Engineering Specification

PART NAME: SPEC - ELECTRICAL & ELECTRONIC SYSTEM	PART NUMBER
VEHICLE INTERIOR ILLUMINATION WITH DAYTIME DIMMING	ES-DS7T-1A278-AD

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			Times and 5.3.5 Police Dark Car Mode			
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1.0 INTRODUCTION

1.1 Purpose and Scope

This specification defines the generic requirements for a vehicle interior illumination dimming subsystem for all new vehicle programs with the Common Global Electrical Architecture (CGEA) version 1.3.

1.2 Document Intent

This specification is intended as a generic guideline for vehicle programs that require a standard dimming control subsystem for both nighttime and daytime illuminated/dimmable components. Non-standard dimming will be the subject of a future specification, if required. Ice Blue™ and Lincoln White component color and intensity targets are defined in ES-DS7T-1A278-B, a supplement to this specification.

2.0 INTERIOR ILLUMINATION SUBSYSTEM OVERVIEW

2.1 Subsystem Components

Figure 1 shows a generic block diagram for the interior illumination dimming subsystem. The main components of this system include the Light Switch Module (LSM), Ambient Light Sensor (ALS), DECM (Dimming Electronics Control Module), DFDCD (Driver Front Door Control Unit), PFDCU (Passenger Front Door Control Unit) and the illuminated components. Illuminated components include, but are not limited to: instrument cluster (including ePRNDL), Electronic Control Panel (ECP), trailer brake module, shifter, door trim switches, steering wheel switches, IP switches, Overhead console and floor console components.

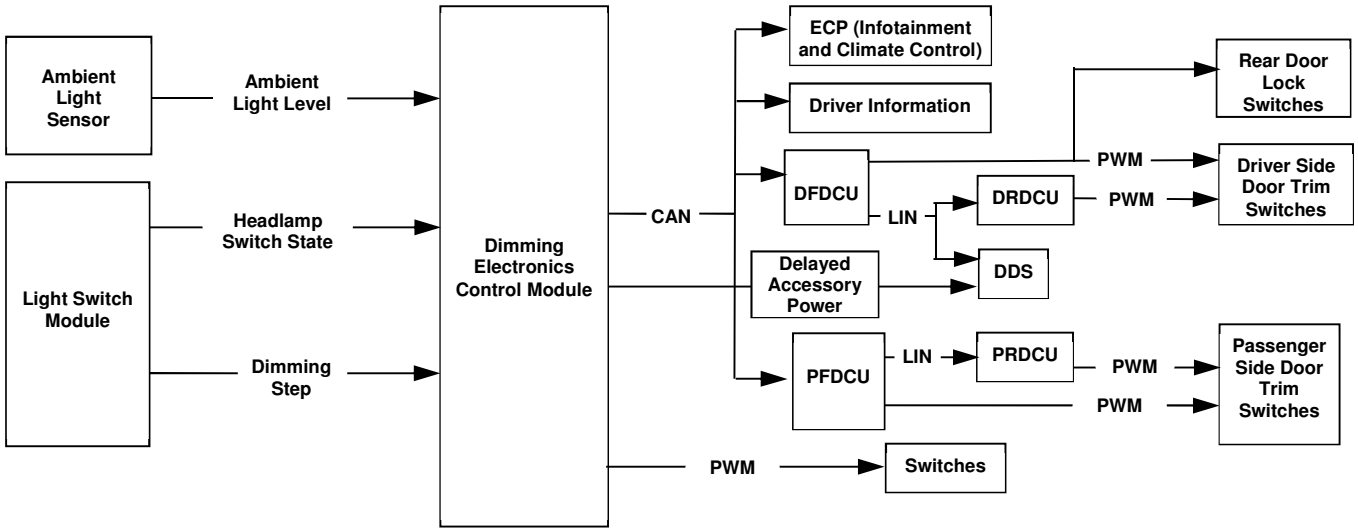

Figure 1. Interior Illumination Subsystem Block Diagram

2.1.1 Dimming Electronics Control Module

The DECM controls the illumination levels for the entire interior illumination subsystem. It reads the inputs from the ALS and LSM then outputs the appropriate Network message and Pulse Width Modulated (PWM) dimming level signal(s). The DECM will control all component illumination either via a hardwire PWM signal(s) and/or Controller Area Network (CAN) message. For all 2013 and beyond Model Year vehicle programs, the DECM will reside within the Body Control Module (BCM).

