off Status
	Night_1	0x1	Night_1 Status
	Night_2	0x2	Night_2 Status
	Night_3	0x3	Night_3 Status
	Night_4	0x4	Night_4 Status
	Night_5	0x5	Night_5 Status
	Night_6	0x6	Night_6 Status
	Night_7	0x7	Night_7 Status
	Night_8	0x8	Night_8 Status
	Night_9	0x9	Night_9 Status
	Night_10	0xA	Night_10 Status
	Night_11	0xB	Night_11 Status
	Night_12	0xC	Night_12 Status
	Unused1	0xD	Unused

	Unused2	0xE	Unused
	Unused2	0xF	Unused

2.1.6 MD-REQ-273750/A-Ignition_Status

Message Type: Status

Signal sent to the infotainment system indicating the ignition status of the vehicle

Logical Signal Name	Literals	Value	Description
Ignition_Status	Unknown	0x0	
	OFF	0x1	
	Accessory	0x2	
	Run	0x4	
	Start	0x8	
	Invalid	0xF	

2.1.7 MD-REQ-201601/A-Delay_Accy

Message Type: Status

This signal is used indicate whether Delayed Accessory is active or not.

Name	Literals	Value	Description
Type	-	-	Status of delayed accessory
	Off	0x00	
	On	0x01	

2.1.8 MD-REQ-455637/A-Day_Night_Status

Message Type: Status

This signal is used to know the status of Day_Night.

Name	Literals	Value	Description
Day_Night_Status	-	-	Day night state form ALS
	Null	0x00	
	Day	0x01	Day Status
	Night	0x02	Night Status
	NotUsed	0x03	

2.1.9 MD-REQ-455657/A-DimmingLvlEvnt_No_Actl

Message Type: Status

This signal is used to know the status of Dimming Level Event.

Name	Literals	Value	Description
DimmingLvlEvnt_No_Actl	-	-	A request to
	Reset	0x00	Reserved for Reset
	Counter	0x01	Rolling Counter
	Counter	0x02	Rolling Counter

	Counter	0x03	Rolling Counter

2.1.10 MD-REQ-460439/A-Dimming_Lvl_RqMnu

Message Type: Status

This signal is used to know the status of Dimming Level Event.

Name	Literals	Value	Description
DimmingLvlEvnt_No_Actl	-	-	A request to
	Reset	0x00	Reserved for Reset
	Counter	0x01	Rolling Counter
	Counter	0x02	Rolling Counter
	Counter	0x03	Rolling Counter

2.2 IIR-REQ-455559/A-IlluminationClient _Tx

2.2.1 MD-REQ-455560/A-HMI_HMIMode_St

Message Type: Status

This signal is used to send the HMI Status

Name	Literals	Value	Description
HMI_HMIMode_St	-	-	A request to
	Invalid	0x00	
	OffMode	0x01	
	On	0x02	
	Phone	0x03	
	Climate	0x04	
	Load_Shed_Acitve	0x05	
	NotUsed1	0x06	
	NotUsed2	0x07	

2.2.2 MD-REQ-455997/A-DrvDsplyPalette_D_Stat

Message Type: Status

This signal is used to know the status of Color Palette.

Name	Literals	Value	Description
DrvDsplyPalette_D_Stat	-	-	A request to
	Null	0x00	Null
	AutoDay	0x01	Auto Day Status
	AutoNight	0x02	Auto Night Status
	ManualDay	0x03	Manual Day Status
	ManualNightBright	0x04	ManualNightBright Status
	ManualNightDark	0x05	ManualNightDark Status
	NotUsed	0x06	NotUsed
	NotUsed	0x07	NotUsed

3 Functional Definition

3.1 SMDM-FUN-REQ-435658/A-Cockpit Illumination Dimming System Operation

3.1.1 Quality Requirements

3.1.1.1 Performance Requirements

3.1.1.1.1 SMDM-REQ-435797/A-General Illumination Requirements

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

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

3.1.1.1.2 SMDM-REQ-435798/A-Lincoln Embrace / Ford Welcome Farewell

- Welcome / Farewell was separated from Cockpit Illumination and is not part of this specification.

3.1.1.1.3 SMDM-REQ-435799/A-LED-Bin Compensation

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

3.1.1.1.4 SMDM-REQ-435800/A-Cockpit illumination shall not flicker while ramping and/or steadily illuminated

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

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

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

3.1.1.1.5 SMDM-REQ-435801/A-Handling subsequent illumination level change requests

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

3.1.1.1.6 SMDM-REQ-435802/A-Performance Latency Requirements

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

3.1.1.1.7 SMDM-REQ-435803/A-Preventing inadvertent illumination of Indicators and Backlighting LEDs

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

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

3.1.1.1.8 SMDM-REQ-435804/A-Compensation of Supply Voltage Variation

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

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

3.1.1.1.9 SMDM-REQ-435805/A-Illumination stabilization For Modules with Own Controller

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

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

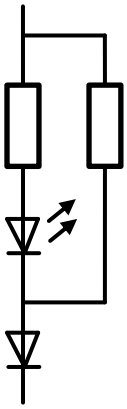
The compensation could be provided by hardware with stabilized supply voltage and/or stabilized current sources. In case a low stabilized supply voltage is used, the supplier should take care, that the part to part variation of the forward voltage of the LEDs causes not different brightness within the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

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

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

3.1.1.1.10 SMDM-REQ-435806/A-External Switches/Indicators without Own Controller (Illumination Circuit)

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



3.1.1.1.11 SMDM-REQ-435807/A-LED specific requirements

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

All electronic control units (ECU) that use the new LEDs shall have its own precautions for enough reverse battery protection covered by the generic reverse battery protection requirements out of the ELCOMP SDS.
All non-intelligent / standalone switches or pushbuttons shall be designed to also have their own reverse battery protection.

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

3.1.1.2 Safety Requirements

3.1.1.2.1 Legal Requirements

3.1.1.2.1.1 SMDM-REQ-435984/A-NAFTA Requirements to abide by (or not violate)

RR ID/ Revision	Country/ Vehicle area	Regulation Number and Title	RR Author
CAN-004911/3	Canada/ Interior Lighting	CMVSS 101/SCHEDULE IV PART II 101 (CMVSS 101) Controls and Displays	Laesch,Renu-RLAESCH1 (rlaesch1)
USA-008716/3	US / Interior Lighting & Vehicle Displays	FMVSS 101/FMVSS 101 Controls and Displays	Laesch,Renu-RLAESCH1 (rlaesch1)
USA-008732/1	US / Interior Lighting & Vehicle Displays	/NHTSA Visual-Manual Guidelines for In-Vehicle Electronic Devices	Leigh,Michael-MLEIGH (mleigh)
USA-011127/2	US / Interior Lighting & Vehicle Display	/2019MY U.S. NHTSA New Car Assessment Program (NCAP)	Buckman,Jennifer-JBARNARD (jbarnard)

3.1.1.2.1.2 SMDM-REQ-435985/A-ECE Requirements to abide by (or not violate)

RR ID/ Revision	Country/ Vehicle area	Regulation Number and Title	RR Author
ECE-005073/16	ECE / Interior Lighting & Vehicle Displays	ECE-121.01/Identification of Hand Controls, Tell-Tales and Indicators	Mueller,Joachim-JMUELLE6 (jmuelle6)

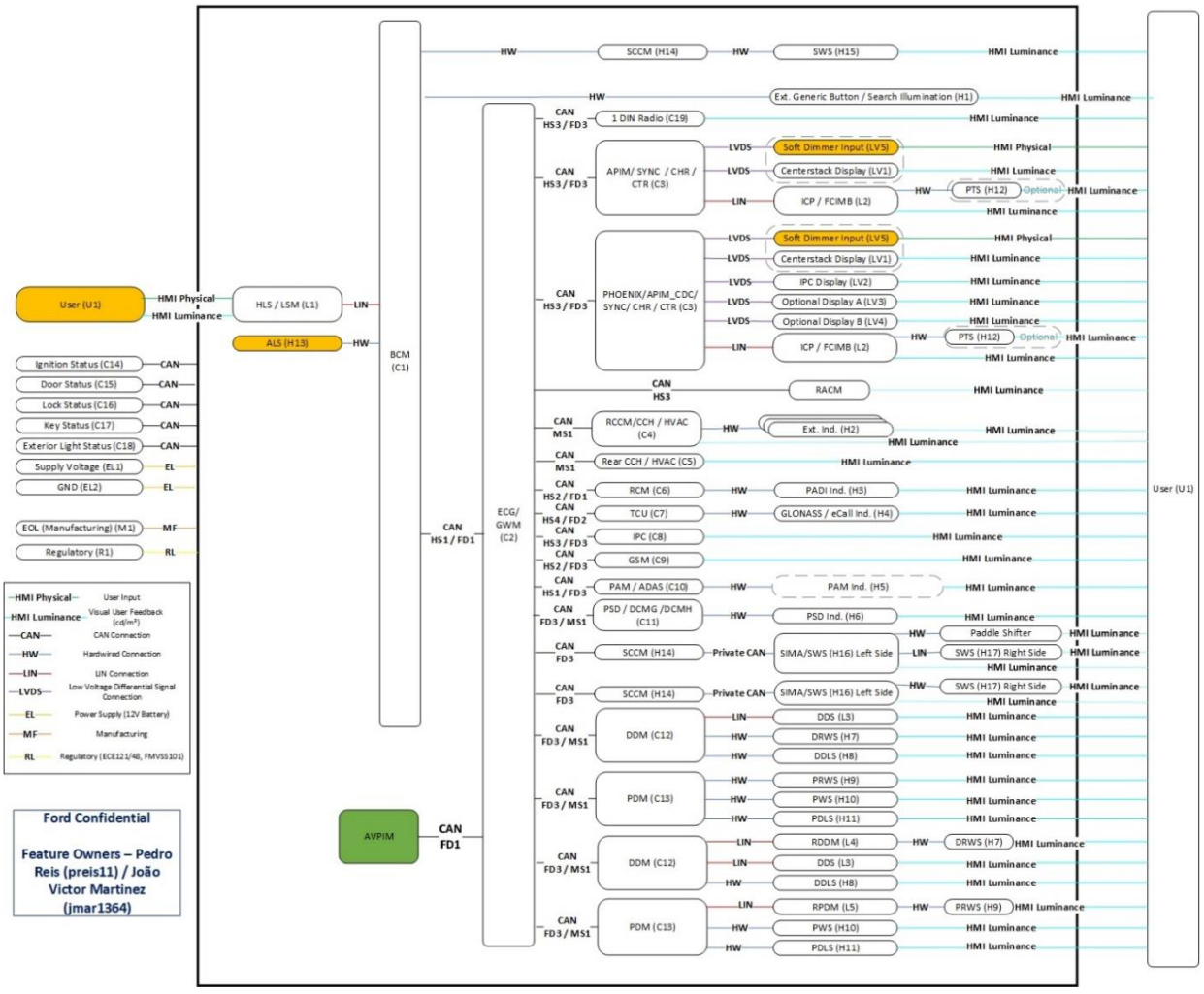
3.1.1.2.1.3 SMDM-REQ-435986/A-China Requirements to abide by (or not violate)

RR ID/Revision	Country	Regulation Number and Title	RR Author
CHN-004329/5	China / Interior Lighting & Vehicle Displays	GB 4094/CHINA: SYMBOLS FOR CONTROLS, INDICATORS, AND TELL-TALES	Zhang,Yue-YZHAN256 (yzhan256)

3.1.2 Generic Boundary Diagram

This boundary diagram shows several program architectures and program executions. The carlines are a subset of this boundary diagram. Several components like IPC, APIM module etc have been shown multiple times in the diagram, but only one instance will be a part of the program specific execution.

Boundary Diagram – Smooth Dimming / Cockpit Illumination / IP and Switch Illumination



3.2 SMDM-FUN-REQ-435605/A-General Functions

3.2.1 Overall Dimming

3.2.1.1 SMDM-REQ-454724/A-Overall Dimming req

There are three basic types of illumination zones.

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

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

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

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

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

3.2.1.2 SMDM-REQ-454725/A-Illumination Calibration via DID

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

3.2.1.3 SMDM-REQ-454757/A-Interpolation Function

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

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

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

Sample code:

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

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

3.2.1.4 Seamless / Smooth Transition on Intensity Change

3.2.1.4.1 SMDM-REQ-454758/A-Seamless / Smooth Transition on Intensity Change requirement

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

1. **DID_TransTime_Usr**
   Intensity transition time that should be used for user inputs

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

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

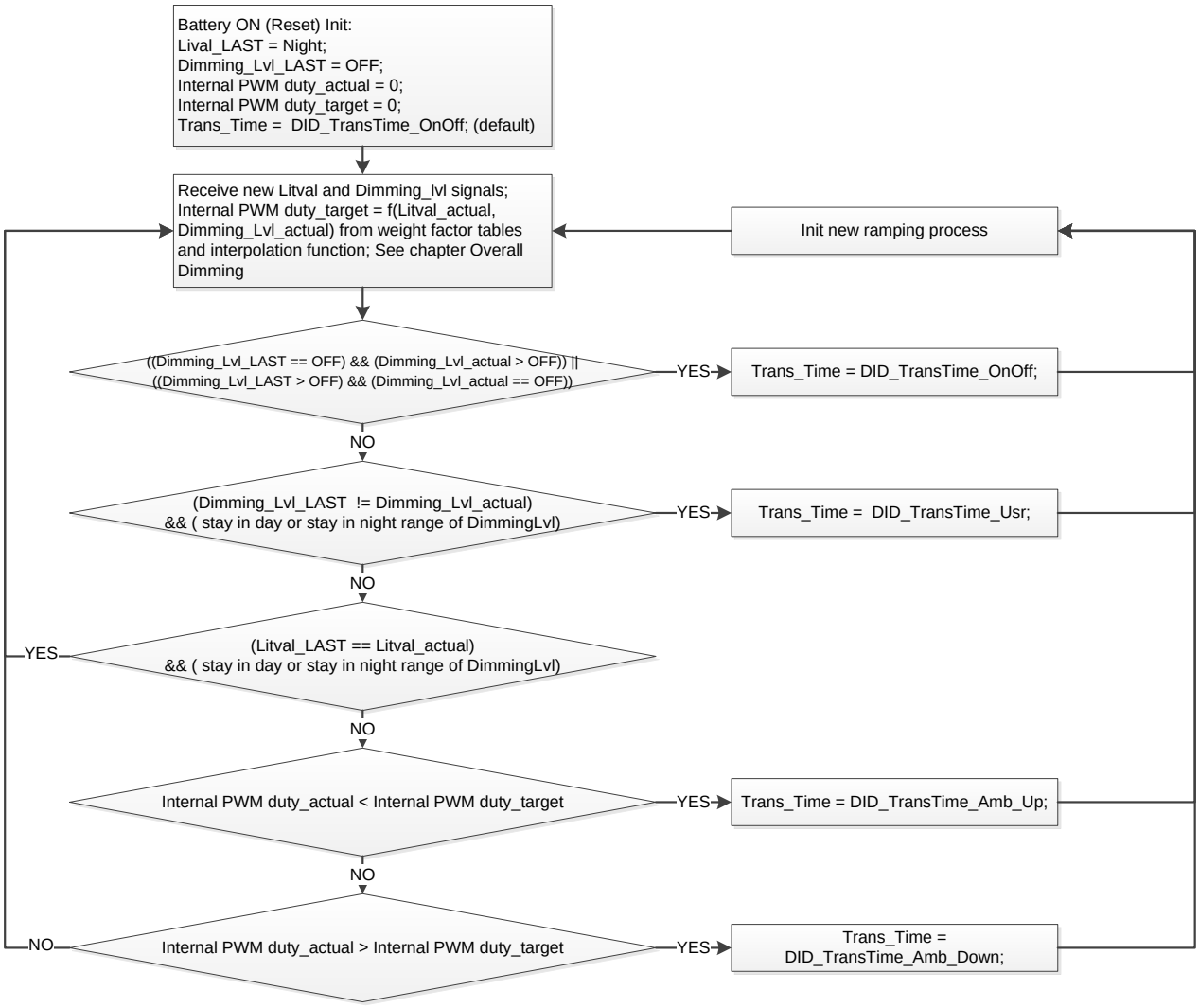
4. **DID_TransTime_Amb_Down**
   Intensity transition time that should be used in response to a change in the environment's ambient light level. The target illumination intensity (PWM duty cycle) is lower than the actual illumination intensity.

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

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

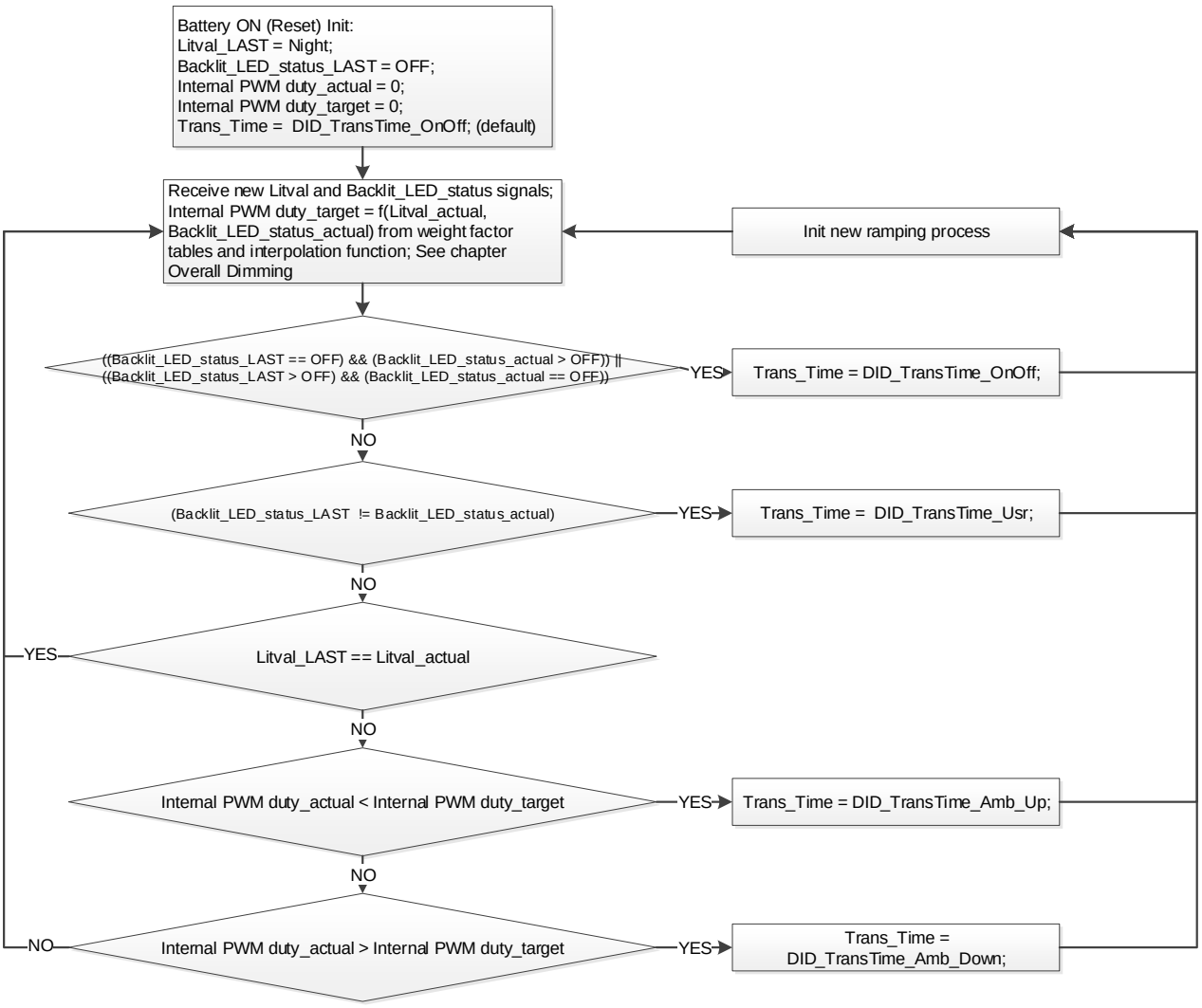
Identifier	Default Value	Size (Byte)	Range	Comment / Description
DID_TransTime_Usr	0	1	0 to 9	Transition time from start to target intensity on user request (see A.). The transition time is dependent on the number of shifts. This amount is the selectable value. Transition time calculation: (40*2^x) ms.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

Determining type of transition using Dimming_Lvl & Litval (Preferred):

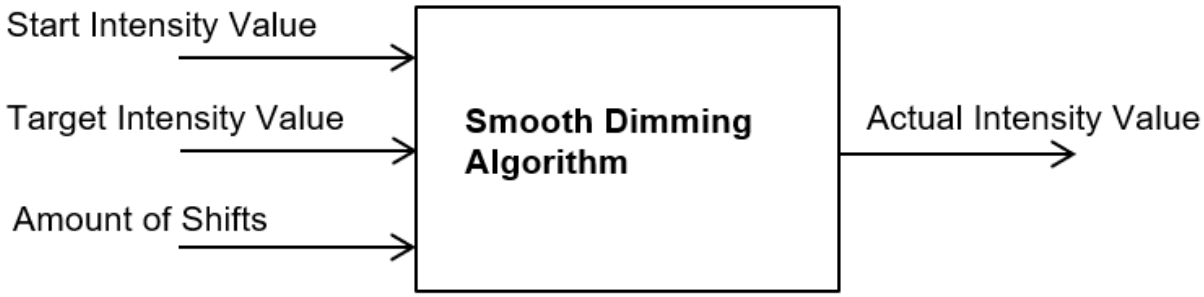


Stay in day or night range of Dimming_Lvl =
(((Dimming_Lvl_LAST<=Night_12) &&(Dimming_Lvl_actual<=Night_12))
||((Dimming_Lvl_LAST>=Day_1) &&(Dimming_Lvl_actual>=Day_1)))

Determining type of transition using Backlit_LED_Status & Litval (Alternative, requires buy-off from program vehicle harmony engineer to use):



3.2.1.4.2 SMDM-REQ-435824/A-Seamless / Smooth Dimming Algorithm



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

3.2.1.4.3 SMDM-REQ-435825/A-Time Coding by Number of Shifts

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

Time Coding based off 40ms application times:

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

Time Coding based off 20ms application times:

Update Rate [ms]	Number of Shifts	Amount of Dimming steps	Transition Time [ms]
20	1	2	40
20	2	4	80
20	3	8	160
20	4	16	320
20	5	32	640
20	6	64	1280
20	7	128	2560

20	8	256	5120
20	9	512	10240
20	10	1024	20480

Time Coding based off 10ms application times

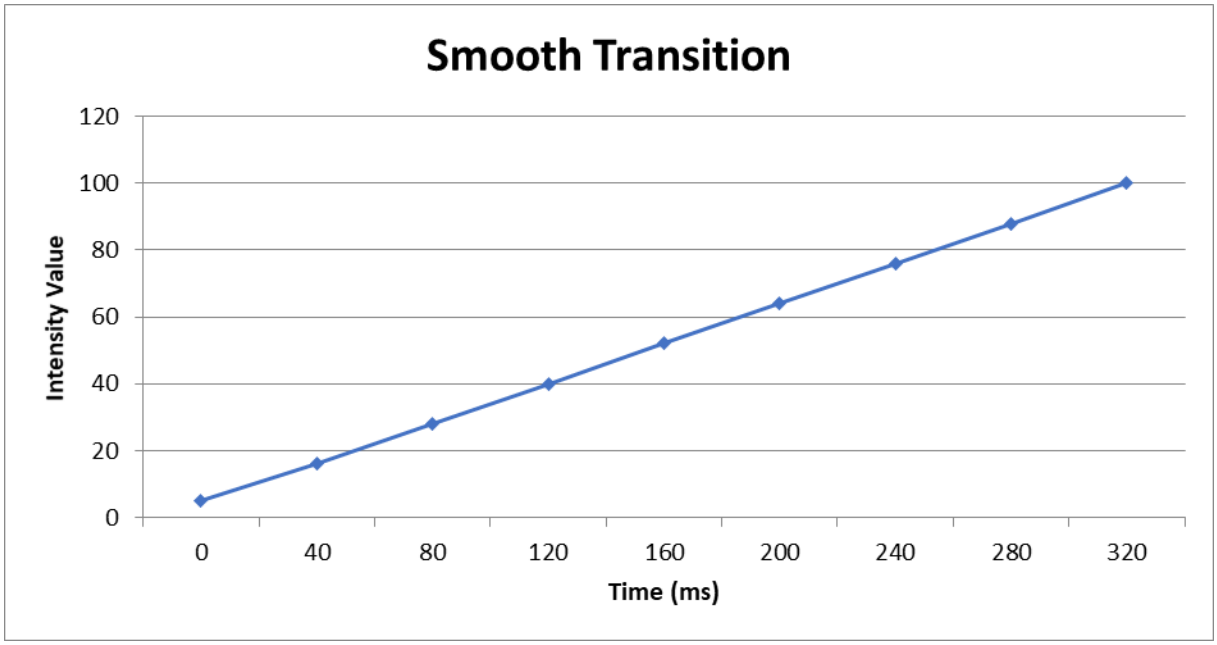
Update Rate [ms]	Number of Shifts	Amount of Dimming steps	Transition Time [ms]
10	2	4	40
10	3	8	80
10	4	16	160
10	5	32	320
10	6	64	640
10	7	128	1280
10	8	256	2560
10	9	512	5120
10	10	1024	10240
10	11	2048	20480

The following example shows how to calculate a smooth intensity change from start to target value.
Start intensity value = 5; Target intensity value = 100; Transition time = 320 ms / 3 shifts / 8 steps;

Amount of steps

Example Smooth Dimming Calcualtion with Shift = 3												
1	2	3	4	5	6	7	8	Addition	DEZ to BIN	Shift >>3	Intensity (DEZ)	Time Index (ms)
Start intensity value												
5	5	5	5	5	5	5	5	40	101000	101	5	0
100	5	5	5	5	5	5	5	135	10000111	10000	16	40
100	100	5	5	5	5	5	5	230	11100110	11100	28	80
100	100	100	5	5	5	5	5	325	101000101	101000	40	120
100	100	100	100	5	5	5	5	420	110100100	110100	52	160
100	100	100	100	100	5	5	5	515	1000000000	1000000	64	200
100	100	100	100	100	100	5	5	610	1001100010	1001100	76	240
100	100	100	100	100	100	100	5	705	1011000001	1011000	88	280
100	100	100	100	100	100	100	100	800	1100100000	1100100	100	320

Target intensity value



3.2.1.4.4 SMDM-REQ-435826/A-Seamless Dimming Examples for Backlight Illumination

The following graphic shows seamless dimming examples for backlight illumination.

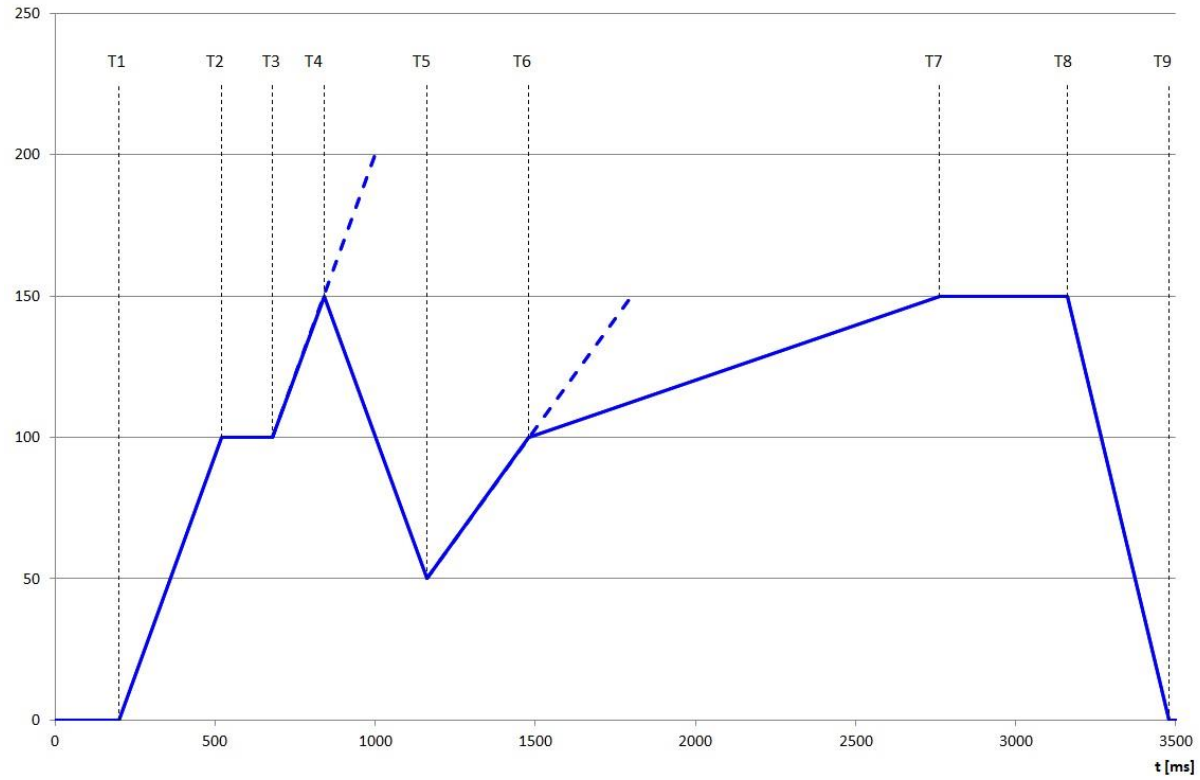


Figure 1

Time	Action
T1	Start new transition with target=100, shift=3 (8x40ms)
T2	Ramping complete, target value reached, no further intensity change until new target is received
T3	Start new transition with target =200, shift=3 (8x40ms)

T4	During ramping up a new transition is started with target=50, shift=3 (8x40ms)
T5	Ramping complete and immediately a new transition is started with Target=150, shift=4 (16x40ms)
T6	During ramping up a new transition is started with target=150, shift=5 (32x40ms)
T7	Ramping complete (stops further change)
T8	Start new transition with Target=0, shift=3 (8x40ms)
T9	Ramping complete (stops further change)

See “10 Bit PWM Display Backlight” for the seamless / smooth dimming sample code.

3.2.1.5 8 / 10 Bit PWM Backlight

3.2.1.5.1 SMDM-REQ-435828/A-Brightness Calibration of 8 Bit Backlight

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

Identifier	Default Value	Bytes	Range	Comment, Description
DID_Low_PWM	5	1	0 - 255	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night" 0 refers to 0% PWM duty cycle (off), 255 refers to 100 % PWM duty cycle (max intensity)
DID_High_PWM	255	1	0 - 255	PWM value for highest brightness e.g.: Dimming_Lvl "Night_12", Litval “Day" 0 refers to 0% PWM duty cycle (off), 255 refers to 100 % PWM duty cycle (max intensity)

3.2.1.5.2 SMDM-REQ-435829/A-Brightness Calibration of 10 Bit Backlight

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

Identifier	Default Value	Bytes	Range	Comment, Description
DID_Low_PWM	20	2	0 - 1023	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night" 0 refers to 0% PWM duty cycle (off), 1023 refers to 100 % PWM duty cycle (max intensity)
DID_High_PWM	1023	2	0 - 1023	PWM value for highest brightness e.g.: Dimming_Lvl "Day_6", Litval “Day" 0 refers to 0% PWM duty cycle (off), 1023 refers to 100 % PWM duty cycle (max intensity)

3.2.1.5.3 SMDM-REQ-435830/A-Definition of Weight Factors for 8 /10 Bit PWM Backlight

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

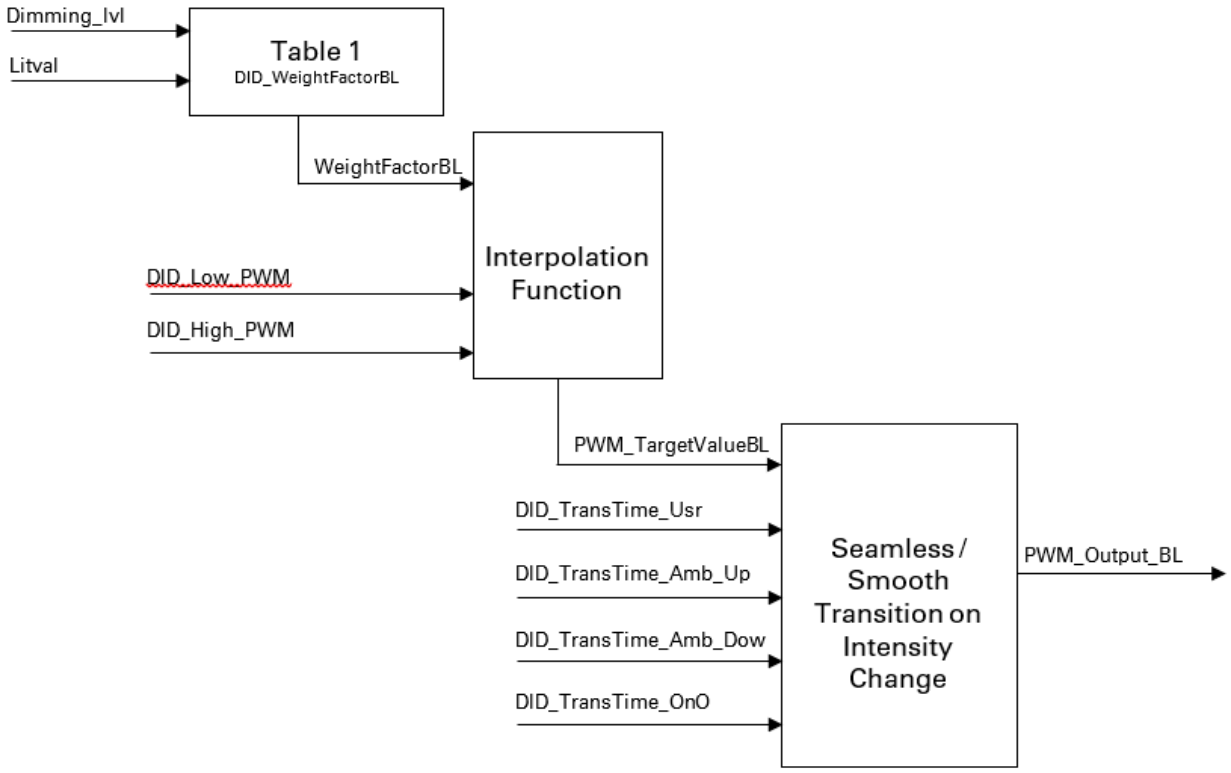
DID_WeightFactorBL:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_lvl	Night_1	0	11	27	52	88	1024
	Night_2	8	22	41	70	113	1024
	Night_3	18	35	59	94	144	1024
	Night_4	32	53	83	124	181	1024
	Night_5	52	78	113	161	227	1024
	Night_6	78	110	152	209	284	1024
	Night_7	113	152	203	269	353	1024
	Night_8	162	209	269	344	438	1024
	Night_9	228	284	354	439	543	1024
	Night_10	317	384	463	558	672	1024
	Night_11	440	516	605	709	830	1024
	Night_12	607	692	789	899	1024	1024
	Day_1	1024	1024	1024	1024	1024	1024
	Day_2	1024	1024	1024	1024	1024	1024
	Day_3	1024	1024	1024	1024	1024	1024
	Day_4	1024	1024	1024	1024	1024	1024
	Day_5	1024	1024	1024	1024	1024	1024
	Day_6	1024	1024	1024	1024	1024	1024

Table 1 Example 8 Bit WeightFactor Table

3.2.1.5.4 SMDM-REQ-435831/A-Determine the PWM Value for 8 / 10 Bit PWM Backlight

Note: If Dimming_lvl = 0x0(Off), PWM_TargetValueBL is 0x0.



3.2.1.5.5 SMDM-REQ-435832/A-Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

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

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

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_lvl	Night_1	0.12	0.18	0.27	0.41	0.62	6.00
	Night_2	0.16	0.24	0.35	0.52	0.77	6.00
	Night_3	0.22	0.32	0.46	0.66	0.94	6.00
	Night_4	0.30	0.42	0.59	0.83	1.16	6.00
	Night_5	0.41	0.56	0.77	1.04	1.42	6.00
	Night_6	0.56	0.75	0.99	1.32	1.75	6.00
	Night_7	0.77	0.99	1.28	1.66	2.15	6.00
	Night_8	1.05	1.32	1.66	2.09	2.64	6.00
	Night_9	1.42	1.75	2.15	2.64	3.24	6.00
	Night_10	1.94	2.32	2.78	3.32	3.98	6.00
	Night_11	2.64	3.08	3.59	4.19	4.88	6.00
	Night_12	3.60	4.09	4.65	5.28	6.00	6.00
	Day_1	6.00	6.00	6.00	6.00	6.00	6.00
	Day_2	6.00	6.00	6.00	6.00	6.00	6.00
	Day_3	6.00	6.00	6.00	6.00	6.00	6.00
	Day_4	6.00	6.00	6.00	6.00	6.00	6.00
	Day_5	6.00	6.00	6.00	6.00	6.00	6.00
	Day_6	6.00	6.00	6.00	6.00	6.00	6.00

Table 2 ARL Example Luminance Table [cd/m²]

Calculation of intensity offset DIDs out of ARL luminance table

DID_Low_PWM =round(255*(L_min)/(L_max))
Example calculation based on Table 2 ARL Example Luminance Table [cd/m²]:
DID_Low_PWM = round(255*0.12/6.00) = 5

DID_High_PWM = round(255*(L_max)/(L_max))
Example calculation based on Table 2 ARL Example Luminance Table [cd/m²]
DID_High_PWM = round(255*6.00/6.00) = 255

Round: choose the next higher integer if first decimal digit is equal or higher than 5.
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Night_12 and Day.

