Evolution Management and Process for
Real-Time Embedded Software Systems

DaimlerChrysler Demonstrator: System Requirements Instrument Cluster

Appendix A to Deliverable D.5

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System Requirements

Instrument Cluster

MODEL EMP01

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Content

1 Overview

This system specification contains requirements for the instrument cluster. This description is the binding specification for the development of the electronic control unit.

Any deviation from the requirements of this system specification has to be announced to the OEM in written form. If for a faultless and unrestricted functionality, the requirements in this specification are not or insufficiently defined, this fact has to be communicated to the OEM. If the supplier is acquainted with improved or low-priced alternatives, this fact has also to be communicated to the OEM.

1.1 Structure of the Document

The section General Remarks provides general remarks describing the market environment, documentation and production constraints.

The section Overview of the Components of the Instrument Cluster presents an overview of the instrument cluster with its functionalities and a basic context diagram of it. This context diagram can be seen as a simplified model of the whole instrument cluster described in this specification. Furthermore, we provide a short survey of the particular functionalities.

The section Functional Description provides the detailed requirements specification of the logical parts of the instrument cluster, in particular the rev meter, the speedometer, the indicator lights, and the digital display with its subfunctions.

These requirements are divided into three abstraction layers: business requirements, user requirements, system requirements. This approach of The EMPRESS Company takes care of a complete and comprehensible requirements specification.

The section Hardware describes the hardware parts of the ECU. The hardware specification consists essentially of a description of the ECU case, the optical design, and the description of the connector.

The section Communication and Parameter describes the communication and memory arrangement. A table lists all possible signals which can be sent and received in the environment of the instrument cluster. Furthermore we present the parameters and their range of values.

1.2 Notation

Hex digits are denoted (as usual in C or C++) by a prefixed 0x (for example 0xA56).

Binary values are denoted by underlined binary digits (for example 0011).

2 General Remarks

2.1 Market

The application of the described electronic control unit is planned for the model EMP01. The automotives will be sold worldwide. For this reason, the electronic control unit has to be configurable for the variants Canada, China, Europe, Great Britain, Japan and the USA. The product has to be ready for series production at the beginning of the 3rd quarter 2006. The expected number of pieces amounts to about 20,000 units per year.

The EMP01 can be characterized as a family car. It offers a lot of storage space and aims to be the general purpose family car, e.g. designed for daily shopping, for family vacation, or for weekend trips. It fulfills the upper-class safety and comfort demands without providing too fancy or technologic-centered innovations.

2.2 Variants

There are four different hardware variants of the instrument cluster.

Variant	Market	Characteristics	Amount
IC EMP01 1221	Europe, RoW	Speedometer km/h, Fuel engine	40%
IC EMP01 1222	Europe, RoW	Speedometer km/h, Diesel engine	30%
IC EMP01 1223	USA	Speedometer miles, Fuel engine	20%
IC EMP01 1224	USA	Speedometer miles, Diesel engine	10%

There is no differentiation between left and right aligned instrument clusters (i.e. for the markets in Great Britain, Japan, Malta, and so on).

2.3 Documentation

To prove the compliance with the requirements specification the following documentations have to be presented to the OEM. If no other arrangements are made, all documents have to be provided as PDF-files.

2.3.1 Hardware Documentation

* Hardware design drawing,
* Circuit diagram,
* Layout diagram,
* Parts list,
* Pinning, and
* Results of the electromagnetic compatibility measurement.

2.3.2 Software Documentation

* Program listings,

* Documentation of the used software tools,

* Flow chart of the software,

* Description of the modules,

* Software architecture,

* Interrupt structure,

* Detailed description of the EEPROM and internal variables (range of values, resolution),

* Quality assurance plan,

* Evidence of the test activities performed, and

* Manual how to upload a new software version.

2.4 Production

The production of the system has to accomplish the requests of the EMPRESS guideline. The EMPRESS guideline is part of the agreement between the OEM and the supplier. The complete guideline is available as EMP - ProcessManual - 0117.

Important is the allocation of tasks to persons that is done by roles, because the OEM wants to have responsible contact persons, whose knowledge and skills form a wide base to fulfill the allocated tasks. The distribution of the roles to persons should be, if possible, constant during the life span of the project.

Furthermore, each person involved in the production process is responsible for the following points:

* No document, draft, concept, prototype, etc. may be abolished without written permission of the OEM.

* Any laws, norms, and prescriptions have to be observed and adhered.

* The production has to be accomplished according to the state of the art.

* Any product, idea, patent, etc. developed in the process of the production of the system is part of the ownership of the OEM and is not allowed to be employed in further projects, to be sold or to be published.

* A meeting of the project team has to take place every week. The number of participating project team personnel has to be arranged during the development process. At least all people in charge shall be present regularly. Further meetings to discuss actual problems and misunderstandings, which cannot be planned and tracked in the weekly meeting, have to be arranged.

* The used materials have to be free from toxicities and have to satisfy highest quality claims. Unusual or new materials have to be communicated to the OEM. Furthermore the used materials have to comply with an ecological and low-priced realization.

* The supplier is responsible for the quality of the development and the production.

* Three sample states with ten prototypes each have to be provided.

* The production process has to be certified by ISO 9000.

* The provision with replacement parts has to be reliable for at least 20 years after the end of the series production.

3 Overview of the Components of the Instrument Cluster

The instrument cluster consists of the following components, which are specified in detail in the chapter Functional Descriptions.

3.1 Activation and Deactivation of the Instrument Cluster

This functionality describes the behavior of the instrument cluster concerning activation and deactivation. Activation has to maintain the balance between the vision to inform the driver at any time about the current car status and the need to save battery energy.

3.2 Rev Meter

The rev meter is an instrument which displays the engine speed in revolutions per minute (RPM). The engine speed is displayed by the help of a scale and a pointer.

3.3 Speedometer

The speedometer displays the speed of the car in mph or km/h. The speed is computed by the help of the speeds of each wheel and displayed by a pointer over a scale.

3.4 Indicator Lights

The instrument cluster has three indicator lights. First, the two blinking lights that show which direction is currently indicated. Second, the engine control light which indicates severe engine problems.

3.5 Display

The instrument cluster has a dot matrix display which is used to provide the driver with various information about the car status.

If no urgent information has to be presented, this display shows information about time, outside temperature, speed, or radio station according to the drivers demands.

By means of a menu tree, the driver can adjust the presented information according to his/her needs.

4 Functional Descriptions

4.1 Activation and Deactivation of the Instrument Cluster

This section describes the activation and deactivation of the instrument cluster. Activation means that the display of the instrument cluster lights up. Deactivation means that the light of the display dims out and the instrument cluster falls asleep (i.e. it only consumes the sleep time energy).

4.1.1 Function Overview

It shall be possible to provide the driver with essential information and a certain comfort whenever needed. So the activation and deactivation of the instrument cluster should be useful and intuitively manageable.

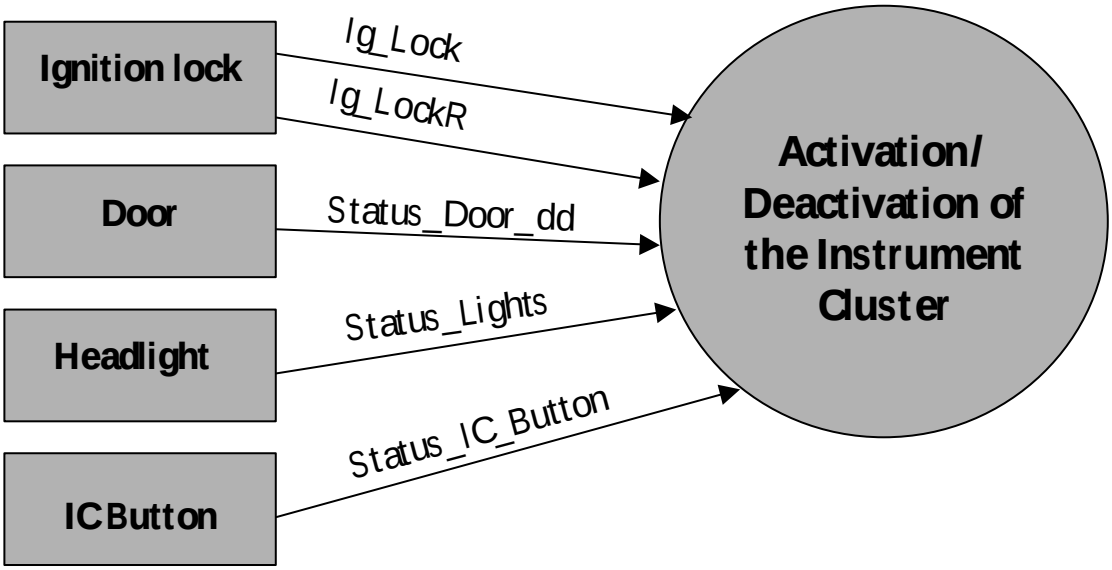
4.1.2 System Requirements

This subsection specifies the behavior of the activation/deactivation of the instrument cluster on a detailed level.

4.1.2.1 Context Diagram

The following context diagram (see figure Context diagram IC – activation/deactivation) presents the context of the activation/deactivation of the instrument cluster. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram IC - activation/deactivation.



4.1.2.2 Functional Requirements

Activation/deactivation operates as long as the instrument cluster is connected to the power supply. After disconnection from the power supply the instrument cluster is completely deactivated.

The functional requirements are divided up into two parts. The first part treats the input signals. The second part treats the processing of the signals, mainly in a comprehensible and short table.

4.1.2.2.1 Input Signals

The following input signals for the activation/deactivation functionality are relevant.

Ig_Lock

Describes the position of the ignition key. If Ig_Lock = 1 then the ignition key is in position ignition on. Sent by the ignition lock control unit. Scope: {0,1}. Received every 100 ms. Transferred by the CAN bus.

Ig_LockR

Describes the position of the ignition key. If Ig_LockR = 1 then the ignition key is in position radio. Sent by the ignition lock control unit. Scope: {0,1}. Received every 100 ms. Transferred by the CAN bus.

Status_Door_dd

Describes the status of the driver's door. Scope: {open (= 1), closed (= 0)}. Sent by the door control unit. Received every 100 ms. Transferred by the CAN bus.

Status_Lights

Describes the status of the headlights. Scope: {on (=1), off (=0)}. Sent by the headlight control unit. Received every 100 ms. Transferred by the CAN bus.

Status_IC_Button

Describes the status of the IC button. Scope: {pressed (=1), not pressed (=0)}. Sent by the IC button control unit. Transmitted internally by the instrument cluster.

4.1.2.2.2 Processing of the Signals

The processing of the signals is described here in a kind of pseudo code.

The processing of the signals is denoted in the table Processing of the signals. It denotes how the input signals shall be processed.

Table: Processing of the signals.

Input Signal	Input Signal	Input Signal	Effect
Ig_Lock = 0	Ig_Lock R = 0	Status_Door_dd = closed, Status_Lights = off, Status_IC_Button = not pressed	The instrument cluster is deactivated 30s after first occurrence of this state of input signals if no change of input signals occurs; changes are treated as requested in this table.
Only regarded changing signals are denoted from now on:			
Ig_Lock = 0	Ig_Lock R = 0	Status_Door_dd = open	The instrument cluster is activated for 30s if no change of input signals occurs. After 30s, the instrument cluster is deactivated again; changes of the input signals are treated as requested in this table.
Ig_Lock = 0	Ig_Lock R = 0	Status_Door_dd = closed	The instrument cluster is activated for 30s if no change of input signals occurs. After 30s, the instrument cluster is deactivated again;

Input Signal	Input Signal	Input Signal	Effect
			changes of the input signals are treated as requested in this table.
Ig_Lock = 0	Ig_Lock R = 0	Status_Lights = on	The instrument cluster is activated for 30s, if no change of input signals occurs. After 30s, the instrument cluster is deactivated again; changes of the input signals are treated as requested in this table.
Ig_Lock = 0	Ig_Lock R = 0	Status_IC_Button = pressed	The instrument cluster is activated for 30s if no change of input signals occurs. After 30s, the instrument cluster is deactivated again; changes of the input signals are treated as requested in this table.
Ig_Lock = 0	Ig_Lock R = 1		The instrument cluster is activated. Changes of the input signals are treated as requested in this table.
Ig_Lock = 1			The instrument cluster is activated. Changes of the input signals are treated as requested in this table.

4.2 Rev Meter

This section describes the rev meter.

4.2.1 Function Overview

The rev meter is an instrument, which displays the engine speed in revolutions per minute (RPM). In principle the rev meter is a voltmeter placed in the motor. The turning action is transferred to an iron core in an electrical coil and thus a measurable voltage is induced. Since the height of the voltage is directly proportional to the turning action of the iron core, the number of revolutions can be displayed with the help of a scale. The output signals of the electronic control unit activate a stepping motor, which affects a pointer over the scale.

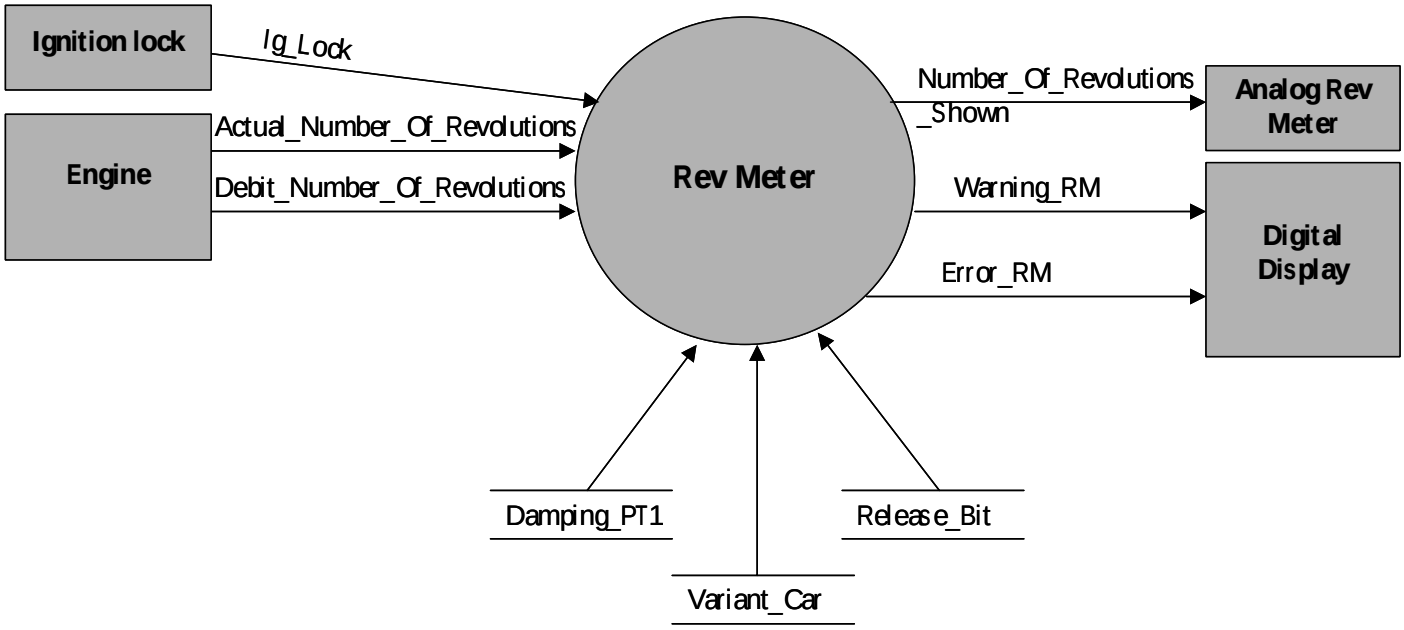
4.2.2 System Requirements

The requirements in this section specify the rev meter on a detailed level meaning that the business and user requirements have to be realized by the system requirements. These requirements correspond to the abstraction level of actual product specifications ("Lastenhefte").