2.1.2 Nighttime Dimmable Components

The nighttime illuminated/dimmable components in the interior illumination subsystem are comprised of three different categories; 1) components that receive/interpret a CAN message from the BCM and internally control their illumination, 2) components that receive/interpret a CAN message and then send a Local Interconnect Network (LIN) message to other components to control their illumination and 3) components that are directly controlled via a PWM hardwire signal from the BCM or Door Control Unit.

2.1.2.1 Networked Components

Networked components or subsystems include but are not limited to; Infotainment, Climate Control, Driver Information, Switch and Brake. Infotainment components include a radio, Electronic Control Panel (ECP), Display Module or Family Entertainment System. Climate Control components include an Automatic or Manual temperature controller. Driver Information components include the Instrument Cluster. Switch components include the Driver Door Switch. Brake components include the Trailer Brake Module. Most networked components have graphics, symbols and/or text, illuminated using Light Emitting Diodes (LEDs) and an electronic display device, i.e. Vacuum Fluorescent Display (VFD) or Liquid Crystal Display (LCD).

2.1.2.2 Directly Controlled Components

Directly controlled components include but are not limited to the illuminated switches or bezels located on the Instrument Panel, Door Trim, Steering Wheel, Floor Console or Overhead Console. These components also illuminate graphics, either symbols or text, with LEDs.

2.1.3 Daytime Dimmable Components

Components in the interior illumination subsystem that are daytime dimmable are network controlled. Currently, only graphics, symbols and/or text, illuminated using LEDs, are daytime dimmable. Any new electronic display devices that are capable of daytime dimming, i.e. Centerstack displays, must consult the appropriate EESE Interior Harmony engineer before implementing daytime dimming to assure overall vehicle harmony.

2.2 Subsystem Operational Description

The main function of the interior illumination dimming subsystem is to provide legible, illuminated graphics for all controls and displays in all ambient lighting conditions. The functional behavior of the subsystem is significantly different daytime versus nighttime. Therefore, there are two different operating modes, daytime and nighttime.

2.2.1 Daytime

The illumination subsystem is in daytime mode when: 1) the Parklamps are ON and the ALS senses daytime or 2) the Parklamps are OFF and Ignition is in Run or Start. All electronic displays in the instrument cluster and centerstack illuminate at their daytime brightness levels. The ePRNDL primary gear indicator and all Climate Control indicators will also illuminate at their daytime illumination level.

If Parklamps are ON and the ALS senses daytime, all components that are not daytime dimmable illuminate at their minimum nighttime lighting level. If Parklamps are OFF, all components that are not daytime dimmable are completely OFF. The driver cannot adjust or dim these illumination levels.

For those components that are daytime dimmable, the initial daytime illumination setting for the graphics, symbols and/or text, stored in the BCM, will be maximum daytime brightness. Using the dimmer switch, the driver can then adjust or "dim" these graphics, symbols and/or text to his/her preferred illumination level for optimum visibility. This new daytime lighting level or set point will replace the initial default setting stored in the BCM. The next daytime drive cycle, all daytime dimmable graphics, symbols and/or text will illuminate to this new daytime illumination level.

If Parklamps are ON and the vehicle is without an ALS, the driver has the option to revert the subsystem into daytime mode by entering the User Selectable Daytime mode. If the driver continuously depresses the dim up button on the dimmer switch until the last nighttime dimming level is attained, the very next dim up press will put the subsystem into daytime mode. The BCM will transmit a predetermined daytime illumination level for the daytime dimmable component(s) to use. All other illuminated components will remain at maximum nighttime brightness while all electronic displays, the ePRNDL primary gear indicator and all Climate Control indicators will illuminate at their daytime brightness levels.

2.2.2 Nighttime

When the Parklamps are ON in dusk/dawn or nighttime conditions, the illumination subsystem is in nighttime mode. The initial default nighttime setting, stored in the BCM, for all illuminated components will be maximum nighttime brightness. Using the dimmer switch, the driver can then adjust or "dim" the illuminated components to his/her preferred illumination level for optimum visibility. This new nighttime lighting level or set point will replace the initial default setting stored in the BCM. The next nighttime drive cycle, all illuminated components will illuminate to this new nighttime illumination level.