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

Weightfactor[Dimming_lvl, Litval] =
roundup (1024*(luminance[Dimming_lvl, Litval] - L_min))/(L_max - L_min)

Luminance [Dimming_lvl, Litval] = Luminance value at the table intersection point Dimming_lvl and Litval
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Night_12 and Day.

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_lvl	Night_1	0	11	27	52	88	1024
	Night_2	8	22	41	70	113	1024
	Night_3	18	35	59	94	144	1024
	Night_4	32	53	83	124	181	1024
	Night_5	52	78	113	161	227	1024
	Night_6	78	110	152	209	284	1024
	Night_7	113	152	203	269	353	1024
	Night_8	162	209	269	344	438	1024
	Night_9	228	284	354	439	543	1024
	Night_10	317	384	463	558	672	1024
	Night_11	440	516	605	709	830	1024
	Night_12	607	692	789	899	1024	1024
	Day_1	1024	1024	1024	1024	1024	1024
	Day_2	1024	1024	1024	1024	1024	1024
	Day_3	1024	1024	1024	1024	1024	1024
	Day_4	1024	1024	1024	1024	1024	1024
	Day_5	1024	1024	1024	1024	1024	1024
	Day_6	1024	1024	1024	1024	1024	1024

Table 3 Example Weight Factor Table

SAMPLE: Resulting 8 bit PWM output using DID_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See SMDM-REQ-454757 "Interpolation Function" for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in SMDM-REQ-454758 “Seamless / Smooth Transition on Intensity Change”.

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

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_lvl	Night_1	5	8	12	18	26	255
	Night_2	7	10	15	22	33	255
	Night_3	9	14	19	28	40	255
	Night_4	13	18	25	35	49	255
	Night_5	18	24	33	44	60	255
	Night_6	24	32	42	56	74	255
	Night_7	33	42	55	71	91	255
	Night_8	45	56	71	89	112	255
	Night_9	61	74	91	112	138	255
	Night_10	82	99	118	141	169	255
	Night_11	112	131	153	178	208	255
	Night_12	153	174	198	224	255	255

Day_1	255	255	255	255	255	255
Day_2	255	255	255	255	255	255
Day_3	255	255	255	255	255	255
Day_4	255	255	255	255	255	255
Day_5	255	255	255	255	255	255
Day_6	255	255	255	255	255	255

Table 4 Resulting 8 Bit PWM Table

3.2.1.6 10 Bit PWM Display Backlight

3.2.1.6.1 SMDM-REQ-435833/A-Brightness Calibration of Display Backlight and Gauge Pointer

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

Identifier	Default Value	Bytes	Range	Comment, Description
DID_Low_PWM	4	2	0 - 1023	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night" 0 refers to 0% PWM duty cycle (off), 1023 refers to 100 % PWM duty cycle (max intensity)
DID_High_PWM	1023	2	0 - 1023	PWM value for highest brightness e.g.: Dimming_Lvl "Day_6", Litval “Day" 0 refers to 0% PWM duty cycle (off), 1023 refers to 100 % PWM duty cycle (max intensity)

3.2.1.6.2 SMDM-REQ-435834/A-Definition of Weight Factors for 10 Bit PWM (Displays, Gauge Dials and Pointers)

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

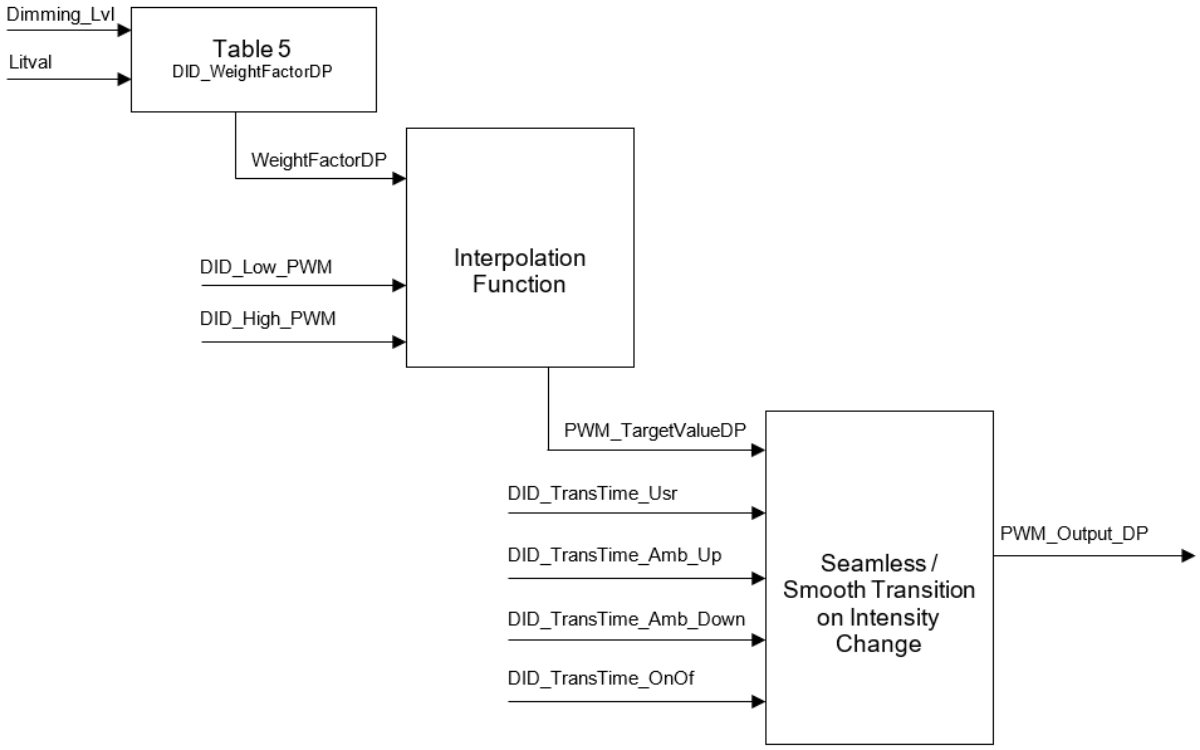
DID_WeightFactorDP:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	2	4	6	9	211
	Night_2	2	3	6	9	12	211
	Night_3	4	6	8	12	17	211
	Night_4	6	9	12	17	23	211
	Night_5	9	12	17	22	30	211
	Night_6	13	17	23	30	39	211
	Night_7	18	23	31	40	51	211
	Night_8	25	32	41	52	66	211
	Night_9	33	43	54	68	85	211
	Night_10	45	57	71	88	110	211
	Night_11	61	75	93	115	141	211
	Night_12	81	99	121	149	181	211
	Day_1	211	227	245	263	283	305
	Day_2	242	266	292	322	354	389
	Day_3	276	311	349	393	441	496
	Day_4	316	363	417	479	550	632
	Day_5	361	424	498	584	686	804
	Day_6	413	495	594	713	854	1024

Table 5 Example 10 Bit Weightfactor Table

3.2.1.6.3 SMDM-REQ-435835/A-Determine the PWM Value for 10 Bit PWM Display Backlight and Pointer PWM

Note: If Dimming_Lvl = 0x0(Off), PWM_TargetValueDP is 0x0.



3.2.1.6.4 SMDM-REQ-435836/A-Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

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

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

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	4.00	5.29	6.99	9.25	12.23	209.00
	Night_2	5.27	6.91	9.07	11.90	15.62	209.00
	Night_3	6.93	9.03	11.76	15.31	19.94	209.00
	Night_4	9.12	11.79	15.24	19.70	25.46	209.00
	Night_5	12.01	15.41	19.76	25.35	32.52	209.00
	Night_6	15.81	20.13	25.62	32.62	41.52	209.00
	Night_7	20.81	26.29	33.22	41.97	53.02	209.00
	Night_8	27.39	34.35	43.07	54.00	67.70	209.00
	Night_9	36.06	44.87	55.83	69.48	86.45	209.00
	Night_10	47.47	58.62	72.39	89.39	110.39	209.00
	Night_11	62.48	76.58	93.85	115.02	140.96	209.00
	Night_12	82.25	100.04	121.68	147.99	180.00	209.00
	Day_1	209.00	224.67	241.51	259.62	279.08	300.00
	Day_2	238.57	262.08	287.90	316.27	347.44	381.68
	Day_3	272.31	305.71	343.20	385.29	432.55	485.59
	Day_4	310.84	356.61	409.13	469.38	538.50	617.80
	Day_5	354.81	415.99	487.71	571.81	670.41	786.00
	Day_6	405.00	485.25	581.40	696.60	834.62	1000.00

Table 6 ARL Example Luminance Table [cd/m²]

Calculation of intensity offset DIDs out of ARL luminance table

DID_Low_PWM =round(1023*(L_min)/(L_max))
Example calculation based on Table 6 ARL Example Luminance Table [cd/m²]:
DID_Low_PWM = round(1023*4/1000) = 4

DID_High_PWM = round(1023*(L_max)/(L_max))
Example calculation based on Table 6 ARL Example Luminance Table [cd/m²]:
DID_High_PWM = round(1023*1000/1000) = 1023

Round: choose the next higher integer if first decimal digit is equal or higher than 5.
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Day_6 and Day.

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

Weightfactor[Dimming_lvl, Litval] =
roundup (1024*(luminance[Dimming_lvl, Litval] - L_min))/(L_max - L_min)

Luminance [Dimming_lvl, Litval] = Luminance value at the table intersection point Dimming_Lvl and Litval
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Day_6 and Day.

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	2	4	6	9	211
	Night_2	2	3	6	9	12	211
	Night_3	4	6	8	12	17	211
	Night_4	6	9	12	17	23	211
	Night_5	9	12	17	22	30	211
	Night_6	13	17	23	30	39	211
	Night_7	18	23	31	40	51	211
	Night_8	25	32	41	52	66	211
	Night_9	33	43	54	68	85	211
	Night_10	45	57	71	88	110	211
	Night_11	61	75	93	115	141	211
	Night_12	81	99	121	149	181	211
	Day_1	211	227	245	263	283	305
	Day_2	242	266	292	322	354	389
	Day_3	276	311	349	393	441	496
	Day_4	316	363	417	479	550	632
	Day_5	361	424	498	584	686	804
	Day_6	413	495	594	713	854	1024

Table 7 Weightfactor Table 10 Bit

SAMPLE: Resulting 10 bit PWM output using DID_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See SMDM-REQ-454757 "Interpolation Function" for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in SMDM-REQ-454758 “Seamless / Smooth Transition on Intensity Change”.

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

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	4	6	8	10	13	214
	Night_2	6	7	10	13	16	214
	Night_3	8	10	12	16	21	214
	Night_4	10	13	16	21	27	214
	Night_5	13	16	21	26	34	214
	Night_6	17	21	27	34	43	214
	Night_7	22	27	35	44	55	214
	Night_8	29	36	45	56	70	214
	Night_9	37	47	58	72	89	214
	Night_10	49	61	75	92	113	214
	Night_11	65	79	97	118	144	214
	Night_12	85	103	124	152	184	214
	Day_1	214	230	248	266	286	308
	Day_2	245	269	295	324	356	391
	Day_3	279	313	351	395	443	498
	Day_4	318	365	419	481	551	633
	Day_5	363	426	500	585	687	804
	Day_6	415	497	595	714	854	1023

Table 8 Resulting PWM Table 10 Bit

3.2.1.7 12 Bit PWM Display Backlight

3.2.1.7.1 SMDM-REQ-435838/A-Brightness Calibration of 12 Bit Illumination Zones

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

Identifier	Default Value	Bytes	Range	Comment, Description
DID_Low_PWM	16	2	0 - 4095	PWM value for lowest brightness e.g.: Dimming_Lvl "Night_1", Litval "Night" 0 refers to 0% PWM duty cycle (off), 4095 refers to 100 % PWM duty cycle (max intensity)
DID_High_PWM	4095	2	0 - 4095	PWM value for highest brightness e.g.: Dimming_Lvl "Day_6", Litval “Day" 0 refers to 0% PWM duty cycle (off), 4095 refers to 100 % PWM duty cycle (max intensity)

3.2.1.7.2 SMDM-REQ-435839/A-Definition of Weight Factors for 12 Bit PWM (Displays, Gauge Dials and Pointers)

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

DID_WeightFactorDP:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	5	11	21	35	649
	Night_2	4	9	17	29	47	649
	Night_3	8	15	25	40	62	649
	Night_4	14	23	36	54	81	649
	Night_5	22	34	50	73	105	649
	Night_6	34	49	69	97	136	649
	Night_7	49	69	94	129	175	649
	Night_8	71	96	128	170	226	649
	Night_9	101	132	172	224	290	649
	Night_10	143	182	231	293	371	649
	Night_11	200	249	309	384	475	649
	Night_12	280	340	413	501	608	649
	Day_1	649	679	710	743	777	813
	Day_2	721	789	862	942	1029	1125
	Day_3	802	916	1045	1193	1362	1555
	Day_4	891	1063	1268	1512	1802	2148
	Day_5	990	1234	1537	1914	2383	2967
	Day_6	1100	1432	1863	2423	3151	4096

Table 9 Example Weightfactor Table 12 Bit

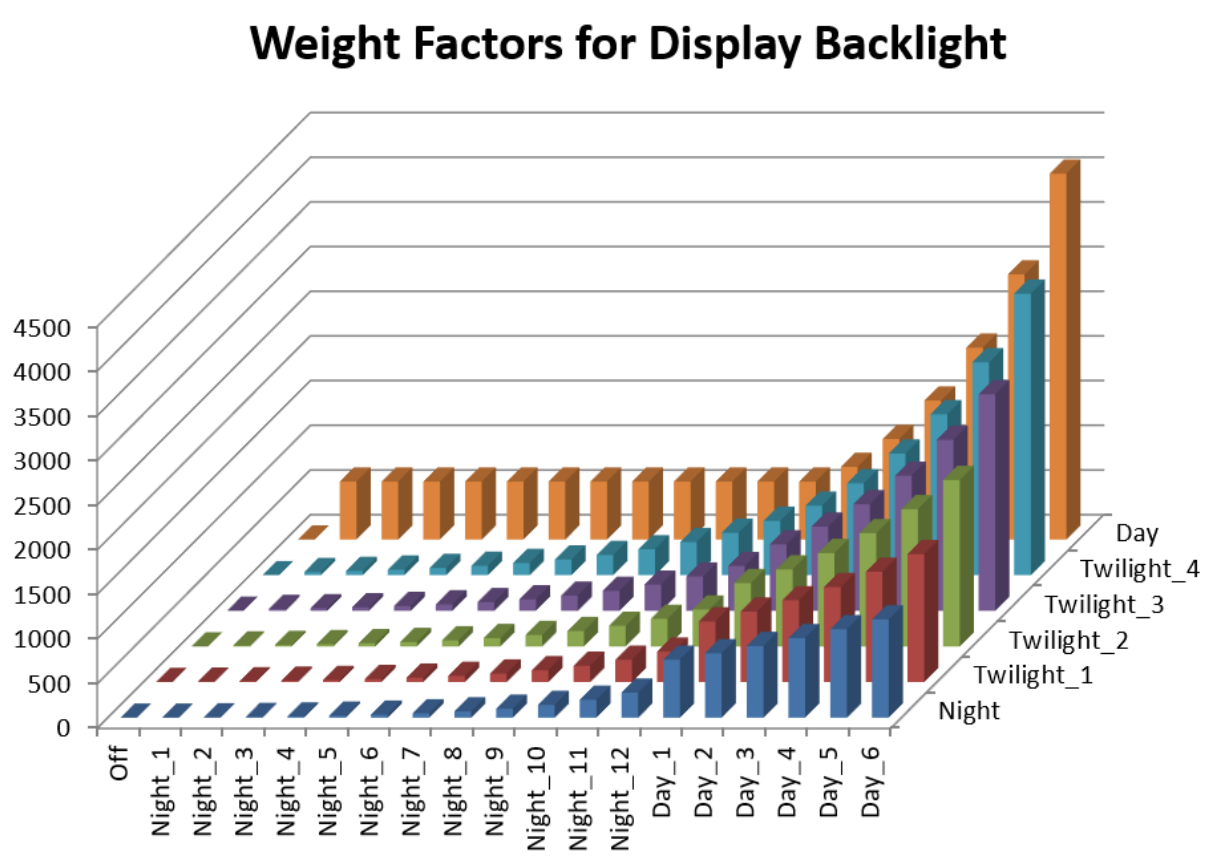
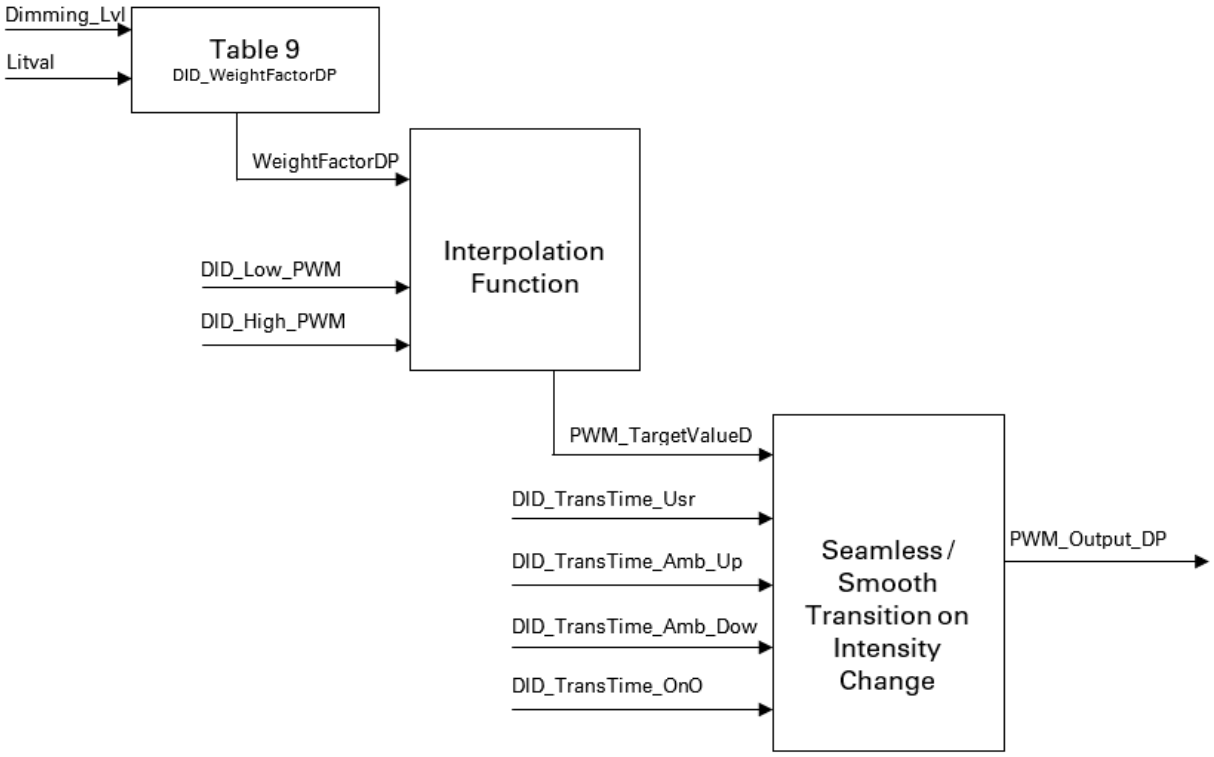


Figure 2

3.2.1.7.3 SMDM-REQ-435840/A-Determine the PWM Value for 12 Bit PWM Display Backlight and Pointer PWM

Note: If Dimming_Lvl = 0x0(Off), PWM_TargetValueDP is 0x0.



3.2.1.7.4 SMDM-REQ-435841/A-Calculation of the WeightFactor table and High and Low DIDs based on candela values from ARL

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

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

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	4.00	5.29	6.99	9.25	12.23	209.00
	Night_2	5.27	6.91	9.07	11.90	15.62	209.00
	Night_3	6.93	9.03	11.76	15.31	19.94	209.00
	Night_4	9.12	11.79	15.24	19.70	25.46	209.00
	Night_5	12.01	15.41	19.76	25.35	32.52	209.00
	Night_6	15.81	20.13	25.62	32.62	41.52	209.00
	Night_7	20.81	26.29	33.22	41.97	53.02	209.00
	Night_8	27.39	34.35	43.07	54.00	67.70	209.00
	Night_9	36.06	44.87	55.83	69.48	86.45	209.00
	Night_10	47.47	58.62	72.39	89.39	110.39	209.00
	Night_11	62.48	76.58	93.85	115.02	140.96	209.00
	Night_12	82.25	100.04	121.68	147.99	180.00	209.00
	Day_1	209.00	224.67	241.51	259.62	279.08	300.00
	Day_2	238.57	262.08	287.90	316.27	347.44	381.68
	Day_3	272.31	305.71	343.20	385.29	432.55	485.59
	Day_4	310.84	356.61	409.13	469.38	538.50	617.80

	Day_5	354.81	415.99	487.71	571.81	670.41	786.00
	Day_6	405.00	485.25	581.40	696.60	834.62	1000.00

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

Calculation of intensity offset DIDs out of ARL luminance table

DID_Low_PWM =round(4095*(L_min)/(L_max))
Example calculation based on Table 10:
DID_Low_PWM = round(4095*4/1000) = 16

DID_High_PWM = round(4095*(L_max)/(L_max))
Example calculation based on Table 10:
DID_High_PWM = round(4095*1000/1000) = 4095

Round: choose the next higher integer if first decimal digit is equal or higher than 5.
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Day_6 and Day.

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

Weightfactor[Dimming_lvl, Litval] =
roundup (4096*(luminance[Dimming_lvl, Litval] - L_min))/(L_max - L_min)

Luminance [Dimming_lvl, Litval] = Luminance value at the table intersection point Dimming_Lvl and Litval
L_min = ARL table field with lowest luminance. Usually the intersection point of Night_1 and Night.
L_max = ARL table field with highest luminance. Usually the intersection point of Day_6 and Day.

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	6	13	22	34	844
	Night_2	6	12	21	33	48	844
	Night_3	13	21	32	47	66	844
	Night_4	22	33	47	65	89	844
	Night_5	33	47	65	88	118	844
	Night_6	49	67	89	118	155	844
	Night_7	70	92	121	157	202	844
	Night_8	97	125	161	206	262	844
	Night_9	132	169	214	270	340	844
	Night_10	179	225	282	352	438	844
	Night_11	241	299	370	457	564	844
	Night_12	322	395	484	593	724	844
	Day_1	844	908	977	1052	1132	1218
	Day_2	965	1062	1168	1285	1413	1554
	Day_3	1104	1241	1395	1569	1763	1981
	Day_4	1262	1451	1667	1914	2199	2525
	Day_5	1443	1695	1990	2336	2741	3216
	Day_6	1650	1980	2375	2849	3416	4096

Table 11 Weightfactor Table 12 Bit

SAMPLE: Resulting 12 bit PWM output using DID_WeightFactorDP and interpolation:

The module supplier is expected to calculate the PWM output based on the interpolation function. See SMDM-REQ-454757 "Interpolation Function" for calculation details. The table below is not a DID and just illustrates the PWM output based on the example values above at a certain dimming step. Intermediate values are calculated during smooth dimming as explained in SMDM-REQ-454758 “Seamless / Smooth Transition on Intensity Change”.

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

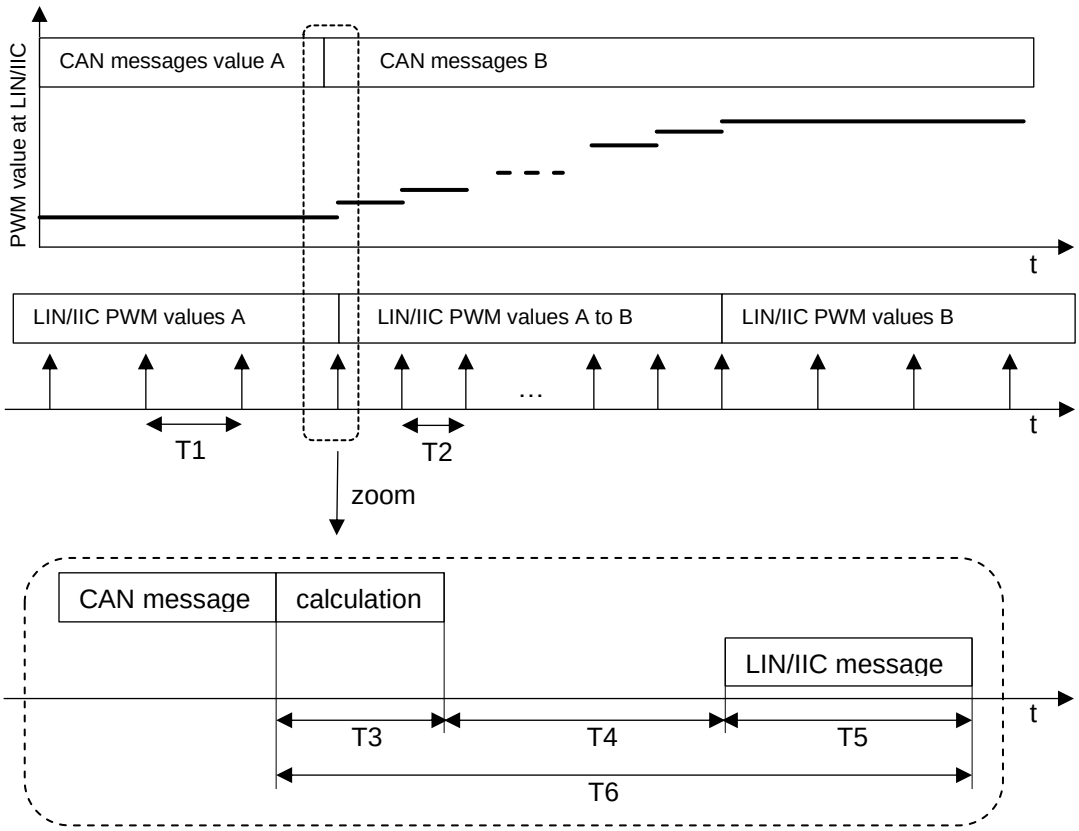
		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	16	22	29	38	50	856
	Night_2	22	28	37	49	64	856
	Night_3	29	37	48	63	82	856
	Night_4	38	49	63	81	105	856
	Night_5	49	63	81	104	134	856
	Night_6	65	83	105	134	170	856
	Night_7	86	108	136	172	217	856
	Night_8	113	140	176	221	277	856
	Night_9	147	184	229	285	355	856
	Night_10	194	240	297	367	452	856
	Night_11	256	314	384	471	578	856
	Night_12	337	409	498	607	737	856
	Day_1	856	920	989	1064	1143	1229
	Day_2	977	1074	1179	1296	1423	1564
	Day_3	1115	1252	1405	1578	1772	1989
	Day_4	1273	1461	1676	1922	2206	2531
	Day_5	1453	1704	1998	2342	2746	3219
	Day_6	1659	1988	2381	2853	3418	4095

Table 12 Resulting PWM Table 12 Bit

3.2.1.8 SMDM-REQ-456681/A-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.



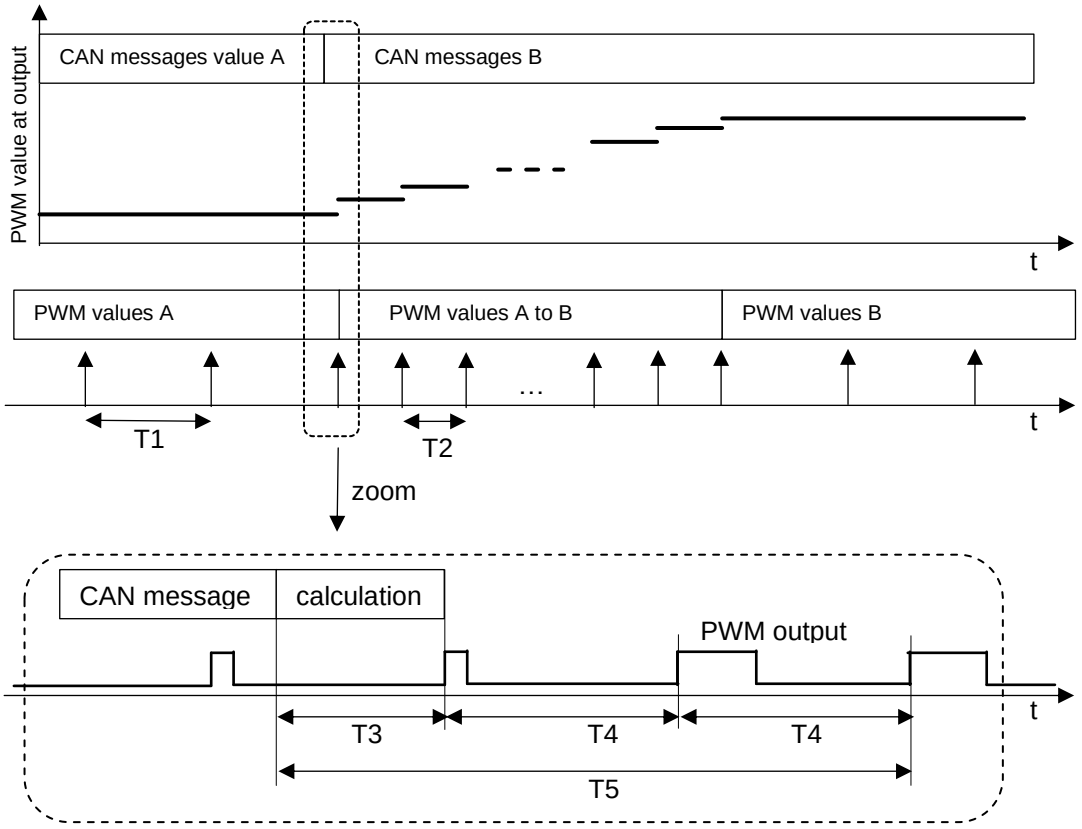
Item	Abbreviation	Description	Max	Unit
1	T1	LIN/IIC cycle time, while no change of PWM value	500	ms
2	T2	LIN/IIC cycle time, while PWM value change	40	ms
3	T3	Calculation time to get new PWM value	5	ms
4	T4	Max time to begin of next LIN/IIC frame	T2	ms
5	T5	Max time to complete a LIN/IIC frame	10	ms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

Note 1: Start measure time after the 3rd interframe bit of CAN message with new PWM value
Stop measure time after first stop bit of check sum at LIN message with new PWM value (T6)
Stop measure time after stop signal at IIC bus with new PWM value (see T6)
Note 2: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

3.2.1.9 SMDM-REQ-459297/A-Maximum Delay from CAN Message to PWM Output

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

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

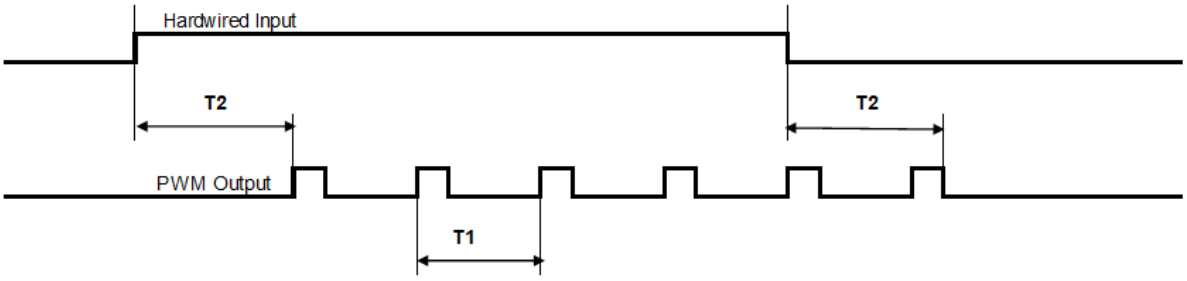


Item	Abbreviation	Description	Max	Unit
1	T1	PWM update time, while no change of PWM value	500	ms
2	T2	PWM update time, while PWM value change	40	ms
3	T3	Calculation time to get new PWM value	NA	ms
4	T4	PWM cycle Time [2]	1 / f_P	ms
5	T5	Max reaction time from CAN to PWM output [1]	25	ms
6	PJ	PWM update 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 (see T5)
Note 2: f_P = PWM output frequency
Note 3: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

3.2.1.10 SMDM-REQ-459298/A-Maximum Delay from Hardwired Indicator Input to PWM Output

The hardwired indicator input is transferred to the PWM square wave. If necessary, the value must be LED bin adjusted and/or adjusted to the supply voltage.

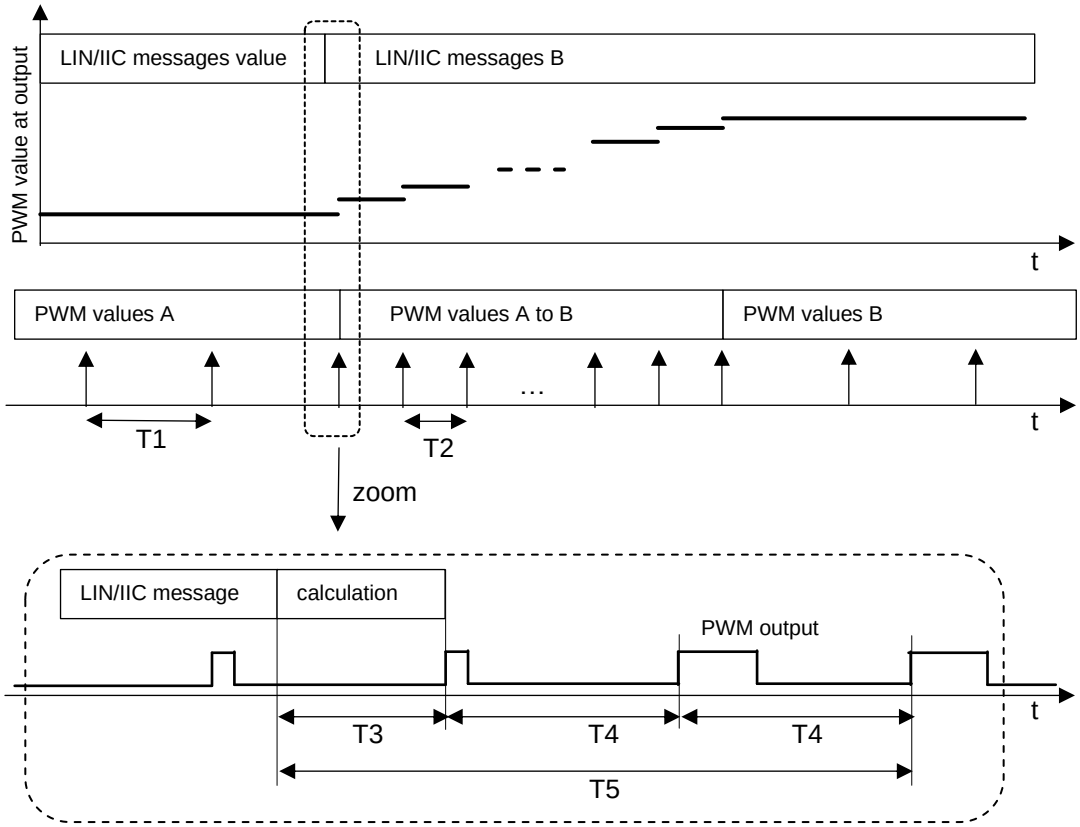


Item	Abbreviation	Description	Max	Unit
2	T1	PWM cycle Time [2]	1 / f_P	ms
3	T2	Max reaction time from hardwired Input to PWM output [1]	50	ms

Note 1: Measure the time from rising edge (turn on) of the input signal to the first rising edge of the PWM output signal. See T2
Measure the time from falling edge (turn off) of the input signal to the last falling edge of the PWM output signal. See T2
Note 2: f_P = PWM output frequency

3.2.1.11 SMDM-REQ-459299/A-Maximum Delay from LIN/IIC Message to PWM Output

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



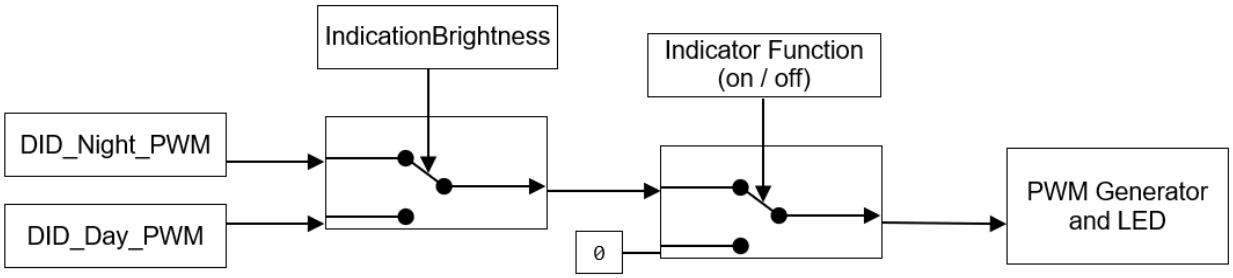
Item	Abbreviation	Description	Max	Unit
1	T1	PWM update time, while no change of PWM value	500	ms
2	T2	PWM update time, while PWM value changes	40	ms
3	T3	Calculation time to get new PWM value	NA	ms
4	T4	PWM cycle Time [2]	1 / f_P	ms
5	T5	Max reaction time from LIN/IIC to PWM output [1]	25	ms
6	PJ	PWM 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 (see T5)
Note 2: f_P = PWM output frequency
Note 3: T2 can be set to 10ms or 20ms. Refer to section 3.1.3 Seamless / Smooth Transition on Intensity Change for additional details.