4.2.2.1 Context Diagram

The following context diagram (see figure Context diagram – rev meter) presents the context of the rev meter. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram - rev meter.



4.2.2.2 Functional Requirements

The functional requirements describe the functional behavior of the rev meter. They are structured concerning their contextual relation.

4.2.2.2.1 Drive of the Rev Meter Pointer

A stepping motor with at least 360 steps per rotation is the drive of the rev meter display pointer.

4.2.2.2.2 Angle of Deflection and Display Tolerance

The display tolerance of the system amounts to ±1,5 degree.

The angle of deflection of the pointer of the rev meter display amounts to 162 degrees.

4.2.2.2.3 Initial Position/Final Position of the Scale

When the car is switched on, thus Ig_Lock = active, the pointer goes from the technical initial position to the initial position of the scale (0 min^{-1}), damped as described below. Engine speed is read out.

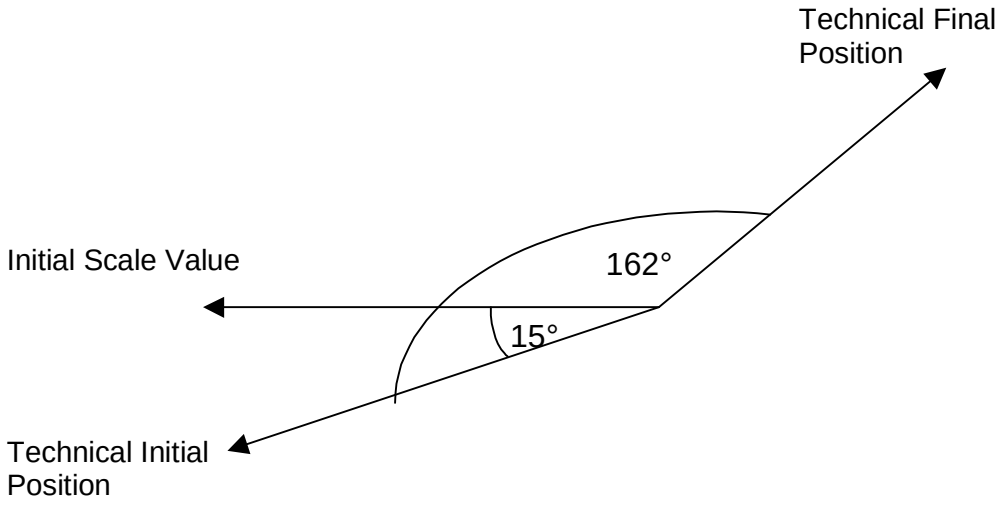
When the car is switched off, thus Ig_Lock = inactive, the readout of the engine speed is stopped. The pointer drops back to the technical initial position, damped as described below.

4.2.2.2.4 Technical Initial Position, Technical Final Position of the Pointer

The technical initial position of the pointer is 15 degrees below the horizontals, the technical final position of the pointer is at the angle of deflection of the pointer over the technical initial position (see figure Illustration of the possible pointer positions).

Rationale: **The technical position of the pointer relative to its environment. The technical initial position is differentiated from the initial position of the scale.**

Figure: Illustration of the possible pointer positions.



4.2.2.2.5 Initial Scale Value, Final Scale Value, Partitioning of the Scale, and Danger Zone

The scale starts 15 degrees over the technical initial position of the pointer.

The initial scale value amounts to 0 min^{-1}.

The end of scale is on the technical final position of the pointer.

The final scale value for the diesel version amounts to 6000 min^{-1}. The danger zone (red field) begins at 4000 min^{-1}.

For the fuel version the final scale value amounts to 7000 min^{-1}. The danger zone (red field) begins at 5000 min^{-1}.

The scale is partitioned linearly.

4.2.2.2.6 Input Signals

The following input signals are digitally transferred by the CAN bus.

Actual_Number_Of_Revolutions

The number of revolutions of the engine, at the moment measured (8 bits: 0x0 – 0xFF; Unit 32 rotations/minute). Received every 100 ms.

Debit_Number_Of_Revolutions

This signal is sent by the engine (8 bits: 0x0 – 0xFF; Unit 32 rotations/minute). Received every 100 ms.

Ig_Lock

Describes the position of the ignition key. If Ig_Lock = 1 then the ignition key is in position ignition on. Scope: {0,1}. Received every 100 ms.

4.2.2.2.7 Output Signals

Error_RM

In case of a realized error (active/inactive). Scope: {0=active, 1=inactive}. Transferred by the CAN bus to the digital display of the instrument cluster. Sent every 100 ms.

Warning_RM

In case of exceeding number of revolutions, this warning signal is transmitted (active/inactive). Transmitted internally of the instrument cluster to the digital display of the instrument cluster. Sent every 100 ms.

Number_Of_Revolutions_Shown

For the display edited engine speed signal (8 bits: 0x0 – 0xFF). Transmitted internally of the instrument cluster to the analog display of the rev meter. Sent every 100 ms.

4.2.2.2.8 Parameter Values

The parameter value is stored internally to provide the possibility to have different characteristics of the rev meter.

Release_Bit

Configuration adjustment for the representation of the number of revolutions. Stored in the EEPROM. Scope: {0, 1}.

Damping_PT1 (in the ROM)

Damping of the PT1 element. Stored in the ROM. Scope: {0, …, max}.

Variant_Car

Stores the variant of the car. The variant has an impact on the scale of the rev meter display. Scope: {0 = diesel, 1 = fuel}. Stored in the EEPROM.

4.2.2.2.9 Discrimination Threshold

The discrimination limit of the rev meter lies above 320 min^{-1}.

Numbers of revolutions below 320 min^{-1} are suppressed, such that the pointer remains at 0 min^{-1} (scale value).

4.2.2.2.10 No or too high CAN Bus Signals and Error Handling

Non-defined transfer values (whether “Actual_Number_Of_Revolutions” or “Debit_Number_Of_Revolutions”) between the final scale value of the display and the maximal transfer value of the CAN are limited by the final scale value.

Furthermore a speed warning is sent and displayed.

The speed warning is sent, if the non-defined transfer value is sent 400 ms.

The warning symbol lights up for 5 s.

Time is started new, whenever the non-defined transfer value is sent for at least 400 ms.

The warning symbol dims out when the car is switched off.

When the input signals are in the normal range of values, the engine speed is displayed as usual, otherwise the pointer stays at the final scale value. An adaptation to the engine cylinder number is not necessary.

If on the CAN bus there is "0xFF" or "Timeout" (whether Actual_Number_Of_Revolutions or Debit_Number_Of_Revolutions), then the pointer of the engine speed indicator is steered directly to the left end of the scale (0 min^{-1}), damped as described below.

Additionally an error warning is sent and displayed.

The error warning is sent, if the error value is sent 400 ms.

The error symbol lights up for 5 s.

Time is started anew, whenever the error value is sent for at least 400 ms.

The error symbol dims out when the car is switched off.

When the system determines input signals in the normal range of values, it waits 400 ms. If the input signals are stable and sent regularly, the engine speed is displayed as usual, otherwise the pointer of the rev meter display stays at the initial point of the scale.

4.2.2.2.11 Damping

The input signals are damped by a PT^1 element.

Rationale: A system with a flattening transient step response is also defined as a system with adjustment. This term is used for all systems, which react to a branch excitation with a transition to a finite final value. Such transfer elements are called PT^1 elements. One typical characteristic of the PT^1 element is that the step response possesses a finite starting upward gradient.

4.2.2.2.12 Pointer Behavior

The following step responses result (see table Step responses):

Rationale: The step response is the characterization of the reaction of the system to a special test function.

Table: Step responses.

Step from 0 degree to	Reaching 95% of the debit value after
80 degrees	500 ms
150 degrees	1200 ms

4.2.2.2.13 Algorithm/Characteristics

In order to avoid a varying of the RPM indication under certain operating conditions, the Actual_Number_Of_Revolutions is not considered all the time, but the Debit_Number_Of_Revolutions, dependent on the speed limits and the Release_Bit. The conditions for it are as follows.

If "Release_Bit" = "1" and “Actual_Number_Of_Revolutions” is greater than “Debit_Number_Of_Revolutions” and “Actual_Number_Of_Revolutions” is less than 110% “Debit_Number_Of_Revolutions”, then “Debit_Number_Of_Revolutions” is displayed meaning that “Number_Of_Revolutions_Shown” = “Debit_Number_Of_Revolutions”.

Otherwise “Actual_Number_Of_Revolutions” is displayed always meaning that “Number_Of_Revolutions_Shown” = “Actual_Number_Of_Revolutions”.

If "Release_Bit" = "0", then “Actual_Number_Of_Revolutions” is displayed always.

The selected value is transferred over a characteristic with 2 bases on the actual output value. Only after exceeding the discrimination limit the output of the number of revolutions begins.

Characteristic for fuel version (see table Characteristic fuel version) (interpolate linearly):

Table: Characteristic fuel version.

Number_Of_Revolutions_Shown (hexadecimal)	Angle of deflection of the pointer
-	0 degree (technical initial position of the pointer)
0x0	15 degrees
0x8	15 degrees
0x19	36 degrees
0x7D	120 degrees
0xAF	162 degrees (technical final position of the pointer)
greater than 0xAF	162 degrees (technical final position of the pointer)

Characteristic for diesel version (see table Characteristic diesel version) (interpolate linearly):

Table: Characteristic diesel version.

Number_Of_Revolutions_Shown (hexadecimal)	Angle of deflection of the pointer
-	0 degree (technical initial position of the pointer)
0x0	15 degrees
0x8	15 degrees
0x19	39.5 degrees
0x64	113 degrees
0x96	162 degrees (technical final position of the pointer)
greater than 0x96	162 degrees (technical final position of the pointer)

4.3 Speedometer

This section describes the speedometer, which displays the speed of the car.

4.3.1 Function Overview

The speedometer displays the speed of the car in mph or km/h. The speed is computed with the help of the speed of each wheel and is displayed by a pointer over a scale.

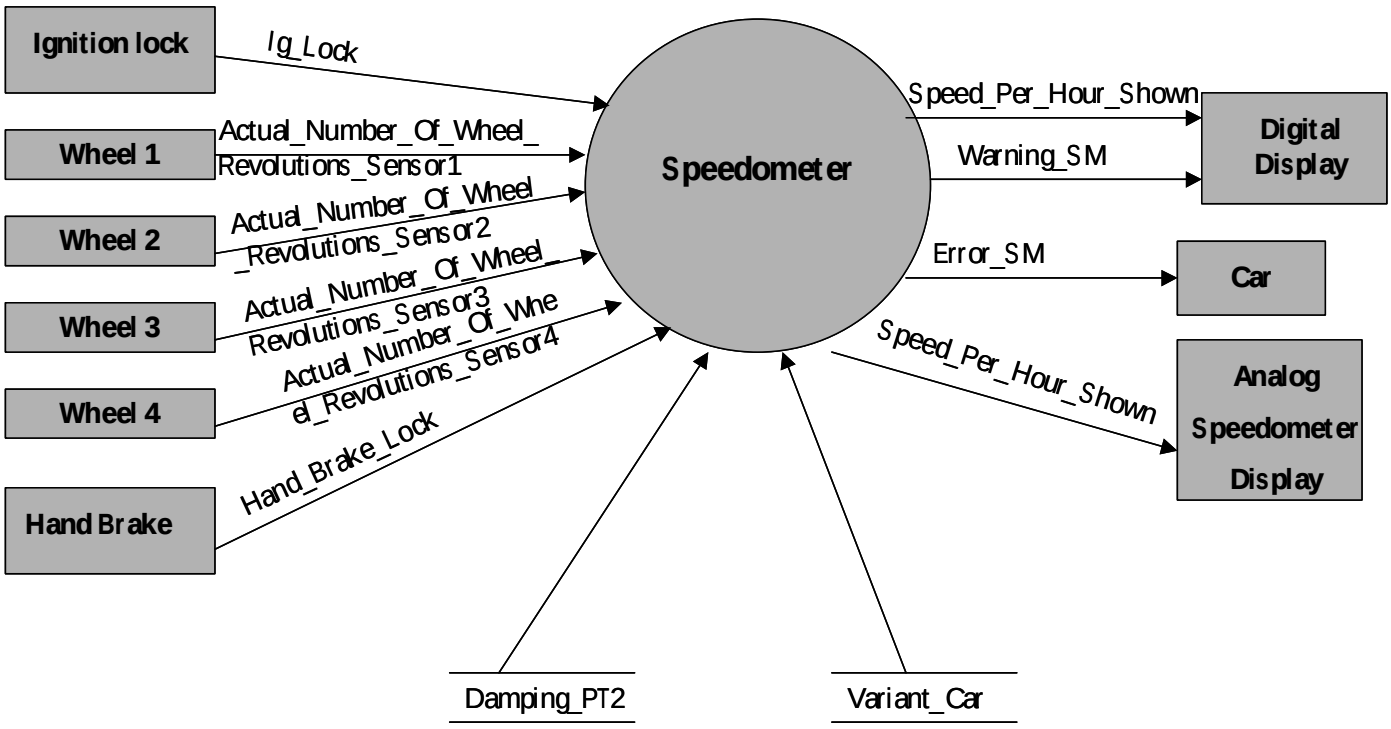
4.3.2 System Requirements

This section specifies the behavior of the speedometer on a detailed level.

4.3.2.1 Context Diagram

The following context diagram (see figure Context diagram speedometer) presents the context of the speedometer. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram speedometer.