3.0 DIMMING CONTROL FUNCTIONAL CHARACTERISTICS

3.1 Dimming Control Inputs

The Parklamps Status and Dimmer Switch inputs are required for all dimming subsystems while the ambient light level input is optional.

3.1.1 Ambient Light Level

The ALS provides an analog voltage signal to the BCM which represents an ambient light level. The ambient light level signal characteristics are defined in the sensor specification ES-DG9T-14A597-A. This ambient light level is used to determine day or night.

3.1.2 Parklamps Status

The BCM provides the Parklamps status over CAN which describes whether Parklamps are ON or OFF. Parklamps status is used to activate daytime or nighttime illumination independent of the Ignition Switch position.

3.1.3 Dimmer Switch

The Dimmer Switch has 2 independent buttons, one for dim up and one for dim down. The LSM provides a hardwired signal to the BCM which represents this increase or decrease in the illumination level. Refer to the appropriate switch specification for further details of these input signals.

3.2 Dimming Control Outputs

The BCM will output a high current PWM signal for those components that are hardwired to the BCM and a CAN message for those components that are on the network. The four Door Modules will replicate the high current PWM signal for those illuminated components that are hardwired to those modules.

3.2.1 PWM Dimming Signal Characteristics

PWM dimming is used by the hardwired components as a power signal to directly drive the LEDs used for illumination. Figure 2 shows the waveform characteristic for the "Positive" PWM dimming signal. The BCM must have the capability to generate this signal at pulse width duty cycles from 5% to 100%. The duty cycle, measured at 50% of the peak output voltage (V_{pk}), is defined as:

Duty Cycle (%DC) = PulseWidth (PW) / Period (P)

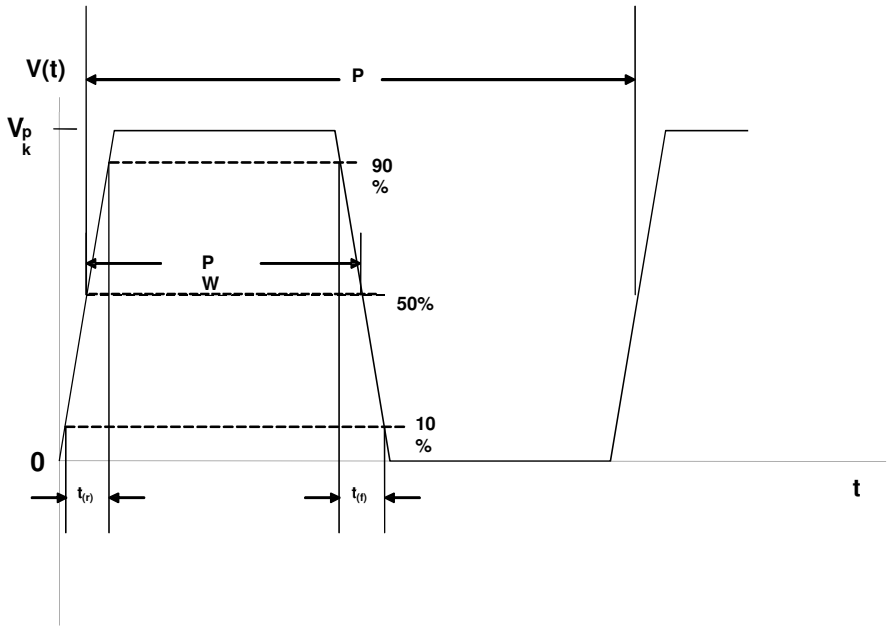

Figure 2. PWM Waveform Characteristics

Table 1 shows the electrical parameters for the PWM signal. The frequency and rise/fall times have been chosen to minimize Electromagnetic Compatibility (EMC) effects while still maintaining adequate performance. The rise/fall times are defined as the transition time between 10% and 90% of the waveform amplitude.

