Layer Setting Services and Protocol
(LSS)

CiA Draft Standard Proposal 305

Version 1.1.1

Date: 5. November 2002

History

Date	Changes
Feb 2002	• Switch from LSS ‘Operation Mode’ to LSS ‘Configuration’ mode independent of NMT state. • Definition of invalid Node-ID. • Introduction of state ‘LSS Init’. • New service ‘Inquire Node-ID’. • New service ‘Identify Non-Configured Remote Slaves’. • Removed redundant parameter mode in service ‘Switch Mode Selective’. • Corrected error in table of service ‘Inquire LSS address’.
Sep 2002	• Reference to DS-205-x added. • Figure 1 extended. • Clarification of how many LSS Slaves may be in configuration mode for the different LSS services. • Clarification that LSS slaves respond to identification services in configuration and operation mode • LSB and MSB of multibyte values indicated in all protocol related figures. • Correction of typing errors.
Nov. 2002	• changed entry 100kBit to reserved in baudrate table

CONTENTS

1 Scope

This document contains the protocol specification of the Layer Setting Services (LSS) for CANopen.

2 Normative references

/1/ ISO 11898: Road vehicles - Interchange of digital information – Controller area network (CAN) for high-speed communication, 1993-11-15

/2/ CiA DS 301: CANopen - Application Layer and Communication Profile, Version 4.0, 1999-06-16

/3/ CiA DS 205-1: CAN Application Layer for Industrial Applications, LMT Service Specification, February 1996

/4/ CiA DS 205-2: CAN Application Layer for Industrial Applications, LMT Protocol Specification, February 1996

3 Abbreviations and definitions

3.1 Abbreviations

COB Communication Object. A unit of transportation in an CAN network. Data must be send across a CAN network inside a COB. A COB can contain at most 8 bytes of data.

COB-ID Each COB is uniquely indentified in a CAN network by a number called the COB Identifier (COB-ID). The COB-ID determines the priority of the COB for the MAX sub-layer.

LMT Layer Management. Functions to inquire and change the settings of certain parameters of the local layers on a CAL module (see /3/, /4/).

LSS Layer Setting Services. Functions to inquire and change the settings of certain parameters of the local layers on a CANopen module.

MAC Medium Access Control. One of the sub-layers of the Data Link Layer in the CAN Reference Model that controls who gets access to the medium to send a message.

NMT Network Management. One of the service elements of the application layer in the CAN Reference Model. The NMT serves to configure, initialize, and handle errors in a CAN network.

3.2 Definition

LSS offers the possibility to inquire and change the settings of certain parameters of the local layers on a CANopen module with LSS Slave capabilities by a CANopen module with LSS Master capabilities via the CAN Network.

The following parameters can be inquired and/or changed by the use of LSS:

- Node-ID of the CANopen Slave
- Bit timing parameters of the physical layer (baud rate)
- LSS address (/2/ Identity Object, Index 1018H)

By using LSS a LSS Slave can be configured for a CANopen network without using any hardware devices like DIP-switches for setting the parameters. There are several solutions available for LSS Slaves with and without a unique LSS-address or non-volatile storage.

3.2.1 LSS Objects and Attributes

LSS functionality is modeled using two objects. The LSS Master object exists exactly once in a CANopen network supporting LSS. The LSS Master configures layer parameters of connected CAN modules by the use of LSS Slave objects residing on the individual modules.
Communication between LSS Master and LSS Slaves is accomplished by the LSS protocol.

3.2.2 LSS Master Object

The module that configures other modules via a CANopen network is called the LSS Master. There may be only one LSS Master in a network. The LSS Master has no attributes.

3.2.3 LSS Slave Object

The module that is configured by the LSS Master via a CANopen network is called the LSS Slave. The number of LSS Slaves in a network is not limited. The LSS Slave has the following attributes:

- **LSS Address**
  An LSS Slave is identified by an LSS Address. An LSS Address consists of a vendor-id, a product-code, a revision-number and a serial-number. The vendor-id and product-code are numerical numbers. The revision-number contains the major an minor revision as numerical number. The serial-number is coded as a numerical number too. They adhere to the following syntax:

<LSS-ADDRESS>	::=	<vendor-id><product-code><revision-number><serial-number>
<vendor-id>	::=	'UNSIGNED32'
<product-code>	::=	'UNSIGNED32'
<revision-number>	::=	'UNSIGNED32'
<serial-number>	::=	'UNSIGNED32'

A <vendor-id> is assigned to module suppliers by CiA. A <product-code>, <revision-number> and a <serial-number> are assigned by the module supplier. For LSS-Addresses the following conditions must be met:

- The LSS address is identical to the CANopen identity object.
- The LSS address of a LSS Slave can be inquired.
- There exists no other LSS Slave in the world with the same <LSS-Address>

• **LSS Modes**

The LSS service distinguishes between the LSS configuration mode and the operation mode of the module. Any module that is not in 'Configuration Mode' is in 'Operation Mode'. In 'Configuration Mode' all LSS services, in 'Operation Mode' only the switch mode services are available.