4.3.2.2 Functional Requirements

The functional requirements are divided up into the following parts: (1) Cruise Display, (2) Cruise Computation Algorithm, (3) Input Signals, (4) Output Signals, (5) Parameter Values, (6) Discrimination Threshold, (7) Damping and (8) Error and Wrong Signal Handling.

4.3.2.2.1 Cruise Display

Speed can be displayed in two ways. Firstly by means of an analog indicator device. Secondly by means of a digital value presented on the display. Details on the digital presentation are described in section User Configuration and Menu Tree.

The analog and the digital speedometer both display the same speed at the same moment with an allowed deviation of +/-2km/h or 1mph.

The speedometer converts the measured speed of the car into an equivalent scale value and an equivalent digital value, respectively.

The speed scale has a minimum scale value (MinSV) of 0 km/h respective 0 mph.

The digital display has a minimum display value of 0 km/h respective 0 mph.

The speed scale has a maximum scale value (MaxSV) of 260 km/h respective 160 mph.

The digital speed display has a maximum display value of 260 km/h respective 160 mph.

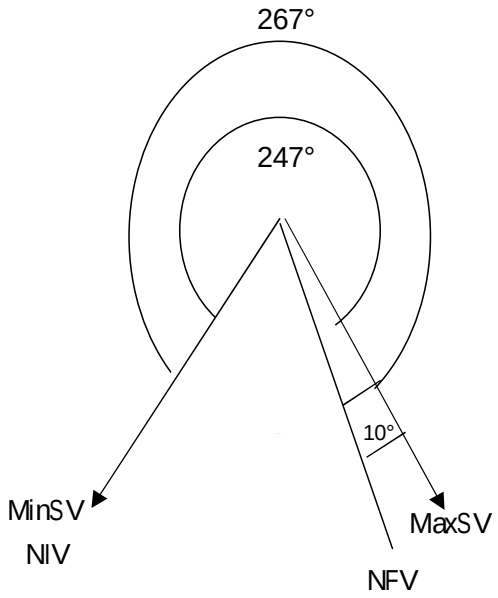
The deflection angle of the pointer of the speedometer scale is 257 degrees.

The NFV is 10 degrees above the MaxSV, i.e. the indicator can pass the maximum scale value by 10 degrees.

In case of speeds, which are higher than the MaxSV, the indicator can pass the MaxSV up to NFV.

The NIV is 0 degree below the MinSV. The following figure Pointer Positions illustrates the possible pointer positions of the analog speedometer.

Figure: Pointer Positions.



When the ignition is switched off (Ig_Lock = 0), the speed display pointer is positioned at the NIV, while the digital display displays 0km/h or 0mph, respectively.

When the car is started (Ig_Lock = 1) but the speed is at 0 km/h or 0 mph the pointer position is equal to the MinSV, while the digital display displays a speed value of zero.

The reaction time of both, the pointer and the digital display, to a signal given is 500 ms +/- 10 ms, independently of its actual position.

The speedometer display pointer is powered by a stepping motor.

4.3.2.2.2 Cruise Computation Algorithm

The speed of the car is calculated as the arithmetic average of the valid actual number of wheel revolutions.

The input values of the cruise computation algorithm are the four current wheel speed values, supplied by the CAN, see subsection Input Signals.

The output value of the cruise computation algorithm is the computed vehicle speed, see subsection Output Signals.

The threshold value of the algorithm at speeds between 0 - 45 km/h or 0 - 28 mph is 75 %.

The threshold value of the algorithm at speeds between 45 km/h or mph and MaxSV is 20 %.

4.3.2.2.3 Input Signals

The following input signals are transferred digitally by the CAN bus.

Actual_Number_Of_Wheel_Revolutions_Sensor1,

Actual_Number_Of_Wheel_Revolutions_Sensor2,

Actual_Number_Of_Wheel_Revolutions_Sensor3,

Actual_Number_Of_Wheel_Revolutions_Sensor4

The number of revolutions of each of the four wheels, at the moment measured (8 bits:0x0 - 0xFF, Unit: 1/6 wheel rotation per second, 0xFF = Error value). Received every 150 ms.

Ig_Lock

Describes the position of the ignition key. If Ig_Lock = 1 then the ignition key is in position ignition on. Scope: {0, 1}. Received every 100 ms.

Hand_Brake_Lock

Indicates that the hand brake is locked (0 = hand brake locked, 1= hand brake is not locked)

4.3.2.2.4 Output Signals

Speed_Per_Hour_Shown

The speed signal calculated and converted into a scale value (8 bits: 0x0 - 0xFF; Unit 1 km/h). Transmitted from the speedometer to the display.

Error_SM

In case of a detected error (active/inactive). Transferred by the CAN bus. Sent every 100 ms.

Warning_SM

In case of driving with locked hand brake, this warning is transmitted (0= active/1=inactive). Transferred internally.

4.3.2.2.5 Parameter Values

The parameter values are stored to provide the possibility of different characteristics of the speedometer.

Damping_PT2

Damping of the PT2 element. Scope {0, ... 0xFF, Unit: degree/second}. Stored in the EEPROM.

Variant_Car

Stores the variant of the instrument cluster speedometer scale. Scope: {0 = kmhl, 1 = mphl}. Stored in the EEPROM.

4.3.2.2.6 Discrimination Threshold

The discrimination threshold of the speedometer is defined with 30 rotations/minute. Numbers of wheel revolutions below 30 rotations/minute are blanked. In this case the pointer remains at MinSV.

4.3.2.2.7 Damping

The cruise computation algorithm dampens the calculated display value with a PT2 module.

4.3.2.2.8 Error and Wrong Signal Handling

If the driver drives with locked handbrake, a warning messages is diyplayed (see section Warning Messages).

If there is "0xFF" or "Timeout" for one of the signals Actual_Number_Of_Wheel_Revolutions on the CAN, the pointer of the speedometer swings up to the MinSV, damped as described below.

4.4 Indicator Lights and Engine Control Light

The section describes the indicator lights and the engine control light.

4.4.1 Function Overview

The indicator lights and the engine control light shall support the driver to keep the overview about the car. The indicator lights shall indicate audibly (via a periodic sound) that a turn signal has been set and visually, which turn signal is set. The engine control light shall indicate a problem with the engine of the car.

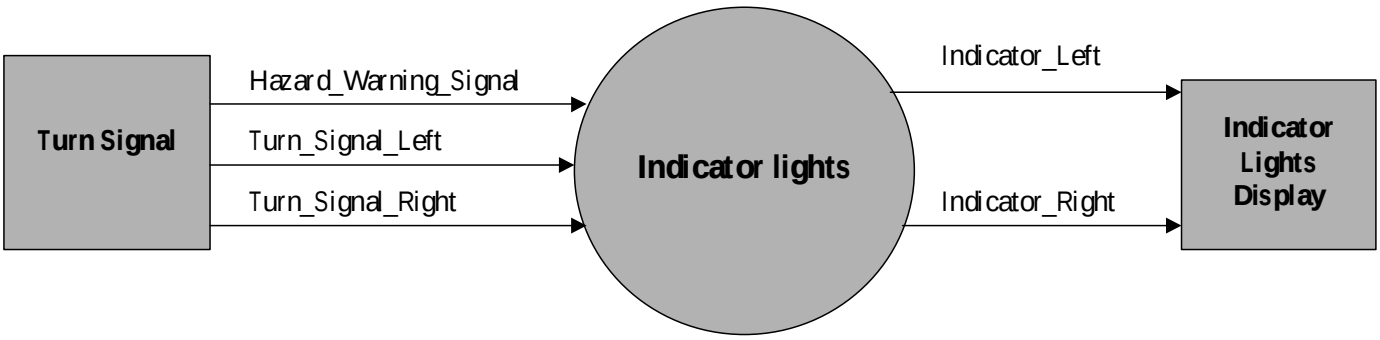
4.4.2 System Requirements

This subsection specifies the behavior of the indicator lights and the engine control light on a detailed level.

4.4.2.1 Context Diagrams

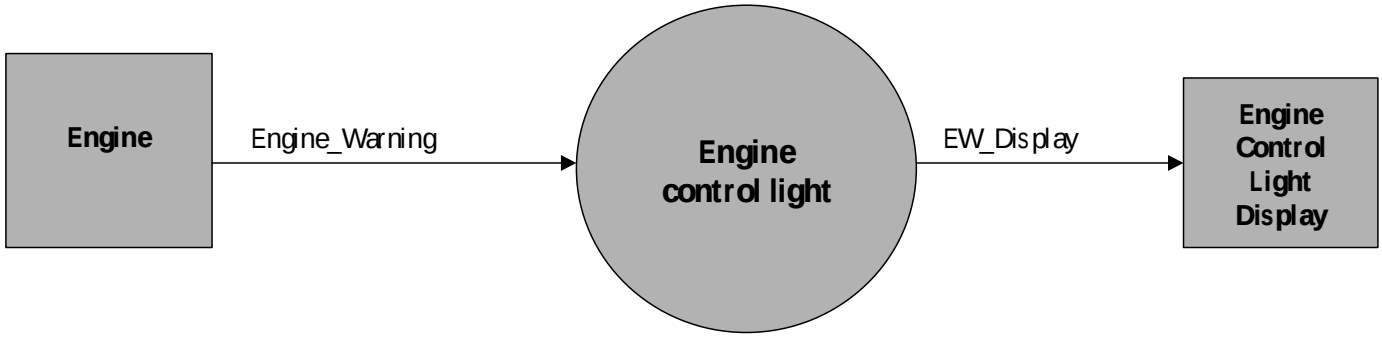
The following context diagram (see figure Context diagram indicator lights) presents the context of the indicator lights. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram indicator lights.



The following context diagram (see figure Context diagram engine control light) presents the context of the engine control light. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram engine control light.



4.4.2.2 Functional Requirements

The functional requirements are organized as follows. After the description of the colors of the displays, the lights check is specified. Then the indicator lights and the engine control light are specified. Finally the signals are specified.

4.4.2.2.1 Color of the Indicator Lights

The color of the arrows of the indicator lights is light green, when they light up.

4.4.2.2.2 Color of the Engine Control Light

The color of the engine control light is crimson, when it lights up.

4.4.2.2.3 Lights Check

The indicator lights and the engine control light light up continuously 2s, whenever the instrument cluster is activated.

The lighting up of the indicator lights and the engine control light is addressed as specified in section Activation and Deactivation of the Instrument Cluster.

The indicator lights light up in the same color as specified above.

The engine control light lights up in the same color as specified above.

A sound during the lights check is not audible.

After 2s lighting up of the indicator lights and the engine control, the lights dim out.

The further behavior of these lights is as specified below.

4.4.2.2.4 Indicator Lights

The indicator lights consist of two arrows, placed on the right and left part of the instrument cluster (see section Hardware).

If the driver sets the turn signal left (turn signal right), the left (right) arrow of the indicator lights begins to blink (Indicator_Left = 1 respective Indicator_Right = 1).

The arrow blinks as long as the turn signal is set (only after periodic steps, the blinking is stopped, if the turn signal is not set anymore, see below for the explanation of a periodic step).

The lighting up of the arrows of the indicator lights behaves as follows:

The arrow lights up 1s and dims out 1s.

This blinking behavior recurs periodically.

One periodic step lasts 2s.

The blinking is accompanied by a sound.

The sound is audible at the beginning of each periodic step.

The sound lasts 0,5s.

The sound shall be a deep and scratching tone.

The sound shall be loud enough to be audible for the driver in most traffic situations.

4.4.2.2.5 Hazard Warning

If the hazard warning signal flasher is set, both arrows of the indicator lights begin to blink as described in the subsection Indicator Lights (Indicator_Left = Indicator_Right = 1).

The hazard warning takes priority over the turn signals.

If any turn signal is set and the hazard warning is set additionally, the hazard warning signal lights up in the same periodic steps as the turn signal blinked.

If the turn signal is not set anymore, when the hazard warning is stopped, the indicator lights stop their blinking after their last periodic step.

If the hazard warning is stopped, but a turn signal is still activated, the according arrow of the indicator lights blinks on in the same periodic mode as the hazard warning signal blinked.

The blinking of the arrow of the indicator lights is stopped as described in subsection Indicator Lights.

4.4.2.2.6 Engine Control Light

The engine control light is placed in the left part of the instrument cluster, near the middle (see section Hardware).

The engine control light lights up for at least 5s, if Engine_Warning = 1, for at least 400ms.

If Engine_Warning = 0 for at least 400ms, the engine control light dims out.

The engine control light dims out, when the instrument cluster is deactivated (see section Activation and Deactivation of the Instrument Cluster).

4.4.2.2.7 Input Signals of the Indicator Lights

The following signals are digitally transferred by the CAN bus.

Turn_Signal_Left

> *The signal describes the status of the combination switch and is sent by the combination switch control unit. Turn_Signal_Left = 1 means, the driver sets the combination switch in the turn signal left position. Turn_Signal_Left = 0 means, the driver does not set the turn signal left. Scope: {0,1}. Transmitted every 250ms.*

Turn_Signal_Right

> *The signal describes the status of the combination switch and is sent by the combination switch control unit. Turn_Signal_Right = 1 means, the driver sets the combination switch in the turn signal right position. Turn_Signal_Right = 0 means, the driver does not set the turn signal right. Scope: {0,1}. Transmitted every 250ms.*

Hazard_Warning_Signal

The signal describes the status of the hazard warning signal flasher. The signal is sent by the hazard warning signal flasher control unit. If the hazard warning signal flasher is set, then Hazard_Warning_Signal = 1, otherwise Hazard_Warning_Signal = 0. Scope: {0,1}. Transmitted every 50ms.

Rationale: The high transmission rate is important to support the security of the car occupants. The faster a hazard warning can be displayed the faster another road user can react.

4.4.2.2.8 Input Signal of the Engine Control Light

Engine_Warning

This signal describes the status of the engine. The signal is sent by the engine control unit. If the engine control unit determines a problem with the engine, Engine_Warning = 1 is sent, otherwise Engine_Warning = 0. Scope: {0,1}. Transmitted every 100ms by the CAN bus.

4.4.2.2.9 Output Signals of the Indicator Lights

The following signals are transferred internally of the instrument cluster.

Indicator_Left

This signal activates the left arrow of the indicator lights. If Indicator_Left = 1, then the left arrow of the indicator lights starts to blink as described in subsection Indicator Lights. If Indicator_Left = 0, the left arrow of the indicator lights is deactivated. This signal is sent to the indicator lights display. Scope: {0,1}.

Rationale: The high transmission rate is needed because of the high transmission rate of the Hazard_Warning_Signal, to provide a prompt display of hazard warning set for the driver, because the hazard warning is activated by this signal, too.