Table 1. PWM Signal Specifications

Operating Conditions [1]		System Voltage: 9.5 $< V_{sys} <$ 16.0 volts Ambient Temperature: -40°C $< T_{amb} <$ 85°C			
Characteristic	**Unit**	**Min**	**Typical**	**Max**	**Comments**
PWM Output Frequency [2]	Hz	100	220	300	Configurable in the BCM
PWM Output Voltage (V_{pk})	Volts		V_{sys} – 1.3		Short circuit & reverse battery protected
Ground Offset	Volts	See ELCOMP requirement RQT-191001-009976 & 009989			
PWM Rise/Fall Time	µsec	8	-	50	Must meet component and vehicle level EMC requirements [4]
PWM Output Duty Cycle	%	5	-	100	See Table 3
PWM Output Duty Cycle Jitter	Δ %	-	-	0.5	
Total PWM output duty cycle change vs. volt and temp	%	-3	-	3	Maximum cumulative change across entire operating range.
Output Frequency jitter	Δ %	-	-	0.5	
PWM input resolution [3]	%	-	0.4	1	Recommended values
PWM input hysteresis	%	1	2	-	
Input Response Time	msec	-	-	100	

1. All specifications apply across voltage and temperature ranges noted
2. All "Output" specifications refer to and are measured at the BCM
3. All "Input" specifications refer to and are measured at the illuminated component receiving the PWM signal
4. Rise and Fall times outside this specification must be approved by EESE Interior Harmony Core Engineering

3.2.2 Network Messages

The BCM will send CAN signals to communicate dimming levels to all illuminated components on the network. Daytime and Nighttime illumination are controlled by the Parklamp_Status, Dimming_Lvl, Backlit_LED_Status and Day_Night_Status signals. Further details of all these signals will be explained in the following sections. All illuminated components that use a CAN signal to control their dimming need to respond to any changes in dimming within 100 milliseconds to prevent any customer perceived latency. Details of the CAN signals are shown in Table 2 below. The messages and signals are in the EESE CGEA Core Multiplex Data Base (CMDB) from which vehicle application message lists are derived.

Table 2. CAN Dimming Signal Details

Description	Length	Detailed Meaning	State Encoded	Min	Max	Comment
Parklamp_Status	2			0 (0x0)	3 (0x3)	
		Off	0x0			
		On	0x1			
		Unknown [1]	0x2			
		Invalid [1]	0x3			
Day_Night_Status	2			0 (0x0)	2 (0x2)	
		Null	0x0			
		Day	0x1			
		Night	0x2			
Dimming_Lvl	8			0 (0x0)	253 (0xFD)	
		Off	0x0			Illumination Off
		Night_1	0x1			Barely Discernible
		Night_2	0x2			
		Night_3	0x3			
		Night_4	0x4			
		Night_5	0x5			
		Night_6	0x6			
		Night_7	0x7			
		Night_8	0x8			
		Night_9	0x9			
		Night_10	0xA			
		Night_11	0xB			
		Night_12	0xC			Max Nighttime Brightness
		Day_1	0xD			
		Day_2	0xE			
		Day_3	0xF			
		Day_4	0x10			
		Day_5	0x11			
		Day_6	0x12			Max Daytime Brightness
		Unknown [1]	0xFE			
		Invalid [1]	0xFF			
Litval	8			0 (0x0)	253 (0xFD)	
		Night	0x0			
		Twilight_1	0x1			
		Twilight_2	0x2			
		Twilight_3	0x3			
		Twilight_4	0x4			
		Day	0x5			
		Unknown [1]	0xFE			
		Invalid [1]	0xFF			

1. **NEVER** sent by BCM

Table 2. CAN Dimming Signal Details *(con't)*

Description	Length	Detailed Meaning	State Encoded	Min	Max	Comment
Backlit_LED_Status	4			0 (0x0)	253 (0xFD)	
		Off	0x0			Illumination Off
		Night_1	0x1			Barely Discernible
		Night_2	0x2			
		Night_3	0x3			
		Night_4	0x4			
		Night_5	0x5			
		Night_6	0x6			
		Night_7	0x7			
		Night_8	0x8			
		Night_9	0x9			
		Night_10	0xA			
		Night_11	0xB			
		Night_12	0xC			Max Nighttime Brightness
Delay_Accy	1			0 (0x0)	1 (0x1)	
		Off	0x0			
		On	0x1			

The DFDCU will send LIN signals to the Driver Rear Door Control Unit (DRDCU) to communicate the dimming levels to the illuminated components on the driver side doors. The PFDCU will send LIN signals to the Passenger Rear Door Control Unit (PRDCU) to communicate the dimming levels to the illuminated components on the passenger side doors. Nighttime illumination will be controlled by the IndicationIllumCmd and BacklitLEDCmd signals. Further details of all these signals will be explained in the following sections. All illuminated components that use a these signals to control their dimming need to respond to any changes in dimming within 100 milliseconds to prevent any customer perceived latency. Details of the LIN signals are shown in Table 3 below.