A mode switch of a device to 'Configuration Mode' has to be initiated explicitly by the LSS-Master and is independent of the NMT state. With the exception of the LSS service 'Configure Node-ID' the NMT state of the device is not affected by LSS services. If the Node-ID of the LSS slave is changed with the LSS service 'Configure Node-ID' and the slave is switched back from 'Configuration Mode' to 'Operation Mode' a power on like reset has to be performed by the LSS slave which affects the NMT state. For this reason the LSS-Master has to reside on the same device which holds the NMT-Master.

3.3 LSS Init State

To provide the possibility to configure the Node-ID of a slave before the device enters the NMT 'Initialisation' state according to /2/ the LSS slave enters the 'LSS Init' state after power on or hardware reset. If the Node-ID is valid the slave continues to enter NMT 'Initialisation' state autonomously (see figure 1). If the Node-ID is invalid the slave remains in this 'LSS Init' state in LSS 'Operation Mode' where only service requests by a LSS master can be executed. In this case the only way to leave the 'LSS Init' state is to configure a valid Node-ID with the LSS 'Configure Node-ID' service which is followed by an implicit power on like reset on switch back to 'Operation Mode' as described above. By definition a device's node ID is invalid if it is set to FFh.

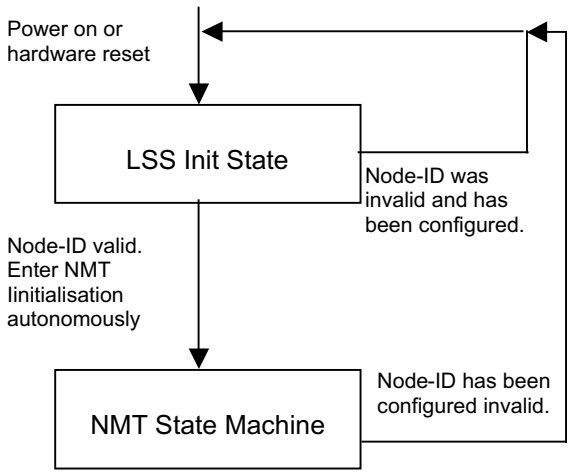


Fig. 1 : LSS Init State

4 LSS Modes and Services

LSS services can be functionally grouped in three areas:

- The switch mode services provide a way to logically connect the LSS Master and LSS Slave(s) for configuration purposes. They change the LSS mode attribute of the LSS Slave (see figure 2).
- The configuration services perform the actual task of configuring the layer parameters of a LSS Slave. The configuration services are only available in configuration mode.
- The inquiry services provide a way for the LSS Master to determine layer parameters. The inquiry services are available only in configuration mode.
- The identification services provide a way for the LSS Master to determine the presence of a device and to check for devices with invalid Node-ID. The identification services are available in configuration and operation mode.

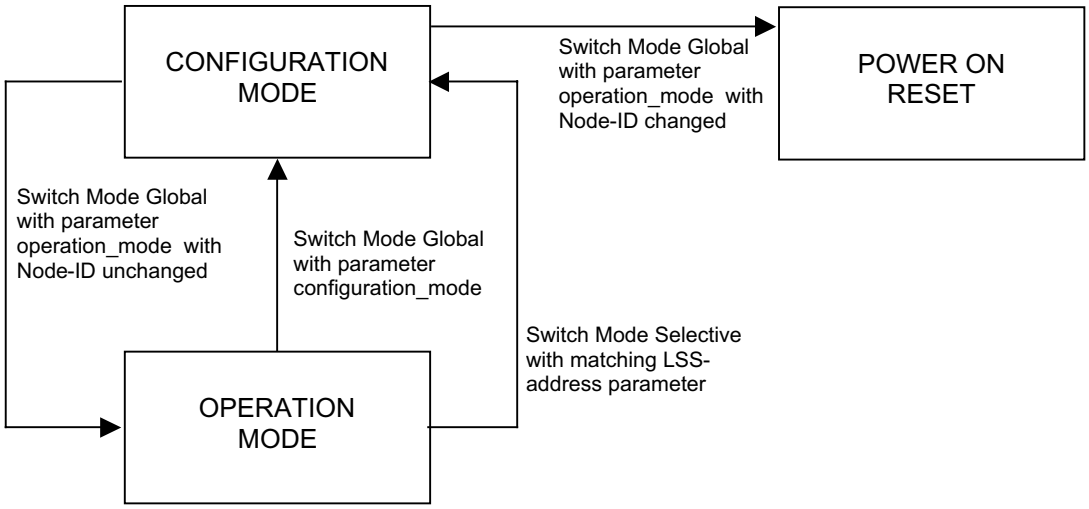


Fig. 2 : LSS slave modes and switching procedure

The LSS services are described in a tabular form that contains the parameters of each service primitive.

4.1 SWITCH MODE SERVICES

The Switch Mode Services control the mode attribute of a LSS Slave. LSS provides two ways to put a LSS Slave into configuration mode, Switch Mode Global and Switch Mode Selective. Switch Mode Selective switches exactly one LSS Slave between configuration and operation mode. Switch Mode Global switches all LSS Slaves between configuration and operation mode.