Indicator_Right

This signal activates the right arrow of the indicator lights. If Indicator_Right = 1, then the right arrow of the indicator lights begins to blink as described in subsection Indicator Lights. If Indicator_Right = 0, the right arrow of the indicator lights is deactivated. This signal is sent to the indicator lights display. Scope: {0,1}.

Rationale: The high transmission rate is needed because of the high transmission rate of the Hazard_Warning_Signal, to provide a prompt display of hazard warning set for the driver, because the hazard warning is activated by this signal, too.

4.4.2.2.10 Output Signal of the Engine Control Light

EW_Display

This signal activates the display of the engine warning light. If EW_Display = 1, the engine warning light lights up, if EW_Display = 0, the engine warning light dims out. This signal is sent to the engine control light display. Scope: {0,1}. Transmitted internally of the instrument cluster.

4.5 Display

The display of the instrument cluster is described in the following. For a detailed description of the menu see section User Configuration and Menu Tree.

4.5.1 Digital Watch

This section describes the digital watch, which is displayed in the digital display of the instrument cluster.

4.5.1.1 Function Overview

The digital watch displays the current time in digital letters. It's placed in the instrument cluster towards the driver. The time is displayed in a 12h or 24h-mode, see section Communication and Parameter.

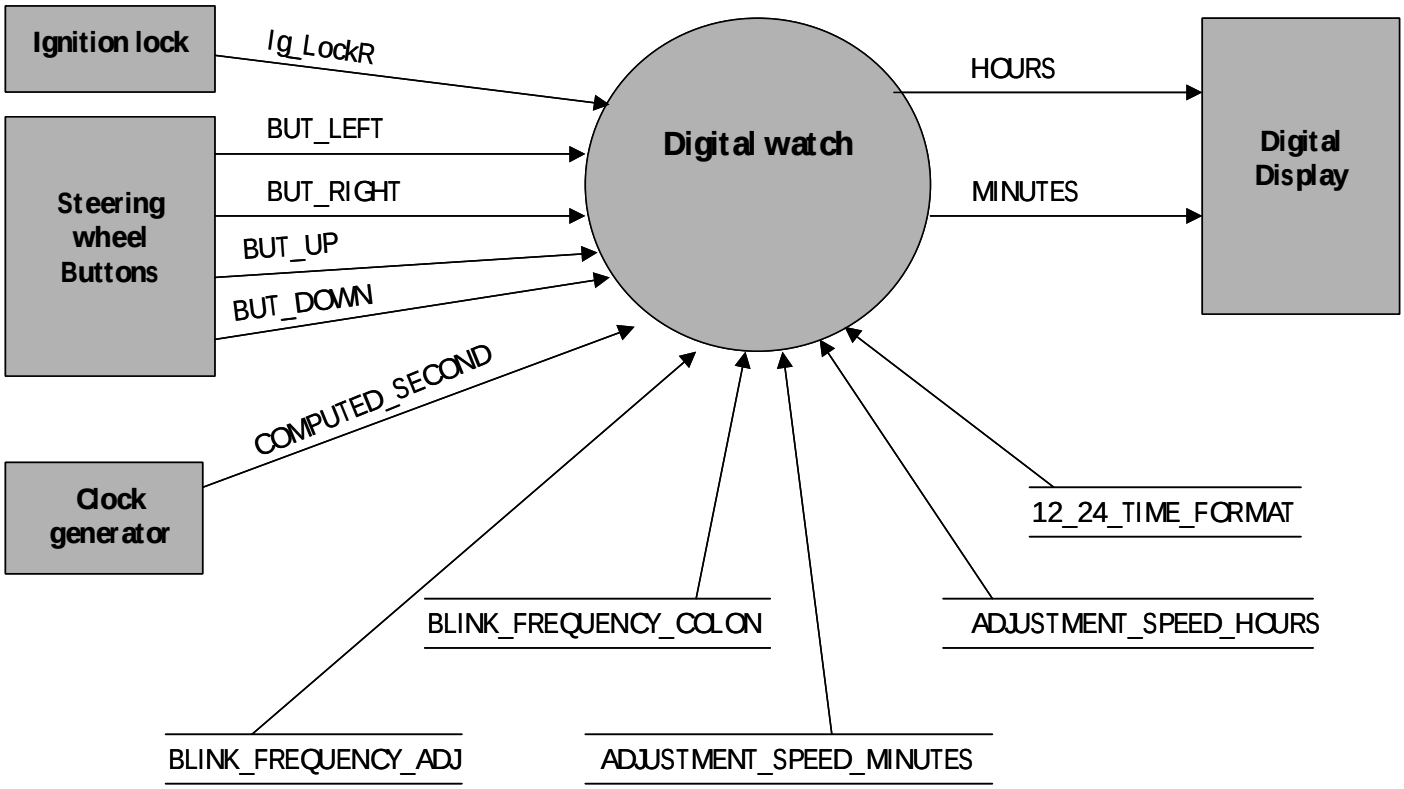
4.5.1.2 System Requirements

The requirements in this subsection specify the digital watch on a detailed level meaning that the business and user requirements have to be realized by the system requirements. These requirements correspond to the abstraction level of actual product specifications ("Lastenhefte").

4.5.1.2.1 Context Diagram

The following context diagram (see figure Context diagram digital watch) presents the context of the digital watch. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram digital watch.



4.5.1.2.2 Functional Requirements

The functional requirements are divided into the following parts: Displaying the Time, Setting the Time, Instrument Cluster Time on CAN Bus, Parameterization (via Diagnosis), Input Signals, Output Signals, and Parameter Values.

4.5.1.2.2.1 Displaying the Time

The digital watch displays the time in the standard page of the digital display (see section User Configuration and Menu Tree and section Activation and Deactivation of the Instrument Cluster).

The display shall use the style “hh:mm”.

If the current hour is one digit (1-9), a leading 0 shall be displayed.

The colon in the time display blinks in a frequency according to parameter BLINK_FREQUENCY_COLON.

In 12 h-mode, after 12:59 the digital watch shall display 1:00.

In 24 h-mode, after 23:59 the digital watch shall display 0:00.

4.5.1.2.2.2 Setting the Time

The driver is able to set the time.

A menu “clock regulator” shall be used, from which the driver is able to set the hours or set the minutes. (see section User Configuration and Menu Tree).

The driver shall be able to increase or decrease the hours in steps +/- 1.

While the time is set by the driver, the time shall blink in a frequency, which can be parameterized (see subsection Parameter Values).

The settings are stored if completed before Ig_LockR is inactive.

4.5.1.2.2.3 Instrument Cluster Time on CAN Bus

Time is computed by the help of the signal COMPUTED_SECOND. Whenever COMPUTED_SECOND is set from 0 to 1, an internal stored counter is incremented.

If the counter reaches 60, the signal MINUTES is incremented by one.

If the signal MINUTES is incremented to 00, the signal HOURS is incremented.

4.5.1.2.2.4 Parameterization (via Diagnosis)

12/24-mode (time format): The time format can be set to either 12 h - or 24 h - mode via diagnosis (12_24_TIME_FORMAT).

The other parameters described in the parameter table shall also be setable via diagnosis.

4.5.1.2.2.5 Input Signals

The following input signals are digitally transferred by the CAN bus.

COMPUTED_SECOND

> *A cyclically sent signal to synchronize the time. COMPUTED_SECOND = 1 is sent 500ms, then COMPUTED_SECOND = 0 is sent 500ms. One periodic step lasts 1s. Scope: {0,1}. Transferred every 100ms.*

BUT_UP

> *If BUT_UP = 1, the steering wheel button "up" is pressed, otherwise the steering wheel button is not pressed. Sent by the steering wheel buttons control unit. Scope: {0,1}. Transferred every 100ms.*

BUT_DOWN

> *If BUT_DOWN = 1, the steering wheel button "down" is pressed, otherwise the steering wheel button is not pressed. Sent by the steering wheel buttons control unit. Scope: {0,1}. Transferred every 100ms.*

BUT_LEFT

> *If BUT_LEFT = 1, the steering wheel button "⇐" is pressed, otherwise the steering wheel button is not pressed. Sent by the steering wheel buttons control unit. Scope: {0,1}. Transferred every 100ms.*

BUT_RIGHT

> *If BUT_RIGHT = 1, the steering wheel button "⇒" is pressed, otherwise the steering wheel button is not pressed. Sent by the steering wheel buttons control unit. Scope: {0,1}. Transferred every 100ms.*

Ig_LockR

> *Describes the position of the ignition key. If Ig_LockR = 1 then the ignition key is in position radio. Sent by the ignition lock control unit. Scope: {0,1}. Received every 100 ms.*

4.5.1.2.2.6 Output Signals

The following output signals are transmitted internally of the instrument cluster.

HOURS

> *This signal sends the hours to the digital display. Scope: 5 Bit; hours: {00000 = 0h,00001 = 1h, ... ,10111 = 23h} , default: 0.*

MINUTES

This signal sends the minutes to the digital display.Scope: 6 Bit; minutes: {000000= 0min,000001 = 1min, ... ,111011 = 59min}, default: 0.

4.5.1.2.2.7 Parameter Values

BLINK_FREQUENCY_ADJ

When the driver is adjusting the time (hours or minutes), the time is blinking. This parameter sets the blinking frequency to X/2 blinks (on/off) per second. Scope: 3 Bit, {000=0, 001= 1, ..., 111= 7}. Stored in the EEPROM.

BLINK_FREQUENCY_COLON

This parameter sets the blinking frequency of the colon (when displaying the time) to X/2 blinks (on/off) per second. Scope: 3 Bit, {000=0, 001= 1, ..., 111= 7}. Stored in the EEPROM.

ADJUSTMENT_SPEED_HOURS

How long the left/right-button has to be pressed in order to increase/decrease the hour (when adjusting the time) in milliseconds. Scope: 3 Bit, {000=100ms, 001=200ms, ... 111=800ms}. Stored in the EEPROM.

ADJUSTMENT_SPEED_MINUTES

How long the left/right-button has to be pressed in order to increase/decrease the minutes (when adjusting the time) milliseconds. Scope: 3 Bit, {000=100ms, 001=200ms, ..., 111=800ms}. Stored in the EEPROM.

12_24_TIME_FORMAT

If hours are displayed in 12-hours-mode or 24-hours-mode. Scope: 1 Bit {0 = 24-hours-mode, 1 = 12-hours-mode}. Stored in the EEPROM.

4.5.2 Outside Temperature

This section describes the outside temperature display of the instrument cluster.

4.5.2.1 Function Overview

The indication of the outside temperature is additional information for the driver.

Because of the different variants of the instrument cluster, the temperature is displayed in degree Celsius or degree Fahrenheit (see section Communication and Parameter). Each driver is able to have the unit displayed he prefers.

A sensor measures the temperature by means of resistance. The instrument cluster processes this input by an algorithm. First, the values are mapped on values of degree Celsius or degree Fahrenheit before they are displayed. The outside temperature is presented as a numeric value on the digital display.

A warning message of an imminent danger of ice on the road in case of a quite low outside temperature enables the driver to a more secure driving.

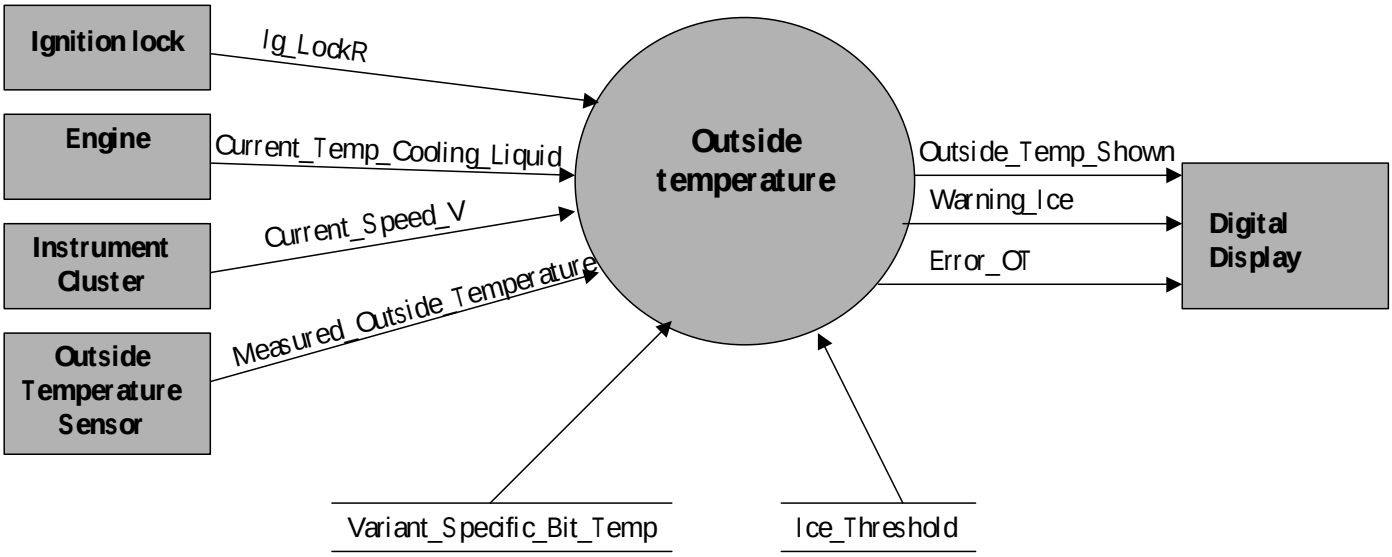
4.5.2.2 System Requirements

The requirements in this subsection specify the indication of the outside temperature on a detailed level meaning that the business and user requirements shall be realized by the system requirements. These requirements correspond to the abstraction level of current product specifications ("Lastenhefte").

4.5.2.2.1 Context Diagram

The following context diagram (see figure Context diagram - outside temperature) presents the context of the outside temperature. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram - outside temperature.



4.5.2.2.2 Functional Requirements

This subsection is structured as follows. Firstly we provide a description of the indication of the outside temperature, followed by a detailed listing of the input and output signals and an algorithm describing how these signals shall be processed.

4.5.2.2.2.1 Indication

The outside temperature is shown on the standard page of the pull-down menu of the display.

For a precise description of the chosen font, its style etc. see section User Configuration and Menu Tree.

4.5.2.2.2.2 Transmitted and Indicated Value

There is a difference in the transmitted and the indicated value. The transmitter is able to measure higher and lower temperatures than the indicator is able to show.

Please see the following table Mapping of the measured values to the indicated ones for details.

Table: Mapping of the measured values to the indicated ones.