Table 3. LIN Dimming Signal Details

Signal Name	Hex	Decimal	Description	Comment
IndicationIllumCmd				Indicator Illumination Level
	0x1	0	Day	Daytime
	0x2	1	Night	Nighttime
BacklitLEDCmd				Graphic Illumination Level
	0x0	0	Off	Illumination Off
	0xC	12	Night_12	Maximum Nighttime Brightness

4.0 DIMMING CONTROL FUNCTIONAL OPERATION

4.1 Nighttime Dimming

Due to the nature of the dimming rates and the perception of the human eye, it has been determined that 12 discrete dimming steps are needed for the subsystem to operate such that there would be no objectionable steps or jumps as the customer adjusts the dimming level. The 12 steps are not equally spaced because of the non-linearity of the perceived intensity. The 12-step PWM signal for driving LEDs is detailed in Table 4. The Backlit_LED_Status, Dimming_Lvl and BacklitLEDCmd signals will be broadcast as shown in Table 4, under "Network Signals", for nighttime dimming levels.

Table 4. Standard Nighttime Dimming Table

Nighttime Dimming Step	Network Signals[1]	LED Duty Cycle (% PWM)	Comments
1	Night_1	5.00	Barely Discernible Level
2	Night_2	7.00	
3	Night_3	9.00	
4	Night_4	12.00	
5	Night_5	17.00	
6	Night_6	22.00	
7	Night_7	30.00	
8	Night_8	39.00	
9	Night_9	50.00	
10	Night_10	63.00	
11	Night_11	80.00	
12	Night_12	100.00	Maximum Nighttime Brightness

1. The DDM and PDM shall use 100% PWM for any direct outputs for all values from Night_1 – Night_12.

4.2 Daytime Dimming

Daytime dimming will have 6 discrete dimming steps, as shown in Table 5, to allow the customer to adjust the daytime illumination level. The BCM will send out the Dimming_Lvl signal in the CAN message. The details of the signal will be discussed in the following sections.

Table 5. Standard Daytime Dimming Table

Daytime Dimming Step	Dimming_Lvl Signal	Comments
1	Day_1	Minimum Daytime Brightness
2	Day_2	
3	Day_3	
4	Day_4	
5	Day_5	
6	Day_6	Maximum Daytime Brightness

5.0 DIMMING CONTROL OPERATION LOGIC

All backlighting shall be controlled either via PWM or CAN message per Figure 3 below. The figure is for illustration only depicting normal nighttime operation; the actual slopes of the dimming curves may be different depending on the specific application. Refer to the appropriate Interior Illumination Color Specification for actual dimming curves.

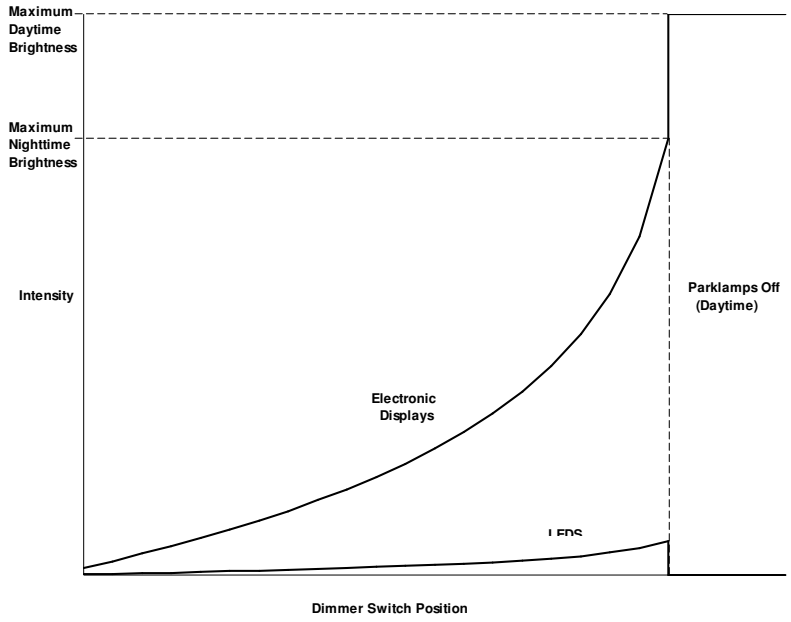

Figure 3. Standard Dimming Curves

5.1 12 Step PWM Signal

Manual adjustment of the dimmer switch adjusts the brightness in the vertical direction of the curve. The 12 Step PWM signal is derived directly from this dimmer switch input and is detailed in Table 4. The output states for this signal are described in Table 6 below.