If the Node-ID of a slave is changed with the LSS ‘Configure Node-ID’ service a Switch Mode Global with parameter operation_mode results in a power on like reset of the LSS Slave to force a change in the Pre-Defined Connection Set defined in /2/.

Most LSS configuration and inquiry services require that only one LSS Slave is in configuration mode. Besides the LSS Switch Mode Services there may be other (local and module specific) means to change the mode of an LSS Slave, that are not within the scope of this document.

4.1.1 Switch Mode Global

This service is used to switch all LSS Slaves in the network between operation mode and configuration mode.

Parameter	*Request/Indication*
Argument mode configuration_mode operation_mode	**Mandatory** Mandatory Selection Selection

4.1.2 Switch Mode Selective

This service is used to switch the LSS Slave, whose LSS address attribute equals LSS_address, into configuration mode.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument LSS_address **Remote Result**	**Mandatory** Mandatory	 **Mandatory**

4.2 CONFIGURATION SERVICES

The configuration services are available only in configuration mode. Some of the services require that exactly one LSS Slave is in configuration mode.

4.2.1 Configure Node-ID

By means of this service the LSS Master configures the NMT-address parameter of a LSS Slave.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument Node-ID **Remote Result** success failure reason	**Mandatory** mandatory	 **Mandatory** selection selection optional

This service allows only one LSS Slave in configuration mode. The remote result parameter confirms the success or failure of the service. In case of a failure optionally the reason is confirmed.

4.2.2 Configure Bit Timing Parameters

By means of the Configure Bit Timing Parameters service the LSS Master sets the new bit timing on a LSS Slave.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument table_selector table_index Remote Result success failure reason	**Mandatory** mandatory mandatory	 **Mandatory** selection selection optional

By means of the table_selector the bit timing parameter table to be used is specified. In the bit timing parameter table the bit timing parameters for different baud rates are specified. With table_selector value ´0´ the standard CiA bit timing parameter table is referenced. The table_index selects the entry (baud rate) in the selected table (value '0' refers to the highest baud rate).

Standard CiA bit timing table according to /2/:

Baud Rate	*Tabel_Index*
1000 kBit	0
800 kBit	1
500 kBit	2
250 kBit	3
125 kBit	4
reserved	5
50 kBit	6
20 kBit	7
10 kBit	8

This service allows only one LSS Slave in configuration mode. The service has to be followed by an Activate Bit Timing Parameters service to activate the configured parameters. After execution of the Configure Bit Timing Parameters service the node may not execute any remote LSS services except the services Configure Bit Timing Parameters, Activate Bit Timing Parameters and Switch Mode.

The remote result parameter confirms the success or failure of the service. In case of a failure optionally the reason is confirmed.

4.2.3 Activate Bit Timing Parameters

By means of the Activate Bit Timing Parameters service the LSS Master activates the bit timing as defined by the Configure Bit Timing Parameters service.

Parameter	*Request/Indication*
Argument switch_delay	**Mandatory** mandatory

The switch_delay parameter specifies the length of two delay periods of equal length, which are necessary to avoid operating the bus with differing bit timing parameters. Each node performs the actual switch of the bit timing parameters ´switch_delay´ milliseconds after the reception of the command. After performing the switch, a node does not transmit any messages before the second time ´switch_delay´ has passed. This service allows all LSS Slaves in 'Configuration Mode'.

Note

Nodes may have different processing times for performing the Activate Bit Timing Parameters command and messages that are transmitted before this command may still be in the receive queue of a node. This means that a node may still transmit CAN messages with the old bit timing during the duration of the processing delay. Therefore switch_delay has to be longer than the longest processing time of any node in the network to avoid that a node already switches while another node still transmits using the old bit timing parameters. After the time specified by switch_delay has passed the first time, every node must perform the switch during the second duration of switch_delay. Therefore after switch_delay has passed the second time, all nodes are guaranteed to be listening with the new bit timing parameters. The diagram in figure 3 shows the location of the two switch_delay periods.

