Carling Technologies®

CM-Series

Interface Specification

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1. Overview

The scope of this document is to describe the CM-Series functional specification.
Acronyms: LIN = Local Interconnect Network, CAN = Control Area Network, NM = Network Management

2. Introduction

CM-Series is a Controller/Node system over CAN and LIN network. Figure 1 describes the block diagram of CM-Series system. Controller module consists of CAN and LIN module.

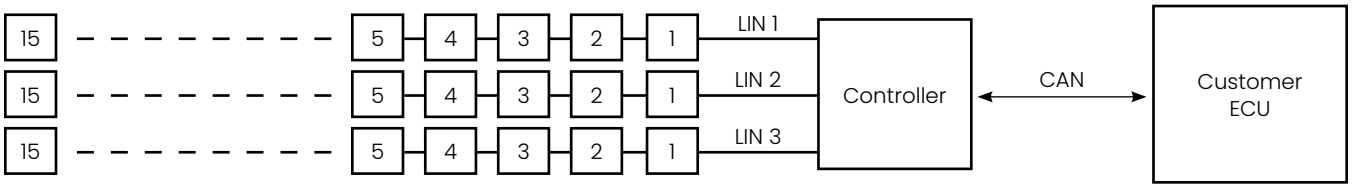

Figure 1 - CM-Series Block Diagram

Three LIN buses (LIN 1, LIN 2 and LIN3) are connected to the Controller. Each LIN bus will have a maximum of 15 switches. The maximum number of switches supported by the CM Series system is 45. Nodes/switches communicate with the Controller over LIN bus with their switch status. Controller will acknowledge this information over LIN bus and communicate to Customer ECU over CAN bus. Customer ECU will send Functional LED status to the Controller via CAN which is relayed to the switches via the LIN bus.

CM-Series Controller Module

There are two subsystems in the CM Series Controller module: CAN Controller module and LIN Controller module. The CAN Controller module consists of the CAN driver and Network Management (NM) State Machine. The LIN Controller consists of the LIN driver, wakeup – shutdown functionality and schedule tables.

2.1 CAN Controller Module

CAN Controller module network management strategy is given below:

2.1.1 Wake-up

CAN Controller wakes up when it receives a Network_Man_Wakeup message from Customer ECU. CAN Controller can also be woken up by LIN when there is a state change (OFF-ON) on any of the wake-up switches. On receiving wake up, CM Series will initiate the wake-up process. On successful wake up, CM Series Controller module will start sending Network_Man_Wakeup message on the network. Details of the Network Management message are given in Figure 2.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
			Active Bit			Reserved	Repeat Message Bit

Figure 2 - Control Bit Vector Format

NetworkMan_Wakeup message is a 1-byte message, where the message structure is as described in Control Bit Vector Format (Figure 2). Upon a state change into Network mode (from Bus Sleep or Prepare Bus Sleep), i.e. due to an active wakeup, the Active Wakeup Bit is set. Upon leaving Network mode this bit is cleared.
Network_Man_Wakeup message will be sent every 100ms. Bit 0 and 4 in the message will be set as defined below:
Bit 0: Repeat Message Request
0: Repeat Message State not requested
1: Repeat Message State requested
Bit 4 Active Wakeup Bit
0: Node has not woken up the network (passive wakeup)
1: Node has woken up the network (active Wakeup

The active wake up bit in CM_NM message will be set to zero when CSM is leaving Network Mode. CSM as receiver of CM_NM messages shall ignore the value of the active wake up bit.

2.1.2 Repeat Message State

When the Network Mode is entered from Prepare Bus-Sleep and Bus-Sleep mode, by default, CAN NM will enter the Repeat Message State. The Repeat Message State ensures that any transition from Bus-Sleep or Prepare Bus-Sleep to the Network Mode becomes visible to the other nodes on the network. Additionally, it ensures that any node stays active for a minimum amount of time. It can be used for detection of present nodes. The NM state machine shall stay in the Repeat Message State for an amount of time determined by the Repeat Message Timer; after that time CAN NM module shall leave the Repeat Message State.