5.2 Network Messages

The BCM will broadcast the CAN signals as described in Table 6.

Table 6. BCM Dimming Outputs

Functional State	Ignition_ Status	Parklamp _Status	Day_ Night_ Status	12 Step PWM Signal	Backlit_ LED_ Status	Dimming_ Lvl	Comments
Parklamps Off	Off or ACC	Off	Don't Care	Off	Off	Off	Illumination Off
Parklamps On during Illuminated Entry	Off or ACC	On	Don't Care	Off	Off	Off	Illumination Off
Parklamps Off during Illuminated Exit, Night	Off	Off	≠ Day	Night_1 – Night_12	Night_1 – Night_12	Night_1 – Night_12 or Day_3	Nighttime Illumination
Parklamps Off during Illuminated Exit, Day	Off	Off	Day	Night_1	Night_1	Day_1 – Day_6	Daytime Dimming
Parklamps Off	Run/Start	Off	Don't Care	Off	Off	Day_1 – Day_6	Daytime Dimming
Parklamps Off	Run/Start	Off	Don't Care	Off	Off	Off or Night_1	If Police Dark Car is set to Dark
Parklamps On, User Selectable Daytime Mode	Don't Care	On	≠ Day	Night_12	Night_12	Night_12 or Day_3	Daytime Illumination
Parklamps On, Day	Don't Care	On	Day	Night_1	Night_1	Day_1 – Day_6	Daytime Dimming
Parklamps On, Night	Don't Care	On	≠ Day	Night_1 – Night_12	Night_1 – Night_12	Night_1 – Night_12	Nighttime Dimming
Parklamps On, Stuck Dimmer Switch, Night	Don't Care	On	≠ Day	Night_7	Night_7	Night_7	Nighttime Illumination
Parklamps On, Stuck Dimmer Switch, Day	Don't Care	On	Day	Night_1	Night_1	Day_6	Daytime Illumination
Parklamps On, Ambient Light Sensor short to ground or open circuit	Don't Care	On	Night	Night_1 – Night_12	Night_1 – Night_12	Night_1 – Night_12	Nighttime Dimming

The DFDCU and PFDCU on CAN control illumination of some components over LIN. The DFDCU and PFDCU shall use the Delay_Accy, Parklamps_Status, Backlit_LED_Status and Day_Night_Status signals to send the BacklitLEDCmd and IndicationIllumCmd signals as described in Tables 7 and 8. All door trim switch illumination should reflect what is broadcast in the BacklitLEDCmd LIN signal.

Table 7. BacklitLEDCmd Output

CAN Dimming Inputs		LIN Output
Delay_Accy	Backlit_LED_Status	BacklitLEDCmd
OFF	OFF	OFF
OFF	Night_1 – Night_12	OFF
ON	Night_1 – Night_12	Night_12
ON	OFF	OFF

Table 8. IndicationIllumCmd Output

CAN Dimming Inputs		LIN Output	Comments
Parklamp_Status	Day_Night_Status	IndicationIllumCmd	
Don't Care	Night	Night	Sensor Present
Don't Care	Day	Day	Sensor Present
OFF	Null	Day	Sensor Not Present
ON	Null	Night	Sensor Not Present

5.3 BCM Configurations

5.3.1 Ambient Light Sensor Present

In order for Daytime Dimming to function properly, the BCM must correctly configure the following parameter:

AmbientLightSensorPresent_Cfg = [Present, Not_Present]

This parameter broadcasts the presence of an ALS which is used to determine the status of the Day_Night_Status signal.

5.3.2 Ambient Light Sensor Parameters

There are two types of sensors: Ambient Light Sensor only or combined Sunload and Ambient Light Sensor (Sunload Sensor). Either sensor provides an analog signal to the BCM that is a function of the ambient light level inside the vehicle. The BCM compares the analog signal to the parameters in Table 9 to determine the correct Litval and Day_Night_Status value as described in Tables 10 and 11. Since the sensor and package location are relatively the same across vehicle lines, the sensor voltages provided in Table 9 should be used as initial values for all new vehicle applications and changed only with agreement of EESE Interior Harmony Core engineering.