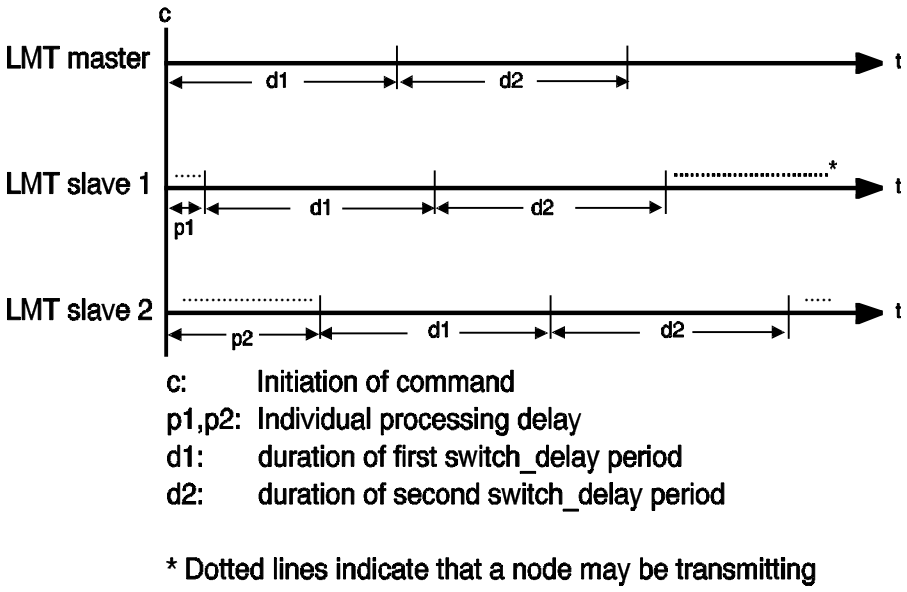


Fig. 3 : Definition of the two switch_delay periods

4.2.4 Store Configured Parameters

The Store Configured Parameters service is used to actuially store the configured parameters into non-volatile storage.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument	**Mandatory**	
Remote Result success failure reason		**Mandatory** selection selection optional

The remote result parameter confirms the success or failure of the service. In case of a failure optionally the reason is confirmed. This service allows only one LSS Slave in ‘Configuration Mode’.

4.3 INQUIRY SERVICES

The inquiry services are available only in configuration mode.

4.3.1 Inquire LSS Address

This service allows to determine the LSS-address parameters of a LSS Slave in configuration mode.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument	**Mandatory**	
Remote Result LSS_address vendor-id product-code revision-number serial-number		**Mandatory** selection mandatory mandatory mandatory mandatory

Exactly one LSS slave may be in configuration mode when this service is executed. The remote result parameter confirms the LSS address of the LSS Slave in configuration mode or the failure of the service.

4.3.2 Inquire Node-ID

This service allows to determine the Node-ID of a LSS Slave in configuration mode.

Parameter	*Request/Indication*	*Response/Confirmation*
Argument	**Mandatory**	
Remote Result Node-ID		**Mandatory** mandatory

Exactly one LSS slave may be in configuration mode when this service is executed. The remote result parameter is the Node-ID of the LSS Slave in configuration mode.

4.4 Identification Services

The identification services are available in configuration and operation mode.

4.4.1 LSS Identify Remote Slaves

By means of this service, the LSS Master requests all LSS slaves, whose LSS address meets the LSS_Address_sel to identify themselves by means of the 'LSS Identify Slave' service. LSS_Address_sel consists of a fixed vendor id and product code and a span of revision and serial numbers. This service is unconfirmed.

Parameter	*Request/Indication*
Argument LSS_Address_sel	Mandatory mandatory

4.4.2 LSS Identify Slave

By means of this service, an LSS Slave indicates, that it is a Slave with an LSS address within the LSS_Address_sel of a 'LSS Identify Remote Slave' service executed prior to this service. The service is unconfirmed.

Parameter	*Request/Indication*
Argument	**Mandatory**

4.4.3 LSS Identify Non-Configured Remote Slaves

By means of this service, the LSS Master requests all LSS slaves, whose Node-ID is not configured (FFh) to identify themselves by means of the 'LSS Identify Non-Configured Slave' service. This service is unconfirmed.

Parameter	*Request/Indication*
Argument	Mandatory

4.4.4 LSS Identify Non-Configured Slave

By means of this service, an LSS Slave indicates, that it is a Slave whose Node-ID is not configured (FFh) if a 'LSS Identify Non-Configured Remote Slave' service is executed by the LSS Master prior to this service. The service is unconfirmed.

Parameter	*Request/Indication*
Argument	**Mandatory**

5 LSS Protocol Perspective

The LSS Protocol is executed between the LSS Master and each of the LSS Slaves to implement these services.

5.1 LSS Slave Synchronisation

Since in the LSS Protocol all LSS Slaves use the same COB to send information to the LSS Master, there must be only one LSS Slave at a time that communicates with the LSS Master. For all protocols the LSS Master takes the initiative, a LSS Slave is only allowed to transmit within a confirmed service after it has been uniquely switched into configuration mode.

5.2 LSS Protocol Descriptions

A protocol description specifies the sequence of COB's and their format that are exchanged between the LSS Master and LSS Slave(s) for a particular LSS service.

Requesting Messages (from LSS Master) using COB-ID 2021. Response Messages (from LSS Slave) using COB-ID 2020.

LSS uses command specifiers to identify the commands. Command specifiers from 0 - 07fh are reserved for use by LMT (see /3/, /4/), respectively LSS. The range from 0 – 03fh are reserved for use by LMT services. The range from 040h – 07fh are reserved for use by standard LSS services. Command specifiers from 080h - 0ffh are free for application specific purposes and may only be used with at most one LSS Slave in configuration mode.