3.2.2 Telltale and Indicator Dimming

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

3.2.2.1 SMDM-REQ-455481/A-Two-step Dimming



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

Identifier	Default Value	Range	Comment, Description
DID_Night_PWM	23[1)]	0 - 255	PWM value for night time telltale / indicator brightness. 0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle
DID_Day_PWM	255	0 - 255	PWM value for day time telltale / indicator brightness. 0 refers to 0% PWM duty cycle, 255 refers to 100% PWM duty cycle

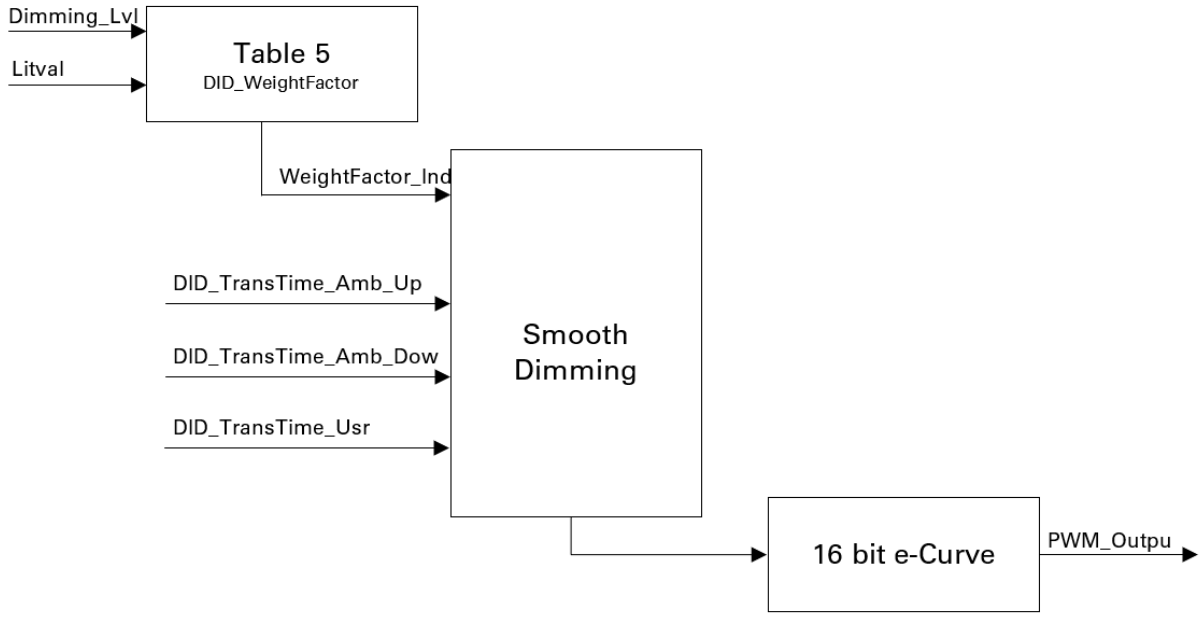
1) If ALS is not present (not recommended), DID_Night_PWM must be adjusted to ensure legibility in all conditions, e.g. bright daytime conditions. The adjustment must be approved by a FORD representative responsible for legibility.

See SMDM-REQ-454725 “Illumination Calibration via DID” for DID calibration details.

3.2.2.2 SMDM-REQ-435842/A-Telltale and Indicator Day / Night Selection

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

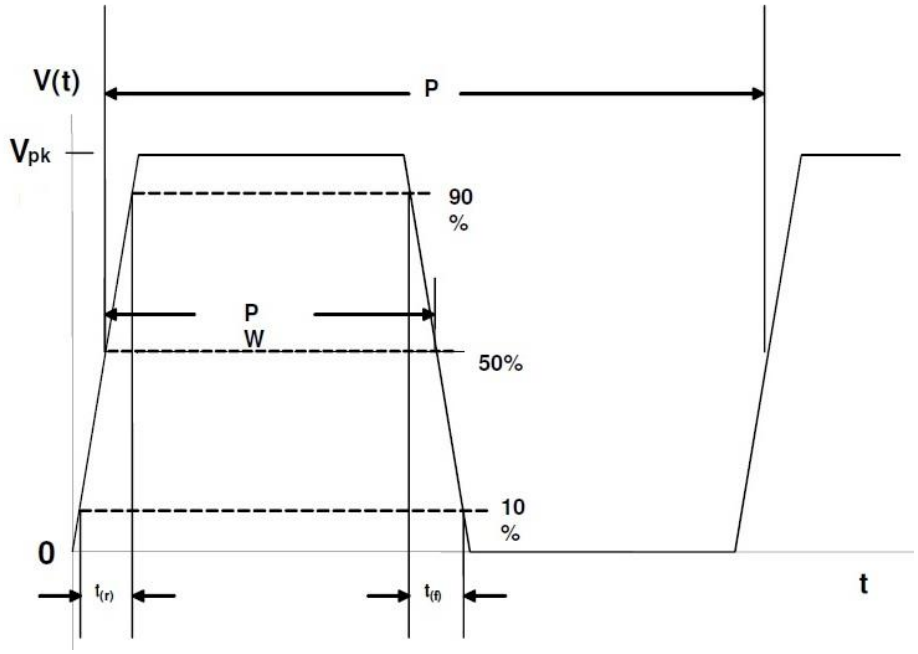
Inputs			Output
Dimming_Lvl	**Day_Night_Status**	**Parklamp_Status**	**IndicationBrightness**
Day_1 .. Day_6	Don't care	Don't care	Day
Night_1 .. Night_12	Don't care	Don't care	Night
Off, (Unknown, Invalid)[1]	Day	Don't care	Day
Off, (Unknown, Invalid)[1]	Night	On	Night
Off, (Unknown, Invalid)[1]	Night	Off	Day
Off, (Unknown, Invalid)[1]	Null, NotUsed	On	Night
Off, (Unknown, Invalid)[1]	Null, NotUsed	Off, (Unknown, Invalid)[1]	Day



3.2.3 PWM Signals

3.2.3.1 SMDM-REQ-455477/A-PWM Signals requirement

Definition of PWM values:



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

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

3.2.3.2 SMDM-REQ-435843/A-PWM Signals at Vehicle Wire harness

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

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

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

Note 2: Output values are measured at the ECU with the PWM output and related to ECU GND.
Note 3: For zones without software voltage compensation
Note 4: For zones with software voltage compensation
Note 5: Time when message is complete at bus to PWM response is measured at ECU PWM output.
Note 6: Time when voltage jump is applied to PWM response is measured at ECU PWM output.
This value is only applicable if software voltage compensation is used.
Note7: Any received PWM duty cycle shall be mapped to the closed available (considering resolution) duty cycle in the receiving ECU.

3.2.3.3 SMDM-REQ-435844/A-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.

3.2.3.4 SMDM-REQ-435845/A-Internal 8-bit PWM Signals

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

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

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.
Note 2: Output values are measured at the related LED(s) related to ECU GND.
Note 3: Vsys is related to control module pins
Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).
Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).
This value is only applicable if software voltage compensation is used.

3.2.3.5 SMDM-REQ-435846/A-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[6]		Hz
2	Frequency jitter	Measured via 1 second sliding window			0.02	Δ %
3	PWM output duty cycle jitter	Measured via 1 second sliding window			0.02	Δ %
4	PWM output duty cycle tolerance total				0.04	Δ %
5	PWM resolution	10 bit or better			1/1023	
6	PWM response time message [4]				21	ms
7	PWM response time voltage [5]				18	ms

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.
Note 2: Output values are measured at the related LED(s) related to ECU GND.
Note 3: Vsys is related to control module pins
Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).
Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).
This value is only applicable if software voltage compensation is used.
Note 6: The PWM update frequency and the display screen update frequency must be chosen in a manner that the differential frequency does not produce visible flicker or other interferences on the screen.

3.2.3.6 SMDM-REQ-435847/A-Internal 12-bit PWM Signals

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

Operating Conditions: [1,2,3] System Voltage: 9.5 < Vsys < 16.0 volts Ambient Temperature: -40oC < Tamb < 85oC						
No	**Characteristic**	**Comment**	**Min**	**Typ**	**Max**	**Unit**
1	PWM Output frequency 1/P		200	300[6]		Hz
2	Frequency jitter	Measured via 1 second sliding window			0.02	Δ %
3	PWM output duty cycle jitter	Measured via 1 second sliding window			0.02	Δ %
4	PWM output duty cycle tolerance total				0.04	Δ %
5	PWM resolution	12 bit or better			1/4095	
6	PWM response time message [4]				21	ms
7	PWM response time voltage [5]				18	ms

Note 1: Specified values are valid for complete range of system voltage and ambient temperature.
Note 2: Output values are measured at the related LED(s) related to ECU GND.
Note 3: Vsys is related to control module pins
Note 4: Time when message is complete at bus to PWM response is measured at the related LED(s).
Note 5: Time when voltage jump is applied to PWM response is measured at the related LED(s).
This value is only applicable if software voltage compensation is used.
Note 6: The PWM update frequency and the display screen update frequency must be chosen in a manner that the differential frequency does not produce visible flicker or other interferences on the screen.

3.2.4 CAN Signals

CAN Signals are found in the Architectural Design Section.

3.2.5 SMDM-REQ-454759/A-Warnings

Every module that needs to indicate / display a warning shall display the warning with the normal calculated illumination intensity if a valid illumination signal is available. A warning shall be displayed with the maximum illumination intensity (Day_6 / Day or Night_12 / Day) if the illumination input is received as OFF or invalid / missing.

3.2.6 SMDM-REQ-454760/A-Network Sleep with Active Illumination

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

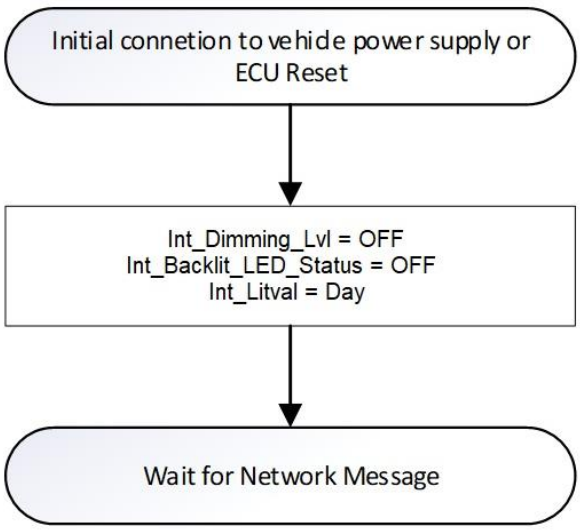
3.2.7 CAN / LIN Error Handling for Illumination specific signals

The signals Dimming_Lvl, Litval and Backlit_LED_Status are real CAN / LIN network signals. The ECU internal variables Dimming_Lvl_Int, Litval_Int and Backlit_LED_Status_Int are derived from the respective real network signals. These variables are used ECU internally instead of the real network signals. The variables are introduced to illustrate the desired ECU internal illumination status including a CAN / LIN network error condition. The variable initialization is allowed on ECU reset or initial connection to the vehicle power supply (e.g. battery exchange) only. The variables must be stored in all other instances (e.g. ignition Off periods or ECU sleep conditions).

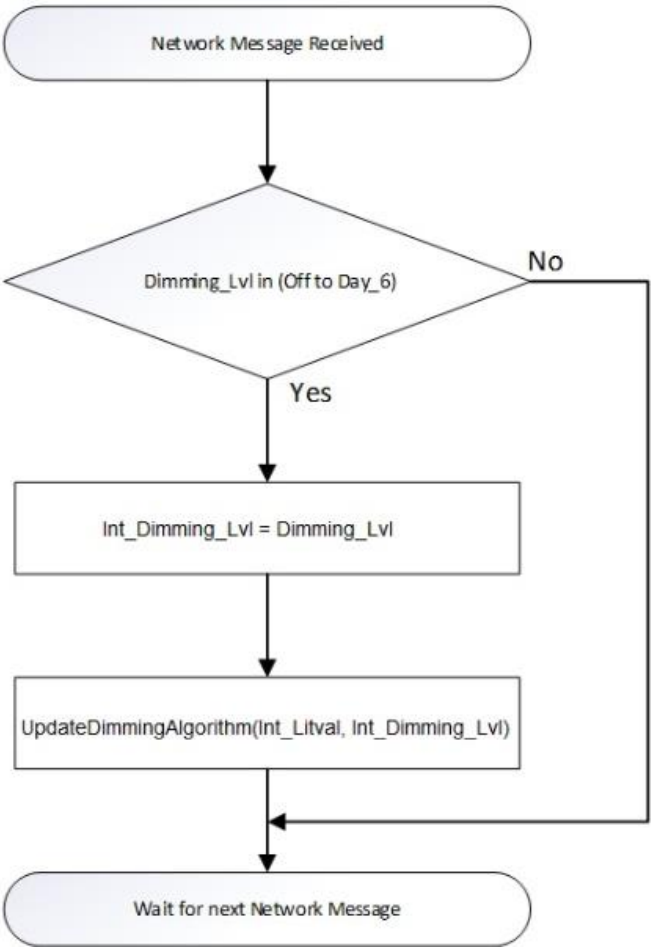
Individual ECUs may require a specific Network-error / extended illumination handling. The individual Network-error / extended illumination handling overrides this general section if defined in the respective ECU relevant section.

Telltale and Indicator handling is described in section SMDM-REQ-455481“Telltale and Indicator Dimming”

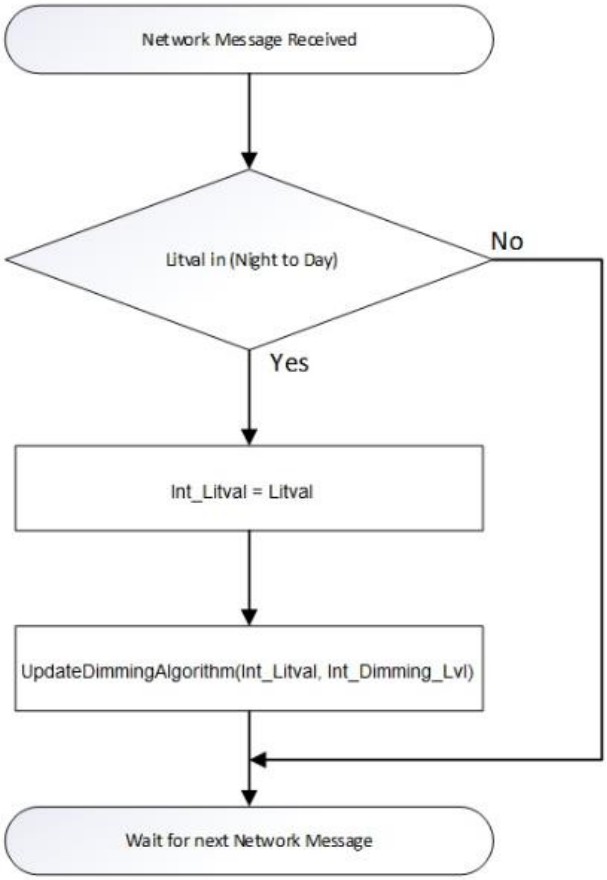
3.2.7.1 SMDM-REQ-435862/A-Initialization on ECU Reset or Initial Connection to Power Supply



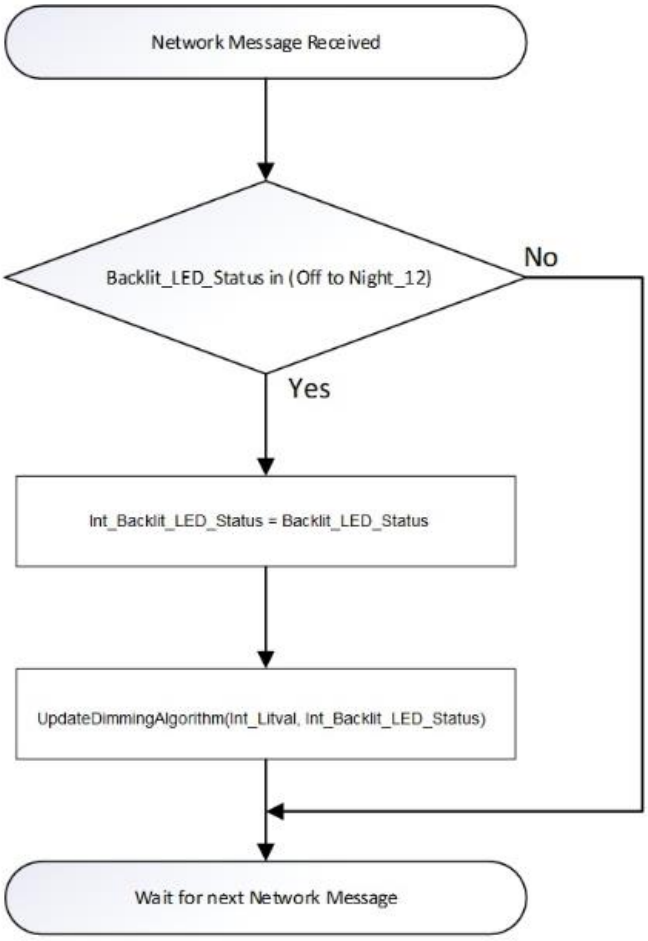
3.2.7.2 SMDM-REQ-435863/A-Dimming_Lvl Error Handling



3.2.7.3 SMDM-REQ-435864/A-Litval Error Handling



3.2.7.4 SMDM-REQ-435865/A-Backlit_LED_Status Error Handling



3.2.8 Soft Dimmer via Onscreen Menu

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

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

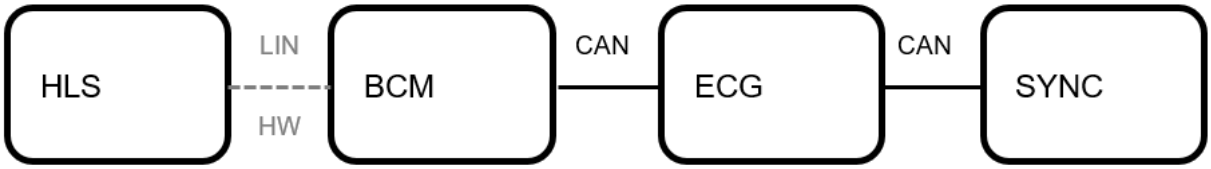
The following executions are possible:

3. Physical dimmer buttons only
4. Soft HMI dimmer via screen menu only
5. Physical dimmer buttons and soft HMI dimmer
6. No user selectable dimmer input (not recommended)

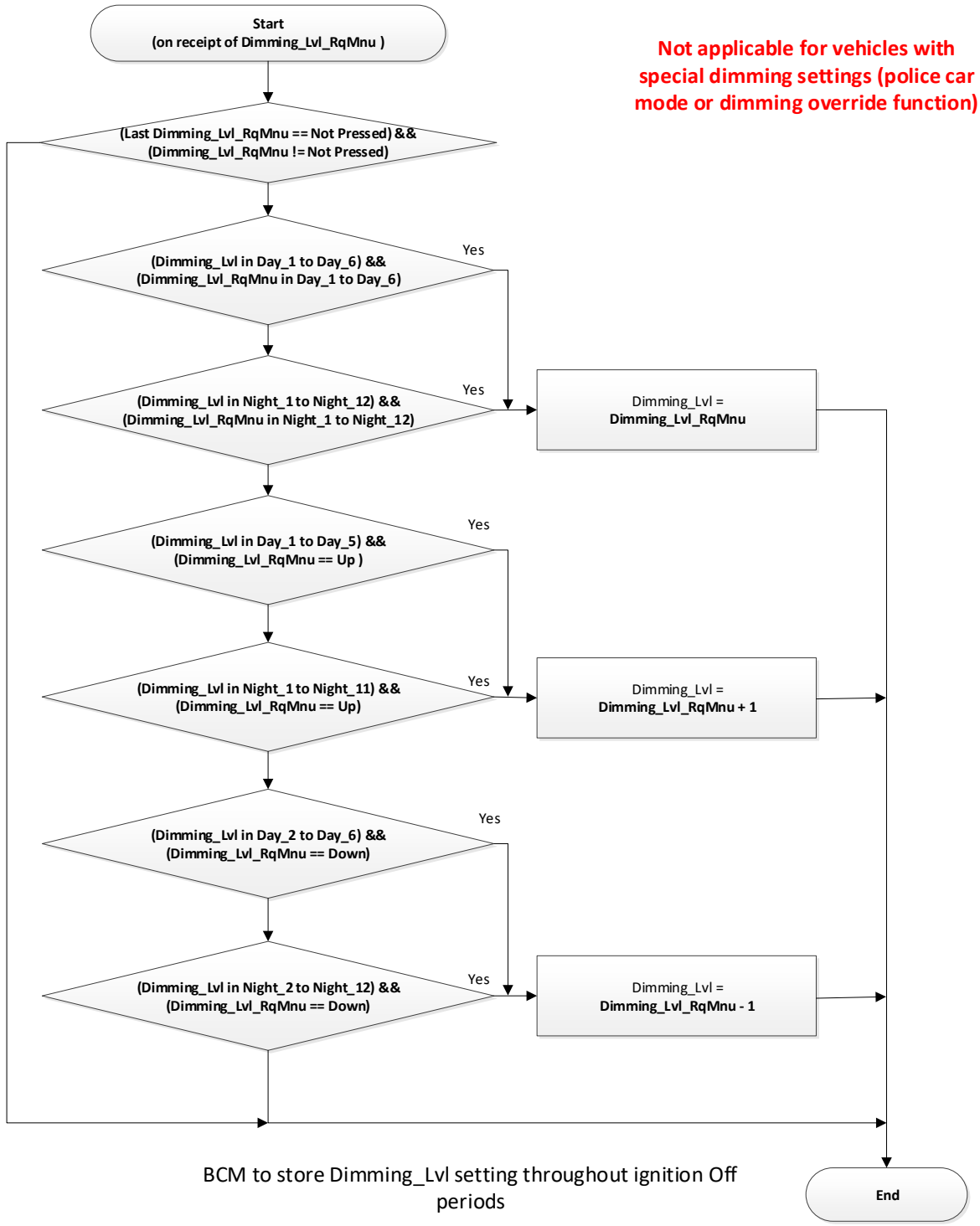
The soft HMI dimmer via

The Carline specific execution needs to be agreed with the Core and Application Function Owner for Cockpit Illumination!

3.2.8.1 Soft HMI Dimmer Interface



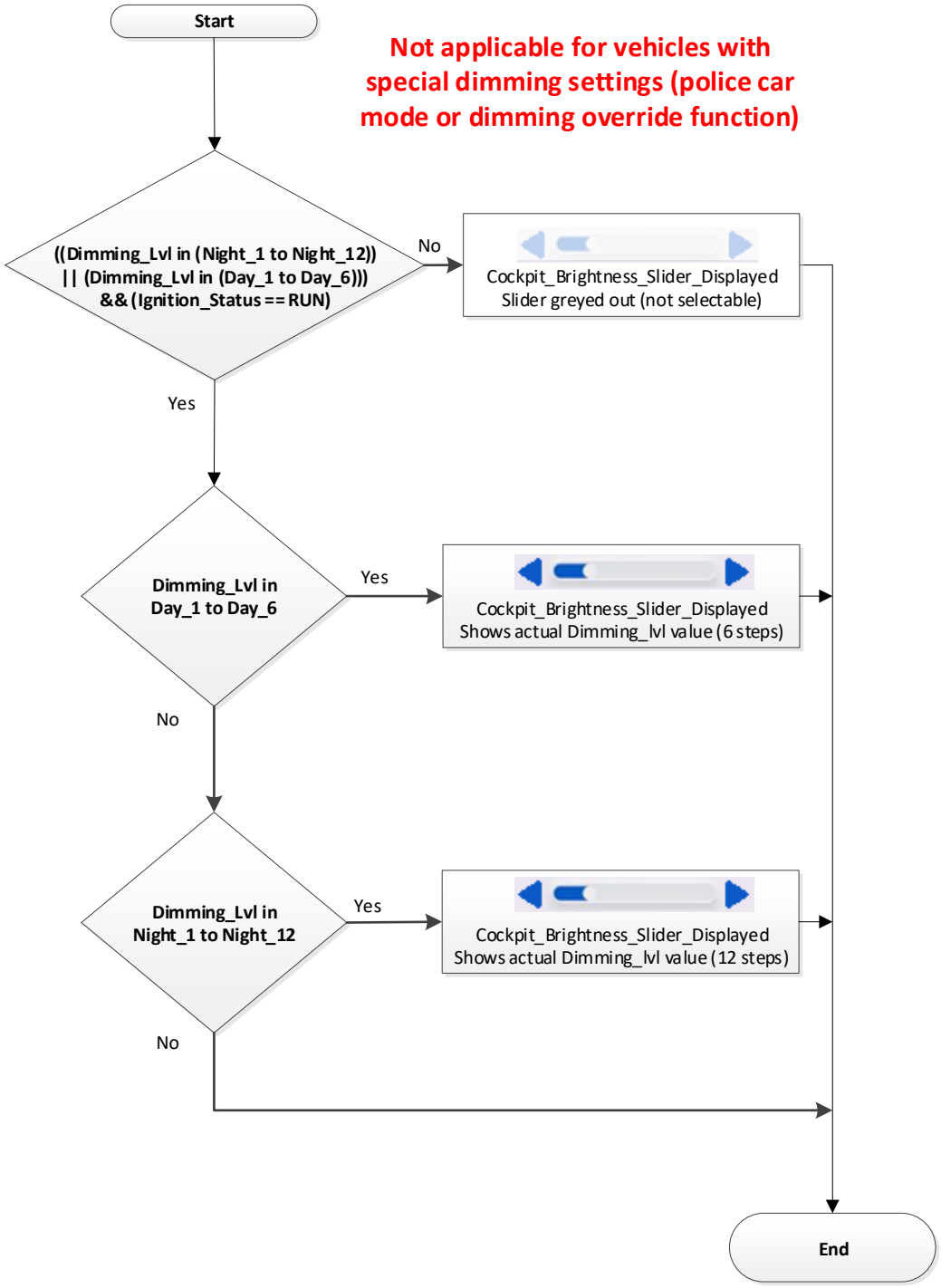
3.2.8.1.1 BCM



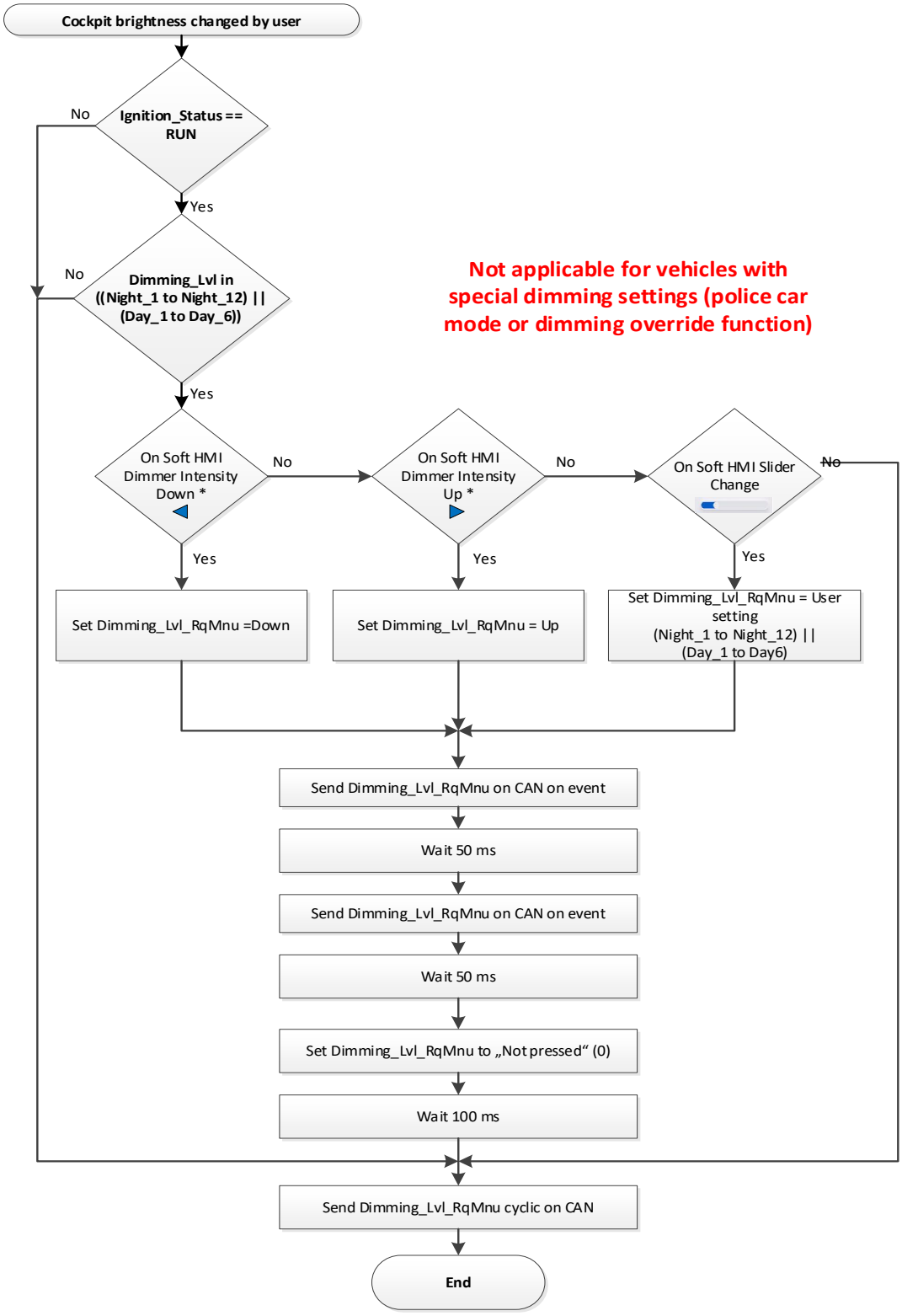
BCM to store Dimming_Lvl setting throughout ignition Off periods

3.2.8.1.2 SYNC / Infotainment

3.2.8.1.2.1 SMDM-REQ-435868/A-Soft HMI Slider Indication



3.2.8.1.2.2 SMDM-REQ-456677/A-Soft HMI Slider Operation



Remarks:

- While 100 ms timer is running and different user inputs are recognized only the last one user input will be processed after the 100 ms.
- Dimming_Lvl_RqMnu cannot be set to OFF by the user. Valid range is Night_1 to Night12 and Day_1 to Day_6

- The default setting is defined by BCM and received via CAN signal Dimming_Lvl
- The dimming slider does not have a reset. Dimming_Lvl signal is the default
- The HMI soft dimmer is configurable present / not-present via DID in the Infotainment ECU.
- The soft HMI dimmer is not selectable / greyed-out if Dimming_Lvl is missing
- Long press dynamic timing behavior is defined by HMI /SYNC in accordance with other HMI elements of the same kind

3.2.8.1.2.3 Dimming Up feature

In some rare cases (sunlight through the rear window) it could happen, that the screen is washed out by the sunlight, if the user selected a low Dimming_Lvl setting. To ensure, the user can operate the system in these cases, a Dimming Up feature has to be implemented. The algorithm is only applicable in night range (Night_1 .. Night_12).

3.2.8.1.2.3.1 REQ-456678/A-Dimming Up feature calibration parameters

The following calibration parameters needs to be supported:

Identifier	Default Value Without Hard Dimmer Buttons	Default Value With Hard Dimmer Buttons	Resolution	Min Value	Max Value	Unit	Remark
DID_Dim_Up_Value	Night_6	Off	1	Off	Night_12	-	Below this threshold the DimmingUp function is active
DID_Dim_Up_Time	5	5	1	0	9	Shifts (see SMDM-REQ-435826)	Time for dimming up
DID_Dim_Down_Time	8	8	1	0	9	Shifts (see SMDM-REQ-435826)	Time for dimming down
DID_Dim_Up_Hold_Time	10	10	1	0	255	Sec.	Time holding the **DimmedUp** state while screen not touched

See SMDM-REQ-454725 for DID calibration details.

3.2.8.1.2.3.2 REQ-456679/A-Dimming Up feature definitions

There are basically 3 states:

a) HighIllumination

In this state the content is visible in any situation. No need to boost the intensity to a higher level. All user inputs at the screen are fed to the HMI control logic. So the user can operate the system by touching the symbols at the screen.

b) DimmedUp

In this state the display is dimmed up from a low level to a level, where all screen control elements are visible in any ambient lighting situation. All user inputs at the screen are fed to the HMI control logic. So the user can operate the system by touching the symbols at the screen.

c) LowIllumination

At this state, there is the potential risk for not visible control elements on the screen. The normal/standard HMI functions are suppressed, to avoid inadvertent activation of control elements, which are not visible.