At Repeat Message Request Bit indication from Customer ECU in the Normal Operation State and Ready sleep state, the CAN NM module shall enter the Repeat Message State. When the Repeat Message State is entered from Bus-Sleep Mode, Prepare-Bus-Sleep Mode, Normal Operation State or Ready Sleep State, the CAN NM module shall start transmission of Network Management PDUs. Once CAN NM leaves Repeat Message state, the Repat message bit will be cleared.

Bit 0 (Figure 3) in the Control Bit vector is set when NM Can enter Repeat Message State. Repeat Message State is entered during the following conditions:
1. Communication with other ECU's is required
2. Communication required or NM Frame required
3. Synchronization of the entire bus system

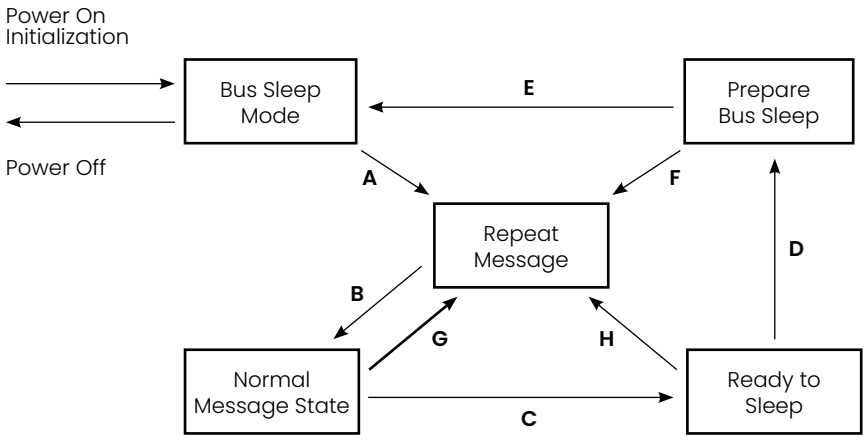

Figure 3 - Network Management State Machine

Transitions in and out of Repeat Message State are given below:
A, H, F – Repeat Message State can be entered from Bus Sleep State, Ready to Sleep State and Prepare Bus Sleep State.
B – Normal Message State will be entered once Repeat Message state timer expires.
G – Upon receiving a request from Customer ECU, CAN NM will enter Repeat Message State.

2.1.3 Normal Operation State

When the Normal Operation State is entered from Repeat message state, CAN NM state machine will start transmitting Switch Status messages. In this state there is periodic transmission of switch status messages.

Switch status message and Functional LED status message have the same identical message structure as given in Figure 5. Every Switch Status consists of switch status for 3 switches. In total for a maximum of 45 switches, 15 switch status messages will be sent to the Customer ECU. Switch status update will be 1, 2, 3...4, 5, 6...7, 8, 9.....43, 44, 45 where 1...45 are switch1, switch2 .... switch45. But when there is a switch event change on any of the switches, this periodic pattern is interrupted. For e.g., if there is a switch event change on 32 then the pattern would be 7,8,32. Function LED Status message will be received by CM Series CAN Controller every 100ms. The NM state machine shall stay in the Normal Message State for an amount of time determined by the Normal Message State Timer; after that time CAN NM module shall leave the Repeat Message State. Transition B, G and C from figure below describe the conditions for entry and exit for Bus Sleep.

Byte	1	2	3	4	5	6	7	8
Description	Switch 1 Data Byte 1	Switch 1 Data Byte 2	Switch 2 Data Byte 1	Switch 2 Data Byte 2	Switch 3 Data Byte 1	Switch 3 Data Byte 2	Reserved	Checksum and Rolling Counter

Figure 4 - Switch Status and Functional LED status message structure

2.1.4 Ready Sleep State

The purpose of the Bus-Sleep Mode is to reduce power consumption in the node when no messages are to be exchanged. When the communication controller is switched into the sleep mode, respective wakeup mechanisms are activated and finally power consumption is reduced to the adequate level in the Bus-Sleep Mode. CM Series Controller module will remain active as long as the CAN message communication is going on the bus. If there is no further communication on the bus, CM Series will enter Bus-sleep mode state and will enter low power mode. CAN bus should not be kept active, if not needed anymore from a functional point of view. Active CAN communication when not required can lead to unnecessary current consumption and battery drainage.