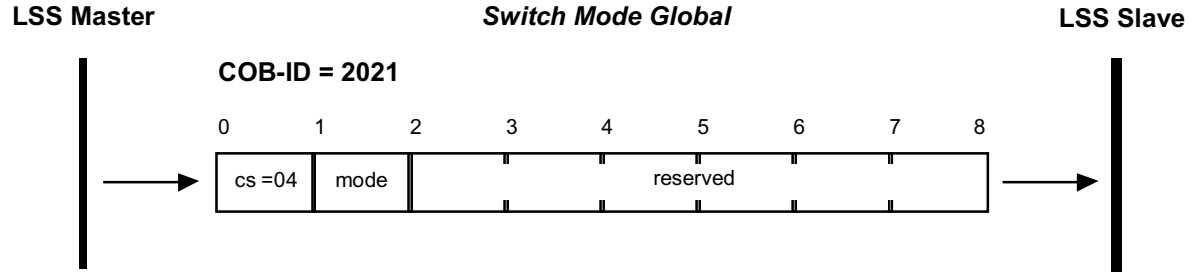
In the description of the COB data format, bytes are numbered from zero to and including seven. Bits within a byte are numbered from zero to and including seven. Byte zero is transmitted first, byte seven is transmitted last. Within a byte, bit zero is the least significant bit, bit seven is the most significant bit.

The terms 'lsb' and 'msb' stand for 'least significant byte' and 'most significant byte' respectively and are used to define how an integer number is represented in more than one byte for the LSS Protocol (see Encoding Rules defined in /2/).

5.3 SWITCH MODE PROTOCOLS

5.3.1 Switch Mode Global

This protocol is used to implement the 'Switch Mode Global' service.



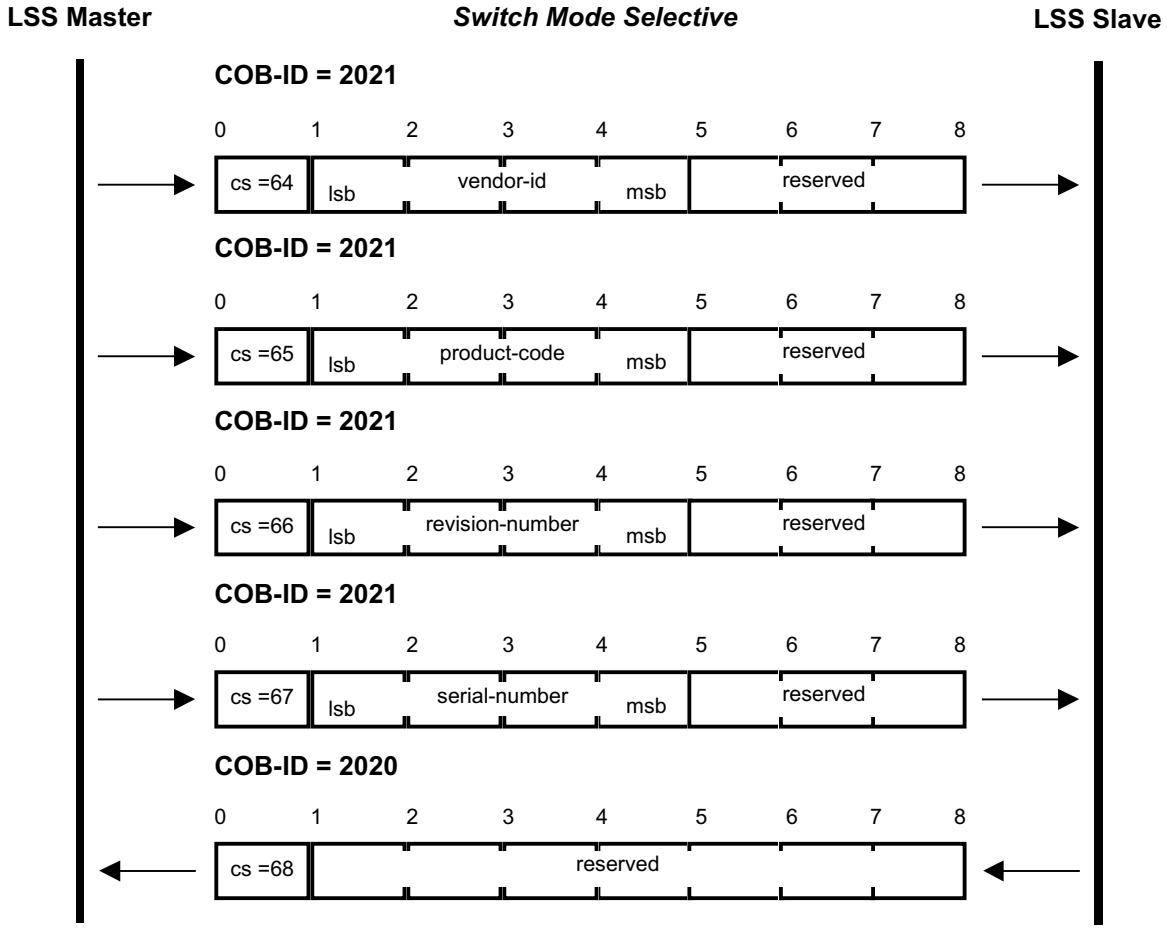
- **cs**:
  LSS command specifier
  04 for Switch Mode Global

- **mode**:
  The LSS mode to switch to:
  0: switches to operation mode
  1: switches to configuration mode

- **reserved**:
  reserved for further use by CiA.