Transmitted value	Corresponding value °C	Corresponding value °F
more than 30000	error	error

Transmitted value	Corresponding value °C	Corresponding value °F
27490 - 22810	-35	-31
20640	-30	-22
18583	-25	-13
16640	-20	-4
14810	-15	5
13093	-10	14
11490	-5	23
10000	0	32
8623	5	41
7360	10	50
6210	15	59
5173	20	68
4250	25	77
3440	30	86
2743	35	95
2160	40	104
1690	45	113
1333 – 960	50	122
less than 943	error	error

4.5.2.2.2.3 Variations between US and ROW (Rest of World) Instrument Clusters

Each instrument cluster must be able to translate the outside temperature in units of degree Celsius or degree Fahrenheit. Therefore each instrument cluster is equipped with a variant specific bit for the temperature (Variant_Specific_Bit_Temp).

It is possible to modify this default assignment by using the configuration menu. In the pull-down menu of the display is one page, on which a driver can choose which unit he wants to be displayed (see section User Configuration and Menu Tree).

4.5.2.2.2.4 *Activation of Indication*

The indication (optical display) of the outside temperature has to be activated not later than 1s after the activation of the display, (see section Activation and Deactivation of the Instrument Cluster) or the switch-on of the ignition (Ig_LockR = 1).

The time until the 1s is reached, the display shows “--°C“ or “--°F”.

The starting value for the displayed outside temperature is calculated as the average value of 8 measurement points, which are provided in the first second, until the indication is displayed.

If only the display is activated and not the car, but the ignition on position radio (Ig_LockR = 1) the indication of the outside temperature is updated each minute. Else the display is activated according to the Algorithm/Characteristics (see subsection Algorithm/Characteristics).

While the outside temperature algorithm is not working or there are no meaningful temperature values available, the temperature '---°C' or '---°F' is shown.

4.5.2.2.2.5 Deactivation of Indication

The indication of the outside temperature is deactivated by the deactivation of the display (see section Activation and Deactivation of the Instrument Cluster).

4.5.2.2.2.6 Input Signals

Measured_Outside_Temperature

Outside Temperature measured directly by a sensor in the front of the car. Unit Ohm (65536 in case of an error), transmitted internally of the instrument cluster.

Current_Speed_V

Describes the current speed of the car with access at any time; received internally from speedometer

Current_Temp_Cooling_Liquid

Temperature of the cooling liquid (centigrade: -10 until +150). Scope 0x00..0xFF (Temp [°C] = Value + 50). Received every 80ms by the CAN bus.

Ig_LockR

Describes the position of the ignition key. If Ig_LockR = 1 then the ignition key is in position radio. Scope: {0,1}. Received every 100 ms. Transferred by the CAN bus.

4.5.2.2.2.7 Output Signals

Outside_Temp_Shown

For the display edited outside temperature (Scale [°C]: -35 up to +50 and Scale [°F]: -31 up to +122). Transmitted internally.

Error_OT

In case of a realized error (active/inactive). Scope: {0=active, 1=inactive}. Transferred every 100ms by the CAN bus.

Warning_Ice

Indicates the possibility of ice on the road (1 = activated, 0= inactive) Transferred internally.

4.5.2.2.2.8 Parameter Values

The parameter values are stored to provide the possibility to have different characteristics of the outside temperature.

Variant_Specific_Bit_Temp

Configuration adjustment for the representation unit of the outside temperature. Scope: {0 = °C (default value for ROW variants),1 = °F (default value for the US variants)}. Stored in the EEPROM.

Ice_Threshold

Internal threshold, with which the produced outside temperature for the display is compared. Stored in the EEPROM. Scope: 0x00..0x1F (0x00=-20°C, 0x01=-19°C, ... 0x1F=11°C).

4.5.2.2.2.9 Missing CAN Signals and Error Handling

If the signal Current_Temp_Cooling_Liquid is not available, the indication of the outside temperature shows the same behavior as described in the algorithm below in case of Current_Temp_Cooling_Liquid >= 60 Centigrade.

If we cannot get any speed signal (i.e. Current_Speed_V = 0xFF), the indication of the outside temperature behaves as described in the algorithm in the part where the Current_Temp_Cooling_Liquid >= 60 Centigrade and the current speed Current_Speed_V is an element of the interval from 30km/h to 50km/h.

If the temperature exceeds or falls within 10 centigrade over resp. under the end of the indication scale then the indication shows the maximum respective minimum possible corresponding indication value.

If the temperature exceeds or falls more than 10 centigrade over respective under the end of the indication scale an Error_Value is transmitted and the display shows three dashes "---" and the registered temperature unit "°C" or "°F".

The same happens if an error value is transmitted for more than 3 minutes. Until then the indicator rests on the temperature shown before.

As soon as the errors are removed for more than 3,5 minutes, the temperature values are displayed as described before.

If the produced Outside_Temp_Shown falls under a certain threshold (Ice_Threshold) for more than 5 minutes an ice warning (Warning_Ice = 1) has to occur in the display. (For a detailed description of the warning see section Warning Messages).

4.5.2.2.2.10 Damping

The response time of the display shall not exceed 0,5s (T63 without electronic damping).

Rationale: We have to find a compromise between high sensitivity (long response time, small damping) and short response time (low sensitivity, big damping).

The internal signal Internal_Temp shall be damped by a PT2 element.

4.5.2.2.2.11 Precision

The accuracy of the different temperature units degree Celsius and degree Fahrenheit that has to be reached is combined in the following tables, see table Accuracy of different temperature units - centigrade and Accuracy of different temperature units - degree Fahrenheit. Errors which occur in case of the transmitter and the construction are already considered.

Table: Accuracy of different temperature units - centigrade.

Area	Precision
-35°C until -30°C	±3,5°C
-30°C until -25°C	±2°C
-25°C until +30°C	±1°C
+30°C until +35°C	±1,5°C
+35°C until +40°C	±2°C

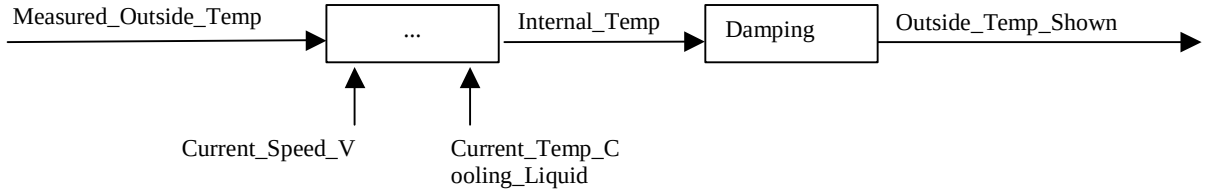
Area	Precision
+40°C until +50°C	±2,5°C

Table: Accuracy of different temperature units - degree Fahrenheit.

Area	Precision
-31°F until -22°F	±6°F
-22°F until -13°F	±4°F
-13°F until +86°F	±2°F
+86°F until +95°F	±3°F
+95°F until +104°F	±4°F
+104°F until +122°F	±5°F

4.5.2.2.2.12 Algorithm / Characteristics

Figure: Schematic representation of the algorithm.



The displayed value of the outside temperature (Outside_Temp_Shown) is determined considering the current

- speed (Current_Speed_V)
- temperature of cooling liquid (Current_Temp_Cooling_Liquid) and
- Ig_LockR.

If Current_Temp_Cooling_Liquid < 60 centigrade, the Internal_Temp is damped and displayed afterwards. There is no differentiation between rising or falling Internal_Temp values.

> *First we distinguish between: Current_Temp_Cooling_Liquid < 60 degree Celsius and Current_Temp_Cooling_Liquid >= 60 degree Celsius.*

If Current_Temp_Cooling_Liquid >= 60 centigrade, the value of Current_Speed_V has to be considered additionally.

Therefore the speed values 30 km/h and 50 km/h are important threshold values:

If Current_Speed_V < 30 km/h and the Internal_Temp values are sinking, then Outside_Temp_Shown = Internal_Temp. Rising Internal_Temp values are ignored.

If 30 km/h <= Current_Speed_V <= 50 km/h rising Internal_Temp values are ignored for three minutes. After that Outside_Temp_Shown = Internal_Temp. Falling Internal_Temp values are indicated in time.

If Current_Speed_V >= 50 km/h the rising Internal_Temp values are ignored for 1,5 minutes. After that Outside_Temp_Shown = Internal_Temp. Falling Internal_Temp values are indicated in time.

If Current_Temp_Cooling_Liquid >= 60 centigrade and the engine is off (Ig_LockR = 0), we have to avoid that in case of the temperature of the engine, a wrong value of the outside temperature is displayed. Therefore we implement a so called delay-time. The delay-time is predefined to one hour.

During this delay-time only falling, no rising Internal_Temp values are allowed. So an appreciation of the displayed outside temperature over the value displayed while turning off the engine is impossible.

If the engine is turned on before the delay-time has finished, the rest of the delay-time is deleted.

If Current_Temp_Cooling_Liquid < 60 centigrade, the delay-time is immediately deleted and the announcement of falling and rising measured data is similarly allowed.

4.5.3 Radio Information

This section describes the communication between radio and instrument cluster.

4.5.3.1 Function Overview

It shall be possible to present essential information about the radio status (i.e. operation mode, current frequency, current RDS radio station) in the instrument cluster and to control basic functionalities (i.e. loudness, radio station) by means of the steering wheel buttons.

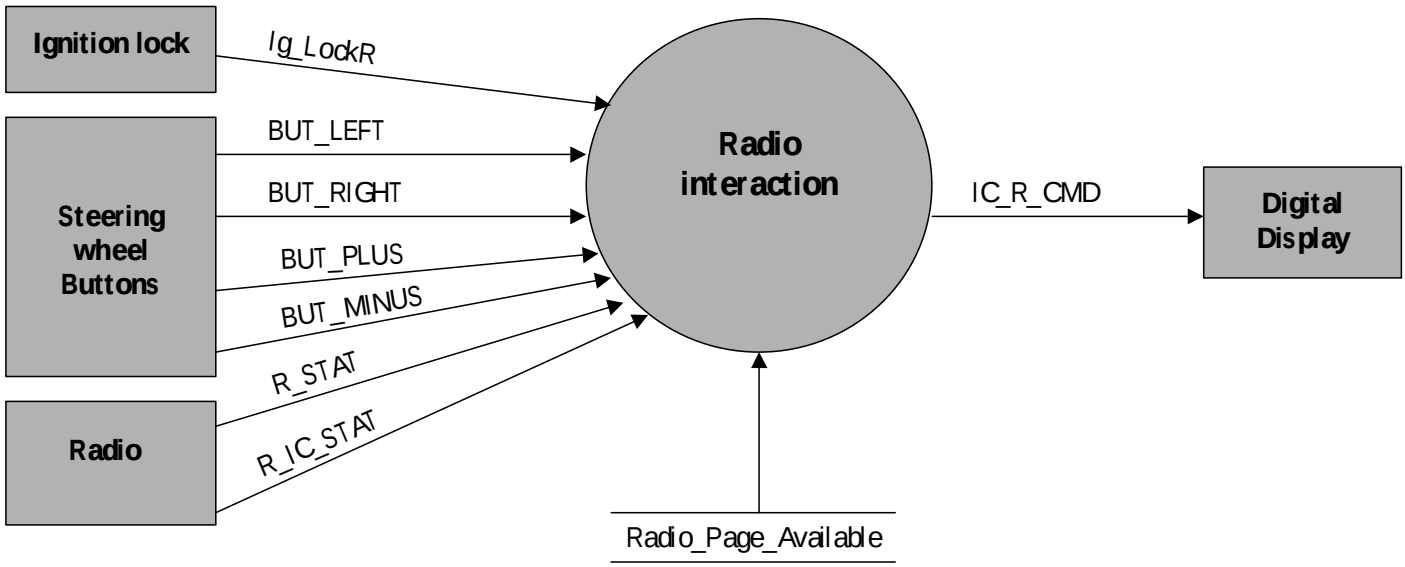
4.5.3.2 System Requirements

This subsection specifies the behavior of the IC menu page and the intercommunication protocol with the radio on a detailed level.

4.5.3.2.1 Context Diagram

The following context diagram (see figure Context diagram IC – radio interaction) presents the context of the IC – radio interaction. The used notation is similar to the common notation for context diagrams SA/RT (see section References [2]).

Figure: Context diagram IC - radio interaction.



4.5.3.2.2 Functional Requirements

The functional requirements are divided up into the following parts: (1) Communication with the radio via the IRC Protocol (IC – radio communication protocol), (2) Processing of IRC Messages (3) Displaying Radio Information in the Radio Menu Page, (4) User Interaction IRC Protocol Validation, (5) Input/Output Signals, and (6) Parameter Values.

4.5.3.2.2.1 IRC Protocol, V2.0

The IRC protocol V2.0 (IC – radio communication protocol) is run via the CAN bus.

It consists of one cyclic message and two event-driven messages.

The cyclic message R_STAT is produced by the radio reporting its availability and some information about the current status.

The messages R_IC_STAT and IC_R_CMD are event-driven messages. The first contains additional information about the radio status. The second sends commands to the radio (e.g. increase loudness).

The figures Message R_STAT**,** Message R_IC_STAT, and Message IC_R_CMD describe the detailed content of these messages.

Figure: Message R_STAT.

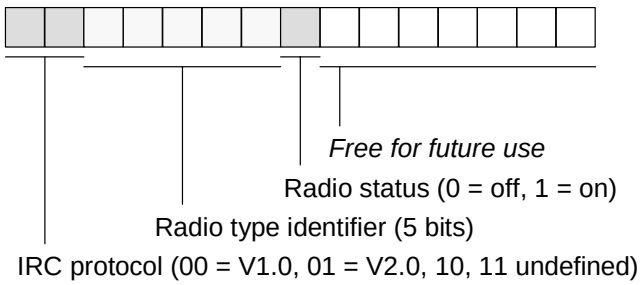
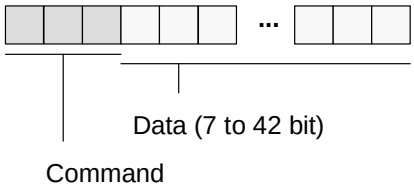


Figure: Message R_IC_STAT.

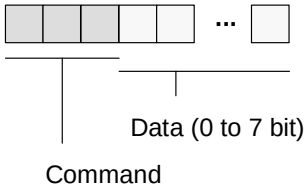


The following commands are supported:

Table: Message R_IC_STAT.

CMD	Name	Description	Datalength	Data
000	Unknown	Free for future use		
001	New frequency	Provides information about the currently seeked or used frequency	7 Bit	7 Bit (0..127); 0x00 = 85.0 MHz, 0x01 = 85.5 MHz, … 0x7F = 148.5 MHz
002	New RDS radio station part 1	Provides information about the currently used Radio (first 6 signs)	42 Bit	Each 7 Bit encode one sign; ASCII encoded
003	New RDS radio station part 2	Provides information about the currently used Radio (last 5 signs)	35 Bit	Each 7 Bit encode one sign; ASCII encoded
004	Loudness	Provides information about loudness	7 Bit	7 Bit (0..99)
005 to 007	Unknown	Free for future use		

Figure: Message IC_R_CMD.