If CM Series Controller module detects that no CAN communication is needed anymore, it will enter the Ready Sleep state. The Ready Sleep State ensures that any node in the network management cluster waits with transition to the Prepare Bus-Sleep Mode as long as any other node keeps the network management cluster awake.

In this state the Network_Man_Wakeup message will not be sent anymore. If CM Series Controller module detects that there are no Network_Man_Wakeup messages anymore it will prepare for shut down and will enter into the Prepare Bus-Sleep state. When the Ready Sleep State is entered from Repeat Message State or Normal Operation State, CM Series Controller module will stop transmission of Network_Man_Wakeup messages. When the timer expires in the Ready Sleep State, CM Series Controller module shall enter the Prepare Bus-Sleep Mode. CM Series Controller module will stay in the Prepare Bus-Sleep Mode for an amount of time by ready sleep timer. Transition D, H and C from Figure 4 describe the conditions for entry and exit for Ready Bus Sleep.

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2.1.5 Prepare Bus sleep

The purpose of the Prepare Bus-Sleep Mode is to ensure that all nodes have time to stop their network activity before the Bus-Sleep Mode is entered. In Prepare Bus-Sleep Mode the bus activity is calmed down (i.e. queued messages are transmitted in order to make all Tx-buffers empty) and finally there is no activity on the bus in the Prepare Bus-Sleep Mode. CM Series Controller module will stay in the Prepare Bus-Sleep Mode for an amount of time defined by Prepare Bus Sleep Timer. Transition E,F and D from Figure 4 describe the conditions for entry and exit for Prepare Bus Sleep state.

2.1.6 Bus Sleep

CM Series Controller module will monitor the network communication for a certain pre-defined period and if there is no message on network then it will go into the bus-sleep mode state. If there are no messages frames received during the pre-defined time, CM Series Controller module will enter into the prepare bus sleep state. CM Series Controller module shall enter into the Bus-sleep state if it does not have any internal activity, valid wake up input and no communication on the CAN bus for Bus Sleep Timer. After the time out, Bus-Sleep Mode shall be entered. Transition E and A from Figure 4 describe the conditions for entry and exit for Bus Sleep.

As long as a wake-up switch is actuated to ON position, network communication shall be set to true. Controller has to initiate and maintain communication regarding wake-up switch information. During the period between wake-up and the reception of Ignition status, the Controller shall send active wake-up switch(es) only. Transmission rate shall be 20 msec. Only on reception of any NM_CM message the Controller shall enter CAN Repeat Message State. During the period between wake-up and the reception of Ignition Status the CSM shall send the active wake-up switch(es) only. Transmission rate shall be 20 msec. At reception of first Ignition status message the status of wake-up switche(s) shall be sent once at the beginning, followed by all learned switches, on a repetition rate dependant of the received Contact Lock KL15 signal value in Ignition status message.

CM_Sw_Stat_Msg message will be sent, with a transmission rate of 20 msec, if no Ignition status message is received OR if Ignition status is received with signal KL15 being OFF. If Ignition status is received with value ON for signal KL15 then the CM_Sw_Stat_Msg shall be sent with the transmission rate of 100 msec. If Ignition status is received with value ON for signal KL15 THEN the CM_Sw_Stat_Msg shall be sent (if there is a switch status change) on this change but not faster than 20 msec after the last CM_Sw_Stat_Msg message.

2.2 Application Fault Handling

Function LED Status Message Checksum fault and Function LED Status Message Counter fault will be detected by the state machine. When the calculated checksum for the Function LED Status Message does not match the checksum in the Function LED Status Message, CM Series Controller module will send out a DTC for Function LED Status Message Checksum error. When there is a Function LED status message counter sequence error, CM Series Controller module will send out a DTC for Function LED Status Message counter error. Switch status messages will be sent out when Function LED Status Message checksum and Functional LED Status Message counter faults are detected.