Definitions:

a) Definition of NightRange(Value):
```
If (Value > Night_12)
  NightRange = Night_12
else if (Value < Night_1)
  NightRange = Night_1
else
  NightRange = Value
```
b) Definition of CameraThresholdNight:
```
at SYNC:      DID_RVC_MinThreshold_Night
at Phoenix:   DID_Camera_MinThreshold_Night
```
c) Definition of ActualDimLvl:
```
If (Camera is active)
  ActualDimLvl = Max(NightRange(Dimming_Lvl + Offset), CameraThresholdNight)
else
  ActualDimLvl = NightRange(Dimming_Lvl + Offset)
```
d) Definition of Brightness_Slider_Area:
```
All HMI control elements for the purpose of adjusting vehicle Dimming_Lvl and/or
display brightness offset. Actual execution:
a) brightness slider with up/down buttons for setting the Dimming_Lvl
b) display brightness offset slider with up/down buttons (-4..0..+4)
```
e) Definition of UserActionActive:
```
During this condition all touch input is processed by HMI logic
```
f) Definition of UserActionDisabled:
```
During this condition touch input is not transmitted to HMI logic
```

Transitions:

a) HighIllumination ➔ LowIllumination:
If (ActualDimLvl < DID_Dim_Up_Value) AND (User don't touch screen)

b) LowIllumination ➔ HighIllumination:
If (ActualDimLvl >= DID_Dim_Up_Value) OR (User enter Brightness_Slider_Area)

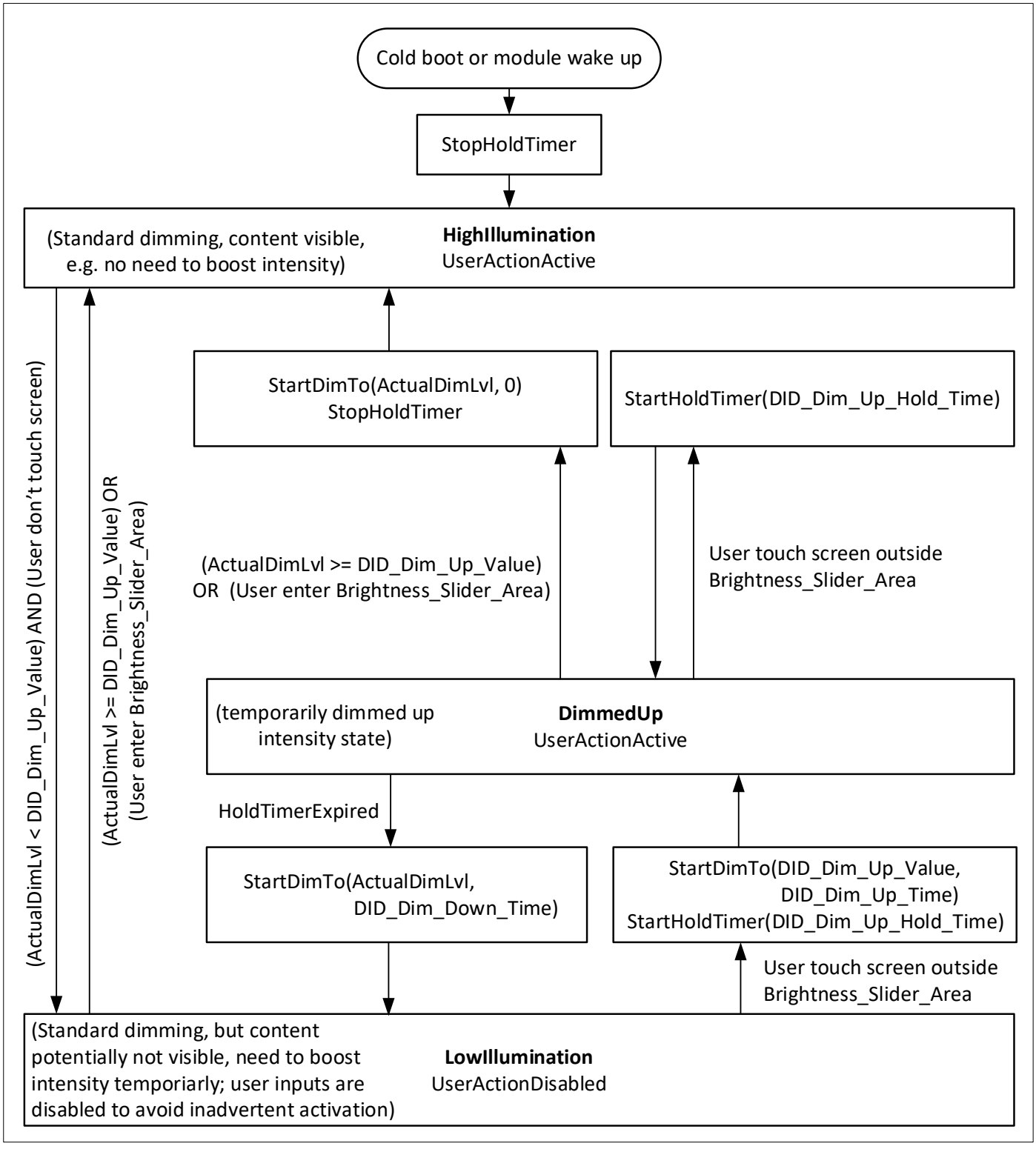
c) LowIllumination ➔ DimmedUp:
If user touch screen outside Brightness_Slider_Area
During transition, DimUp process is started and HoldTimer is started.

d) DimmedUp ➔ LowIllumination:
If HoldTimer is expired
During transition DimDown process is started

e) DimmedUp ➔ DimmedUp:
If user touch screen outside Brightness_Slider_Area
HoldTimer is restarted

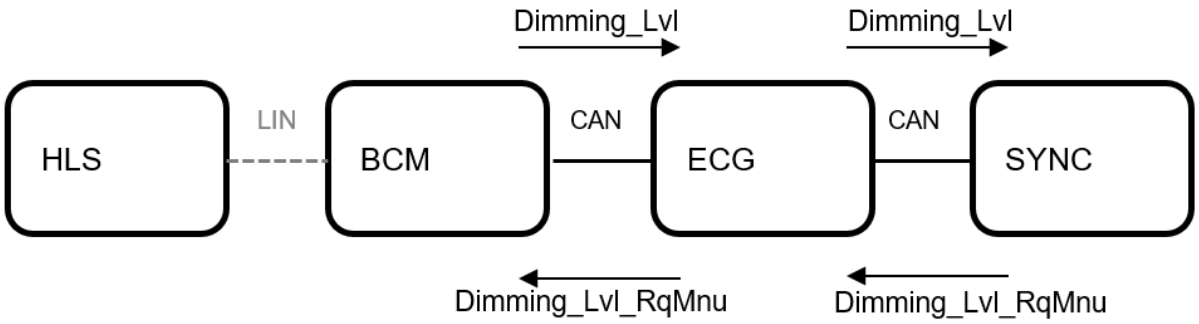
f) DimmedUp ➔ HighIllumination
If (ActualDimLvl >= DID_Dim_Up_Value) OR (User enter Brightness_Slider_Area)
HoldTimer stopped, Dim process started

3.2.8.1.2.3.3 REQ-456680/A-Dimming Up feature state logic



3.2.8.1.2.4 SMDM-REQ-453477/A-ECG

The ECG shall receive the CAN signal Dimming_Lvl_RqMnu on HS3 and distribute the signal on HS1/FD1.



3.3 SMDM-FUN-REQ-435618/A-Display Day / Night Color Palette Selection

3.3.1 REQ-459300/A-Display Day / Night Color Palette Selection Requirement

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

Important note: Any component with a day / night color palette switch is only applicable to vehicles equipped with an ambient light sensor. The ambient light sensor is the main input for the color palette switching. The related CAN signal Litval must support all signal values Night, Twilight_1, Twilight_2, Twilight_3; Twilight_4 and Day.

The Day_Night_Status signal is used for initialization of the logic and missing sensor input detection.
The Litval signal contains the ambient light information. It is the main input to switch between the color sets.

The DID `DID_Threshold_to_Night` defines the value based lower threshold for the night color set trigger.

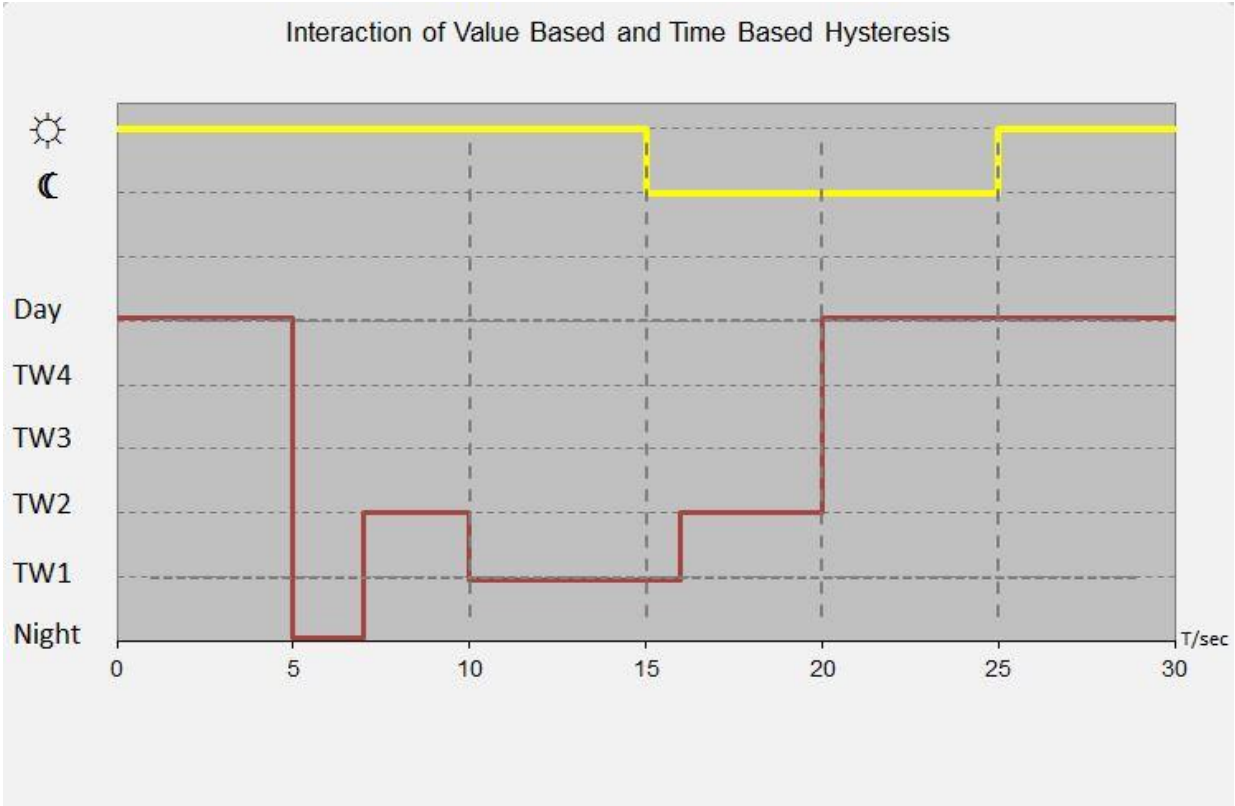
Identifier	Default Value FNA	Default Value ROW	Resolution	Min Value	Max Value	Range
DID_Threshold_to_Night	Twilight_1	Twilight_1	1	Night	Twilight 4	Night to Twilight_4 (0x0 to 0x4)

The DID `DID_DayToNightTime` defines the time based hysteresis to switch from day to night color set.
The DID `DID_NightToDayTime` defines the time based hysteresis to switch from night to night day set.

Identifier	Default Config Value FNA	Default Value Config ROW	Resolution	Min Value	Max Value	Unit
DID_DayToNightTime	10	10	1	0	255	Sec
DID_NightToDayTime	5	5	1	0	255	Sec

See SMDM-REQ-454725 “Illumination Calibration via DID” for DID calibration details.

See below for detailed description



Precondition for this example use case visualization: `DID_Threshold_to_Night = Twilight_1; DID_DayToNightTime = 5 sec; DID_NightToDayTime = 5 sec;`

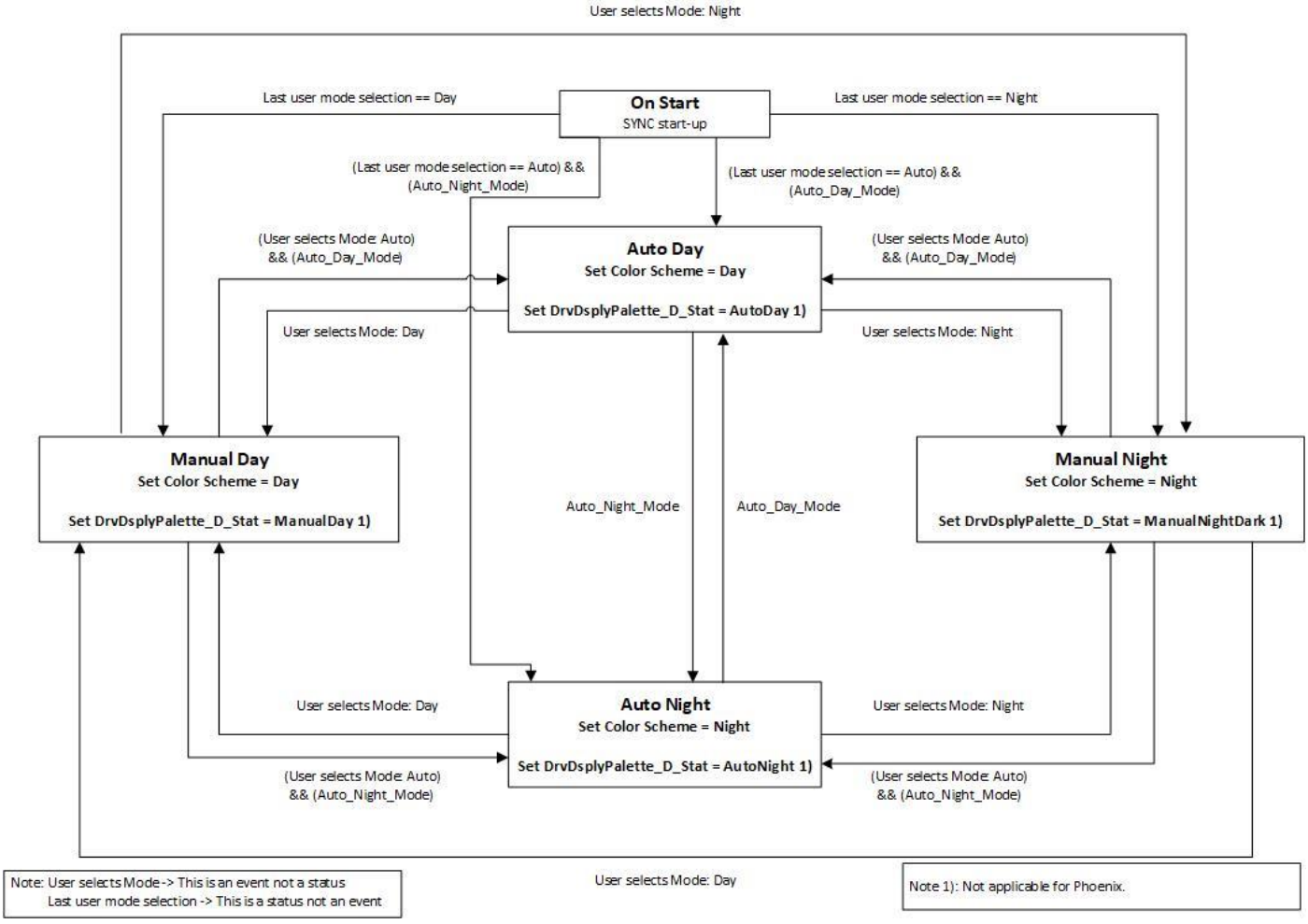
T=0sec:Day color set displayed
T=5sec: Value threshold for night color set reached / undershot; hysteresis timer `DayToNightTime` start; Day color set still displayed
T=7sec: Value threshold for night color set exceeded again; Hysteresis timer `DayToNightTime` stopped and reset; Day color set still displayed
T=10sec: Value threshold for night color set reached; hysteresis timer `DayToNightTime` start; Day color set still displayed
T=15sec: Hysteresis timer `DayToNightTime` elapsed; change from Day to Night color set displayed
T=16sec: No threshold relevant event; No change
T=20sec: Value threshold for day color set reached; hysteresis timer `NightToDayTime` start; Night color set still displayed
T=25 sec: Hysteresis timer `NightToDayTime` elapsed; change from Night to Day color set displayed

3.3.2 SMDM-REQ-435648/A-SYNC Screen Display:

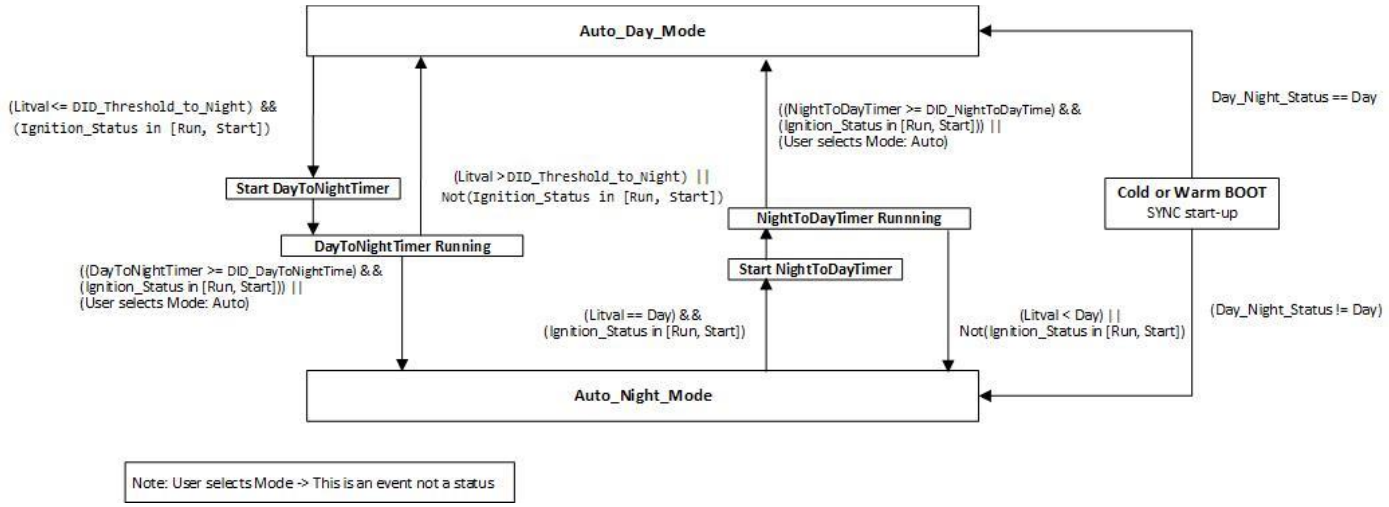
The Sync screen supports 4 states, which are ManualDay, ManualNight, AutoDay and AutoNight. If the user selects mode AUTO and the Auto_Mode state is Auto_Day_Mode then the state is AutoDay. If the user selects mode AUTO and the Auto_Mode state is Auto_Night_Mode then the state is AutoNight.
If the user selects mode AUTO, the state machine which defines Auto_Mode must be updated first.

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

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


User selects Mode: Night
Last user mode selection == Day
On Start
SYNC start-up
Last user mode selection == Night
(Last user mode selection == Auto) && (Auto_Night_Mode)
(Last user mode selection == Auto) && (Auto_Day_Mode)
(User selects Mode: Auto) && (Auto_Day_Mode)
Auto Day
Set Color Scheme = Day
Set DrvDsplyPalette_D_Stat = AutoDay 1)
(User selects Mode: Auto) && (Auto_Day_Mode)
User selects Mode: Day
User selects Mode: Night
Manual Day
Set Color Scheme = Day
Set DrvDsplyPalette_D_Stat = ManualDay 1)
Auto_Night_Mode
Auto_Day_Mode
Manual Night
Set Color Scheme = Night
Set DrvDsplyPalette_D_Stat = ManualNightDark 1)
User selects Mode: Day
Auto Night
Set Color Scheme = Night
Set DrvDsplyPalette_D_Stat = AutoNight 1)
User selects Mode: Night
(User selects Mode: Auto) && (Auto_Night_Mode)
(User selects Mode: Auto) && (Auto_Night_Mode)
Note: User selects Mode -> This is an event not a status
Last user mode selection -> This is a status not an event
User selects Mode: Day
Note 1): Not applicable for Phoenix.

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



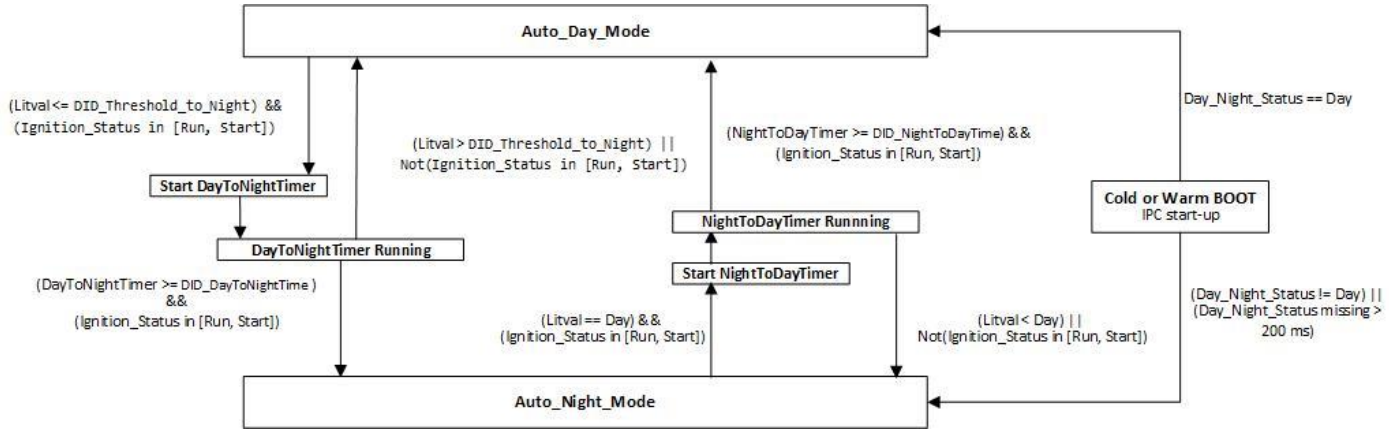
3.3.3 SMDM-REQ-435649/A-Digital Instrument Panel Cluster

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

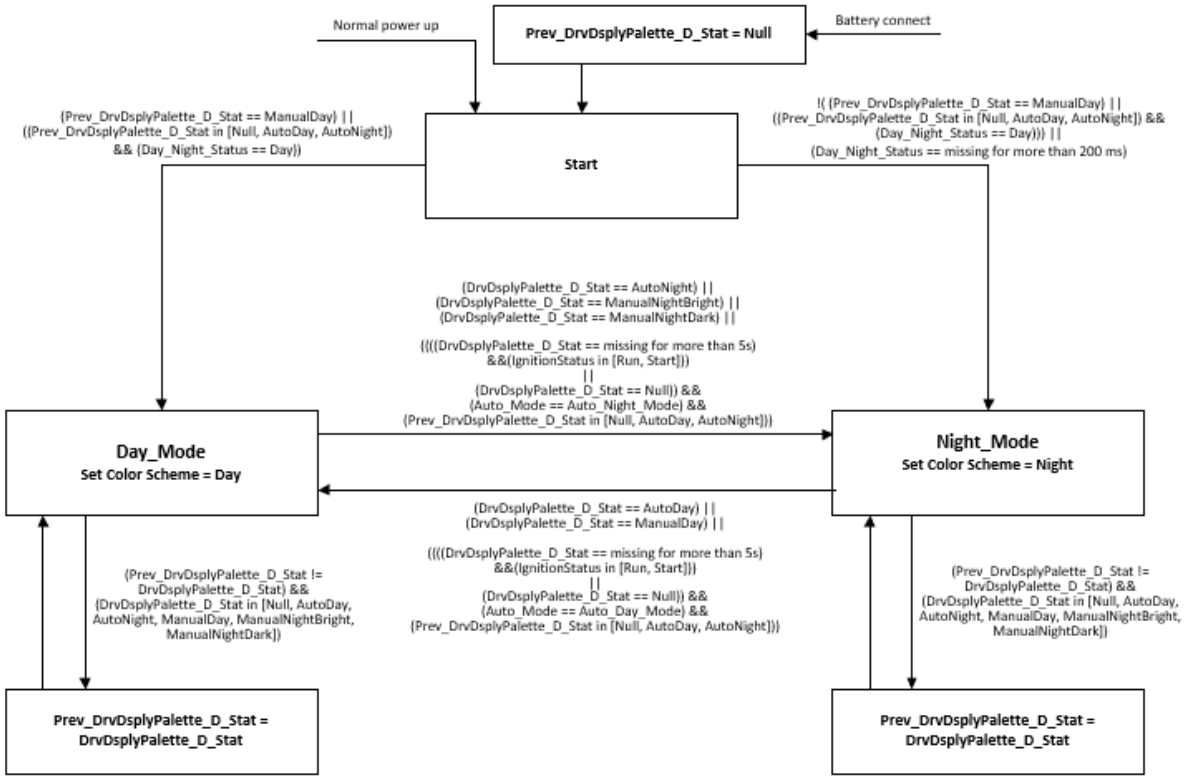
The CAN Signal being transmitted is called DrvDsplyPalette_D_Stat and it consists of 4 independent states: ManualNight (ManualNightBright and ManualNightDark), ManualDay, AutoDay and AutoNight. If the Litval signal is equal to day and user selects Auto Mode, we switch to AutoDay and similarly if Litval signal is less than or equal to DID_Threshold_to_Night (which is Twilight_1) and user selects Auto Mode, we switch to AutoNight. If the user selects Day Mode, we switch to ManualDay and similarly if the user selects Night Mode, we switch to ManualNight, regardless of litval.

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

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



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



3.4 SMDM-FUN-REQ-435621/A-Extended Illumination

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

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

3.4.1 Sources Of Extended Illumination Requests

3.4.1.1 SMDM-REQ-454762/A-HMI Request

The infotainment module (APIM) shall set signal HMI_HMIMode_St = 0x2 (On) whenever illumination of the display or control (FCIM / FCIMB etc.) is needed.

If HMI_HMIMode_St is 0x2 (On), display and button illumination will be turned on.

3.4.1.2 SMDM-REQ-454763/A-OTA Request

The Over The Air update feature (OTA) may request extended illumination. The OTA feature must ensure that:

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

If OTA_Illum_Rq is 0x1 (On), display illumination will be turned on.

3.4.1.3 SMDM-REQ-454764/A-CEA Request

The Clear Exit Assist feature (CEA) may request extended illumination.

There are currently two signals under investigation to be used for illumination request:

a) CAN signal ClrExitAsstActv_B_Rq == Active

b) CAN signal ClrExitAsstMsgTxt2_D_Rq > 0

At the DCR it will be clarified, which signal shall be used to request illumination. This will be fixed in the next release of this spec.

3.4.1.4 SMDM-REQ-454765/A-IPC Request

The Instrument Panel Cluster (IPC) may request extended illumination.

The IPC shall set the internal signal

a) IPC_Illum_Rq = 0x1 (On) for illumination request.

b) IPC_Illum_Rq = 0x0 (Off) for no illumination request.

If IPC_Illum_Rq is 0x1 (On), display illumination will be turned on.

3.4.1.5 SMDM-REQ-454766/A-RSOA Request

The rear seat occupant alert (RSOA) feature may request extended illumination.

The signal and condition, to request illumination for the RSOA feature will be defined in the related DCR. This item will be updated in next release of this spec.

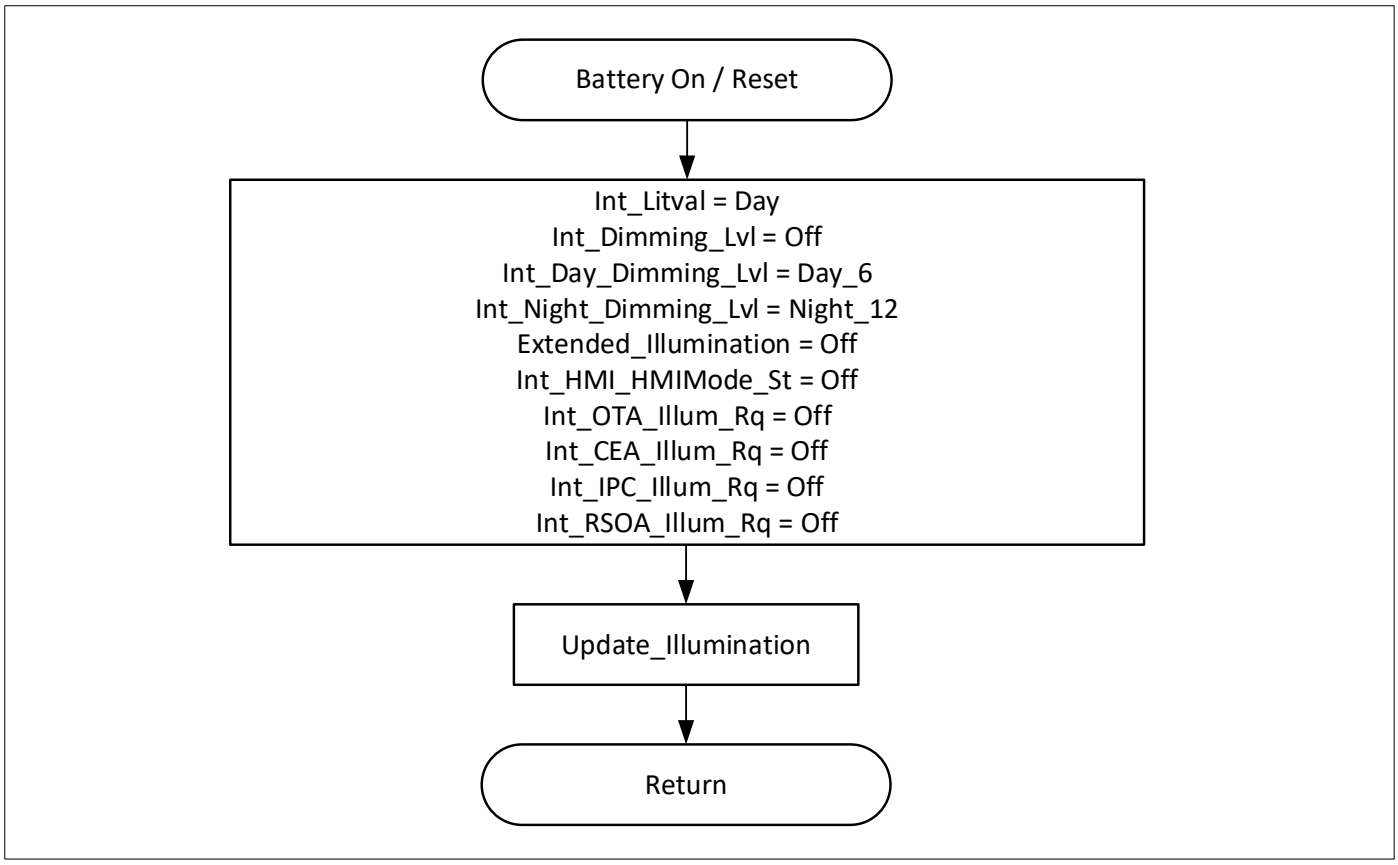
3.4.2 Flow Charts For Extended Illumination Requests

3.4.2.1 SMDM-REQ-455417/A-Extended Illumination Variable Definition

Int_Litval is the last valid signal derived from CAN signal Litval.
Int_Dimming_Lvl is the last valid signal derived from CAN signal Dimming_Lvl.
Int_Day_Dimming_Lvl is the last valid day signal derived from CAN signal Dimming_Lvl.
Int_Night_Dimming_Lvl is the last valid night signal derived from CAN signal Dimming_Lvl.
The variable Int_HMI_HMIMode_St is derived from CAN signal HMI_HMIMode_St.
The variable Int_OTA_Illum_Rq is derived from the internal signal OTA_Illum_Rq.
The variable Int_CEA_Illum_Rq is derived from the **tbd** signal.
The variable Int_IPC_Illum_Rq is derived from the internal signal IPC_Illum_Rq.
The variable Int_RSOA_Illum_Rq is derived from the **tbd** signal.
The variable Extended_Illumiantion is calculated from the above 4 variables. If one of them is ON, extended Illumination is active.

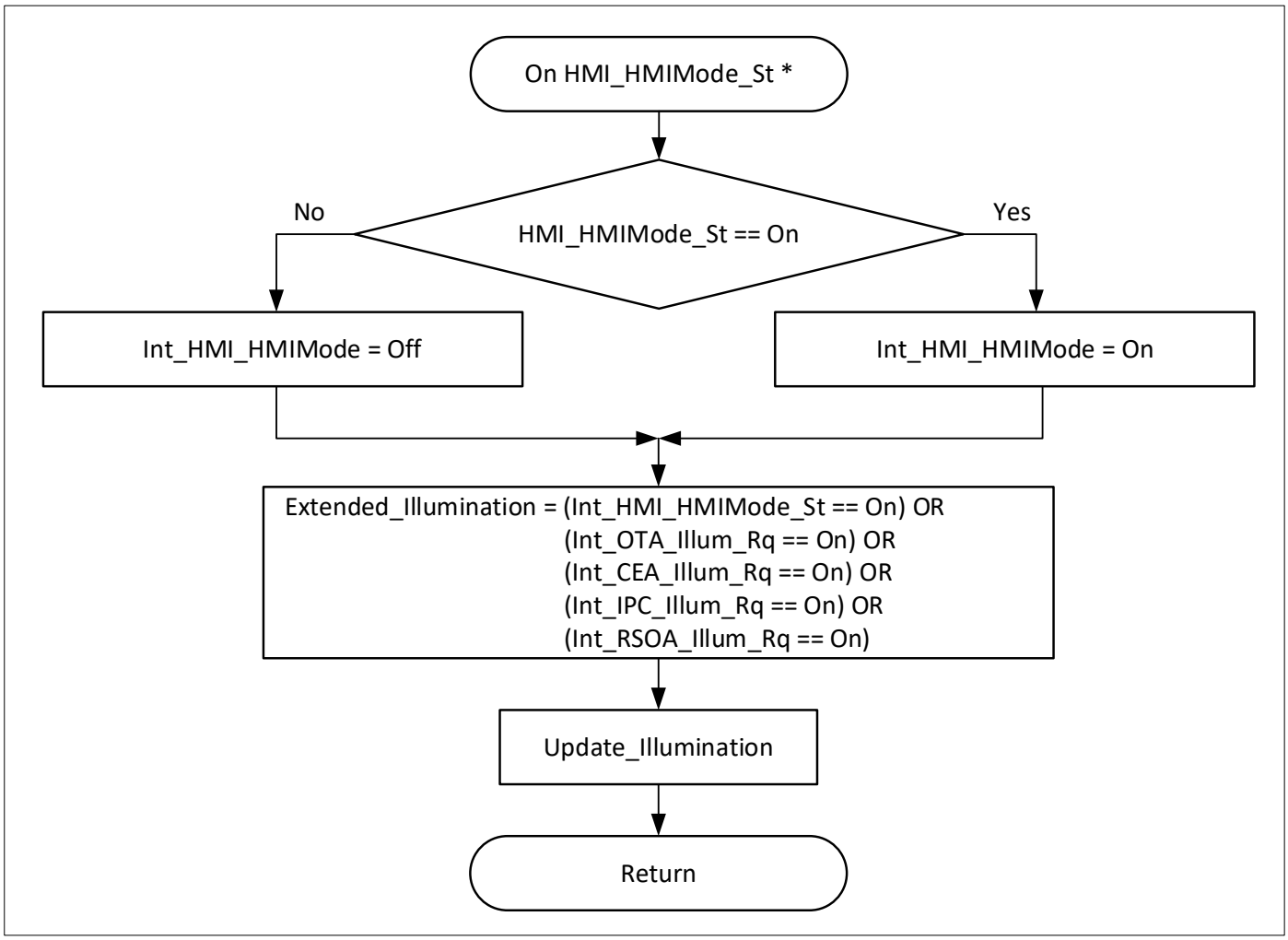
3.4.2.2 SMDM-REQ-455418/A-Initialization

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



3.4.2.3 SMDM-REQ-455419/A-Extended Illumination Request From HMI

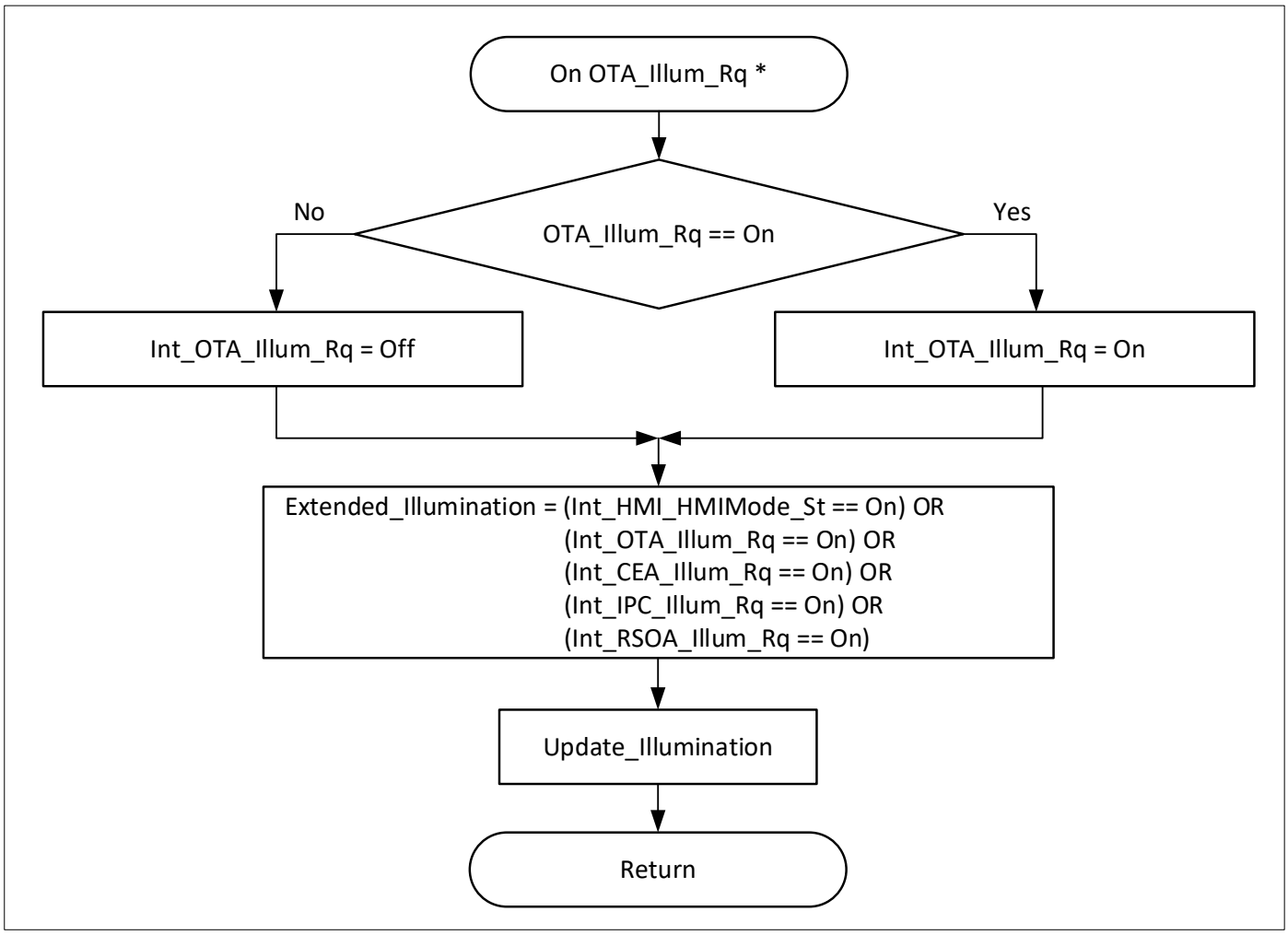
The variable Int_HMI_HMIMode_St is derived from the CAN signal HMI_HMIMode_St.