The following commands are supported in IRC protocol V1.0.

Table: Message IC_R_CMD, V1.0.

CMD	Name	Description	Datalength	Data
000	Turn off	Turn radio off	0 Bit	None
001	Turn on	Turn radio on	0 Bit	None
002	Reset	Set radio back to its default values	0 Bit	None
003	Provide data	Forces radio to send a R_IC_STAT message	0 Bit	None

CMD	Name	Description	Datalength	Data
004	Adjust loud-ness	Increments or decrements loudness	2 Bit	00 = maintain loudness, 01 = increment loudness, 10 = decrement loudness, 11 = invalid
005	Next station	Skip to next station	2 Bit	00 = previous station, 01 = next station

The following commands are supported in IRC protocol V2.0.

Table: Message IC_R_CMD, V2.0.

CMD	Name	Description	Datalength	Data
000	Turn off	Turn radio off	2 Bit	00 = immediately, 01 = smoothly (if sup-ported)
001	Turn on	Turn radio on	2 Bit	00 = using previous state (e.g. loudness), 01 = using reset state
002	Reset	Set radio back to its default values	0 Bit	None
003	Provide data	Forces radio to send a R_IC_STAT message on frequency or RDS radio station	0 Bit	None
004	Adjust loud-ness	Increments or decrements loudness	5 Bit	See table Adjust loudness parameter
005	Next station	Skip to next station	2 Bit	00 = previous station, 01 = next station

Table: Adjust loudness parameter.

Data (binary)	Explanation
00 000	Set loudness to reset default
00 001	Mute on
00 010	Mute off
01 000	Maintain loudness
01 101	Increment loudness small
01 110	Increment loudness medium
01 111	Increment loudness strong
01 001	Decrement loudness small
01 010	Decrement loudness medium
01 011	Decrement loudness strong

4.5.3.2.2.2 Processing of IRC Messages

IRC messages are only processed if Radio_Page_Available is 1. Otherwise all messages are ignored and no IC_R_CMD message is generated.

If there is no R_STAT message it is assumed that no radio is available. Thus, R_IC_STAT messages are ignored and no IC_R_CMD messages are generated. The radio menu page displays “No radio available”.

If R_STAT messages are present, information about radio on/off and IRC V1.0/V2.0 is stored internally. All information broadcasted through message R_IC_STAT is stored internally, too.

Subsection User Interaction describes criteria for sending IC_R_CMD messages.

4.5.3.2.2.3 Displaying Radio Information in the Radio Menu Page

The radio menu page is only available if Radio_Page_Available is 0. Otherwise navigation in the IC menu will skip the radio menu page.

When the user enters the radio menu page, the current status of the radio is displayed. Table Displayed information summarizes all possible states.

Table: Displayed information.

Nr.	Condition	Displayed information
1	No radio available (no R_STAT messages)	“No radio available”
2	Radio off	“Radio off, use ◊ to turn on”
3	Radio on, no R_IC_STAT message received	“Radio”
4	Radio on, R_IC_STAT message received (New frequency)	Display frequency
5	Radio on, R_IC_STAT message received (New RDS radio station part 1 and 2)	Display RDS radio station
6	Detected communication error (see subsection IRC protocol validation)	“Radio interface error”

The information update frequency should not exceed 0.5 Hz (for displays number. 1, 2, 3, 5, 6) or 1 Hz (for display number. 4).

The interval starts when the information is displayed initially. This means, that after altering the radio menu page any information is displayed for at least 1 or 2 seconds before it is updated (even if there is an immediate frequency change, for example, reported by R_IC_STAT).

Frequency and RDS radio station are displayed center aligned.

Special characters in RDS radio station identifiers (i.e. characters 0x00 to 0x1F) shall be completely ignored.

Example: The identifiers ‘S’, ‘D’, ‘R’, #9, ‘3’ are displayed as ‘SDR3’.

Detailed information about layout of all display messages are presented in section Display.

4.5.3.2.2.4 User Interaction

The following activities are only performed if Radio_Page_Available is 0, Ig_LockR = 1 and no communication error is present. Otherwise no IC_R_CMD message is sent.

The IC_R_CMD messages have to take the IRC version into account.

Every time the user presses the '+' button at the steering wheel (BUT_PLUS = 1), the command 'Adjust loudness – increment loudness' (IRC V1.0) or 'Adjust loudness – increment loudness small' (IRC V2.0) is sent.

If the user keeps the '+' button pressed for more than 1 second, the command is sent every 0.5 seconds until the user releases the '+' button.

Pressing the '–' button (BUT_MINUS = 1) is handled accordingly (using the messages 'Adjust loudness – decrement loudness' (IRC V1.0) or 'Adjust loudness – decrement loudness small' (IRC V2.0), respectively).

Loudness is possible all the time the radio is on (regardless of the displayed menu page).

If the radio menu page is the current menu page …

… the radio is off and the '⇒' button is pressed (BUT_RIGHT = 1), the command with data 'Turn on' (IRC V1.0) or 'Turn on – using previous state' (IRC V2.0) is sent.

… the radio is on and the '⇒' button is pressed (BUT_RIGHT = 1), the command with data 'Next station – next station' is sent.

… the radio is on and the '⇐' button is pressed (BUT_LEFT = 1), the command with data 'Next station – previous station' is sent.

There is no auto-repeating for the '⇐' and '⇒' buttons.

4.5.3.2.2.5 IRC Protocol Validation

As the IRC protocol is mainly event message based, there are no predefined response intervals. Thus, there is the need for a more sophisticated protocol validation.

It is assumed that within 5 seconds after activating the IC the radio is ready to operate. Thus the first R_STAT message has to be there within 5 seconds after activating the IC.

Otherwise it is assumed that there is no radio. R_STAT messages that are detected later on will be ignored.

If a radio has once been detected and later on a R_STAT message is dropped (time out), we face a communication error. This error reveals after ten consecutive R_STAT messages have been received.

It is assumed that each IC_R_CMD message results in a corresponding R_IC_STAT message, see table Corresponding messages.

If there is no adequate response, the IC_R_CMD message is repeated once. If there is again no adequate response we try to recover. This means that an Reset command followed by 'Turn on' (IRC V1.0) or 'Turn on – using reset state' (IRC V2.0) is sent. If there is again no adequate response we face a communication error. This error remains until the IC is deactivated. Figure IRC protocol validation depicts the IRC protocol validation mechanism. Table Corresponding messages defines the term 'corresponding' message.

Figure: IRC protocol validation.

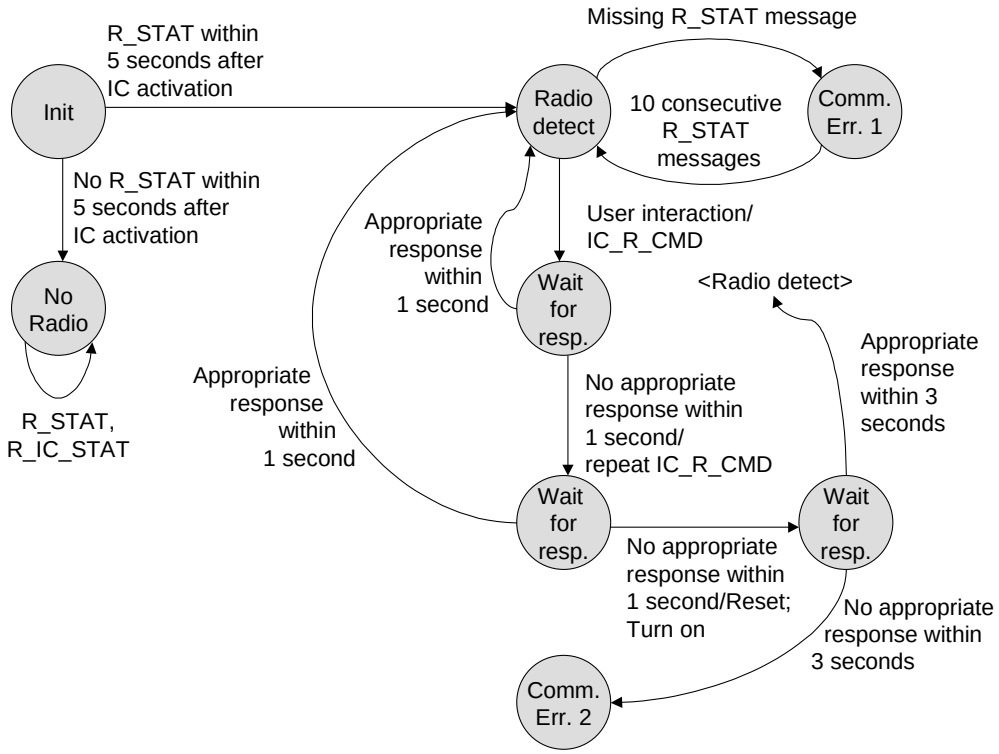


Table: Corresponding messages.

Sent message IC_R_CMD	Expected answer (corresponding R_IC_STAT message)
Turn radio off	None
Turn radio on	New frequency or New RDS radio station part 1
Reset	None
Provide data	New frequency or New RDS radio station part 1
Adjust loudness	Loudness
Next station	The following commands are supported:

4.5.3.2.2.6 Input Signals

The following input signals are digitally transferred by the CAN bus.

R_STAT

Cyclic information concerning radio status (see figure Message R_STAT)

R_IC_STAT

Event-driven message providing information about the radio status (see figure Message R_IC_STAT)

BUT_LEFT

Steering wheel button '⇐' pressed; Scope: {0=not-pressed, 1=pressed}. Transmission rate: sent every 200ms. Sender: Steering wheel Buttons.

BUT_RIGHT

Steering wheel button '⇒' pressed; Scope: {0=not-pressed, 1=pressed}. Transmission rate: sent every 200ms. Sender: Steering wheel Buttons.

BUT_PLUS

Steering wheel button '+' pressed; Scope: {0=not-pressed, 1=pressed}. Transmission rate: sent every 200ms. Sender: Steering wheel Buttons.

BUT_MINUS

Steering wheel button '–' pressed; Scope: {0=not-pressed, 1=pressed}. Transmission rate: sent every 200ms. Sender: Steering wheel Buttons.

Ig_LockR

Describes the position of the ignition key. If Ig_LockR = 1 then the ignition key is in position radio. Scope: {0, 1}. Received every 100 ms.

4.5.3.2.2.7 Output Signal

The following output signal is transferred by the CAN bus.

IC_R_CMD

Event-driven message requesting services from the radio (see figure Message IC_R_CMD)

4.5.3.2.2.8 Parameter Value

The parameter value is stored internally to provide the possibility of different characteristics of the radio.

Radio_Page_Available

Used to deactivate the IC – radio communication and the corresponding radio menu page. Scope: 0 = active, 1 = not-available.

4.5.4 User Configuration and Menu Tree

The following section contains a description of the various levels of the menu tree. At the end of the section, there is a survey of the coherences and connections between the levels.

The menu tree is divided into several levels:

Standard Page:

The standard page is divided into two sections, whereby in the upper half of the display the time is indicated. In the other part of the display, there is the option of denoting either the speed or the temperature.

Radio Display:

With the radio display, the programs of the radio can be chosen.

Clock Regulator:

With the clock regulator, the time can be adjusted and the illustration of time in 12 or 24 hours can be defined.

Temperature Regulator:

In this level of the menu tree, the index of degree can be chosen.

Language:

There is the possibility to set the display text either in English or in German.

Speedometer Regulator:

The speed can be indicated either in kmh or in mph.

The above-named levels of the menu tree can be changed with the steering wheel buttons „up“ (indicated on the steering wheel as "⇑" - button) and „down“ (⇓). With the assistance of the steering wheel buttons „left“ (⇐) and „right“ (⇒), it is possible to make modifications of the configurations in the different levels which affect the appearance in the display.

The steering wheel buttons "plus"(+) and "minus" (-) are only relevant to adjust the volume (see Subsection Radio Display and Section Radio Information).

4.5.4.1 Standard Page

The standard page is divided into two sections. In the upper half (100x25 pixels) of the 100x50 pixels display, the time is illustrated centered to the colon.

Hours < 10 are indicated with a preceding zero. In the lower part of the display, there is an option to indicate either the outside temperature or the speed. The choice can be conducted by the steering wheel buttons „left“ and „right“.

The speed can be indicated as kmh or mph. This differentiation must be chosen in the level „speedometer regulator“ of the menu tree.

A positive outside temperature is displayed with a preceding „+“, a negative one with a preceding „ - “. „Zero“ is always written as: „+0°C“ or „+0°F“.

Table: Display range (temperature).

display	**°C**	**°F**	
display range	-40°C - +50°C	-40°F - +122°F	
display definition	1 °C	1 °F	

Figure: Example of a standard page (temperature).

Figure: Definition of the graphic representation (temperature).

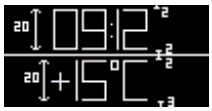


Figure: Example of a standard page (speed).

Figure: Definition of the graphic representation (speed).

The distance between the letters/ numbers amounts to two pixels. The letters/numbers are between 1 and 13 in width (proportional font) and 20 pixels vertical. The colon counts as a letter with a width of 1 pixel. The distance between the signs “+” (or “-”) and the temperature is 3 pixels.

4.5.4.2 Radio Display

With the steering wheel button “down”, the menu of the radio can be chosen. The radio programs can be changed with the steering wheel buttons “left” or “right”. The volume can be changed with the buttons "plus" and "minus".

In the upper half of the display, the RDS radio station is indicated, in the other part of the display, the frequency of the radio station is represented (in MHz, with one digit after comma). Both indications are centered to every side of the rectangular display.

If the parameter value Radio_Page_Available = 1 (non - available), the subsection "Radio Display" is skipped and the next level "Clock Regulator" is indicated.

Figure: Example of a radio display.

Figure: Definition of the radio display.

If no RDS radio station information is available, the upper line shows three centered dashes instead of RDS radio station.

Figure: Example of a radio display without available RDS radio station information.

If no radio is available (see section Radio Information), the according message is displayed.

Figure: No radio message.

If the radio is available but turned off, the according message is displayed. Pressing the "⇒" button on the steering wheel activates the radio (see section Radio Information).

Figure: Radio off message.

If an communication error is detected (see section IRC protocol validation), the message Radio interface error is presented.

Figure: Radio interface error.

4.5.4.3 Clock Regulator

With the steering wheel button “down”, the level can be changed to the next subjacent display: from the radio display to the clock regulator.