When the Controller is in prepare bus sleep and bus sleep mode CM_Sw_Stat_Msg and DM1 will not be sent on CAN bus. CAN network communication will be stopped if no wake-up switch is pressed anymore. When CSM is in prepare bus sleep state or ready sleep state then functional LED's will be switched OFF. Ignition status will not be processed during prepare bus sleep and bus sleep mode.

For message CM_FLED_Stat_Msg a rolling counter error will be validated if at 5 [NRollingCounterRetry] consecutive times a CM_FLED_Stat_Msg messages is received containing an equal rolling counter value. When on the CM_FLED_Stat_Msg message a rolling counter error is validated the Controller shall switch OFF all feedback illumination. When in the CM_FLED_Stat_Msg message a checksum error is detected the CSM will ignore the content of this CM_FLED_Stat_Msg message. When CM_FLED_Stat_Msg message is received for 5 consecutive times a checksum error is detected the Controller shall switch OFF all functional LED. If the time-out for CM_FLED_Stat_Msg messages becomes TRUE, then all feedback LED's shall be switched OFF. When for CM_FLED_Stat_Msg a different value for the rolling counter as well as a correct checksum is received then the feedback illumination shall be according to the new received CM_FLED_Stat_Msg message.

If no switches are present (on any LIN bus) then CM_Sw_Stat_Msg message shall contain Not Available (FF) values. If switch status is unknown for CSM then the value in CM_FLED_Stat_Msg shall be Not Available (F). During prepare bus sleep mode or sleep mode, if a non-wake up maintain switch changes position Controller shall be able to discover this change at the next moment the CSM becomes awake. The time out value for message Ignition status message shall be 5 times the repetition rate. In case value Not Available ($FFFF) is received in CM_FLED_Stat_Msg message no action shall be taken.

3. Nodes/Switches

This section of the document describes CM Series Node/Switch functionality.

3.1 Simple Switches

Simple switches may have a maximum of one Function LED and a maximum of two Backlight LED's. The switches operate a visual feedback latch, when the switch changes state (OFF to ON or ON to OFF) the state of the Function LED will change accordingly. It will remain in this state for at least 2 seconds, after which it shall take the state transmitted as received by the Function LED Status message (CM_Sw_Stat_Msg). Wakeup switches will behave as described under all conditions.

Non-Wakeup switches will only illuminate the Function LED when the KL15 signal is ON. If the KL15 signal is OFF the Function LED shall be OFF. Therefore, if the switch is operated when KL15 is OFF the Function LED will not illuminate. Similarly, if the Switch receives a Function LED ON signal when KL15 is OFF it will not illuminate the Function LED. If KL15 is ON it shall behave as described above. The state of the switch (for wakeup and non-wakeup switches) is not affected by the state of the KL15 signal. Function LED status represents the status of the function in the truck. As non-wake up switches cannot wake up the Controller, function LED is kept off when KL-15 is OFF. See Appendix for detailed state machine flow chart.

Backlight LED brightness is controlled by Customer ECU using the CL message. The CSM shall only act on CL messages containing the CSM destination address. The CSM shall take the two channels (entry = SPN 5532 and drive = SPN 1487) in the CL_CSM message into account. Time out for CL_CSM message will be at 25s after the last received CL_CSM message. During a time out backlights for entry as well as drive will be turned off. When error is received on CL_CSM message, the CSM shall keep the last valid value. When CSM is in prepare bus sleep state or ready sleep state, backlights will be turned off.

0 – OFF
1 – ON
2...13 – Reserved
14 – Error
15 – Not Available

Figure 5 - Switch with back light and no functional LED

0 – OFF
1 – ON 1
2 – ON 2
2...13 – Reserved
14 – Error
15 – Not Available

Figure 6 - Switch with 2 back lights

0 – OFF
1 – ON
2...13 – Reserved
14 – Error
15 – Not Available

Figure 7 - Switch with 1 back light and 1 functional LED

3.2 Switch Detection and Switch Relocation

When KL30 is enabled, CM Series switch shall automatically scan for new switches. CM Series switch shall check if all known switches are still present and automatic detection of any relocated switch shall be possible. After checking all switches, the CM Series switch shall transmit the status of all switches to the Customer ECU.