3.4.2.4 SMDM-REQ-455420/A-Extended Illumination Request From OTA

The variable Int_OTA_Illum_Rq is derived from internal signal OTA_Illum_Rq.

This sub chapter needs only be implemented, it OTA messages are shown on the screen of the dedicated device. If not implemented, let the variable `Int_OTA_Illum_Rq` at its initialized value.

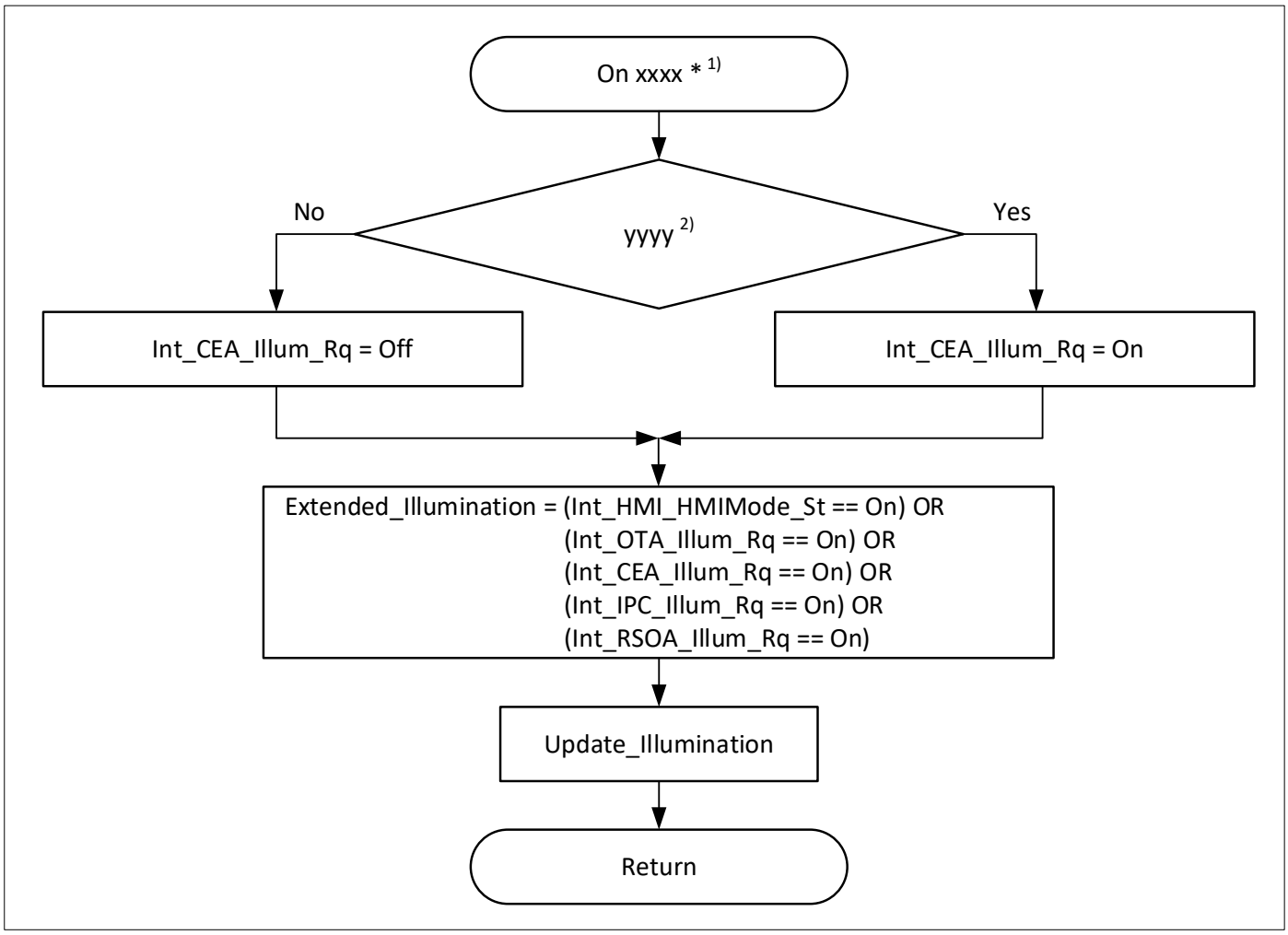


*) Execute when signal is received or changed

3.4.2.5 SMDM-REQ-455421/A-Extended Illumination Request From CEA

The variable Int_CEA_Illum_Rq is derived from the CAN signal xxxx.

This sub chapter needs only be implemented, it CEA messages are shown on the screen of the dedicated device. If not implemented, let the variable `Int_CEA_Illum_Rq` at its initialized value.



*) Execute when signal is received or changed

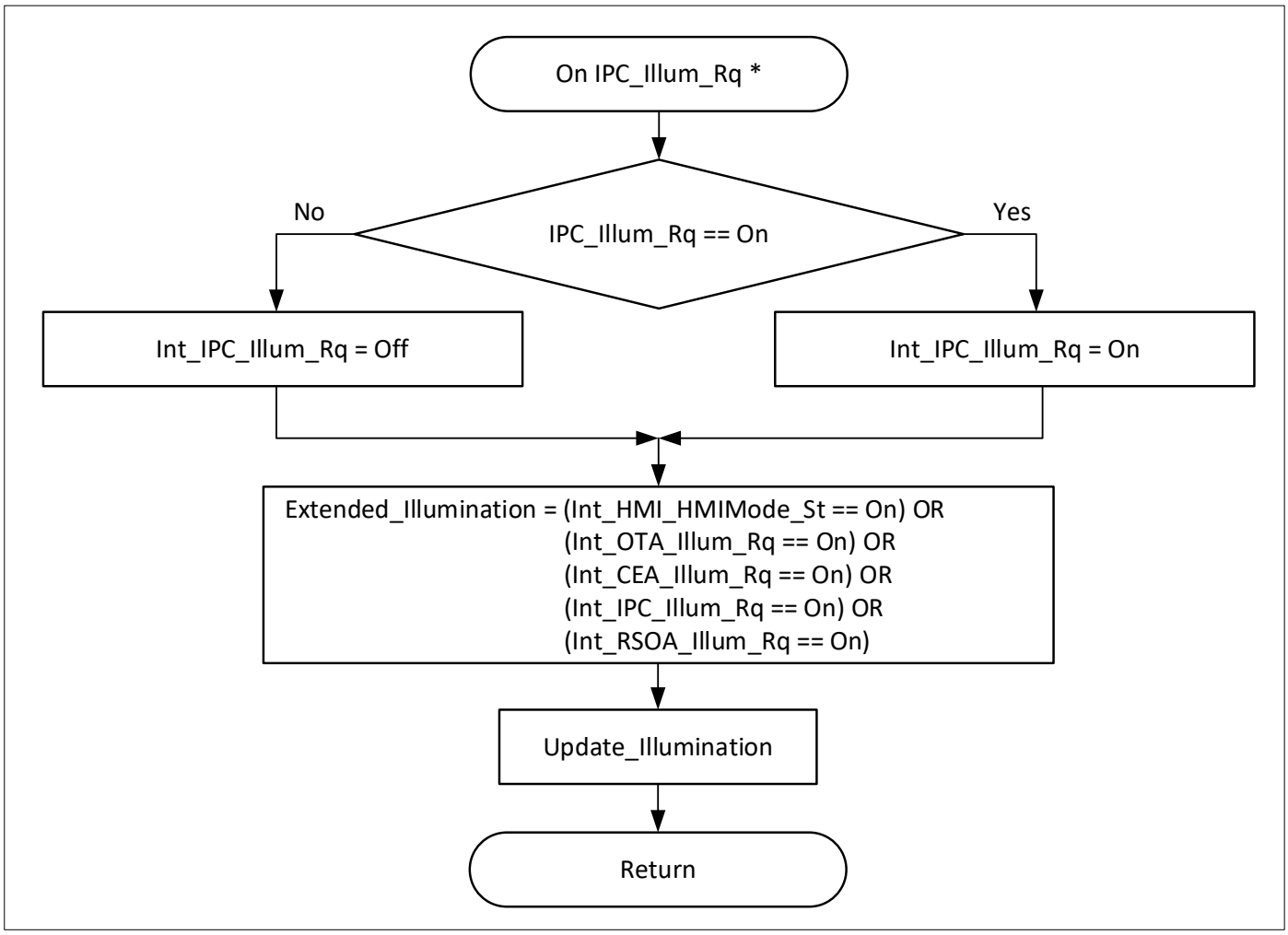
1) Insert the signal which was defined for CEA illumination request – see SMDM-REQ-454764

2) Insert signal and it's condition for illumination request "On" – see SMDM-REQ-454764

3.4.2.6 SMDM-REQ-455422/A-Extended Illumination Request From IPC

The variable Int_IPC_Illum_Rq is derived from the internal signal IPC_Illum_Rq.

This sub chapter needs only be implemented on APIM/SYNC/Phoenix systems, which control the brightness of the cluster (IPC) screen. If not implemented, let the variable `Int_IPC_Illum_Rq` at its initialized value.

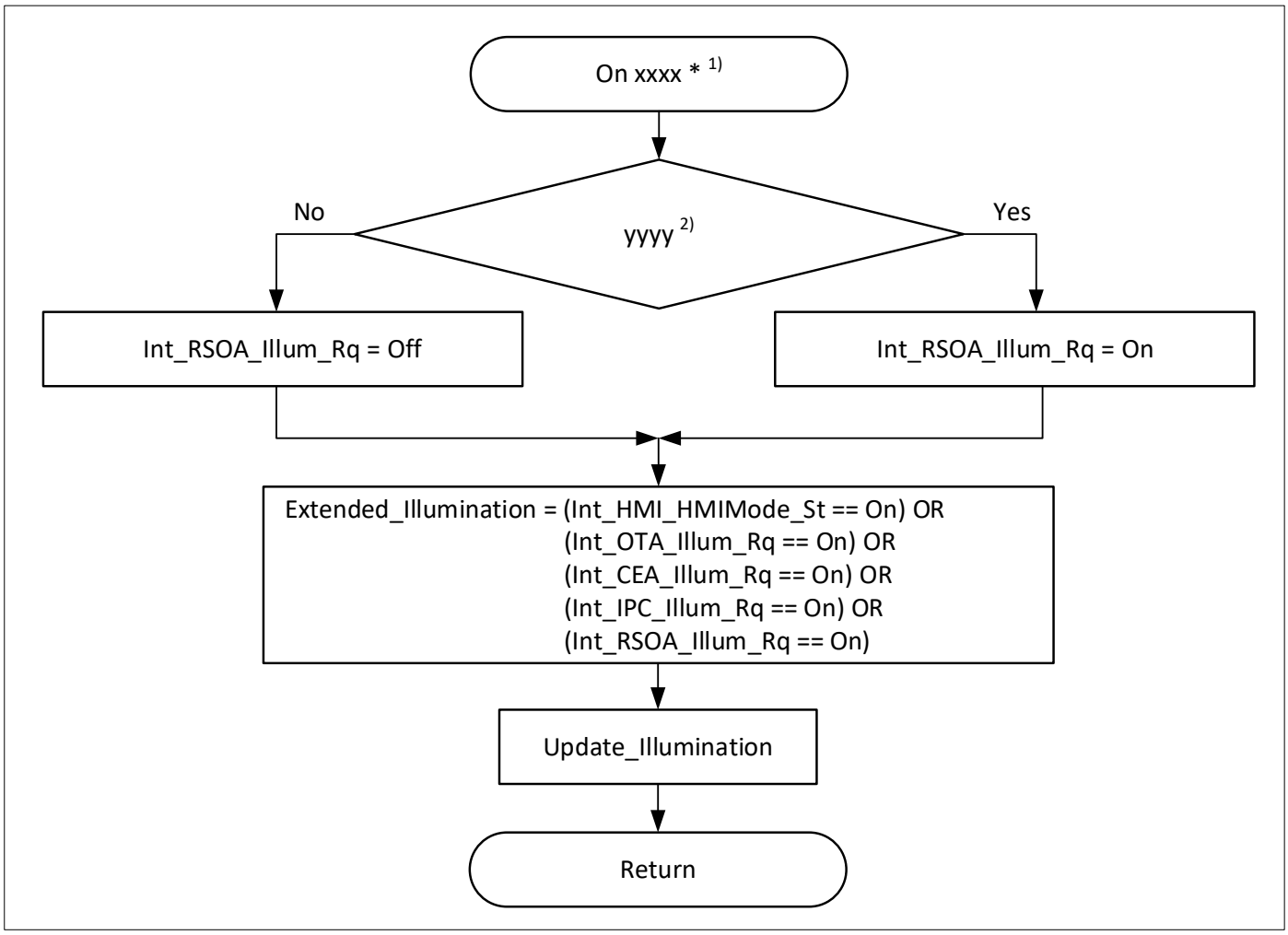


*) Execute when signal is received or changed

3.4.2.7 SMDM-REQ-455423/A-Extended Illumination Request From RSOA

The variable Int_RSOA_Illum_Rq is derived from the CAN signal xxxx.

This sub chapter needs only be implemented, it CEA messages are shown on the screen of the dedicated device. If not implemented, let the variable `Int_RSOA_Illum_Rq` at its initialized value.



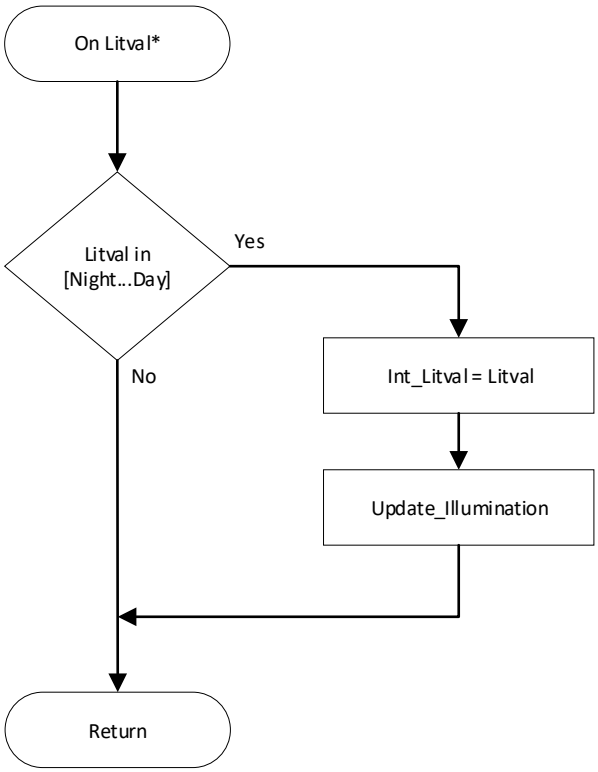
*) Execute when signal is received or changed

1) Insert the signal which was defined for RSOA illumination request – see SMDM-REQ-454766

2) Insert signal and it's condition for illumination request "On" – see SMDM-REQ-454766

3.4.2.8 SMDM-REQ-455424/A-Int_Litval Variable Definition

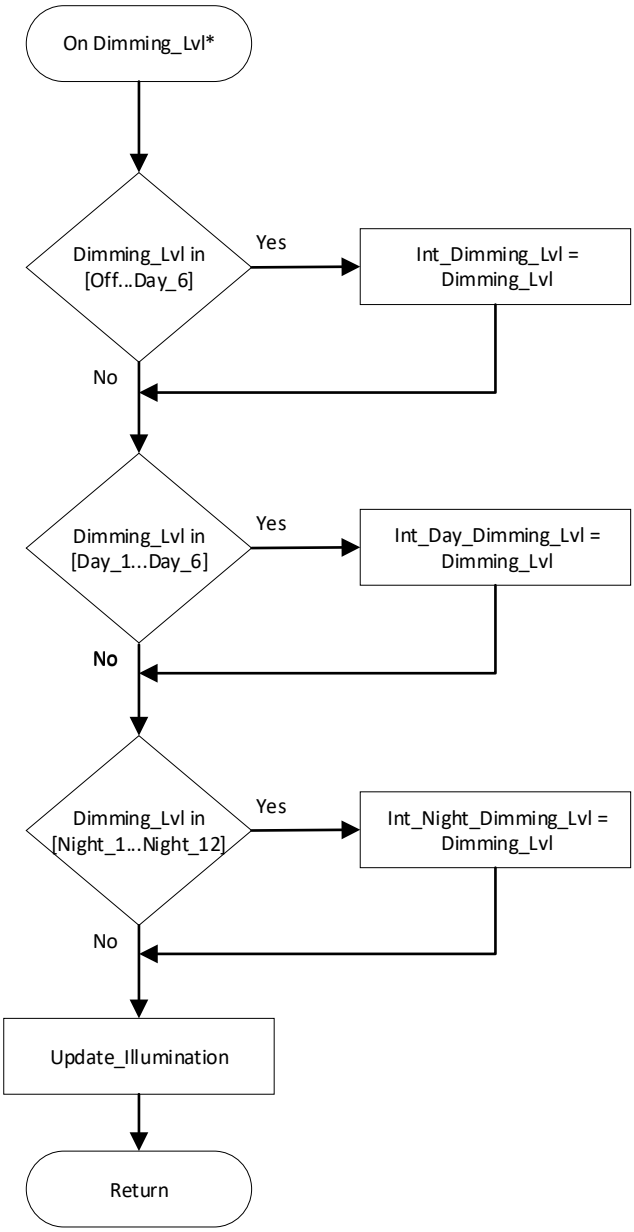
The variable Int_Litval is derived from CAN signal Litval



*) Execute when signal is received or changed

3.4.2.9 SMDM-REQ-455425/A-Int_Dimming_Lvl Variable Definition

The variables Int_Dimming_Lvl, Int_Day_Dimming_Lvl and Int_Night_Dimming_Lvl are derived from CAN signal Dimming_Lvl



*) Execute when signal is received or changed

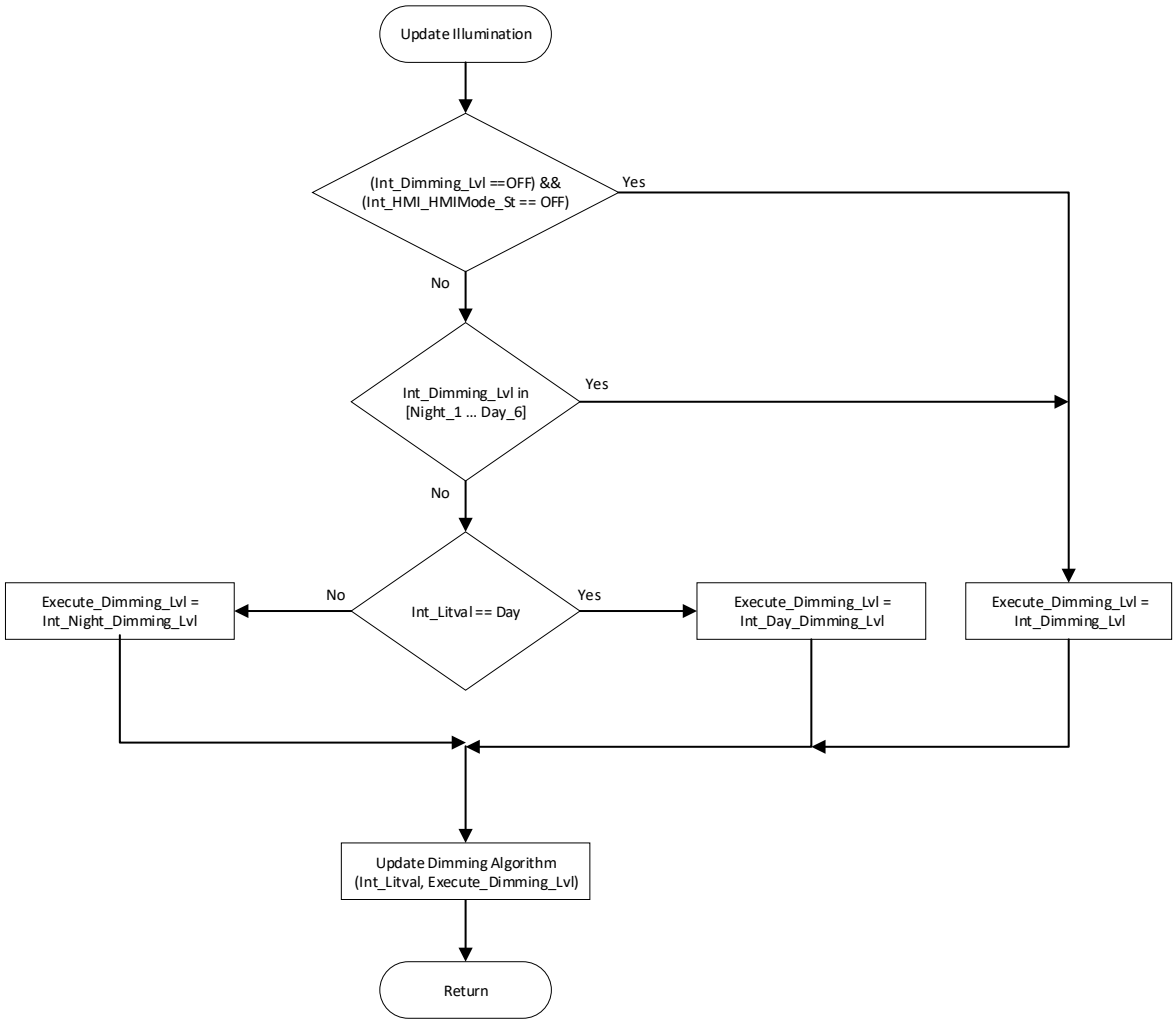
3.4.2.10 Update Illumination – Dimming Algorithm Input Definition

All flowcharts defined in REQ-455418 “Initialization” to REQ-455425 “Int_Dimming_Lvl Variable Definition” trigger an illumination update (Update Illumination). The flowchart below defines the Update Illumination execution and the Input to the dimming algorithm.

3.4.2.10.1 SMDM-REQ-435892/A-Update Illumination – For Displays

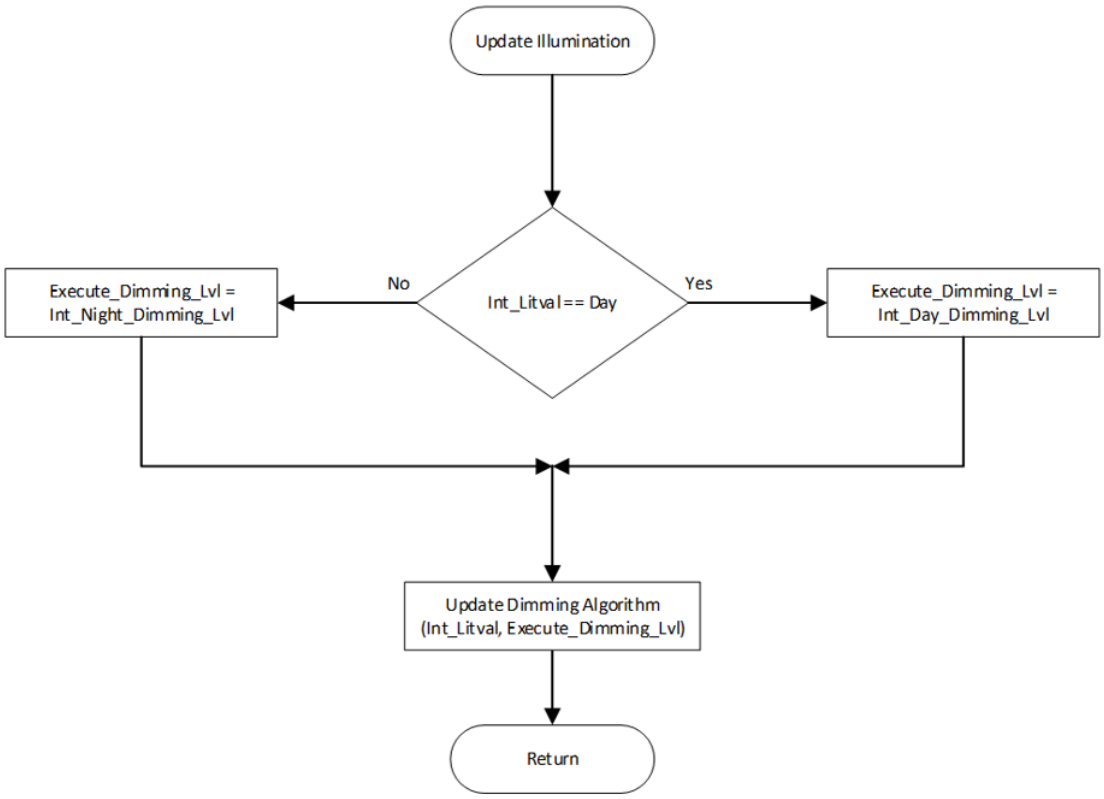
*) The dimming algorithm defined in section “Overall Dimming” assumes Dimming_Lvl and Litval as inputs. Dimming_Lvl is substituted by Execute_Dimming_Lvl and Litval is substituted by Int_Litval.

3.4.2.10.2 SMDM-REQ-435893/A-Update Illumination – For ICP / FCIM Backlight



*) The dimming algorithm defined in section “Overall Dimming” assumes Dimming_Lvl and Litval as inputs. Dimming_Lvl is substituted by Execute_Dimming_Lvl and Litval is substituted by Int_Litval.

3.4.2.10.3 SMDM-REQ-436277/A-Update Illumination – For ICP / FCIM Indicators



*) The dimming algorithm defined in section "Overall Dimming" assumes Dimming_Lvl and Litval as inputs. Dimming_Lvl is substituted by Execute_Dimming_Lvl and Litval is substituted by Int_Litval.

3.5 SMDM-FUN-REQ-435885/A-APIM / AHU / LCIS/ RACM

General Chapters 1 until REQ-435894 "Update Illumination – For ICP / FCIM Indicators" (including FUN-REQ-435621 "Extended Illumination"), REQ-454617"Dimming Intensity Offset", REQ-454618 "LIN communication (APIM / CTR / CHR) – FCIMB" until "REQ-435919/A-Display Backlight PWM" are to be implemented / considered for all components if applicable.

3.5.1 SMDM-REQ-454617/A-Dimming Intensity Offset

The display intensity may be optimized by offsets.

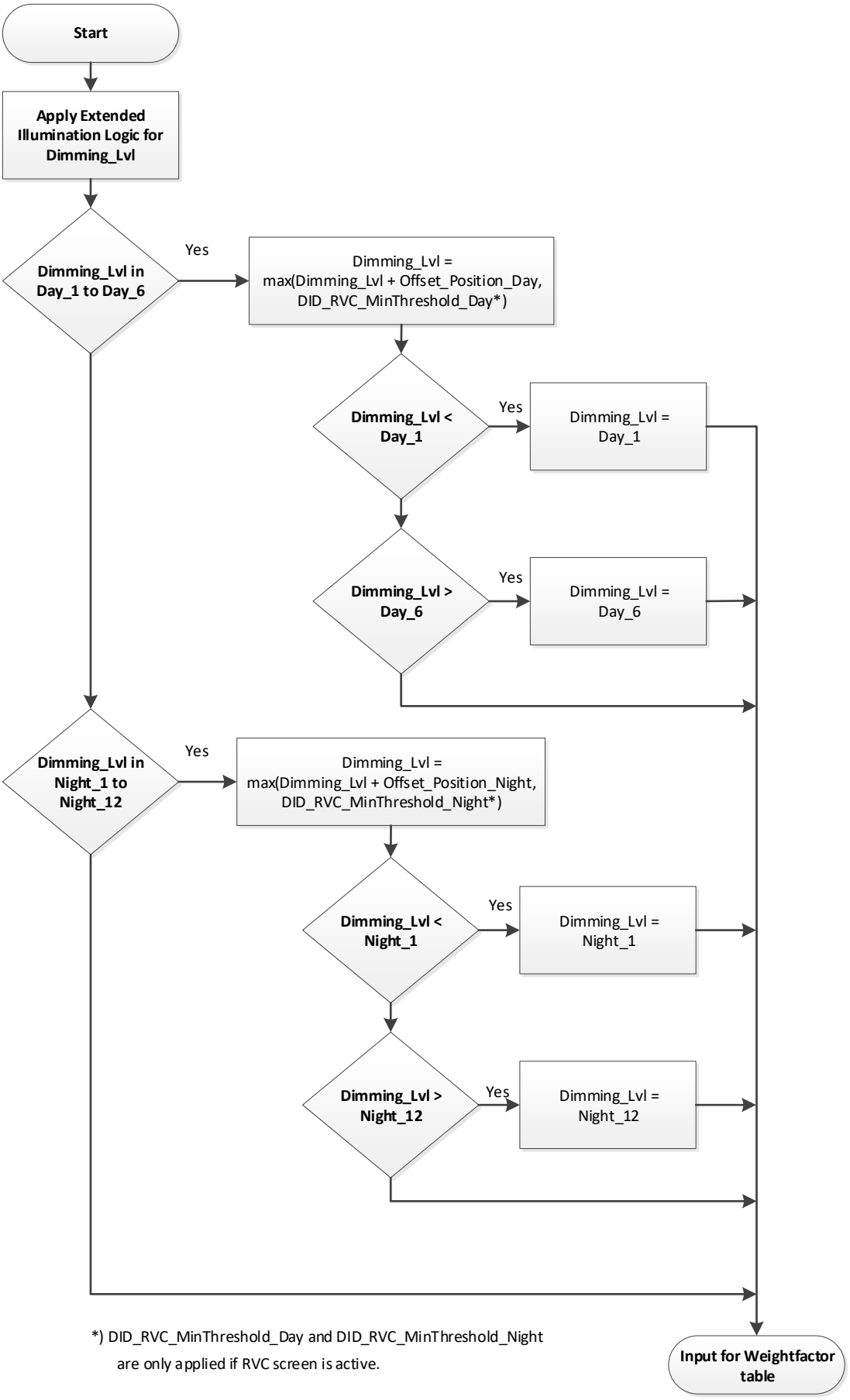
Night-mode: The standard dimming system offers a 12 step customer selectable dimming adjustment in night mode. Offsets are added to the actual dimming system step within the given range of Night_1 to Night_12. Offsets resulting in dimming intensities below Night_1 or above Night_12 are clipped to these borders.

Day-mode: The standard dimming system offers a 6 step customer selectable dimming adjustment in day mode. Offsets are added to the actual dimming system step within the given range of Day_1 to Day_6. Offsets resulting in dimming intensities below Day_1 or above Day_6 are clipped to these borders.

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

Execute any offset change applied to Dimming_Lvl with the transition time `DID_TransTime_Usr`.

The Rear View Camera (RVC) offers additional thresholds. See REQ-435900 "Dimming Intensity Offset via Camera Calibration Parameters"



*) DID_RVC_MinThreshold_Day and DID_RVC_MinThreshold_Night are only applied if RVC screen is active.

3.5.2 SMDM-REQ-435899/A-Dimming Intensity Offset via Screen Menu

Components may choose to offer an on screen menu to offset the local display illumination intensity from the vehicle level intensity. The display intensity is still dependent on the dimming system inputs, but a further user adjustable offset allows local intensity adjustment within the given system borders.
The variables *Offset_Position_Day* and *Offset_Position_Night* are set to zero in case the Dimming Intensity Offset via Screen Menu is not implemented.

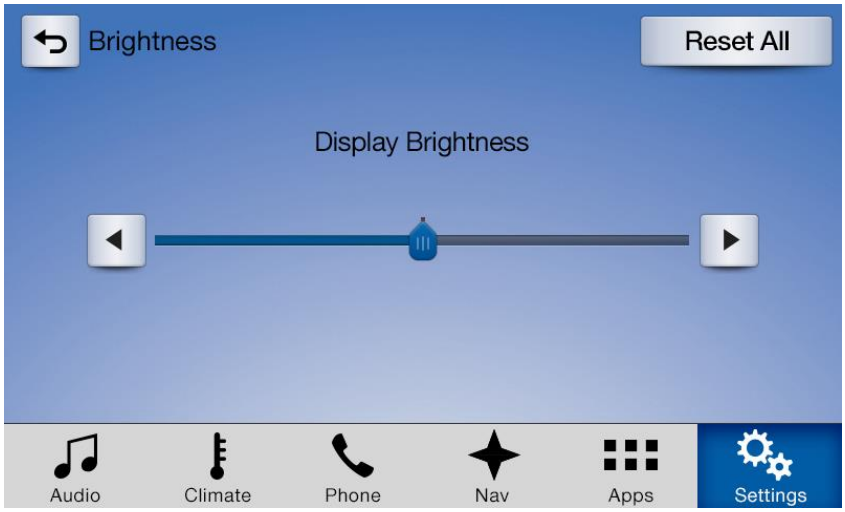


Figure 3 - Intensity Offset Slider

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

3.5.3 SMDM-REQ-435900/A-Dimming Intensity Offset via Camera Calibration Parameters

Vehicles may choose to offer a rear view camera (RVC). A calibratable threshold shall be applied to the received diming level while the rear view camera is active (rear view camera picture is shown on the screen). This threshold allows a dedicated RVC screen intensity minimum tuning possibility. The RVC threshold is compared to the Dimming_Lvl + HMI offset position via slider and only the greater of the two is applied. The calibration parameter `DID_RVC_MinThreshold` is set to zero in case the rear view camera is not installed. See chapter SMDM-REQ-454617"Dimming Intensity Offset" for details.

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

Identifier	Default Value	Bytes	Range	Comment, Description

`SYNC uses:`
`DID_RVC_MinThreshold_Night`
`Phoenix uses:`
`DID_Camera_MinThreshold_Night`
	Night_6	1	Night_1 to Night_12	Threshold (Night 1..Night12) applied while rear view camera is active, for night mode. The threshold value is defined by the RVC Function Owner

`SYNC uses:`
`DID_RVC_MinThreshold_Day`
`Phoenix uses:`
`DID_Camera_MinThreshold_Day`
	Day_3	1	Day_1 to Day_6	Threshold (Day1..Day6) applied while rear view camera is active, for night mode. The threshold value is defined by the RVC Function Owner

See SMDM-REQ-454725 “Illumination Calibration via DID” for DID details.

3.5.4 SMDM-REQ-454097/A-Turn Steering Wheel Graphics Off

If APIM needs to turn off the graphics on the steering wheel switches, it must send the CAN signal StewSwtchIlumnat_B_Rq = Off.
If StewSwtchIlumnat_B_Rq == On, the steering wheel switch graphics will be turned on and off together with the normal Dimming_Lvl and HMI_HMIMode_St request.