First, one can toggle the representation of time between 12 h or 24 h with the steering wheel buttons “left” or “right”.

The small box in front of the numbers measures 12 pixels horizontally and 10 pixels vertically.

The choice of the timing is confirmed by the check mark in the small box in front of “24 h” or “12 h”.

Figure: Example 24h.

Figure: Definition of the 12_24 page.

With the steering wheel button “down”, the next subjacent level can be chosen. On this level, one is able to adjust the hours (the hours flash) with the assistance of the steering wheel buttons “left” and “right”.

Afterwards, the steering wheel button "down" has to be activated to get onto the next level in order to regulate the minutes with the steering wheel buttons “left” and “right”. On this level, the minutes flash.

By a short push on the button “left” or “right”, which lasts less than 3 sec., the minutes/ hours (depends on the level, on which you are situated) can be adjusted.

If the push lasts more than 3 sec., the indication of minutes/ hours is decreased/ increased until the time from the last change of the indication to the unhanding of the button is less than one sec. Increasing/decreasing happens with 1 unit per second. Values are handled in a ring-buffer-fashion, i.e. decreasing 00 minutes results in 59 minutes and so forth.

Figure: Example of a clock display (24h).

Figure: Definition of a clock display (24h).

Figure: Example of a clock display (24h) (hours flash).

Figure: Example of a clock display (24h) (minutes flash).

If the representation of time is not 24 h but 12 h, the according representation rules have to be considered. The subsequent table presents the mapping from 24h to 12h values.

Table: Mapping from 24h to 12h values.

24h Time	12h representation
00:00	12:00pm
00:01	12:01am
00:02	12:02am
...	...
01:00	01:00am
…	…
11:59	11:59am
12:00	12:00am
12:01	12:01pm
12:02	12:02pm
…	…
23:58	11:58pm
23:59	

Figure: Example of a clock display (12h).

Figure: Definition of a clock display (12h).

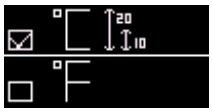
4.5.4.4 Temperature Regulator

The temperature regulator is the next subjacent level below the clock regulator. You can get to the level of the temperature regulator with the steering wheel button “down”.

There are two possibilities of indicating the temperature: °C and °F. On the level “temperature regulator”, the representation can be changed with the steering wheel buttons “left” and “right” between °C and °F.

Figure: Example of the display (temperature regulator).

Figure: Definition of the display (temperature regulator).



4.5.4.5 Language

“Language” is the next level below the “temperature regulator”, which can be chosen with the steering wheel button “down”.

It is possible to select between two languages: English and German. With the steering wheel buttons “left” and “right”, you are able to toggle the choice.

Figure: Example of the display (language).

Figure: Definition of the display (language).

4.5.4.6 Speedometer Regulator

With the steering wheel buttons “left” and “right”, a choice can be made between a kmh or mph representation.

Figure: Example of the display (speedometer regulator).

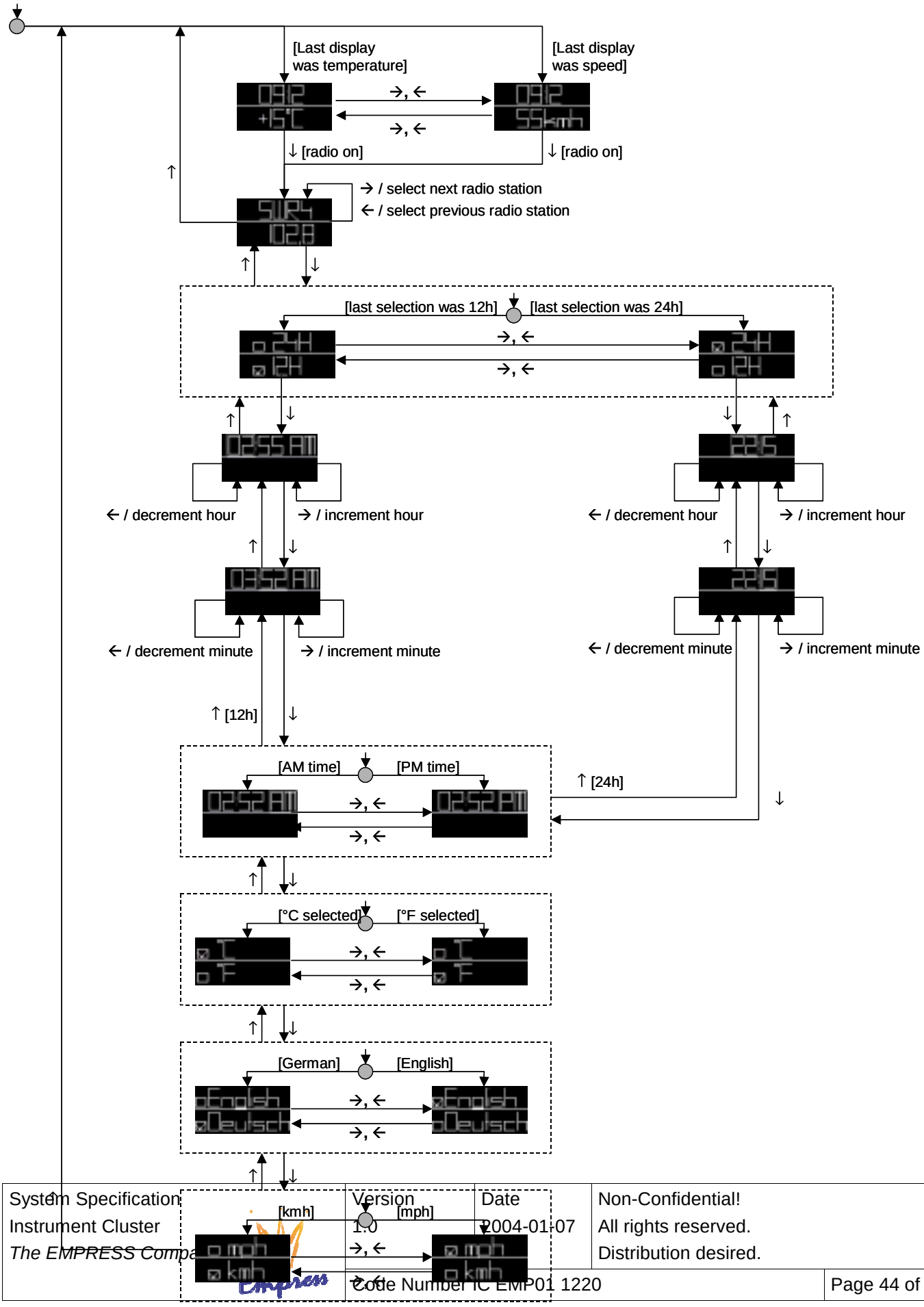
Figure: Definition of the display (speedometer regulator).

4.5.4.7 Survey

The subsequent drawing visualizes the main navigation throughout the menu tree. The notation used is similar to that of hierarchical state diagrams. The notation used at the edges is the Event [Condition] / Action syntax, i.e. when an Event is detected and the Condition is fulfilled, the Action is performed. Condition and Action are optional. Hierarchical states are used to simplify the drawing.

The menu tree does not cover all radio exceptions (see subsection Radio Display).

Table: Survey.


[Last display
was temperature]
[Last display
was speed]
→, ←
→, ←
↓ [radio on]
↓ [radio on]
→ / select next radio station
← / select previous radio station
[last selection was 12h]
[last selection was 24h]
→, ←
→, ←
← / decrement hour
→ / increment hour
← / decrement hour
→ / increment hour
← / decrement minute
→ / increment minute
← / decrement minute
→ / increment minute
↑ [12h]
[AM time]
[PM time]
→, ←
→, ←
↑ [24h]
[°C selected]
[°F selected]
→, ←
→, ←
[German]
[English]
→, ←
→, ←
[kmh]
[mph]
→, ←
→, ←

4.5.4.8 Parameters

Kmh_Mph

If speed is displayed in kmh or mph. Scope: {0 = kmh, 1 = mph}

German_English

If the language is displayed in German od English. Scope: {0 = German, 1 = English}

4.5.5 Handling of Warning Messages

In the following section, the components of the section warning messages are described.

4.5.5.1 Symbols

The following symbols are part of the warning messages and situated in the upper half of the display.

Figure: S01.

Figure: S02.

Figure: S03.

Figure: S04.

Figure: S05.

Figure: S06.

4.5.5.2 Structure

Every warning consists of two parts: the symbol and the text line(s).

Figure: Possibility 1: a symbol and one text line (numbers in pixels).

Figure: Possibility 2: a symbol and two text lines (numbers in pixels).

The display measures 100 x 50 pixels.

The symbol is illustrated in the upper half of the display (100 x 25 pixels) and is centered on every side of the rectangular display.

For each text line, there is a range of 100 x 11 pixels reserved, whereas every text line is pictured centered.

The range between two text lines and the symbol area amounts 1 pixel.

The range between two words measures 4 pixels, the range between two letters amounts 1 pixel.

4.5.6 Warning Characteristics

4.5.6.1 Appearance of a Warning

The appearance of a warning consists of two representations:

- a colored display picture and a warning tone or

- a colored display picture without a warning tone.

Attention should be paid to the warning tone, which may not occur separately without a visual picture.

The period between the appearance of the mistake and the appearance of the warning may not be longer than two analysis intervals.

4.5.6.2 Behavior of Warnings

The behavior of warnings can be modified with the warning characteristics.

4.5.6.2.1 Priority

There are three different priority levels:

- Level 1: These warnings have the highest priority. The previous message will be interrupted if this message occurs. Warnings appearing at the same time with lower priorities are suppressed and turn up later.

- Level 2: These warnings are preferred in contrast to warnings of level 3: the warnings of level 3 are suppressed if warnings of level 2 appear at the same time and are interrupted, if messages of level 2 arrive. Compared with warnings of level 1, messages of level 2 are suppressed and interrupted (see “level 1”).

- Level 3: These warnings have the lowest priority. Any other warnings have preference to these warnings. Moreover, warnings of level 3 are interrupted or suppressed if other warnings appear.

If two warnings of the same priority occur at the same time, they are indicated alternately with a period of 10 sec. each, until the driver confirms one of the warnings or one of the signals is confirmed automatically.

4.5.6.2.2 Automatic Confirmation

If this attribute is activated, the warning disappears automatically, if the cause for the warning is eliminated.

To guarantee a flicker-free display, a message is displayed at least for 10 sec. (only relevant if the activation time is less than 10 sec.).

4.5.6.2.3 Manual Confirmation

If this attribute is activated, the user can terminate the warning manually by a short push on one of the buttons on the steering wheel, whereby it doesn‘ t matter, which one is pushed.

4.5.6.2.4 Color of the Warning Display

There are two different colors. The warnings can be indicated in red or in white, whereby the choice of color depends on the different priorities: warnings of priority level 1 are illustrated red and the others (level 2,3) have always the color white.

4.5.7 Condition to Switch on

The warning appears, if the condition to switch on is fulfilled.

4.5.8 Condition to Switch off

The warning disappears, if the cause of the warning has ceased to exist and thus the condition to switch on is no longer fulfilled.

Moreover, the warning can be confirmed manually or automatically.

4.5.9 Acoustics

Some warnings have a warning tone additional to the message on the display.

The warning tone is either a continuing tone (the tone is not interrupted until the warning is confirmed) or an interval tone (this tone is a short tone, which appears in intervals of 15 sec.). Which tone is dedicated to which warning can be seen in the section Warning Messages.

4.5.10 Analysis Interval

It is examined again and again, whether the error still exists or is already over. The time between every afresh check is called “analysis interval”.

4.5.11 Warning Messages

The following section contains all warnings and their specification. Only the warnings which appear on the display are considered.

4.5.11.1 Number of Revolutions too High

Figure: Number of revolutions too high.

Figure: Drehzahl zu hoch.

Table: specifications of "number of revolutions too high".

Description:	The warning appears, if the number of revolutions is too high.
Condition to switch on:	Warning_RM (see section Rev Meter)
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	200 ms
Priority:	1
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	yes
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S01
text line 1	Number of revolutions
text line 2	too high!
- German	
symbol name	S01
text line 1	Drehzahl
text line 2	zu hoch!

4.5.11.2 Display Defective (Engine)

Figure: Display defective. Visit workshop.

Figure: Anzeige defekt. Werkstatt aufsuchen.

Table: specifications of "display defective (engine)".

Description:	The warning appears if the display concerning the engine is defective.
Condition to switch on:	Eng_Def = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	250ms
Priority:	2
Automatic confirmation:	yes
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	yes (previous message is of priority 3),no (previous message is of priority 1)
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S01
text line 1	Display defective
text line 2	Visit workshop!
- German	
symbol name	S01
text line 1	Anzeige defekt
text line 2	Werkstatt aufsuchen!

4.5.11.3 Slipperiness

Figure: Slipperiness.

Figure: Glatteisgefahr.

Table: specifications of "slipperiness".

Description:	The warning appears if ice danger exists.
Condition to switch on:	Warning_Ice (see section Outside Temperature).
Condition to switch off:	condition to switch on is not fulfilled
Coding:	yes
Analysis interval:	100ms
Priority:	3
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	no
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S02
text line 1	Slipperiness!
text line 2	
- German	
symbol name	S02
text line 1	Glatteisgefahr!
text line 2	

4.5.11.4 Remove Key

Figure: Remove key.

Figure: Schlüssel abziehen.

Table: specifications of "remove key".

Description:	The warning appears if the key is not removed.
Condition to switch on:	Ig_LockC = 1 and Ig_LockR = 0 and Status_Door_dd = 1 and Ig_Lock = 0
Condition to switch off:	condition to switch on is not fulfilled
Coding:	yes
Analysis interval:	150ms
Priority:	2
Automatic confirmation:	yes
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	yes (previous message is of priority 3),no (previous message is of priority 1)
Comment:	especially for the USA
Acoustics:	yes
- type of the audio warning:	interval tone
Language:	
- English	
symbol name	S03
text line 1	Remove key!
text line 2	
- German	
symbol name	S03
text line 1	Schlüssel abziehen!

Description:	The warning appears if the key is not removed.
text line 2	

4.5.11.5 Engine Overheated

Figure: Engine overheated.Visit workshop.

Figure: Motor überhitzt. Werkstatt aufsuchen.

Table: specifications of "engine overheated".

Description:	The warning appears if the engine is overheated.
Condition to switch on:	Eng_Overheated = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	100ms
Priority:	1
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	yes
Comment:	-
Acoustics:	yes
- type of the audio warning:	continuing tone
Language:	
- English	
symbol name	S01
text line 1	Engine overheated
text line 2	Visit workshop!
- German	
symbol name	S01

Description:	The warning appears if the engine is over-heated.
text line 1	Motor überhitzt
text line 2	Werkstatt aufsuchen!