When a known switch is faulty or not present anymore it shall be set to the “Not Available” state since the data is not received and there is a LIN data time out. Switches can be relocated to other LIN buses and will be detected when a switch scan is performed. The new switch will be located when KL-30 is enabled or using the ECU Reset diagnostic service routine. Switches can also be relocated on the same LIN bus and there will be no conflict with other switches already present on the LIN bus.

3.3 Node/Switch Response

Controller LIN module sends out frames and Nodes/Switches respond to the header depending on their switch state. The time taken for a Node/Switch to respond on LIN bus and when it is available on the CAN is considered to be the Node response time. Event triggered frames will be used to scan the switches to detect switch transition. Only those switch nodes shall respond which will detect event change. In case of detection of multiple nodes of state change, controller will switch from normal scheduling to collision prevention schedule and unconditional frames.

4. Interface

Interface between CM Series and Customer ECU is defined in Table 1.

Message	Type	Timing	System Interaction	
CAN	Network Management Message	100ms or instantly on state change	CM -> Customer ECU or Customer ECU-> CM	CM_NM
	Switch Status Message	100ms or instantly on state change	CM -> Customer ECU	CM_SW_STAT_MSG
	DM1	1000ms	CM -> Customer ECU	
	Function LED Status Message	100ms	Customer ECU-> CM	CM_FLED_STAT_MSG
	CL Message	500ms	Customer ECU-> CM	

Table 1 - Network Interface

4.1 Diagnostic Trouble Code (DTC)

DTC’s are implemented according to the SAE J1939 standard. When a fault is detected, a DTC is sent out on the CAN bus. UDS standard and J1939 are used to implement the Fault Handling Software.

Individual DTC’s are defined below:

- CAN Bus - If the calculated message checksum does not match the checksum the switch status message, check sum DTC is sent out on the CAN bus.
- CAN Bus - If there is a message counter sequence error for the switch status message, a message counter sequence error DTC is sent out on the CAN bus.
- LIN Bus 12 V supply – When the LIN Bus 12 V supply is less than 10V, then the corresponding DTC is sent out on the CAN bus.
- LIN Bus 12 V supply – When the LIN Bus 12 V supply is greater than 14V, then the corresponding DTC is sent out on the CAN bus.
- LIN 1, LIN2 and LIN 3 Communication Failure – When there is an internal LIN hardware failure on LIN 1, LIN 2 and LIN 3 a corresponding DTC will be sent out on the LIN bus.
- ID Multiple Appearance - When there are two switches of the same element ID on different LIN busses, then a DTC is sent out on CAN.

4.2 DM13

DM13 was implemented according to the J1939 specification.

4.3 Diagnostic Service Routines

Diagnostic Services for Programming, Read Data by ID, Write Data by ID, ECU Reset and Tester Present was implemented according to UDS protocol. Customer part number, Supplier hardware number and Supplier software version number can be read out using the data read by identifier. Diagnostic service routine can also be used to read switches individually. Vector CDD file has the detailed list of diagnostic identifiers and their functions.

4.4 Freeze Frame

ISO 14229 snapshots capture a set of measurements at the time an event occurs, and only that data is reported in the request. In ISO 14229 occurrence counters are handled using DTC Extended Data.

5. Use Cases

5.1 Switch Actuation

LIN bus has 15 switches – SW1, SW2, SW3.....SW15.

When no switch is actuated, the cyclic switch pattern on CM_Sw_Stat_Msg would be according to figure 8 (Red Font).

HMI Element 1	HMI Element 2	HMI Element 3	
SW1	SW2	SW3	→ 100ms
SW4	SW5	SW6	→ 100ms
SW7	SW8	SW9	→ 100ms
SW10	SW11	SW12	→ 100ms
SW13	SW14	SW15	→ 100ms

Figure 8 - Switch pattern when no switch is actuated

When SW2 is actuated, cyclic switch pattern on CM_Sw_Stat_Msg switch pattern for the priority schedule is given in Figure 9 (Black Font).