3.5.5 SYNC – APIM

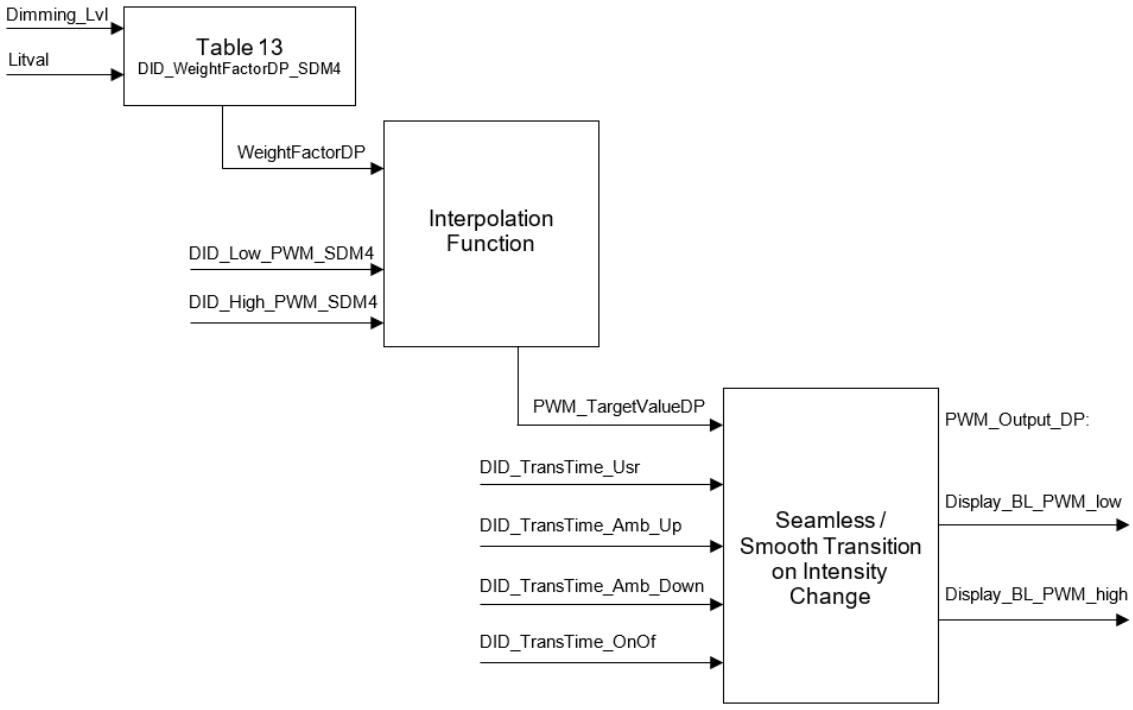
3.5.5.1 SMDM-REQ-454318/A-SYNC- APIM

General Chapters 1 until REQ-435894 “Update Illumination – For ICP / FCIM Indicators” (including Extended Illumination), “Dimming Intensity Offset”, “LIN communication (APIM / CTR / CHR) – FCIMB” until “REQ-435919/A-Display Backlight PWM” are to be implemented / considered for all components if applicable.

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

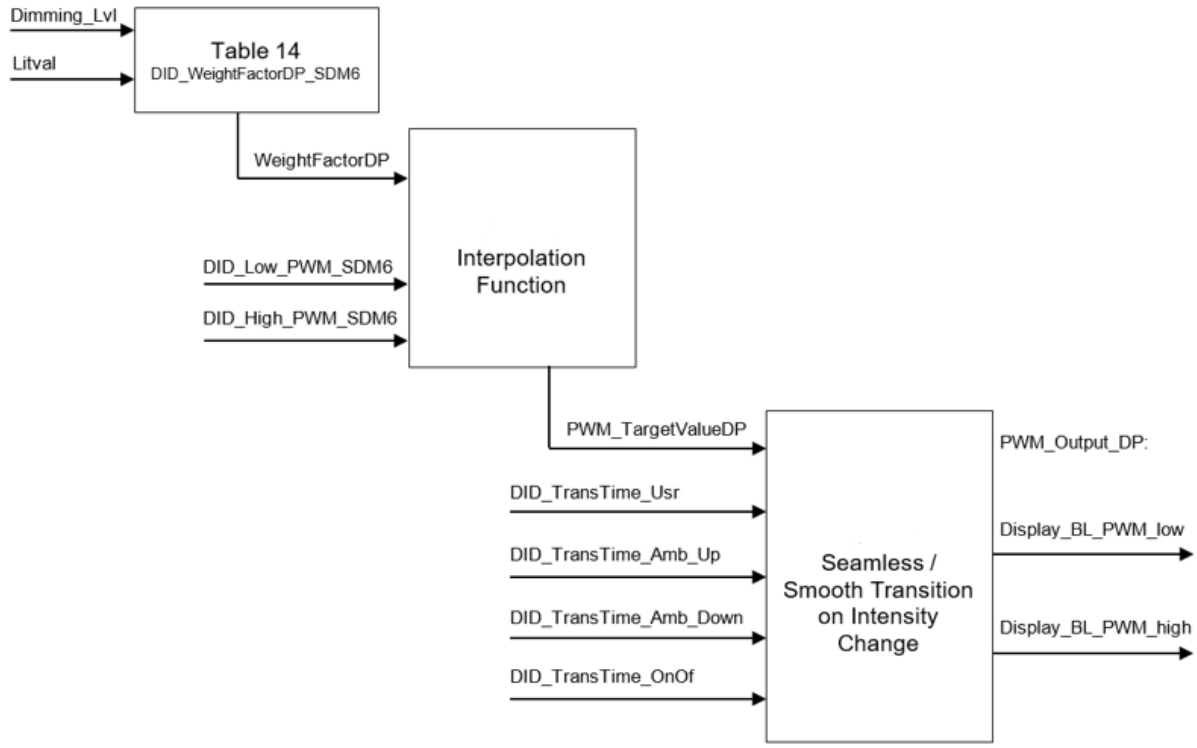
3.5.5.2 SMDM-REQ-435903/A-SDM4 Display Intensity Control

See chapter “10 Bit PWM Display Backlight” for detailed general information



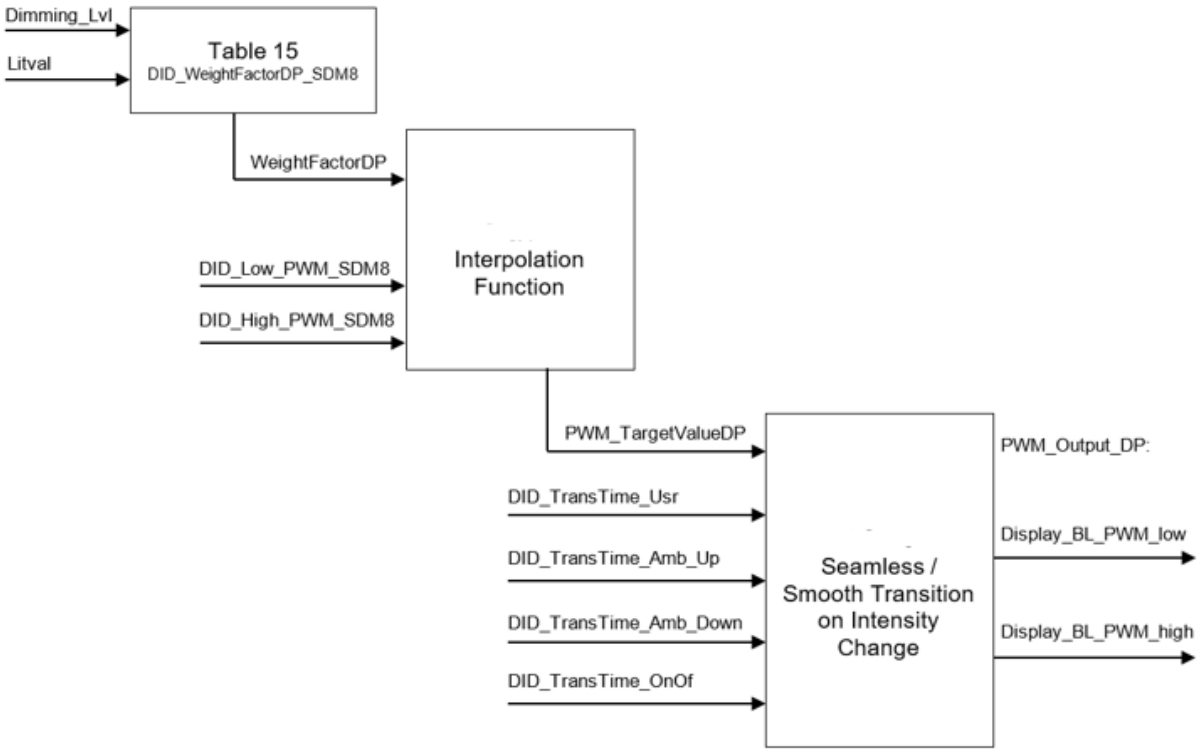
3.5.5.3 SMDM-REQ-435904/A-SDM6 Display Intensity Control

See chapter “10 Bit PWM Display Backlight” for detailed general information



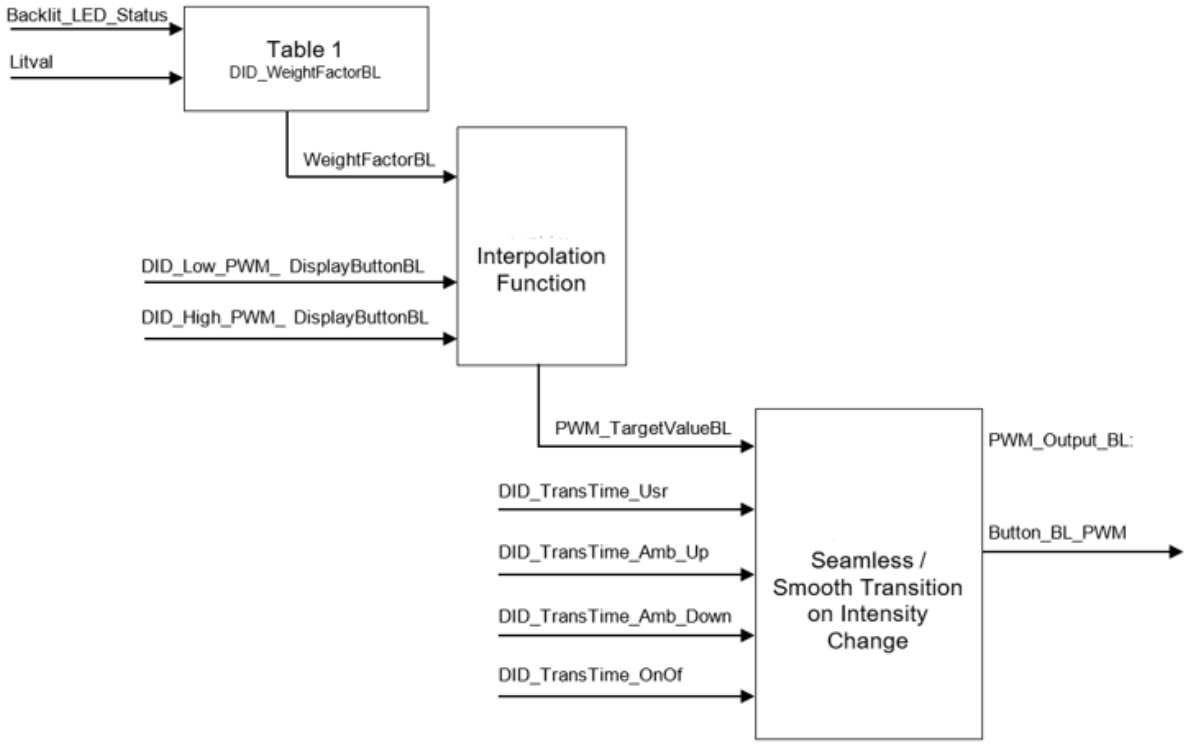
3.5.5.4 SMDM-REQ-435905/A-SDM8 Display Intensity Control

See chapter “10 Bit PWM Display Backlight” for detailed general information



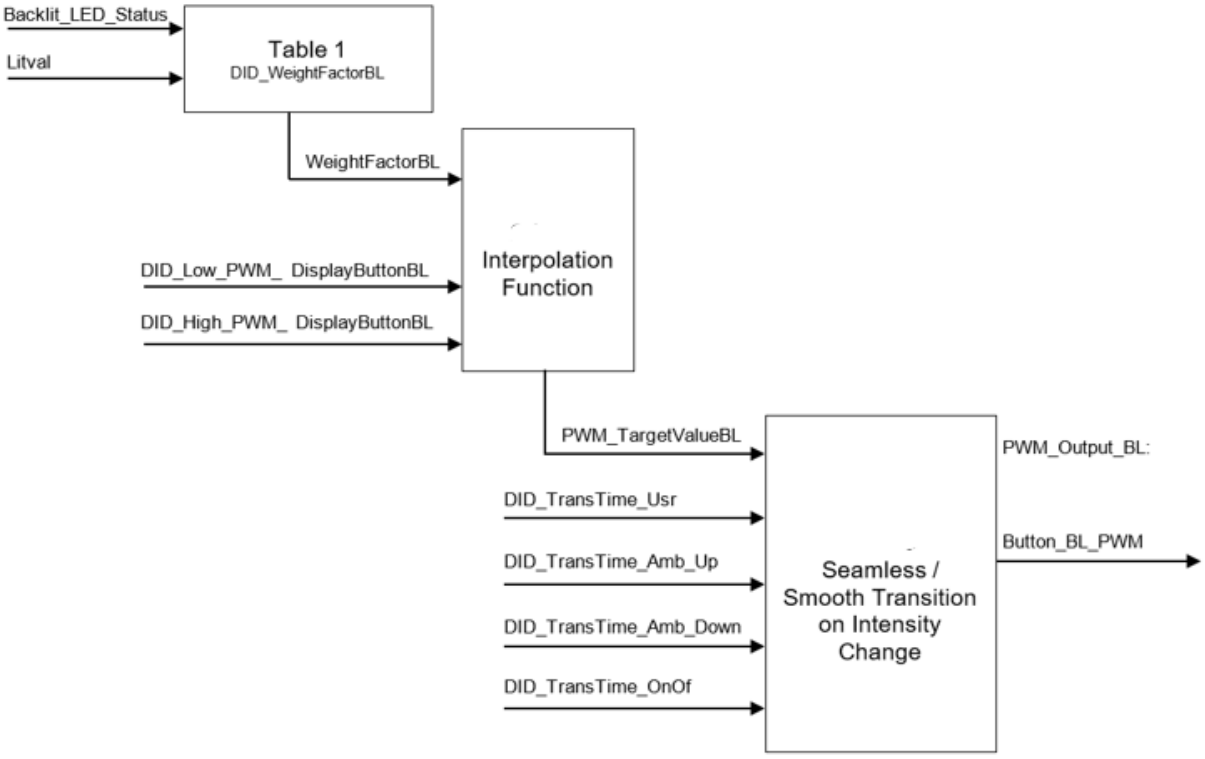
3.5.5.5 SMDM-REQ-435906/A-Display Button Backlight Intensity Control

See chapter “8 / 10 Bit PWM Backlight” for detailed general information



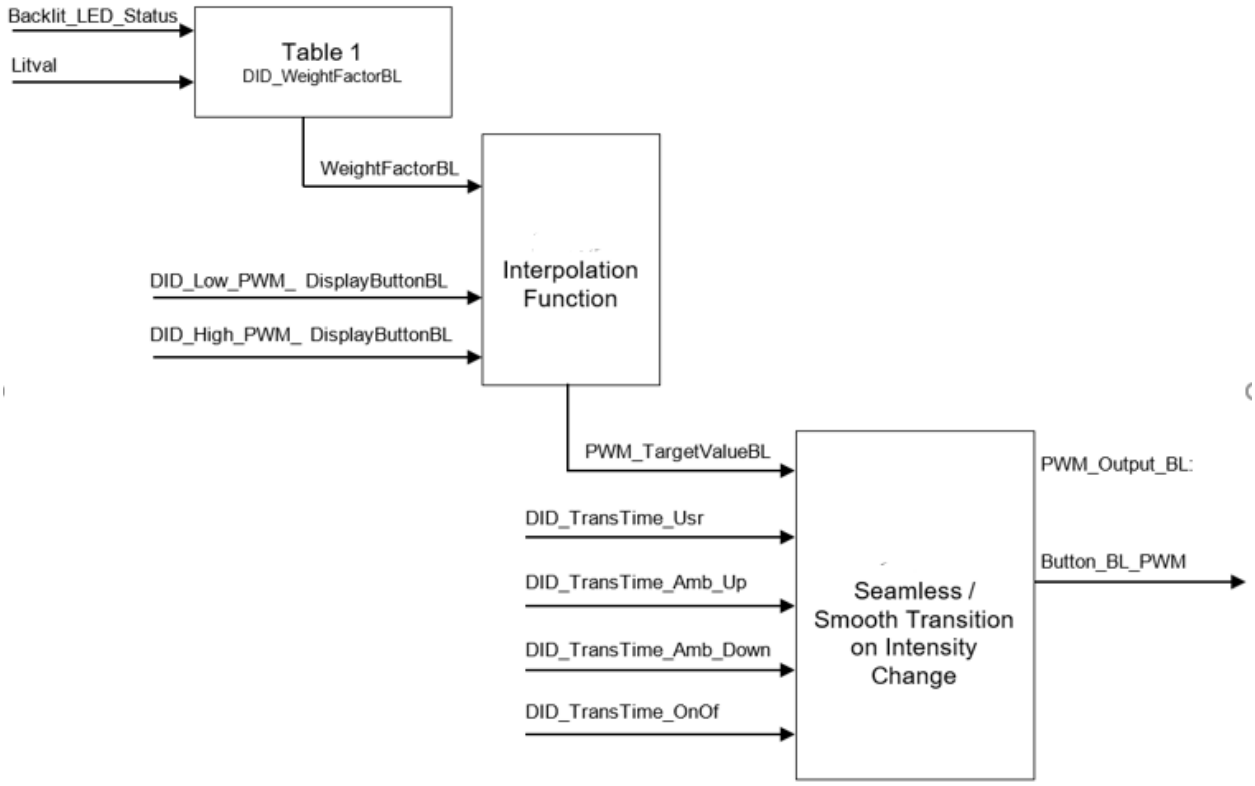
3.5.5.6 SMDM-REQ-435907/A-FCIMB Backlight Rotary Intensity Control

See chapter “8 / 10 Bit PWM Backlight” for detailed general information



3.5.5.7 SMDM-REQ-435908/A-FCIMB Backlight Button Intensity Control

See chapter “8 / 10 Bit PWM Backlight” for detailed general information



3.5.5.8 SMDM-REQ-435909/A-General DIDs for Intensity Calibration

Identifier	Default Value	Bytes	Range	Comment, Description
DID_WeightFactorDP_SDM4	See “REQ-435919/A-Display Backlight PWM” & SMDM-REQ-454698 Table 13	See “10 Bit PWM Display Backlight”	See “10 Bit PWM Display Backlight”	Weight factor table for SDM4 display.
DID_Low_PWM_SDM4	15	2	0 to 1023	PWM value for lowest SDM4 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle

DID_High_PWM_SDM4	1023	2	0 to 1023	PWM value for highest SDM4 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_WeightFactorDP_SDM6	See "REQ-435919/A-Display Backlight PWM" & SMDM-REQ-454698 Table 13	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight"	Weight factor table for SDM6 display.
DID_Low_PWM_SDM6	9	2	0 to 1023	PWM value for lowest SDM6 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_High_PWM_SDM6	1023	2	0 to 1023	PWM value for highest SDM6 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_WeightFactorDP_SDM8	See "REQ-435919/A-Display Backlight PWM" & SMDM-REQ-454698 Table 13	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight"	Weight factor table for SDM8 display.
DID_Low_PWM_SDM8	8	2	0 to 1023	PWM value for lowest SDM8 display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_High_PWM_SDM8	1023	2	0 to 1023	PWM value for highest SDM8 display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_WeightFactorBL	See "8 / 10 Bit PWM Backlight	See "8 / 10 Bit PWM Backlight"	See "8 / 10 Bit PWM Backlight	Weight factor table for backlight.
DID_Low_PWM_ DisplayButtonBL	5	1	0 to 255	PWM value for lowest display button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle
DID_High_PWM_ DisplayButtonBL	255	1	0 to 255	PWM value for highest display button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle
DID_Low_PWM_RotoryBL	5	1	0 to 255	PWM value for lowest FCIMB rotary intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle
DID_High_PWM_RotoryBL	255	1	0 to 255	PWM value for highest FCIMB rotary intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle

DID_Low_PWM_ButtonBL	5	1	0 to 255	PWM value for lowest FCIMB button intensity. This value defines the lowest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle
DID_High_PWM_ButtonBL	255	1	0 to 255	PWM value for highest FCIMB button intensity. This value defines the highest PWM intensity. 0 refers to 0% duty cycle and 255 refers to 100% duty cycle
DID_TransTime_Usr	See SMDM-REQ-454758 "Seamless / Smooth Transition on Intensity Change	1	0 to 9	See SMDM-REQ-454758 "Seamless / Smooth Transition on Intensity Change
DID_TransTime_Amb_Up	See SMDM-REQ-454758	1	0 to 9	See SMDM-REQ-454758
DID_TransTime_Amb_Down	See SMDM-REQ-454758	1	0 to 9	See SMDM-REQ-454758
DID_TransTime_OnOff	See SMDM-REQ-454758	1	0 to 9	See SMDM-REQ-454758

See "Illumination Calibration via DID" for DID calibration details.

3.5.6 LIN communication

3.5.6.1 SMDM-REQ-454618/A-LIN communication (APIM / CTR / CHR) – FCIMB

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

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

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

3.5.6.2 SMDM-REQ-454637/A-Heritage Protocol

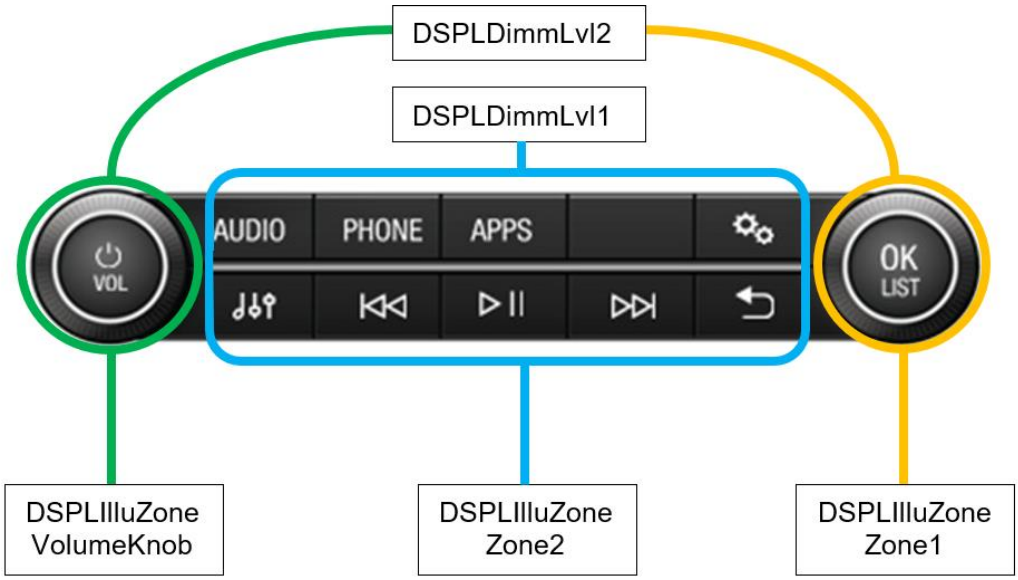
The PWM generators should use the complete range and resolution of 256 steps with 0x00 = off and 0xFF = 100% on.

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

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

See also chapter "Behavior 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 turn on and off all 3 zone bits simultaneously.
The controlling device should set the “Invalid” bit, when LIN message must be sent and brightness information is still not available via CAN (e.g. during power up situations).

3.5.6.3 SMDM-REQ-454638/A-DSPLSendSignals

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

Name	Definition	Description
DSPLIlluZone		Bit 0 .. 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}	Chrome: (buttons) 0: – backlight off 1: – backlight on
	BIT{6}	Reserved
	BIT{7}	Invalid: 0: – valid PWM value ⇨ See “Behaviour after Reset and Invalid Bit Handling” 1: – invalid PWM value ⇨ See “Behaviour after Reset and Invalid Bit Handling”
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.

3.5.6.4 SMDM-REQ-435914/A-Illumination Zones vs. Dimming_lvl.

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

Bit 5 of signal DSPLIlluZone is specific to Chrome buttons which are expected to be “OFF” when Dimming_lvl = Day_1 to Day_6 or OFF, and “ON” when Dimming_lvl = Night_1 to Night_12

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

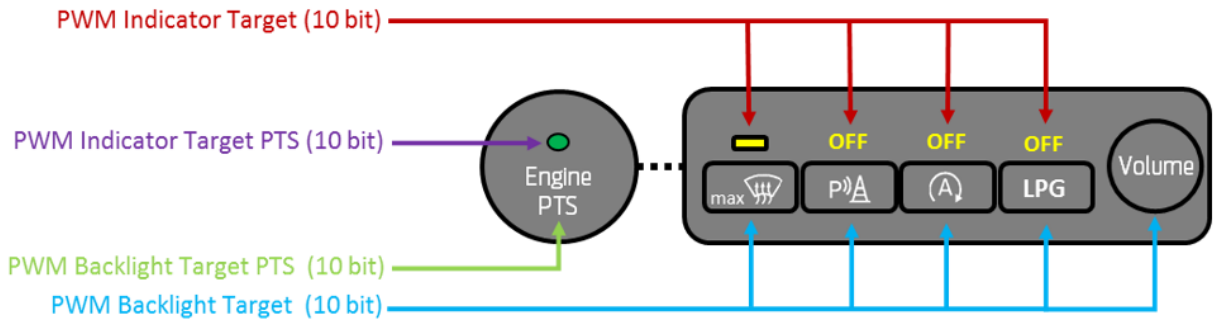
Dimming_Lvl	DSPLIlluZone (bits)	Comments
Night_1 to Night_12	0x7F	Bits 0 to 6 are ON, and these Illumination Zones can follow signal DSPLDimmLvl1 or

		DSPLDimmLvl2 including the OFF state.
Day_1 to Day_6	0x5F	Bit 5 should transition to OFF, while all remaining bits from 0 to 6 remain ON.
Off	keep last valid value	Keep last valid value for DSPLIlluZone (0x7F / 0x5F)

3.5.6.5 SMDM-REQ-454639/A-Behavior after Reset and Invalid Bit Handling

- After RESET or Battery ON the last valid PWM should be set to zero and the InvalidTimeout timer should be reset and run.
- Every time a new valid PWM is received, the last valid PWM should be updated with the new PWM value and the InvalidTimeout timer should be reset and run.
- If InvalidTimeout timer finish and last valid PWM is zero, set last valid PWM to Default_BL_PWM
- Use the last valid PWM for updating the PWM generator.
- Update the PWM generator every time the last valid PWM value changes.
- Default_BL_PWM is 0xFF (for 8 bit values)
- The InvalidTimeout value is 5 sec.

3.5.6.6 Interface for SYNC 4.0 and beyond

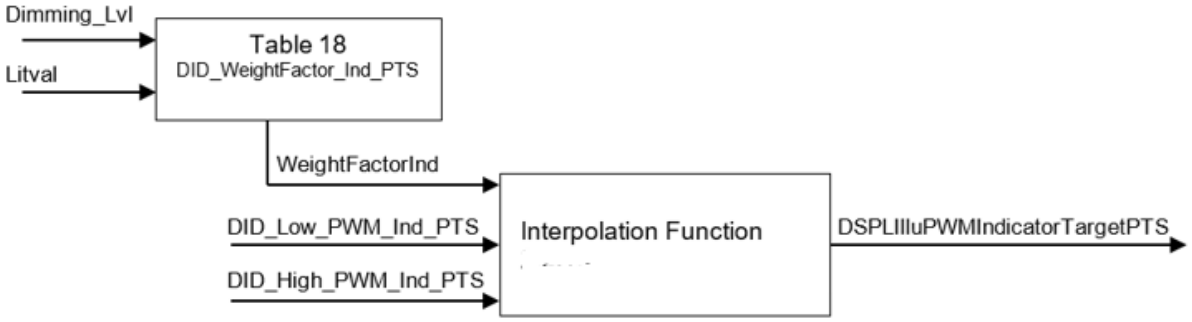


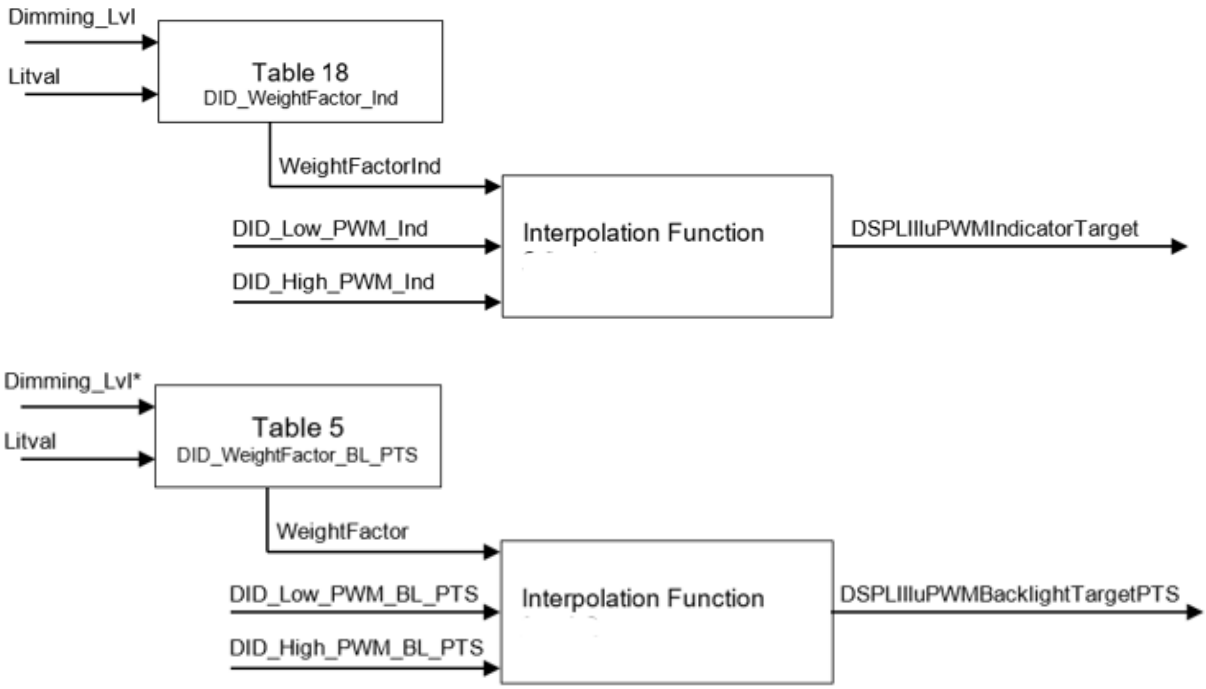
3.5.6.6.1 SMDM-REQ-454658/A-Intensity control

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

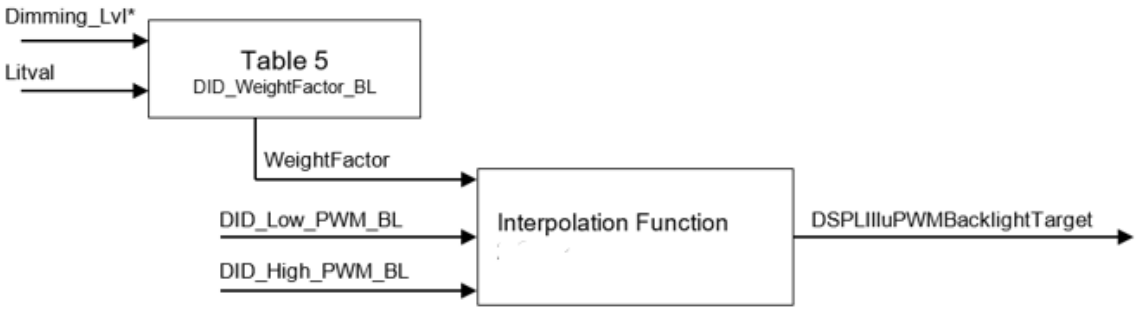
Identifier	Default Value	Bytes	Range	Comment, Description
DID_Low_PWM_Ind_PTS	102	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”

DID_High_PWM_Ind_PTS	1023	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_Low_PWM_Indicator	102	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_High_PWM_Indicator	1023	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_Low_PWM_BL_PTS	4	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_High_PWM_BL_PTS	1023	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_Low_PWM_BL	4	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_High_PWM_BL	1023	2	0 - 1023	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_WeightFactor_Ind_PTS	See Table 18	216	0 - 1024	See ”Definition of Weight Factors for ICP Indicator Illumination”
DID_WeightFactor_Ind	See Table 18	216	0 - 1024	See ”Definition of Weight Factors for ICP Indicator Illumination”
DID_WeightFactor_BL_PTS	See Table 5	216	0 - 1024	See "8 / 10 Bit PWM Backlight”
DID_WeightFactor_BL	See Table 5	216	0 - 1024	See "8 / 10 Bit PWM Backlight”





Note: If Dimming_Lvl = 0x0(Off), DSPLIlluPWMBacklightTargetPTS is 0x0.



Note: If Dimming_Lvl = 0x0(Off), DSPLIlluPWMBacklightTarget is 0x0.