4.5.11.6 Display Defective

Figure: Display defective. Visit workshop.

Figure: Anzeige defekt. Werkstatt aufsuchen.

Table: specifications of "display defective".

Description:	The warning appears if at least two ECU do not provide significant information or at least two speed sensors fail (see section Speed-ometer).
Condition to switch on:	timeout of at least two ECU(electronic control unit) or Error condition is described in section Speed-ometer.
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	100ms
Priority:	2
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this mes-sage:	yes (previous message is of priority 3),no (previous message is of priority 1)
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	

Description:	The warning appears if at least two ECU do not provide significant information or at least two speed sensors fail (see section Speed-ometer).
symbol name	S04
text line 1	Display defective
text line 2	Visit workshop!
- German	
symbol name	S04
text line 1	Anzeige defekt
text line 2	Werkstatt aufsuchen!

4.5.11.7 Release Hand Brake

Figure: Release hand brake.

Figure: Feststellbremse lösen.

Table: specifications of "release hand brake".

Description:	This warning is transmitted (active/inactive) in case of driving with locked hand brake
Condition to switch on:	Warning_SM (see section Speedometer)
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	100ms
Priority:	2
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this mes-sage:	yes (previous message is of priority 3),no (previous message is of priority 1)
Comment:	-
Acoustics:	yes

Description:	This warning is transmitted (active/inactive) in case of driving with locked hand brake
- type of the audio warning:	interval tone
Language:	
- English	
symbol name	S05
text line 1	Release
text line 2	hand brake!
- German	
symbol name	S05
text line 1	Feststellbremse
text line 2	Werkstatt aufsuchen!

4.5.11.8 Turn Signal Front Left Defective

Figure: Turn signal front left defective.

Figure: Blinker vorne links defekt.

Table: specifications of "turn signal front left defective".

Description:	The warning appears if the turn signal front left is defective.
Condition to switch on:	TS_FL_DEF = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	200ms
Priority:	3
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	no
Comment:	-

Description:	The warning appears if the turn signal front left is defective.
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S06
text line 1	Turn signal front left
text line 2	defective!
- German	
symbol name	S06
text line 1	Blinker vorne links
text line 2	defekt!

4.5.11.9 Turn Signal Front Right Defective

Figure: Turn signal front right defective.

Figure: Blinker vorne rechts defekt.

Table: specifications of "turn signal front right defective".

Description:	The warning appears if the turn signal front right is defective.
Condition to switch on:	TS_FR_DEF = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	200ms
Priority:	3
Automatic confirmation:	no
Manual confirmation:	yes

Description:	The warning appears if the turn signal front right is defective.
Interruption of the previous message occurrence this message:	no
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S06
text line 1	Turn signal front right
text line 2	defective!
- German	
symbol name	S06
text line 1	Blinker vorne rechts
text line 2	defekt!

4.5.11.10 Turn Signal Rear Left Defective

Figure: Turn signal rear left defective.

Figure: Blinker hinten links defekt.

Table: specifications of "turn signal rear left defective".

Description:	The warning appears if the turn signal rear left is defective.
Condition to switch on:	TS_RL_DEF = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	200ms
Priority:	3

Description:	The warning appears if the turn signal rear left is defective.
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	no
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S06
text line 1	Turn signal rear left
text line 2	defective!
- German	
symbol name	S06
text line 1	Blinker hinten links
text line 2	defekt!

4.5.11.11 Turn Signal Rear Right Defective

Figure: Turn signal rear right defective.

Figure: Blinker hinten rechts defekt.

Table: specifications of "turn signal rear right defective".

Description:	The warning appears if the turn signal rear right is defective.
Condition to switch on:	TS_RR_DEF = 1
Condition to switch off:	condition to switch on is not fulfilled
Coding:	no
Analysis interval:	200ms

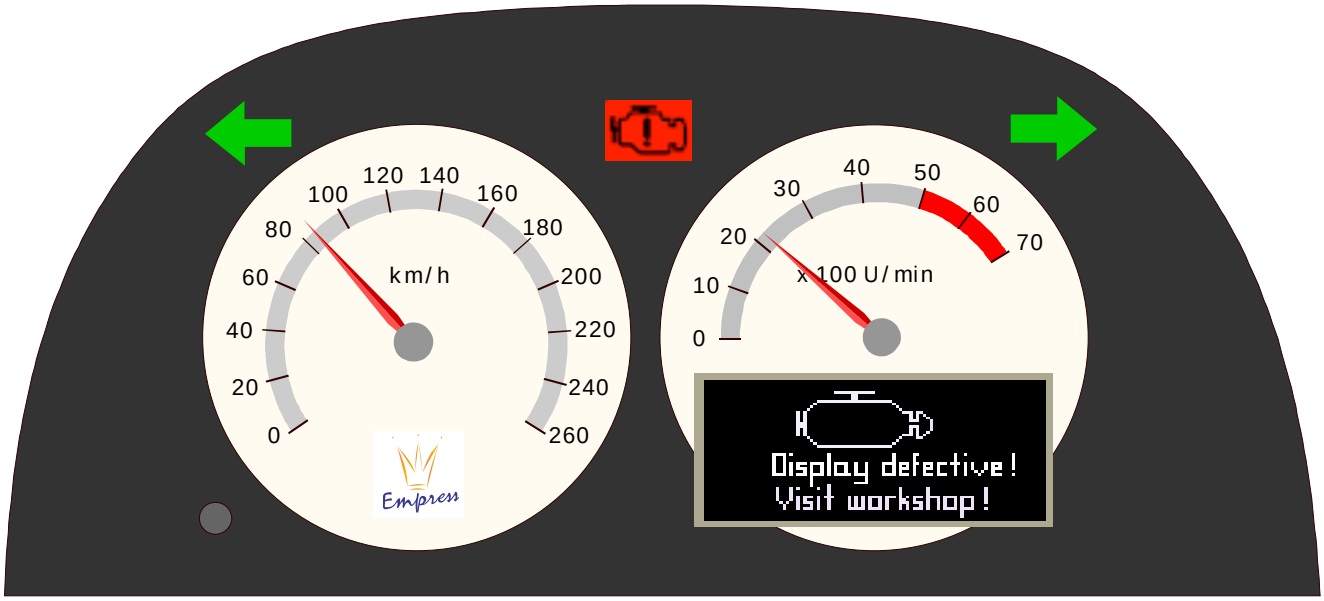
Description:	The warning appears if the turn signal rear right is defective.
Priority:	3
Automatic confirmation:	no
Manual confirmation:	yes
Interruption of the previous message occurrence this message:	no
Comment:	-
Acoustics:	none
- type of the audio warning:	-
Language:	
- English	
symbol name	S06
text line 1	Turn signal rear right
text line 2	defective!
- German	
symbol name	S06
text line 1	Blinker hinten rechts
text line 2	defekt!

5 Hardware

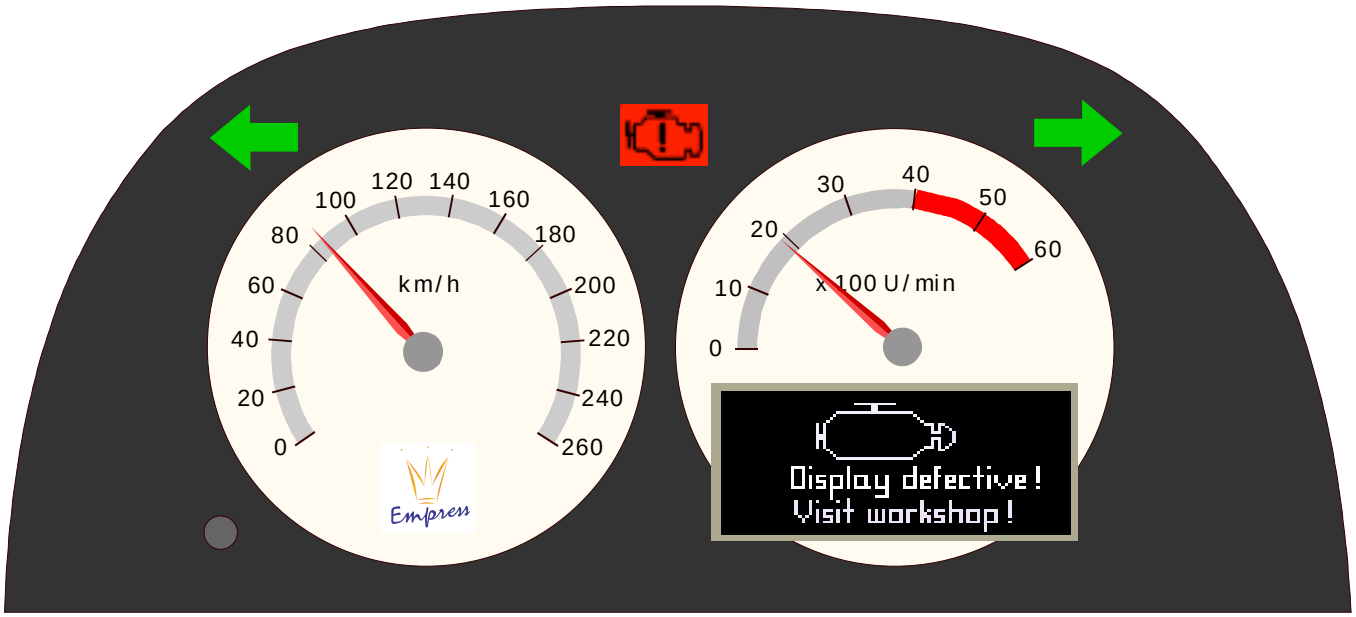
5.1 Optical Design

The following drawings specify the optical design of the instrument cluster in the various variants (see also section General Remarks)

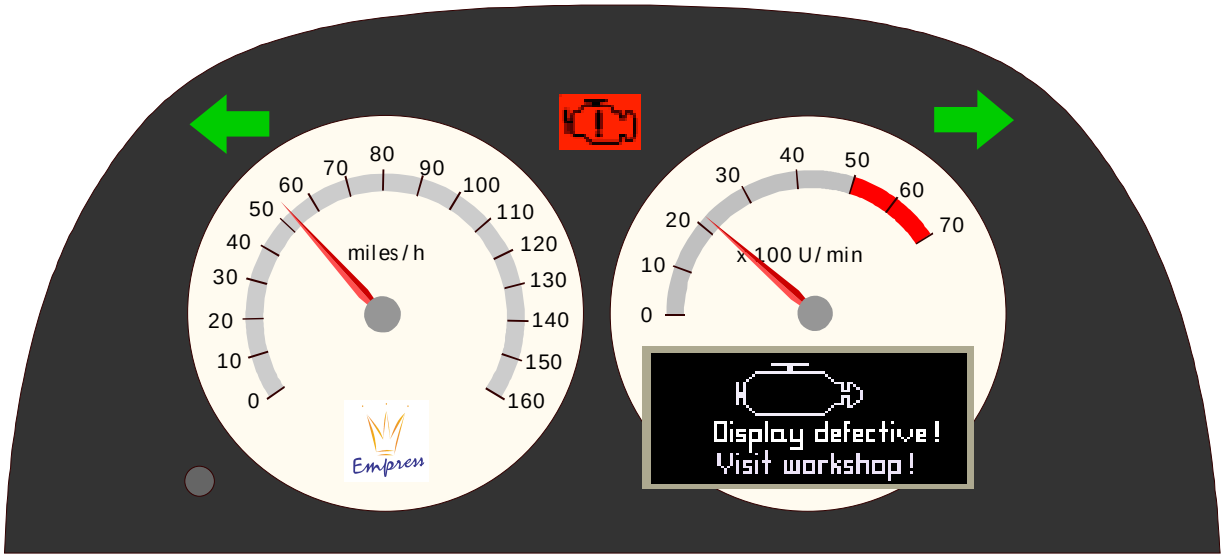
IC EMP01 1221



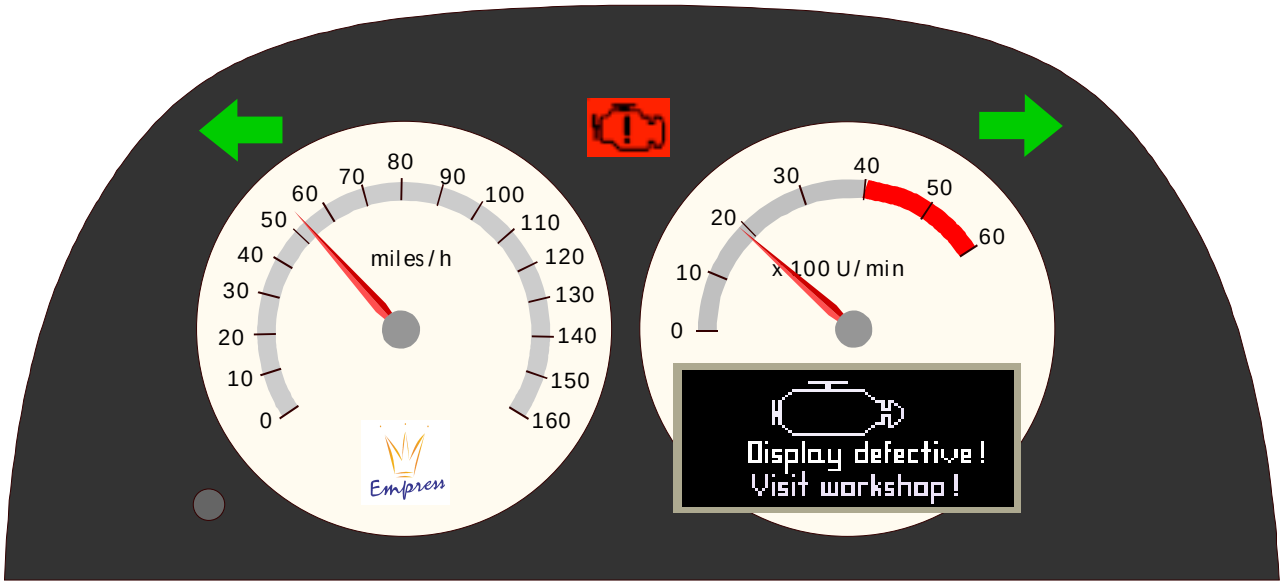
IC EMP01 1222



IC EMP01 1223



IC EMP01 1224



6 References

[1] Empress, Evolution Management and Process for Real-Time Embedded Software Systems, *Framework for Requirements*, Deliverable 3.1.1, Edited by Thomas Zink, December 2002.

[2] D. J. Hatley and I. A. Pirbhai. *Strategies for Real-time System Specification*. Dorset House Publishing, 1987.