5.3.2 Switch Mode Selective

This protocol is used to implement the 'Switch Mode Selective' service.



- **cs**:
  LSS command specifiers;
  64 to 68 for Switch Mode Selective

- **vendor-id**:
  Vendor name part of the LSS address, with respect to index 1018h, subindex 1

- **product-code**:
  Product name part of the LSS address, with respect to index 1018h, subindex 2

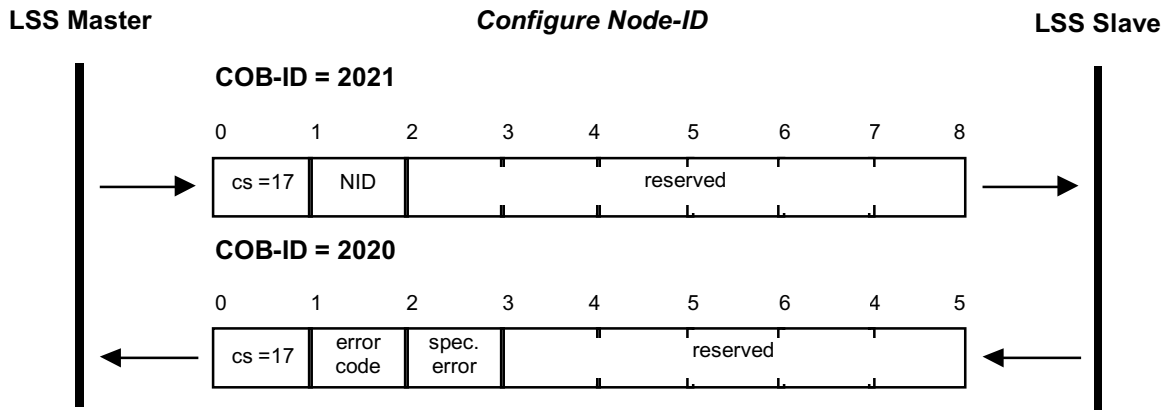
- **revision-number**:
  Revision part of the LSS address, with respect to index 1018h, subindex 3

- **serial-number**:
  Serial number part of the LSS address, with respect to index 1018h, subindex 4

5.4 CONFIGURATION PROTOCOLS

5.4.1 Configure Node-ID Protocol

This protocol is used to implement the 'Configure Node-ID' service for the Node-ID part of the NMT address. After switching back to LSS ‘Operation mode’ to ‘Configuration Mode’ a change of the Node-ID results in a power on like reset of the device.



- **cs**:
  LSS command specifier
  17 for Configure Node-ID

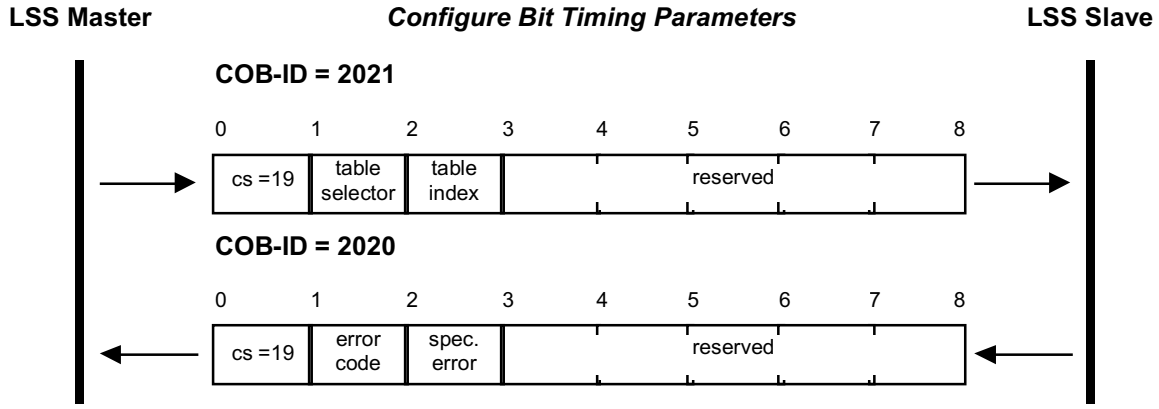
- **NID**:
  The new Node-ID to configure, see /2/. If NID is set to FFh the Node-ID is made invalid and after the switch back to operation mode that results in the power on like reset the slave enters the ‘LSS Init State’ autonomously.

- **error_code**:
  0 : protocol successfully completed
  1 : Node-ID out of range
  2 ... 254 : reserved for further use by CiA
  255 : implementation specific error occured.