HMI Element 1	HMI Element 2	HMI Element 3	
SW1 SW2	SW2 SW1	SW3 SW2	→ Instant
SW4 SW3	SW5 SW4	SW6 SW5	→ 100ms
SW7 SW6	SW8 SW7	SW9 SW8	→ 100ms
SW10 SW9	SW11 SW10	SW12 SW11	→ 100ms
SW13 SW12	SW14 SW13	SW15 SW14	→ 100ms

Figure 9 - Switch pattern when SW2 is actuated

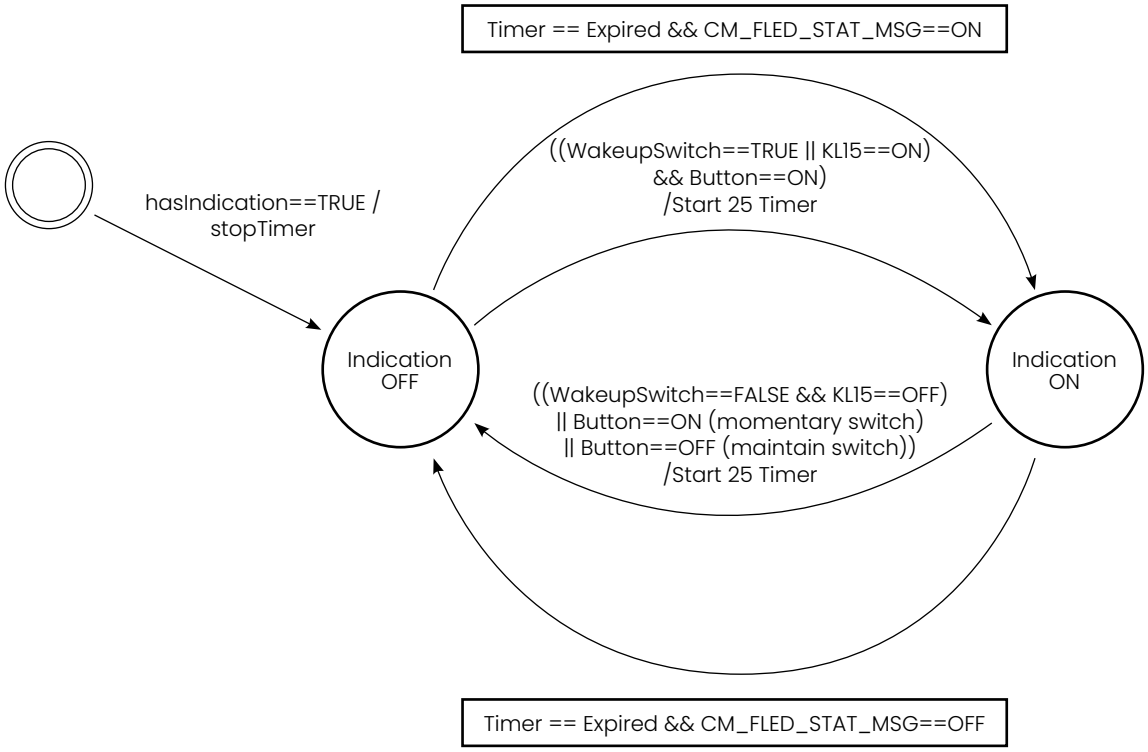
When SW11 is actuated, switch pattern for the priority schedule is given in Figure 10(Black Font).

HMI Element 1	HMI Element 2	HMI Element 3	
SW1 SW11	SW2 SW1	SW3 SW2	Instant
SW4 SW3	SW5 SW4	SW6 SW5	100ms
SW7 SW6	SW8 SW7	SW9 SW8	100ms
SW10 SW9	SW11 SW10	SW12 SW11	100ms
SW13 SW12	SW14 SW13	SW15 SW14	100ms

Figure 10 - Switch pattern when SW11 is actuated

6. Appendix

6.1 Function LED Flow chart



Switch Type:
Momentary Switch, Button == ON means rising edge
Maintain Switch, Button == ON/OFF represents the actual position of the switch