3.5.6.6.2 SMDM-REQ-454659/A-Illumination zone signal control

Zones [LIN]	Function	Resolution [Bit]	Sender	Receiver	Description
DSPLIlluIndPTS	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	PTS Indicator
DSPLIlluInd1	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_1
DSPLIlluInd2	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_2
DSPLIlluInd3	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_3
DSPLIlluInd4	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_4
DSPLIlluInd5	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_5
DSPLIlluInd6	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_6
DSPLIlluInd7	0 =Off, 1 = On, 2 = Blinking	2	APIM, CTR, CHR	ICP	Generic Indicator_7
DSPLIlluBtnPTS	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	PTS Button Backlight
DSPLIlluBtn1	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_1 Backlight
DSPLIlluBtn2	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_2 Backlight
DSPLIlluBtn3	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_3 Backlight
DSPLIlluBtn4	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_4 Backlight
DSPLIlluBtn5	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_5 Backlight
DSPLIlluBtn6	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_6 Backlight
DSPLIlluBtn7	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_7 Backlight
DSPLIlluBtn8	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Generic Button_8 Backlight
DSPLIlluVolKnob	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	On / Off pushbutton on the volume rotary
DSPLIlluBtnChrome	0 =Off, 1 = On	1	APIM, CTR,CHR	ICP	Chrome Buttons Backlight

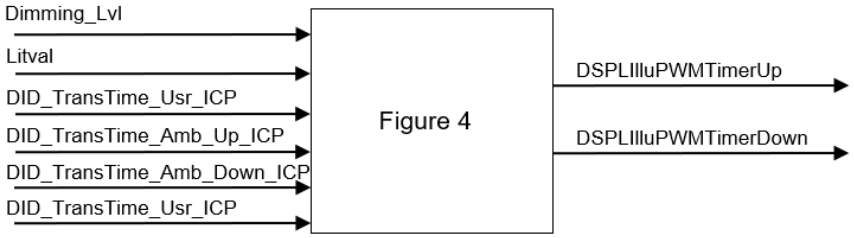
All button illumination zones are set to On (0x1) permanently by default. Individual zone control handling may be added separately. Indicator zones are controlled by the driving function / ECU. The Chrome button zone logic is handled in section REQ-435915 “Chrome Button Zone Handling”

3.5.6.6.3 SMDM-REQ-435915/A-Chrome Button Zone Handling

Dimming_Lvl	DSPLIlluBtnChrome	Comments
Night_1 to Night_12	0x1 (On)	Chrome buttons zone is active
Day_1 to Day_6	0x0 (OFF)	Chrome button zone is disabled
Off / Missing	keep last valid value	Keep last valid value

3.5.6.6.4 SMDM-REQ-454660/A-Smooth dimming timer signals

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



Identifier	Default Value	Bytes	Range	Comment, Description
DID_TransTime_Usr_ICP	5	1	0 - 9	See REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_TransTime_Amb_Up_ICP	6	1	0 - 9	REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_TransTime_Amb_Down_ICP	8	1	0 - 9	REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”
DID_TransTime_Usr_ICP	5	1	0 - 9	REQ-435833 “Brightness Calibration of Display Backlight and Gauge Pointer”

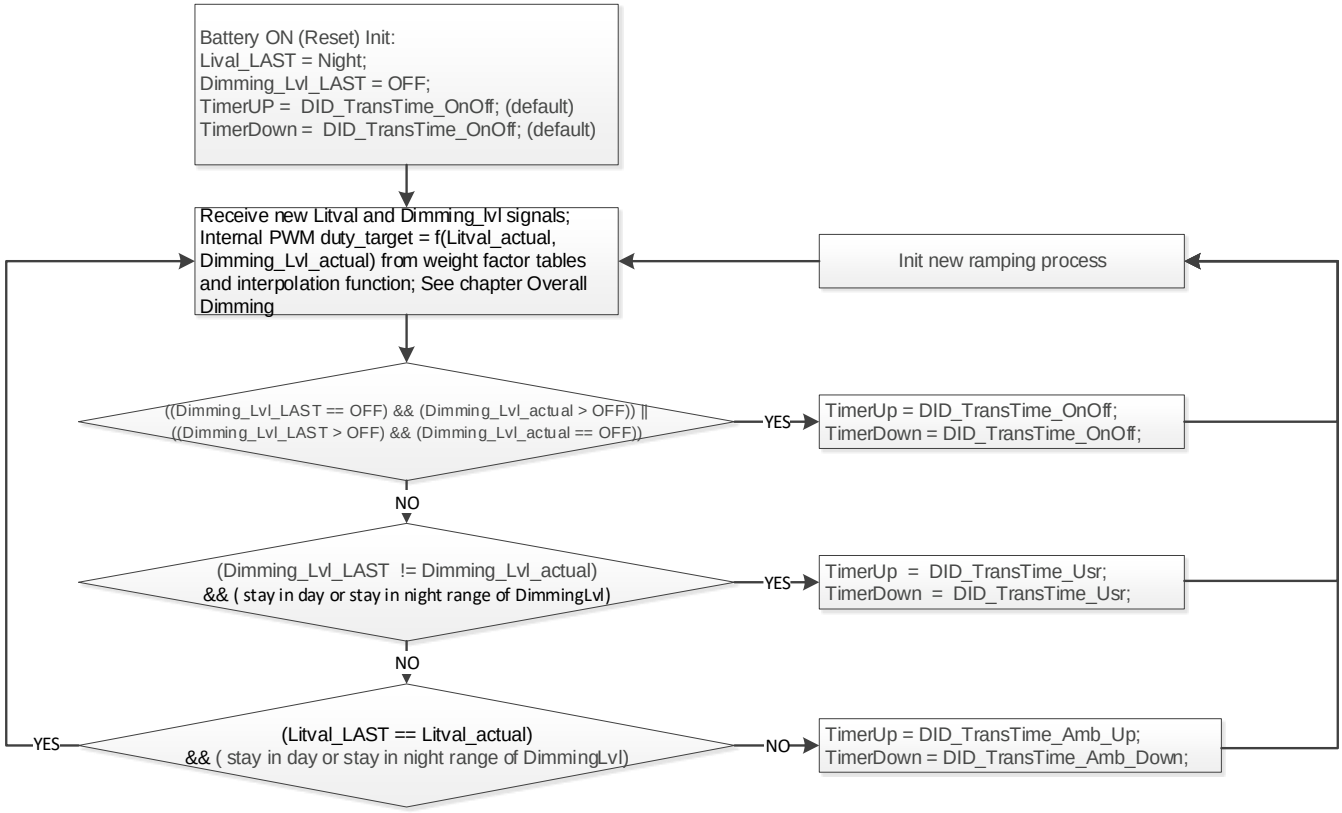


Figure 4

3.5.6.6.5 SMDM-REQ-454677/A-Dimming curve type signals

Dimming_Curve [LIN]	Resolution [Bit]	Sender	Receiver	Description
DSPLIlluDimmingCurveType	1	APIM / CTR / CHR	ICP	Dimming curve type: 0 = linear 1= exponential

3.5.6.6.6 SMDM-REQ-454678/A-Dimming curve type configuration (APIM)

DID Name	Resolution [Bit]	Range	Default	Description
DID_DimmingCurveType_ICP	1	0 to 1	1 = exponential	Dimming curve type: 0 = linear 1= exponential

3.5.7 IIC communication

3.5.7.1 SMDM-REQ-454697/A-IIC communication (APIM / CHR / CTR) – Display

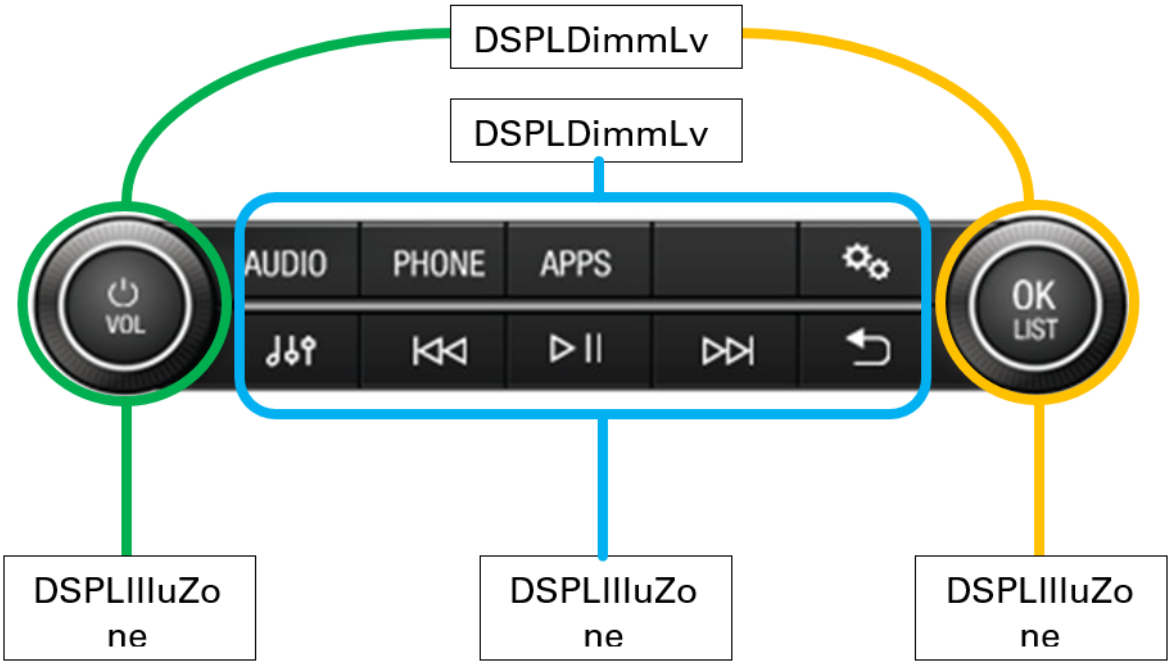
The protocol must be able to send both backlight messages every 40ms or faster, while the PWM values need to be changed. This is every time a new brightness level is selected by the passenger, day light sensor or the welcome / farewell sequence. If no change of the PWM signal is necessary, the back light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

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

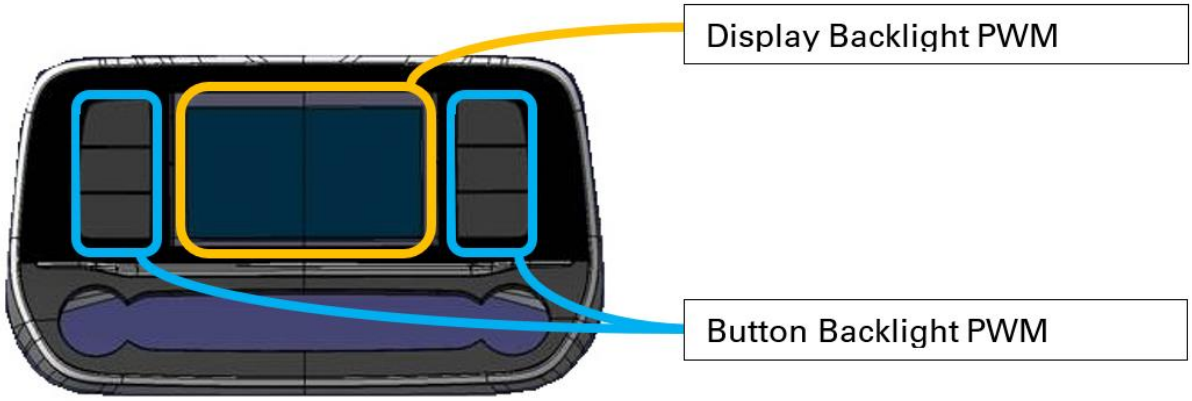
Example: If the actual PWM ratio is 25% and switched to 50%, the PWM wave should have no PWM ratio lower 25% and no PWM ratio higher than 50%. Care must be taken, that during loading a new value in the PWM generator no such side effects are generated.

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

At Display_BL_PWM value 1023 the maximum brightness requirement for display backlight should be fulfilled. Lower PWM values should dim the brightness proportional.



The backlight messages are used for the following zones:



3.5.7.2 SMDM-REQ-435918/A-Display Button Backlight PWM

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

3.5.7.3 SMDM-REQ-435919/A-Display Backlight PW

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

3.5.8 SMDM-REQ-454698/A-Definition of Weight Factors for 10 Bit SDM displays

DID_WeightFactorDP_SDM4:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	2	6	12	20	375
	Night_2	2	5	10	17	27	375
	Night_3	4	8	14	23	36	375
	Night_4	8	13	21	31	47	375
	Night_5	13	19	29	42	61	375
	Night_6	19	28	40	57	79	375
	Night_7	28	40	55	75	102	375
	Night_8	41	55	74	99	132	375
	Night_9	58	77	100	131	170	375
	Night_10	82	106	135	172	219	375
	Night_11	116	145	181	225	281	375
	Night_12	162	198	241	295	360	375
	Day_1	375	392	410	429	449	470
	Day_2	417	441	466	492	520	549
	Day_3	463	495	528	564	601	642
	Day_4	515	555	599	645	696	750
	Day_5	572	623	679	739	805	876
	Day_6	636	700	770	846	931	1024

Table 13

DID_WeightFactorDP_SDM6:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	1	3	6	10	211
	Night_2	1	3	6	9	14	211
	Night_3	3	6	9	13	19	211
	Night_4	6	9	13	18	25	211
	Night_5	9	13	18	24	33	211
	Night_6	13	18	24	33	43	211
	Night_7	19	25	33	43	56	211
	Night_8	26	34	44	57	73	211
	Night_9	36	46	59	75	95	211
	Night_10	49	62	78	98	122	211
	Night_11	67	83	103	127	157	211
	Night_12	90	110	135	165	202	211
	Day_1	211	227	244	263	283	304
	Day_2	241	265	292	321	353	388
	Day_3	276	310	349	392	441	495
	Day_4	316	363	417	479	550	631
	Day_5	361	424	497	584	685	804
	Day_6	412	495	594	712	854	1024

Table 14

DID_WeightFactorDP_SDM 8 / 10:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	1	3	5	8	211
	Night_2	1	3	5	8	12	211
	Night_3	3	5	8	12	16	211
	Night_4	5	8	12	16	22	211
	Night_5	8	12	16	22	29	211
	Night_6	12	17	22	29	39	211
	Night_7	17	23	30	39	50	211
	Night_8	24	31	40	51	66	211
	Night_9	33	42	53	67	85	211
	Night_10	45	56	70	88	109	211
	Night_11	60	75	92	114	141	211
	Night_12	81	99	121	148	181	211
	Day_1	211	227	244	263	283	304
	Day_2	241	265	292	321	353	388
	Day_3	276	310	349	392	441	495
	Day_4	316	363	417	479	550	631
	Day_5	361	424	497	584	685	804
	Day_6	412	495	594	712	854	1024

Table 15

DID_WeightFactorDP_SDM 12 / 13 / 13.2:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	2	4	6	10	146
	Night_2	1	3	5	9	13	146
	Night_3	3	5	8	12	17	146
	Night_4	4	7	11	16	22	146
	Night_5	7	10	14	20	29	146
	Night_6	9	14	19	27	37	146
	Night_7	13	18	25	34	46	146
	Night_8	18	25	33	44	58	146
	Night_9	25	33	43	56	74	146
	Night_10	33	43	56	72	93	146
	Night_11	44	57	72	92	117	146
	Night_12	59	74	93	117	146	146
	Day_1	146	156	167	178	190	203
	Day_2	188	204	221	239	259	281
	Day_3	242	266	292	321	353	388
	Day_4	310	346	387	431	481	537
	Day_5	398	451	511	579	655	742
	Day_6	511	587	675	776	892	1024

Table 16

DID_WeightFactorDP_SDM15:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	2	3	6	10	126
	Night_2	1	3	5	8	13	126
	Night_3	2	4	7	11	16	126
	Night_4	3	6	9	14	21	126
	Night_5	5	8	12	18	26	126
	Night_6	7	11	16	23	33	126
	Night_7	10	14	20	29	41	126
	Night_8	13	19	26	37	52	126
	Night_9	17	24	34	47	65	126
	Night_10	23	31	43	59	81	126
	Night_11	30	41	55	75	101	126
	Night_12	39	53	71	94	126	126
	Day_1	126	139	153	168	185	203
	Day_2	167	186	206	229	254	281
	Day_3	221	248	277	310	347	389
	Day_4	293	331	373	421	476	537
	Day_5	387	441	502	572	651	742
	Day_6	511	588	675	776	892	1024

Table 17

3.5.9 SMDM-REQ-454721/A-Definition of Weight Factors for ICP Indicator Illumination

DID_WeightFactor_IndTarPTS:

		Litval					
		Night	Twilight_1	Twilight_2	Twilight_3	Twilight_4	Day
Dimming_Lvl	Night_1	0	0	0	0	0	0
	Night_2	0	0	0	0	0	0
	Night_3	0	0	0	0	0	0
	Night_4	0	0	0	0	0	0
	Night_5	0	0	0	0	0	0
	Night_6	0	0	0	0	0	0
	Night_7	0	0	0	0	0	0
	Night_8	0	0	0	0	0	0
	Night_9	0	0	0	0	0	0
	Night_10	0	0	0	0	0	0
	Night_11	0	0	0	0	0	0
	Night_12	0	0	0	0	0	0
	Day_1	1024	1024	1024	1024	1024	1024
	Day_2	1024	1024	1024	1024	1024	1024
	Day_3	1024	1024	1024	1024	1024	1024
	Day_4	1024	1024	1024	1024	1024	1024
	Day_5	1024	1024	1024	1024	1024	1024
	Day_6	1024	1024	1024	1024	1024	1024

Table 18

3.5.10 SMDM-REQ-454722/A-Phoenix infotainment system

This section is provided to support two different architectures for distributed screens:

1. System with cluster screen and center stack screen.
2. System with 3 panoramic screens.

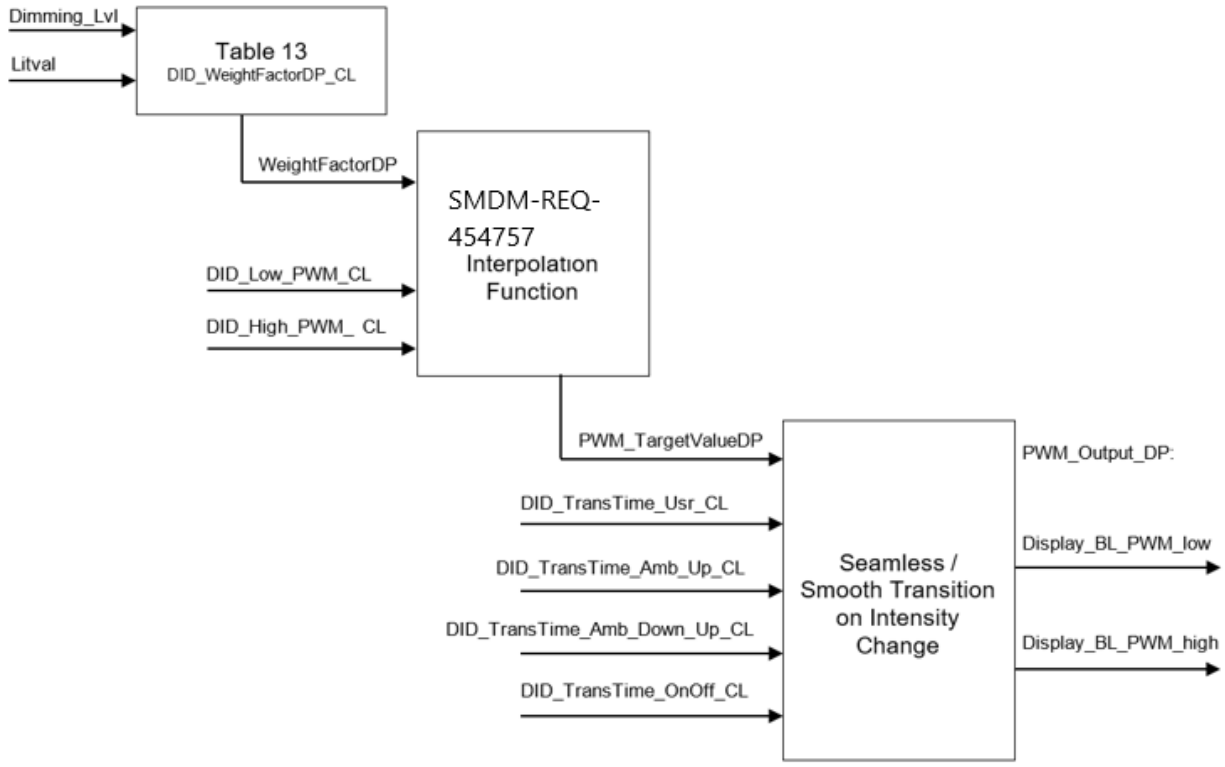
Center stack screen or 3 panoramic screens use the same logic like SYNC system. The same calibration tables as described in SYNC chapter should be used. Also ICP calibration tables from SYNC section should be applied to this kind of system. For system with cluster screen the following calibration table and logic should be applied for the cluster screen.

Identifier	Default Value	Bytes	Range	Comment, Description
DID_WeightFactorDP_CL	See REQ-435919/A-Display Backlight PW & REQ-454698 Table 14	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight"	Weight factor table for Cluster (CL) display.
DID_Low_PWM_CL	9	2	0 to 1023	PWM value for lowest Cluster (CL) display intensity. This value defines the lowest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_High_PWM_CL	1023	2	0 to 1023	PWM value for highest Cluster (CL) display intensity. This value defines the highest intensity. 0 refers to 0% PWM duty cycle and 1023 refers to 100% PWM duty cycle
DID_TransTime_Usr_CL	0	1	0 to 9	SMDM-REQ-454757
DID_TransTime_Amb_Up_CL	6	1	0 to 9	SMDM-REQ-454757
DID_TransTime_Amb_Down_CL	8	1	0 to 9	SMDM-REQ-454757

DID_TransTime_OnOff_CL	5	1	0 to 9	SMDM-REQ-454757

3.5.11 SMDM-REQ-454723/A-Cluster display Intensity Control

See chapter “10 Bit PWM Display Backlight” for detailed general information

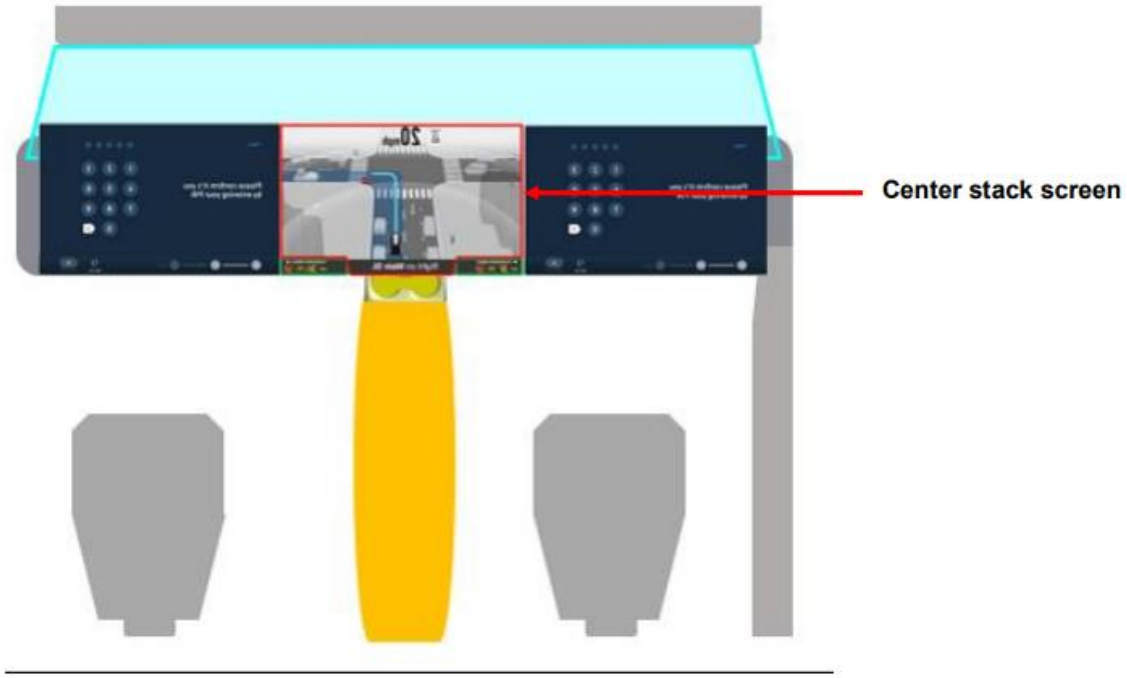


3.5.12 Avis functionality to APIM for AV vehicle

All the general functions from chapters 1 to 3 should be considered as needed.

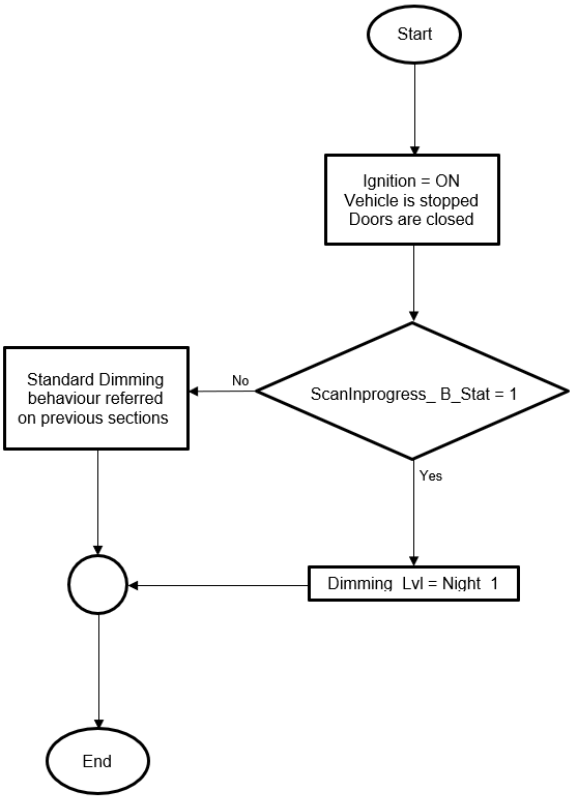
3.5.12.1 SMDM-REQ-455426/A-Autonomous Vehicle Interior Scan (AVIS)

This section was created to support the implementation of Autonomous Vehicle Interior Scan (AVIS) functionality in the lead of autonomous program MY2024 CX482AV. AVIS must provide emptiness status of vehicle after the ride completion, performing scanner supported by cameras and lights inside the car. During the process is considered that customers are out of the car and ignition remains ON. The car will be stopped, doors closed and cabin empty of people (presumably). Then, assuming the preconditions mentioned, the center stack screen brightness level must dims to the lowest available (Night_1) while scanner is activated, because high brightness intensity can disturb its behavior, detecting object or people detection.



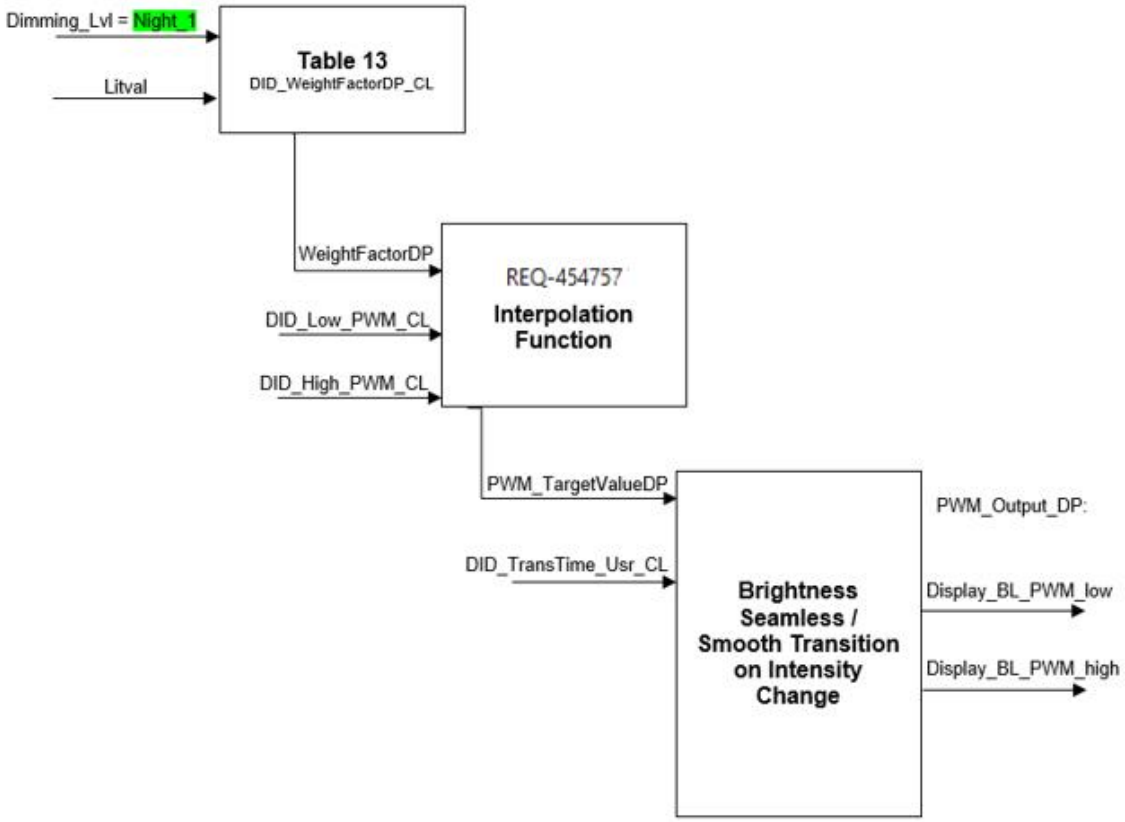
3.5.12.2 SMDM-REQ-455457/A-Logic to trigger the Dimming_Lvl when the scanner is activated

The aim of this section is to support the algorithm logic needed to trigger Dimming_Lvl within APIM module and make the center stack screen brightness down to the lowest level available when the scanner is activated.



3.5.12.3 SMDM-REQ-455458/A-AVIS display intensity control

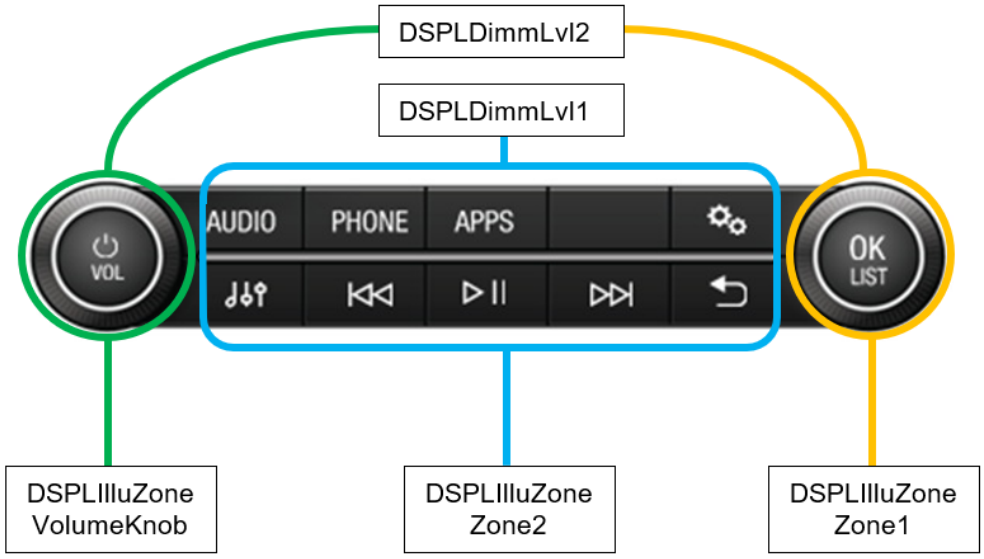
See chapter “Bit PWM Display Backlight” for detailed general information. Dimming_Lvl signal shall be trigged in Night_1 always when the AVIS is activated.



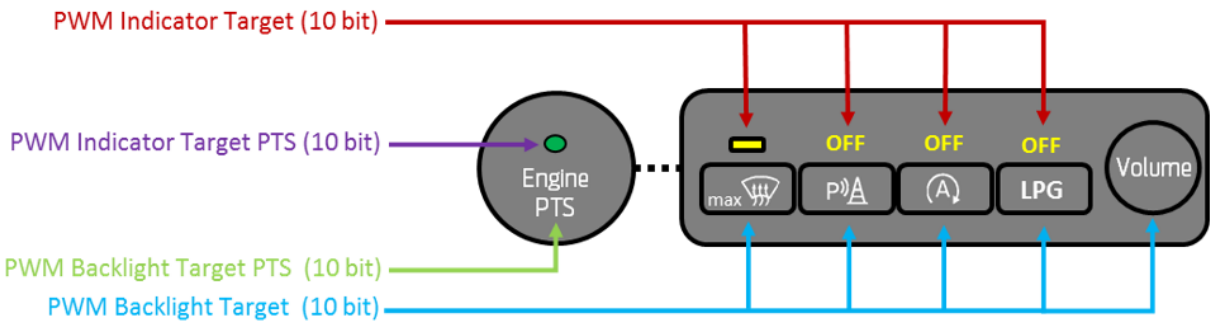
3.6 SMDM-FUN-REQ-435898/A-ICP / FCIMB

General Chapters 1 until REQ-435894 “Update Illumination – For ICP / FCIM Indicators” (including section FUN-REQ-435621 “Extended Illumination”), and REQ-454618 “LIN communication (APIM / CTR / CHR) – FCIMB” are to be implemented / considered if applicable

3.6.1 SMDM-REQ-455459/A-Protocol for SYNC Gen 3

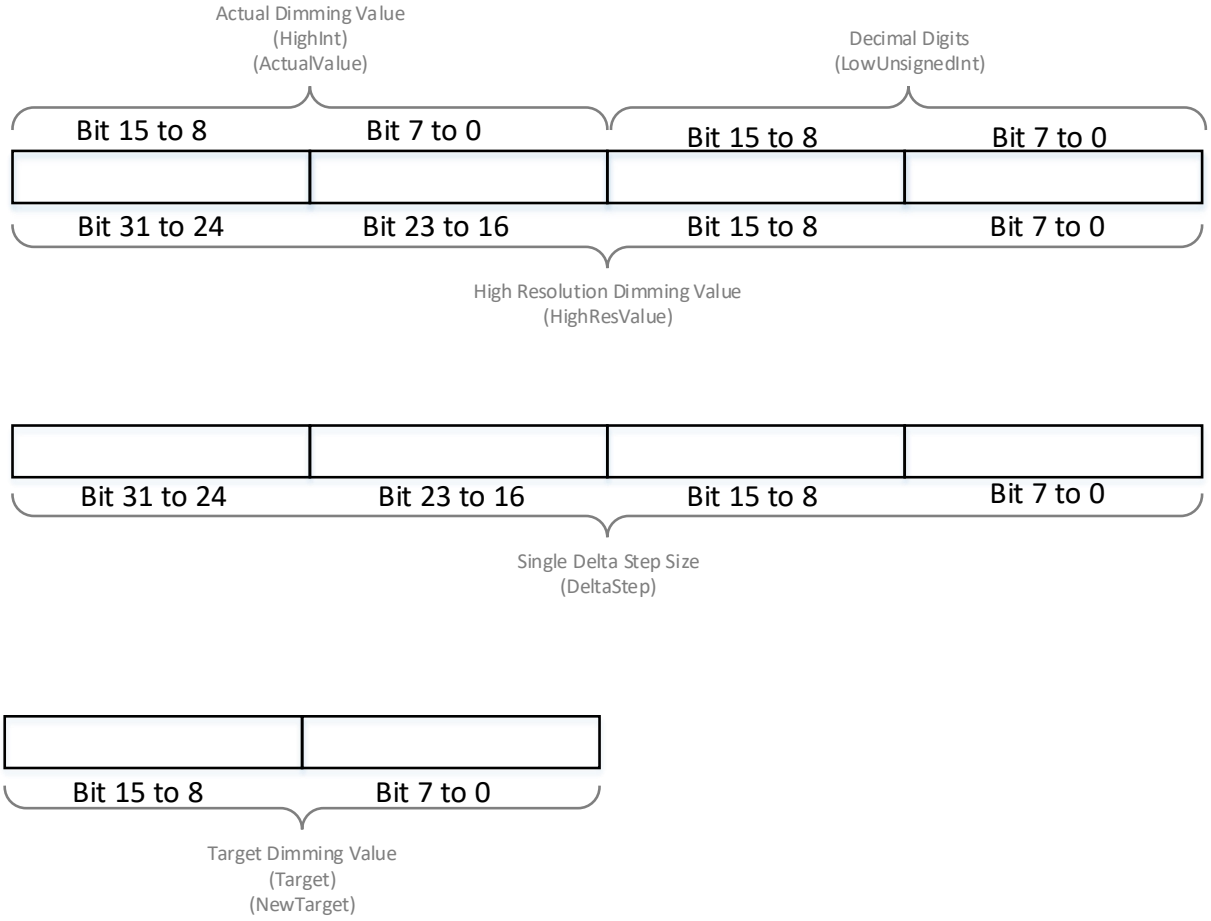


3.6.2 Protocol for SYNC Gen 4.0



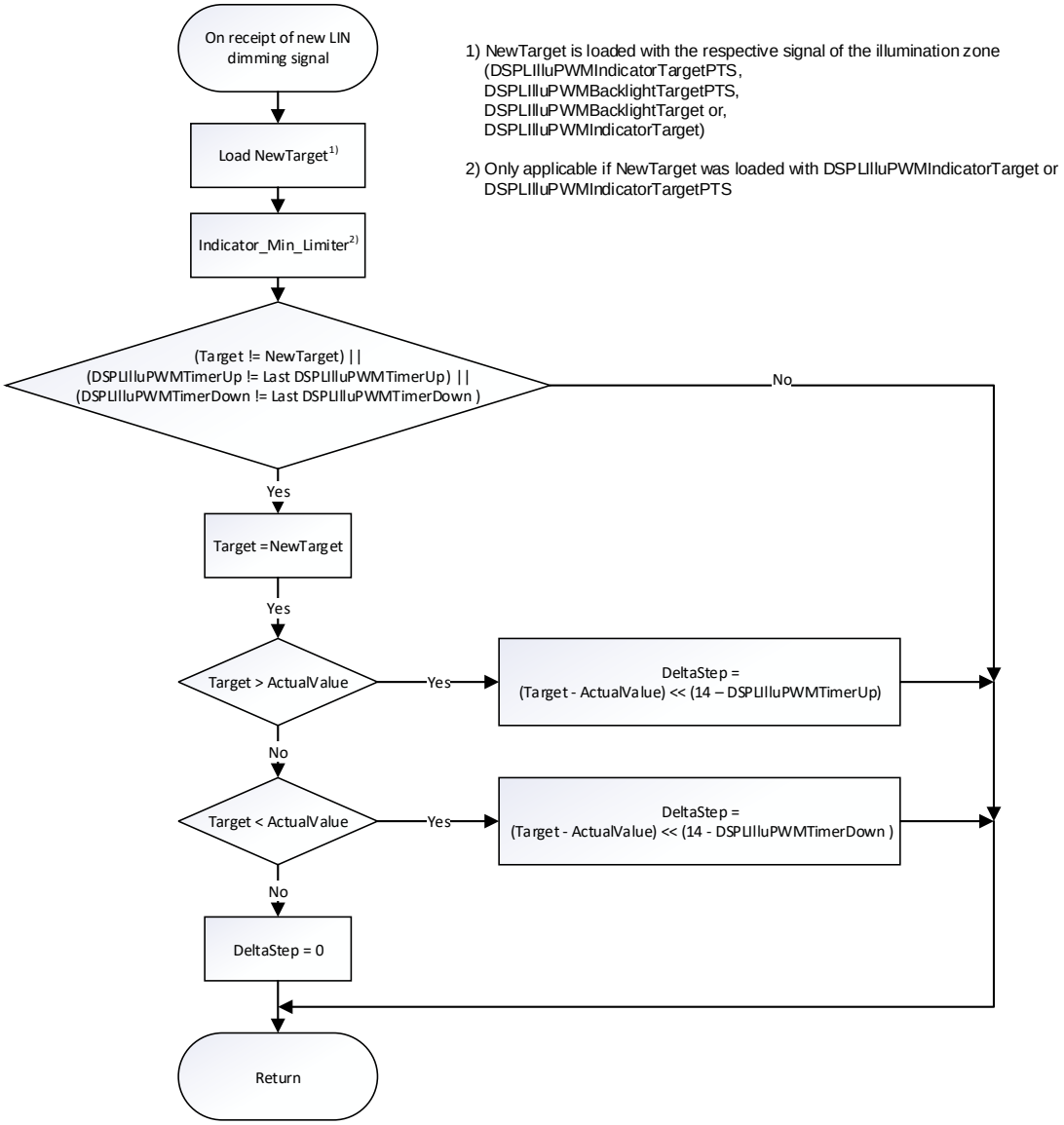
3.6.2.1 Dimming Algorithm / Flow Chart

3.6.2.1.1 SMDM-REQ-435924/A-Variable Structure



3.6.2.1.2 SMDM-REQ-435925/A-Dimming Step Calculation

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



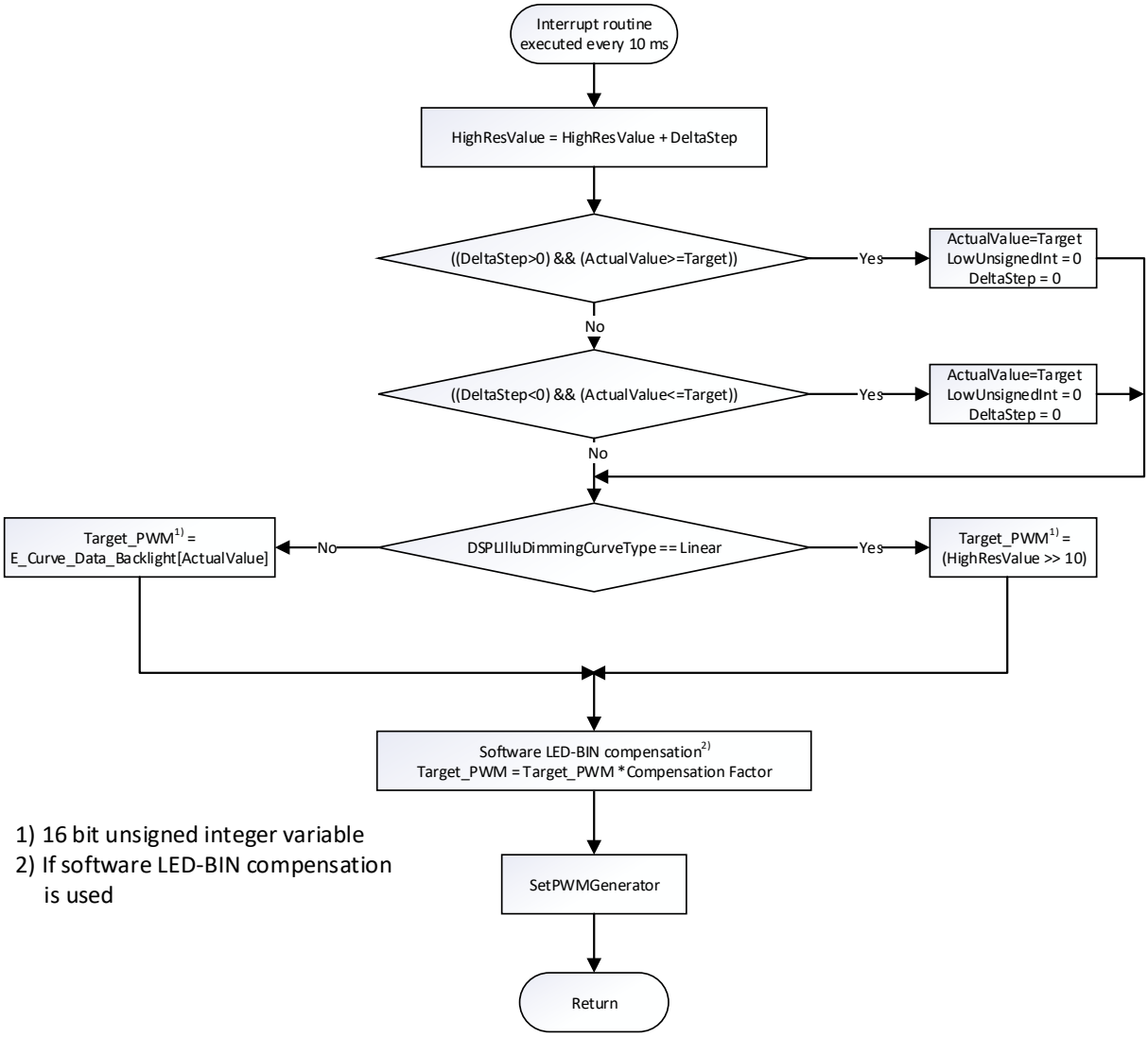
3.6.2.1.3 SMDM-REQ-435926/A-Indicator Blinking State