- **specific_error_code**:
  If error_code equals 255, specific_error_code gives an implementation specific error code, otherwise it is reserved for further use by CiA.
- **reserved**:
  reserved for further use by CiA

5.4.2 Configure Bit Timing Parameters Protocol

This protocol is used to implement the 'Configure Bit Timing Parameters' service



- **cs**:
  LSS command specifier
  19 for Configure Bit Timing Parameters

- **table_selector**:
  selects which bit timing parameters table has to be used
  0: standard CiA bit timing table (see /4/)
  1..127: reserved for further use by CiA
  128..255: may be used for manufacturer specific bit timings

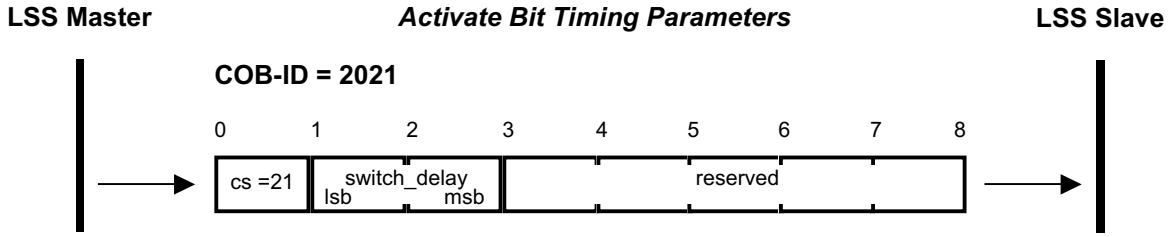
- **table_index**:
  selects the entry (bit timing parameters) in the selected table; see 4.2.2 for valid indices when using the standard CiA bit timings (table_selector = 0)
- **error_code**:
  0: protocol successfully completed
  1: bit timing not supported
  2..254: reserved for further use by CiA
  255: implementation specific error occured

- **specific_error_code**:
  if error_code equals 255, specific_error_code gives an implementation specific error code, otherwise it is reserved for further use by CiA.

- **reserved**: reserved for further use by CiA.

5.4.3 Activate Bit Timing Parameters Protocol

This protocol is used to implement the 'Activate Bit Timing Parameters' service.



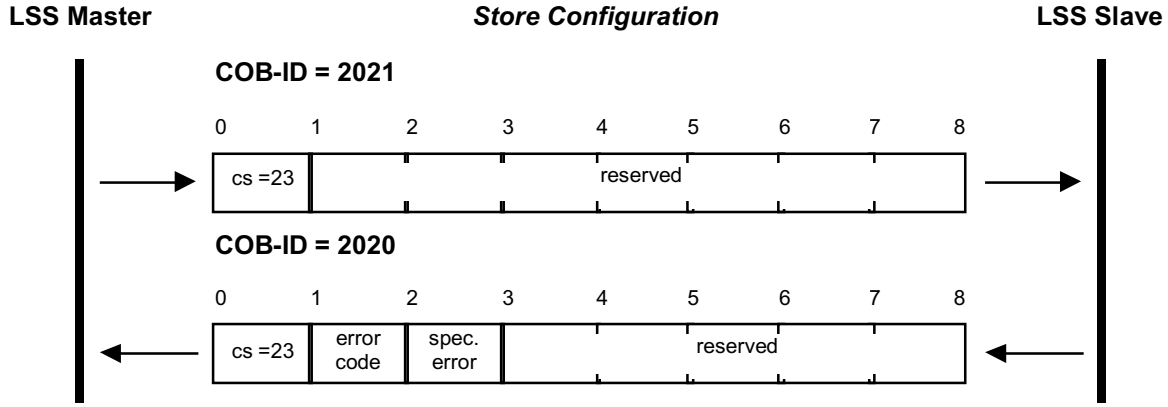
- **cs**:
  LSS command specifier
  21 for Activate Bit Timing Parameters

- **switch_delay**:
  The duration of the two periods of time to wait until the bit timing parameters switch is done (first period) and before transmitting any CAN message with the new bit timing parameters after performing the switch (second period). The time unit of switch delay is 1 ms.

- **reserved**:
  reserved for further use by CiA.

5.4.4 Store Configuration Protocol

This protocol is used to implement the 'Store Configured Parameters' service.



- **cs**:
  LSS command specifier
  23 for Store Configuration

- **error_code**:
  0: protocol successfully completed,
  1: store configuration is not supported,
  2: storage media access error
  3 . . 254: reserved for further use by CiA,
  255: implementation specific error occured.

- **specific_error_code**:
  If error_code equals 255, specific_error_code gives an implementation specific error code, otherwise it is reserved for further use by CiA.