Table 9. Ambient Light Level Recommended Configuration Parameters

BCM Configuration Parameter	Sensor Voltage (volts)	
	North American	Rest of World (ROW)
Ambient_Light_Level_Dusk0_Cfg	4.30	4.30
Ambient_Light_Level_Dusk1_Cfg	4.20	4.20
Ambient_Light_Level_Dusk2_Cfg	4.10	4.10
Ambient_Light_Level_Dusk3_Cfg	4.00	4.00
Ambient_Light_Level_Dusk4_Cfg	3.80	3.80
Ambient_Light_Level_Day_Cfg	3.40	3.40
Ambient_Light_Level_VeryDark_Cfg	4.50	4.30
Ambient_Light_Level_Dark_Cfg	3.80	3.80
Ambient_Light_Level_VeryLight_Cfg	2.37	2.37
Ambient_Light_Level_Light_Cfg	3.40	3.40
Ambient_Light_Level_Fault_Cfg	1.00	1.00

Table 10. Litval Output States ***(going from Dark to Light Ambient)***

Ambient Light Level Comparator	Litval
Dusk0 ≤ Sensor Voltage	Night
Dusk1 ≤ Sensor Voltage < Dusk0	Twilight_1
Dusk2 ≤ Sensor Voltage < Dusk1	Twilight_2
Dusk3 ≤ Sensor Voltage < Dusk2	Twilight_3
Dusk4 ≤ Sensor Voltage < Dusk3	Twilight_4
Day ≤ Sensor Voltage < Dusk4	
Fault ≤ Sensor Voltage < Day	Day
Sensor Voltage < Fault	Night

Table 11. Day_Night_Status Output States ***(going from Dark to Light Ambient)***

Autolamp Comparator	Day_Night_Status
VeryDark ≤ Sensor Voltage	Night
Dark ≤ Sensor Voltage < VeryDark	Night
Light ≤ Sensor Voltage < Dark	Night
VeryLight ≤ Sensor Voltage < Light	Day
Fault ≤ Sensor Voltage < VeryLight	Day
Sensor Voltage < Fault	Night

5.3.3 Ambient Light Sensor Response Times

In order for daytime and nighttime dimming to function properly, the BCM must also correctly configure the following parameters in Table 12. The BCM uses these parameters to determine when to switch between Day and Night.

Table 12. Ambient Light Sensor Response Times

BCM Configuration Parameter	Time (seconds)	
	North American	Rest of World (ROW)
Day_To_Night_Fast_Delay_Duration_Cfg	1.5	1.5
Day_To_Night_Delay_Duration_Cfg	15.0	5.0
Night_To_Day_Delay_Duration_Cfg	15.0	5.0
Night_To_Day_Fast_Delay_Duration_Cfg	4.0	2.0

5.3.4 User Selectable Daytime Level

In order for User Selectable Daytime Mode to function properly, the BCM must correctly configure the following parameter:

Dim_UserDayLevel_Cfg = [Night_12 or Day_3]

If there is an ALS present then configure to Night_12, otherwise, Day_3.

5.3.5 Police Dark Car

If PoliceDarkCar_Cfg is set to Dark, the BCM allows 2 additional daytime dimming steps as shown in Table 13. This allows customers to select complete or minimal brightness while the engine is idling with the exterior lights off.

Table 13. Daytime Dimming Table in Police Dark Car Mode

Daytime Dimming Step	Dimming_Lvl Signal	Comments
1	OFF	Turns all illumination Off
2	Night_1	Minimum Nighttime Brightness
3	Day_1	Minimum Daytime Brightness
4	Day_2	
5	Day_3	
6	Day_4	
7	Day_5	
8	Day_6	Maximum Daytime Brightness

6.0 LIST OF REFERENCES

- Interior Harmony SDS
- FMVSS 101
- Light Sensor Amplifier Assembly Specification, ES-DG9T-14A597-A/B
- Body Control Module Functional Specification, FS-DG9T-14B476-A
- Ice Blue™ and Lincoln White Interior Illumination with Daytime Dimming, ES-DS7T-1A278-B