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

Identifier	Min Value	Max Value	Resolution [Hz]	Default Value [Hz]	Unit
Indicator_1	0.1	5	0.1	See function specification	Hz
Indicator_2	0.1	5	0.1	See function specification	Hz
Indicator_3	0.1	5	0.1	See function specification	Hz
Indicator_4	0.1	5	0.1	See function specification	Hz
Indicator_5	0.1	5	0.1	See function specification	Hz
Indicator_6	0.1	5	0.1	See function specification	Hz
Indicator_7	0.1	5	0.1	See function specification	Hz

Indicator_PTS	0.1	5	0.1	See function specification	Hz

3.6.2.1.4 SMDM-REQ-435927/A-Interrupt Routine

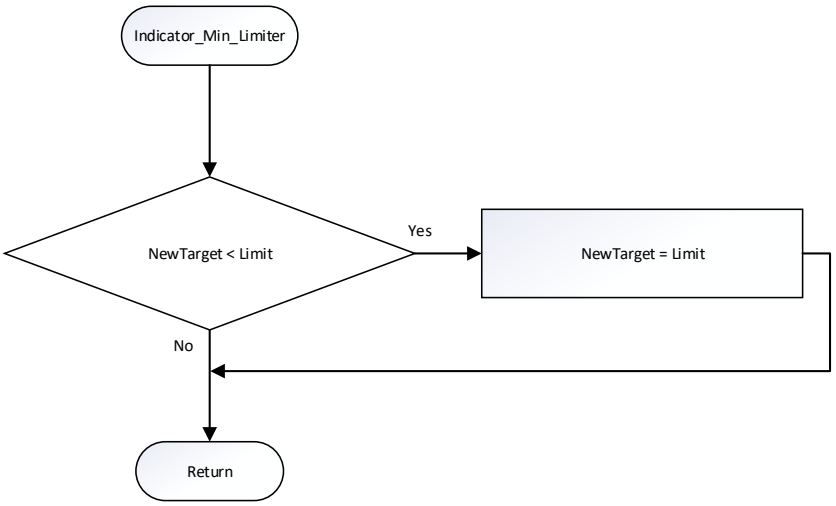


1) 16 bit unsigned integer variable
2) If software LED-BIN compensation is used

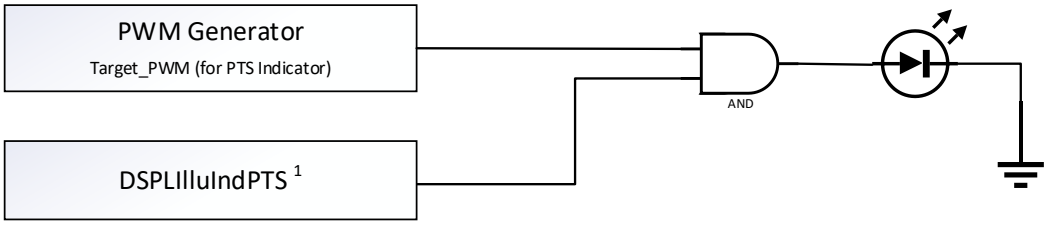
3.6.2.2 Indicators

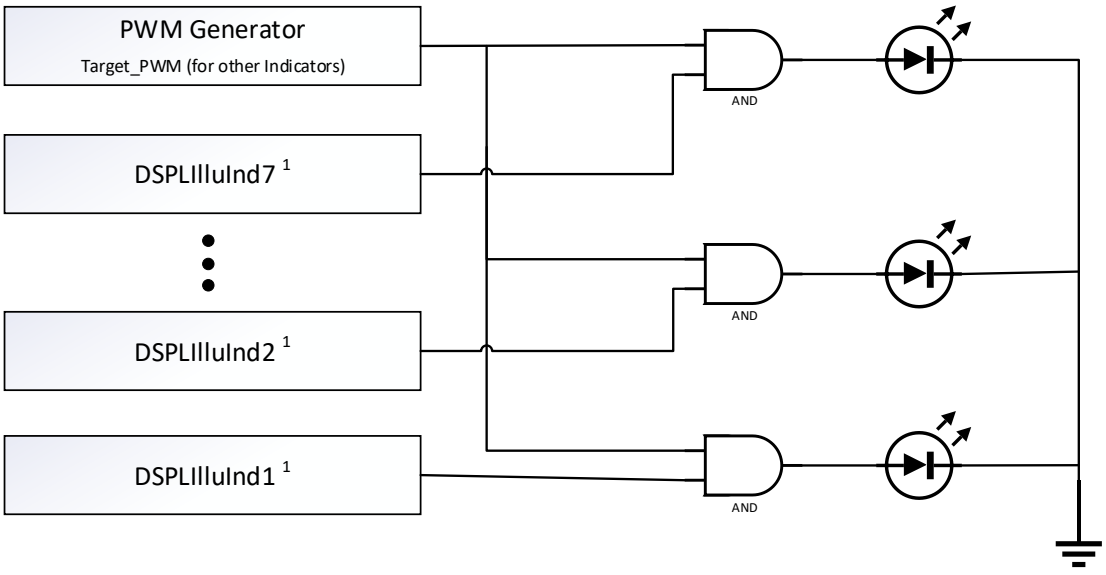
3.6.2.2.1 SMDM-REQ-455460/A-Indicators Requirement

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



Default Limit = 25. The Limit value must be aligned between a Vehicle Harmony representative and the ICP D&R.
Remark: Any change of the limit requires a recalculation of the e-curve tables below.





1) Hardwired indicator inputs are handeled in the same way

3.6.2.2.2 SMDM-REQ-435929/A-Hardwired Indicators

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

1. all indicators are illuminated with the same intensity
2. all indicators are dimming synchronously

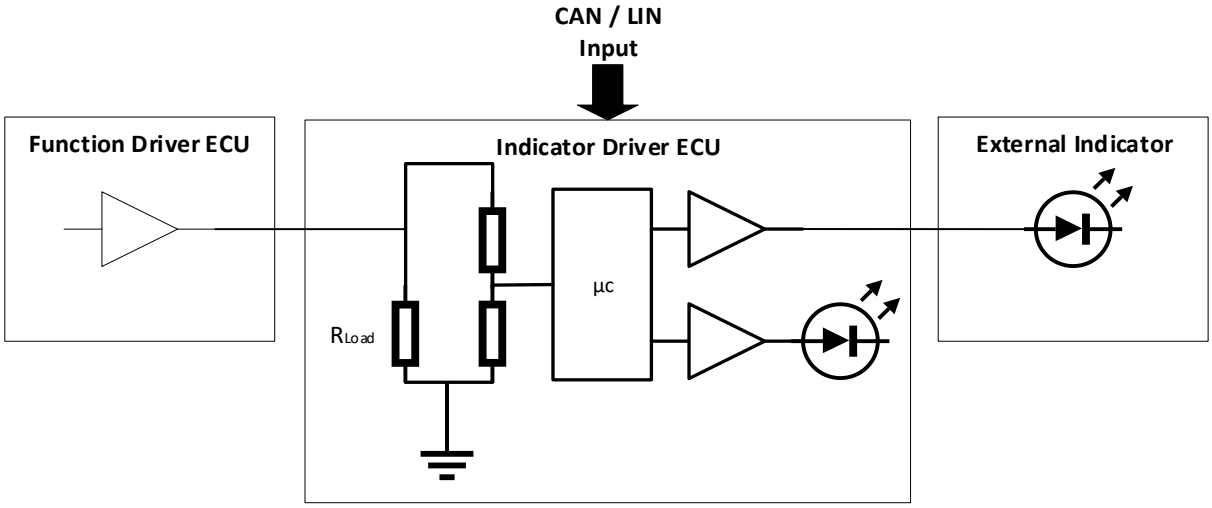


Figure 5 - Example Illustration (High Side Driver)

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

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

Note: Interface partners of function driver ECU, Indicator Driver ECU, External Indicator shall align their assumptions regarding interface compatibility via the known tool chain of GDT and interface control sheets
Note 1: Specified values are valid for complete range of system voltage and ambient temperature.
Note 2: Output values are measured at the ECU with the PWM output and related to ECU GND.
Note 3: The open line detection of the transmitting ECU needs to be considered

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

State	CAN / LIN Indicator PWM Intensity	Indicator Request	Indicator Intensity Output
1	Non-Off value available	ON	Follow CAN / LIN intensity
2	Don't care	OFF	OFF
3	Missing / OFF / sleep request	ON	Maintain last non-Off CAN / LIN intensity level*

*) Memorize the last received non-OFF CAN / LIN intensity level. Apply the memorized value if Indicator is requested on while CAN / LIN signal is missing. Assume maximum intensity level if last received non-OFF value cannot be retrieved (only on ECU reset / battery re-connect) or last non-Off value is not received within 10 seconds.

3.6.2.3 Dimming Algorithm / Sample Code

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

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

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

```
const PROGMEM  unsigned int E_Curve_Data_Backlight[1024] = // used for 6 cd/m² backlight
{  0,  1092,  1097,  1101,  1105,  1110,  1114,  1119,
 1123,  1128,  1132,  1137,  1141,  1146,  1151,  1155,
 1160,  1165,  1169,  1174,  1179,  1183,  1188,  1193,
 1198,  1202,  1207,  1212,  1217,  1222,  1227,  1232,
 1237,  1242,  1247,  1252,  1257,  1262,  1267,  1272,
 1277,  1282,  1287,  1292,  1298,  1303,  1308,  1313,
 1319,  1324,  1329,  1334,  1340,  1345,  1351,  1356,
 1361,  1367,  1372,  1378,  1383,  1389,  1395,  1400,
 1406,  1411,  1417,  1423,  1429,  1434,  1440,  1446,
 1452,  1457,  1463,  1469,  1475,  1481,  1487,  1493,
 1499,  1505,  1511,  1517,  1523,  1529,  1535,  1542,
 1548,  1554,  1560,  1566,  1573,  1579,  1585,  1592,
 1598,  1605,  1611,  1617,  1624,  1630,  1637,  1644,
 1650,  1657,  1663,  1670,  1677,  1684,  1690,  1697,
 1704,  1711,  1718,  1725,  1731,  1738,  1745,  1752,
 1759,  1766,  1774,  1781,  1788,  1795,  1802,  1809,
 1817,  1824,  1831,  1839,  1846,  1853,  1861,  1868,
 1876,  1883,  1891,  1899,  1906,  1914,  1922,  1929,
 1937,  1945,  1953,  1960,  1968,  1976,  1984,  1992,
 2000,  2008,  2016,  2024,  2032,  2041,  2049,  2057,
 2065,  2073,  2082,  2090,  2099,  2107,  2115,  2124,
 2132,  2141,  2150,  2158,  2167,  2176,  2184,  2193,
 2202,  2211,  2220,  2229,  2237,  2246,  2255,  2265,
 2274,  2283,  2292,  2301,  2310,  2320,  2329,  2338,
 2348,  2357,  2367,  2376,  2386,  2395,  2405,  2414,
 2424,  2434,  2444,  2453,  2463,  2473,  2483,  2493,
 2503,  2513,  2523,  2533,  2544,  2554,  2564,  2574,
 2585,  2595,  2605,  2616,  2626,  2637,  2647,  2658,
 2669,  2680,  2690,  2701,  2712,  2723,  2734,  2745,
 2756,  2767,  2778,  2789,  2800,  2811,  2823,  2834,
 2845,  2857,  2868,  2880,  2891,  2903,  2915,  2926,
 2938,  2950,  2962,  2974,  2986,  2998,  3010,  3022,
 3034,  3046,  3058,  3071,  3083,  3095,  3108,  3120,
 3133,  3145,  3158,  3171,  3183,  3196,  3209,  3222,
 3235,  3248,  3261,  3274,  3287,  3300,  3313,  3327,
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 4180,  4197,  4214,  4231,  4248,  4265,  4282,  4299,
 4316,  4333,  4351,  4368,  4386,  4404,  4421,  4439,
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 4752,  4771,  4790,  4809,  4829,  4848,  4867,  4887,
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5947, 5971, 5995, 6019, 6043, 6067, 6092, 6116,
6141, 6165, 6190, 6215, 6240, 6265, 6290, 6315,
6341, 6366, 6392, 6417, 6443, 6469, 6495, 6521,
6547, 6573, 6600, 6626, 6653, 6680, 6706, 6733,
6760, 6787, 6815, 6842, 6869, 6897, 6925, 6953,
6980, 7008, 7037, 7065, 7093, 7122, 7150, 7179,
7208, 7237, 7266, 7295, 7324, 7354, 7383, 7413,
7443, 7472, 7502, 7533, 7563, 7593, 7624, 7654,
7685, 7716, 7747, 7778, 7809, 7840, 7872, 7904,
7935, 7967, 7999, 8031, 8063, 8096, 8128, 8161,
8194, 8227, 8260, 8293, 8326, 8359, 8393, 8427,
8461, 8494, 8529, 8563, 8597, 8632, 8666, 8701,
8736, 8771, 8806, 8842, 8877, 8913, 8949, 8985,
9021, 9057, 9093, 9130, 9166, 9203, 9240, 9277,
9314, 9352, 9389, 9427, 9465, 9503, 9541, 9579,
9618, 9656, 9695, 9734, 9773, 9812, 9852, 9891,
9931, 9971, 10011, 10051, 10091, 10132, 10173, 10213,
10254, 10296, 10337, 10378, 10420, 10462, 10504, 10546,
10588, 10631, 10674, 10716, 10759, 10803, 10846, 10890,
10933, 10977, 11021, 11065, 11110, 11154, 11199, 11244,
11289, 11335, 11380, 11426, 11472, 11518, 11564, 11610,
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13251, 13305, 13358, 13412, 13466, 13520, 13574, 13628,
13683, 13738, 13793, 13848, 13904, 13960, 14016, 14072,
14129, 14185, 14242, 14300, 14357, 14415, 14472, 14531,
14589, 14647, 14706, 14765, 14824, 14884, 14944, 15004,
15064, 15124, 15185, 15246, 15307, 15369, 15430, 15492,
15555, 15617, 15680, 15743, 15806, 15869, 15933, 15997,
16061, 16126, 16190, 16255, 16321, 16386, 16452, 16518,
16584, 16651, 16718, 16785, 16852, 16920, 16988, 17056,
17124, 17193, 17262, 17331, 17401, 17471, 17541, 17611,
17682, 17753, 17824, 17896, 17968, 18040, 18112, 18185,
18258, 18331, 18405, 18479, 18553, 18627, 18702, 18777,
18853, 18928, 19004, 19081, 19157, 19234, 19311, 19389,
19467, 19545, 19623, 19702, 19781, 19861, 19940, 20020,
20101, 20181, 20262, 20344, 20425, 20507, 20590, 20672,
20755, 20839, 20922, 21006, 21091, 21175, 21260, 21346,
21431, 21517, 21604, 21690, 21777, 21865, 21953, 22041,
22129, 22218, 22307, 22397, 22487, 22577, 22668, 22759,
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24363, 24460, 24559, 24657, 24756, 24856, 24955, 25056,
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25975, 26080, 26184, 26289, 26395, 26501, 26607, 26714,
26821, 26929, 27037, 27146, 27255, 27364, 27474, 27584,
27695, 27806, 27918, 28030, 28142, 28255, 28369, 28483,
28597, 28712, 28827, 28943, 29059, 29176, 29293, 29410,
29528, 29647, 29766, 29885, 30005, 30126, 30247, 30368,
30490, 30612, 30735, 30859, 30983, 31107, 31232, 31357,
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36955,  37103,  37252,  37402,  37552,  37703,  37854,  38006,
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39401,  39559,  39718,  39878,  40038,  40198,  40360,  40522,
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57881,  58114,  58347,  58581,  58816,  59052,  59289,  59527,
59766,  60006,  60247,  60489,  60732,  60976,  61220,  61466,
61713,  61961,  62209,  62459,  62710,  62961,  63214,  63468,
63723,  63979,  64235,  64493,  64752,  65012,  65273,  65535 };
```

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

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

```
const PROGMEM  unsigned int E_Curve_Data_Backlight[1024] = // used for deadfront backlight
{  0,  13,  13,  13,  13,  14,  14,  14,
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811, 818, 825, 832, 839, 846, 853, 860,
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1930, 1946, 1962, 1979, 1995, 2012, 2029, 2046,
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2357, 2377, 2397, 2417, 2437, 2457, 2478, 2499,
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2879, 2903, 2927, 2952, 2976, 3001, 3026, 3052,
3077, 3103, 3129, 3155, 3182, 3208, 3235, 3262,
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38766,  39091,  39418,  39748,  40080,  40416,  40754,  41095,
41439,  41786,  42135,  42488,  42844,  43202,  43564,  43928,
44296,  44667,  45040,  45417,  45797,  46181,  46567,  46957,
47350,  47746,  48146,  48549,  48955,  49365,  49778,  50194,
50614,  51038,  51465,  51896,  52330,  52768,  53210,  53655,
54104,  54557,  55013,  55474,  55938,  56406,  56878,  57354,
57834,  58318,  58806,  59298,  59794,  60295,  60799,  61308,
61821,  62339,  62860,  63386,  63917,  64452,  64991,  65535 };
```

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

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

```
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 1796, 1802, 1809, 1816, 1822, 1829, 1836, 1843,
 1850, 1857, 1864, 1871, 1878, 1885, 1892, 1899,
 1906, 1913, 1920, 1927, 1934, 1941, 1949, 1956,
 1963, 1971, 1978, 1985, 1993, 2000, 2008, 2015,
 2023, 2030, 2038, 2045, 2053, 2061, 2068, 2076,
 2084, 2091, 2099, 2107, 2115, 2123, 2131, 2139,
 2147, 2155, 2163, 2171, 2179, 2187, 2195, 2203,
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 3560, 3573, 3587, 3600, 3614, 3627, 3641, 3654,
 3668, 3681, 3695, 3709, 3723, 3737, 3750, 3764,
 3779, 3793, 3807, 3821, 3835, 3849, 3864, 3878,
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7718, 7747, 7776, 7805, 7834, 7863, 7892, 7922,
7951, 7981, 8011, 8041, 8070, 8101, 8131, 8161,
8191, 8222, 8253, 8283, 8314, 8345, 8376, 8408,
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8694, 8726, 8759, 8791, 8824, 8857, 8890, 8923,
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13586, 13636, 13687, 13738, 13789, 13841, 13892, 13944,
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16242, 16302, 16363, 16424, 16485, 16547, 16608, 16670,
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17758, 17825, 17891, 17958, 18025, 18092, 18159, 18227,
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23213, 23299, 23386, 23473, 23561, 23648, 23737, 23825,
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28589, 28695, 28802, 28910, 29018, 29126, 29234, 29343,
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51843, 52036, 52230, 52425, 52620, 52816, 53013, 53211,
53409, 53608, 53808, 54009, 54210, 54412, 54615, 54818,
55023, 55228, 55433, 55640, 55847, 56056, 56264, 56474,
56685, 56896, 57108, 57321, 57534, 57749, 57964, 58180,
58397, 58615, 58833, 59052, 59272, 59493, 59715, 59938,
60161, 60385, 60610, 60836, 61063, 61290, 61519, 61748,
61978, 62209, 62441, 62674, 62907, 63142, 63377, 63613,
63850, 64088, 64327, 64567, 64808, 65049, 65292, 65535};
```
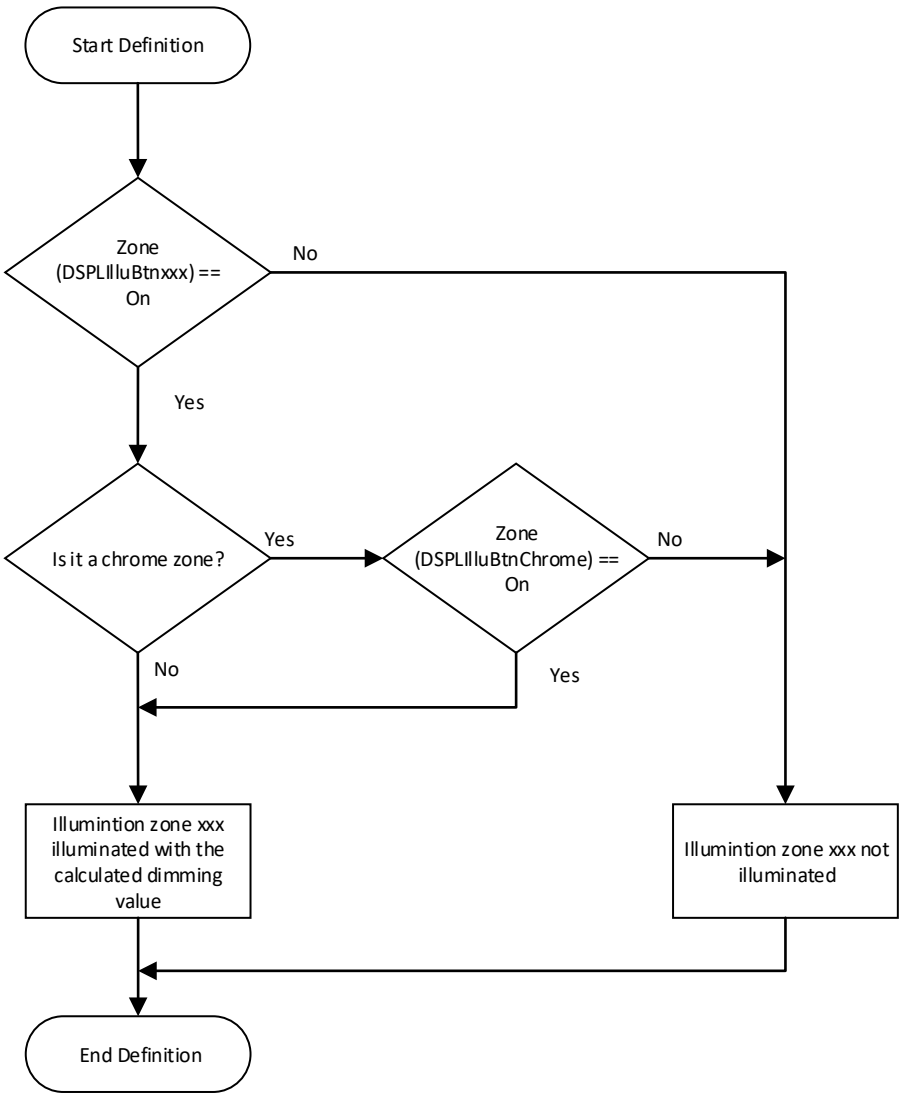

```
typedef union
{
  struct
  {
    // IMPORTANT!!! High / low order of bytes depended on uC architecture
    // This is for Arduino Uno board
    unsigned int LowUnsignedInt;
    signed   int HighInt;
  } HiLow;
  struct
  {
    signed long HighResValue;
  } LongValue;
} HighResType;


HighResType Actual;      // actual Value
int         Target;      // new Target
signed long DeltaStep;   // actual delta to add
void SetNewTarget( int up, int down, int NewTarget )
{
  signed int  ActualValue;
  signed long NewDelta;


  noInterrupts();
  ActualValue = Actual.HiLow.HighInt;
  interrupts();
  if (Target != NewTarget)
  {
    noInterrupts();
    Target = NewTarget;
    interrupts();
```

```
    if (Target > ActualValue)
    {
      NewDelta = ( Target - ActualValue ) << (14 - up) );
    }
    else if (Target < ActualValue)
    {
      NewDelta = ( Target - ActualValue ) << (14 - down) );
    }
    else
    {
      NewDelta = 0;
    }
    noInterrupts();
    DeltaStep = NewDelta;
    interrupts();
  }
} // SetNewTarget
void InterruptRoutine10ms()
// executed every 10ms
{
  int Index;

  Actual.LongValue.HighResValue = Actual.LongValue.HighResValue + DeltaStep;
  if ((DeltaStep>0) && (Actual.HiLow.HighInt>=Target))
  { // stop dimming up
    Actual.HiLow.HighInt = Target;
    Actual.HiLow.LowUnsignedInt = 0;
    DeltaStep = 0;
  }
  if ((DeltaStep<0) && (Actual.HiLow.HighInt<=Target))
  { // stop dimming down
```

```
    Actual.HiLow.HighInt = Target;

    Actual.HiLow.LowUnsignedInt = 0;

    DeltaStep = 0;

  }

  // update PWM generator (or output control)

  Index = Actual.HiLow.HighInt;

  if (DSPLIlluDimmingCurveType == Linear)

  {  // linear behavior

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

  }

  else

  { // exponential behavior

    SetNewPWM(E_Curve_Data_Backlight[Index]);

  }

} // InterruptRoutine10ms




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

SetNewTarget( 6, 8, 500 );
```

3.6.2.4 SMDM-REQ-455461/A-Zone Handling

The zone handling is applicable for each backlight zone. Indicators are not affected. Xxx is a synonym for the different backlight zones defined within section “Illumination zone signal control”



3.7 SMDM-FUN-REQ-435922/A-IPC

General chapters 1 until FUN-REQ-435618 “Display Day / Night Color Palette Selection” are to be implemented / considered if applicable.

3.7.1 Diagnostic DIDs for Intensity Calibration

See chapter SMDM-REQ-454725 “Illumination Calibration via DID” for DID calibration details.

3.7.1.1 General DIDs for Intensity Calibration

3.7.1.1.1 SMDM-REQ-435930/A-Diagnostic DIDs for Zones with an own PWM Generator

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

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

1. 12 bit size zones (0 = OFF, translates to 0% PWM duty cycle; 4095 = max intensity translates to 100% PWM duty cycle).

2. 10 bit size zones (0 = OFF, translates to 0% PWM duty cycle; 1023 = max intensity, translates to 100% PWM duty cycle).
3. Any value between 0 and 1023 (4095) is valid and shall result in a linearly interpolated intensity output. The resolution of 1024 (10 bit) / 4096 (12 bit) steps must be provided.
4. The IPC must meet all intensity targets (as per Interior Harmony SDS) when calibration is set to default.

Identifier	Default Value	Bytes	Range	Comment, Description
DID_WeightFactorDP_10Bit (standard resolution variant)	See "10 Bit PWM Display Backlight"	108*2	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight" (used for displays)
DID_WeightFactorDP_12Bit (high resolution variant)	See "12 Bit PWM Display Backlight"	108*2	See "12 Bit PWM Display Backlight"	See "12 Bit PWM Display Backlight" (used for displays)
DID_WeightFactor_Gauge	See "10 Bit PWM Display Backlight"	108*2	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight" (used for gauge, pointer and ring)
DID_Low_PWM_Display_BL_12Bit (high resolution variant)	20	2	0 - 4095	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_High_PWM_Display_BL_12Bit (high resolution variant)	4095	2	0 –4095	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_Low_PWM_Display_BL_10Bit (standard resolution variant)	5	2	0 - 1023	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Display_BL_10Bit (standard resolution variant)	1023	2	0 - 1023	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Low_PWM_Gauge_BL	5	2	0 - 1023	PWM value for lowest brightness of the gauge. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Gauge_BL	1023	2	0 - 1023	PWM value for highest brightness of the gauge. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Low_PWM_Gauge_Pointer	5	2	0 - 1023	PWM value for lowest brightness of the gauge pointer. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Gauge_Pointer	1023	2	0 - 1023	PWM value for highest brightness of the gauge pointer. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Low_PWM_Gauge_Ring	5	2	0 - 1023	PWM value for lowest brightness of the gauge Ring. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Gauge_Ring	1023	2	0 - 1023	PWM value for highest brightness of the gauge Ring. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Low_PWM_PRNDL_BL	5	2	0 - 1023	PWM value for lowest brightness of the PRNDL backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle

DID_High_PWM_PRNDL_BL	1023	2	0 - 1023	PWM value for highest brightness of the PRNDL backlight. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Blue	408	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (blue). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_Blue	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (blue). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Green	508	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (green). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_Green	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (green). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Turn	508	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (turn indicator). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_Turn	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (turn indicator). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Amber	508	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (amber). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_Amber	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (amber). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Orange	304	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (orange). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_Orange	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (orange). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Night_PWM_Red	508	2	0 - 1023	PWM value for nighttime telltale / indicator brightness (red). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_Day_PWM_ Red	1023	2	0 - 1023	PWM value for daytime telltale / indicator brightness (red). 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle

3.7.2 SMDM-REQ-455478/A-Smooth Dimming Calibration for Enhanced Dimming Algorithm

See "Seamless / Smooth Transition on Intensity Change" for detailed DID information

Identifier	Default Value	Bytes	Range	Comment, Description
DID_TransTime_Usr_BL	0	1	0 - 9	Transition time from start to target intensity on user request. Used for backlight.
DID_TransTime_Amb_Up_BL	6	1	0 - 9	Transition time from start to target intensity if increased intensity is requested. Used for backlight.
DID_TransTime_Amb_Down_BL	8	1	0 - 9	Transition time from start to target intensity if decreased intensity is requested. Used for backlight.

DID_TransTime_OnOff_BL	0	1	0 - 9	Transition time from start to target intensity if start or target is 0FF. Used for backlight.

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

3.7.3 IPC variants

The calibration parameters in chapter "General DIDs for Intensity Calibration" are generic. Only a subset of the generic parameters must be assigned to the related IPC variant. The applicability is dependent on the IPC design and the available illumination zones. The DIDs defined in chapter "Smooth Dimming Calibration for Enhanced Dimming Algorithm" are applicable to every IPC variant.

3.7.3.1 SMDM-REQ-435931/A-Full Screen IPC (SX Cluster)

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

Identifier	Default Value	Bytes	Range	Comment, Description
DID_WeightFactorDP_10Bit (standard resolution variant)	See "10 Bit PWM Display Backlight"	108*2	See "10 Bit PWM Display Backlight"	See 2.2.1.5 "10 Bit PWM Display Backlight" (used for displays)
DID_Low_PWM_Display_BL_10Bit (standard resolution variant)	5	2	0 - 1023	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Display_BL_10Bit (standard resolution variant)	1023	2	0 - 1023	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_WeightFactorDP_12Bit (high resolution variant)	See "12 Bit PWM Display Backlight"	108*2	See "12 Bit PWM Display Backlight"	See 2.2.1.6 "12 Bit PWM Display Backlight" (used for displays)
DID_Low_PWM_Display_BL_12Bit (high resolution variant)	20	2	0 - 4095	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_High_PWM_Display_BL_12Bit (high resolution variant)	4095	2	0 - 4095	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_WeightFactorDP_Additional_Color	TBD	TBD	TBD	TO BE ASSESSED

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

3.7.3.2 SMDM-REQ-435932/A-IPC with Display and further Physical Illumination Zones (S0 / S1 / S2)

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

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

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

DID_WeightFactorDP_12Bit (high resolution variant)	**See "12 Bit PWM Display Backlight"**	**108*2**	**See "12 Bit PWM Display Backlight"**	**See "12 Bit PWM Display Backlight" (used for displays)**
DID_Low_PWM_Display_BL_12Bit (high resolution variant)	20	2	0 - 4095	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_High_PWM_Display_BL_12Bit (high resolution variant)	4095	2	0 - 4095	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 4095 = 100% PWM duty cycle
DID_WeightFactorDP_10Bit (standard resolution variant)	See "10 Bit PWM Display Backlight"	108*2	See "10 Bit PWM Display Backlight"	See "10 Bit PWM Display Backlight" (used for displays)
DID_Low_PWM_Display_BL_10Bit (standard resolution variant)	5	2	0 - 1023	PWM value for lowest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle
DID_High_PWM_Display_BL_10Bit (standard resolution variant)	1023	2	0 - 1023	PWM value for highest brightness of the display. 0 = 0% PWM duty cycle; 1023 = 100% PWM duty cycle

3.7.4 IPC Illumination Zones

3.7.5 Dimming_Lvl HMI Pop Up

3.7.5.1 SMDM-REQ-455480/A-Dimming_Lvl HMI Pop Up Requirement

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

Day mode representation of bar graph

Night mode representation of bar graph.

Operation:

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

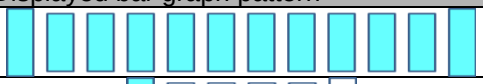
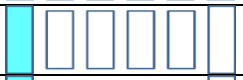
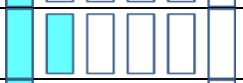
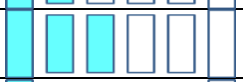
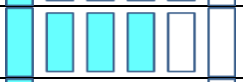
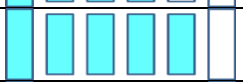
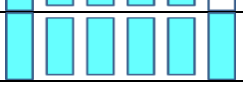
Identifier	Value	Bytes	Range	Comment, Description
DID_Show_Dimming_Lvl_Repeater	1	1	0 - 1	0 -> dimming HMI repeater off / not shown 1 -> dimming HMI repeater on / shown

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

3.7.5.2 SMDM-REQ-435933/A-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	

Dimming_Lvl		Meaning	Output
hex	dec		Displayed bar graph pattern
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

4 Appendix: Reference Documents

Reference #	Document Title
1	Smooth Dimming / Cockpit Illumination System Specification
2	
3	
4	
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