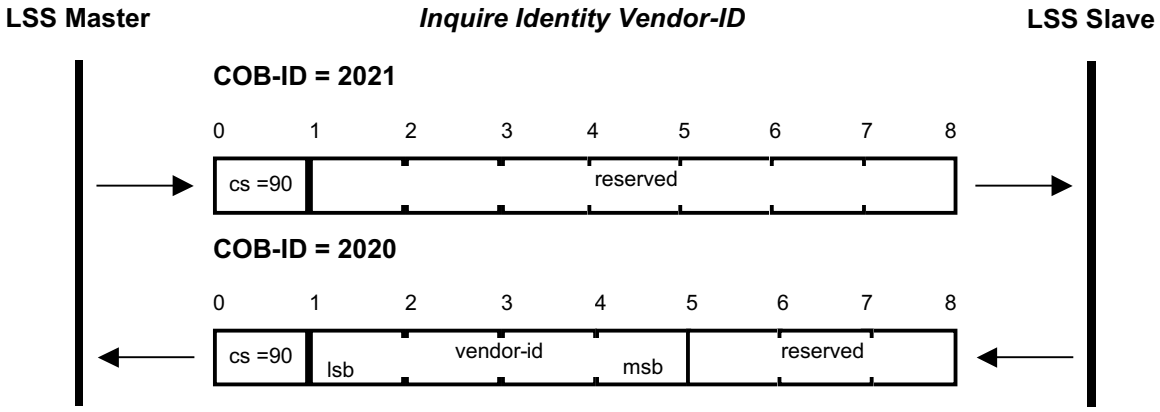
- **reserved**:
  reserved for further use by CiA.

5.5 INQUIRY PROTOCOLS

5.5.1 Inquire LSS Address Protocols

These protocols are used to implement the 'Inquire LSS Address' service. To implement the service, each of the following three protocols has to be executed.

5.5.1.1 Inquire Identity Vendor-ID Protocol

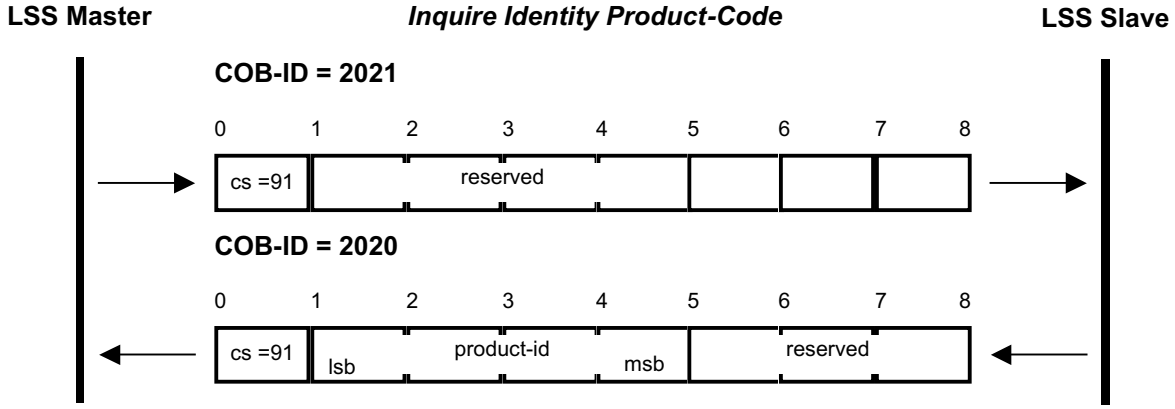


- **cs**:
  LSS command specifier
  90 for Inquire Manufacturer Name

- **vendor-id**:
  The vendor-id (see /2/) of the selected module.

- **reserved**:
  reserved for further use by CiA.

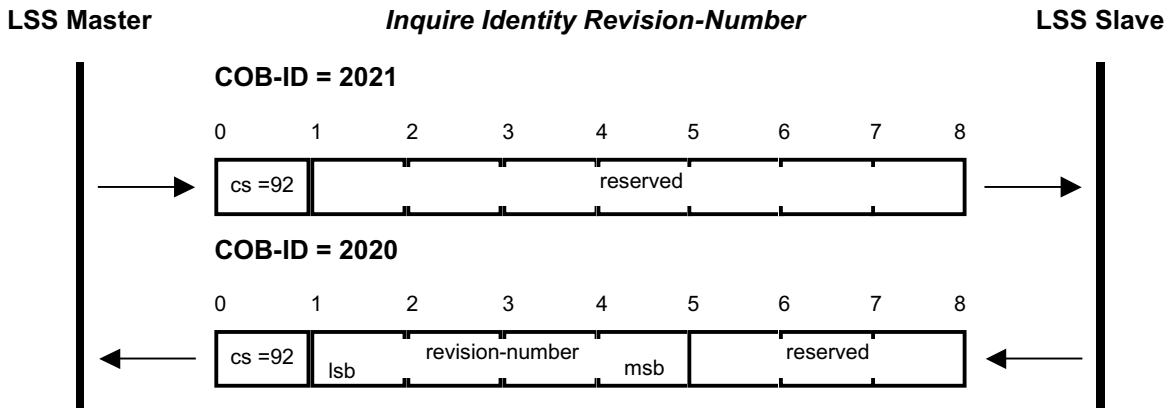
5.5.1.2 Inquire Identity Product-Code Protocol



- **cs**:
  LSS command specifier
  91 for Inquire Product Name
- **product-code**:
  The product-code (see /2/) of the selected module.

- **reserved**: reserved for further use by CiA.

5.5.1.3 Inquire Identity Revision-Number Protocol

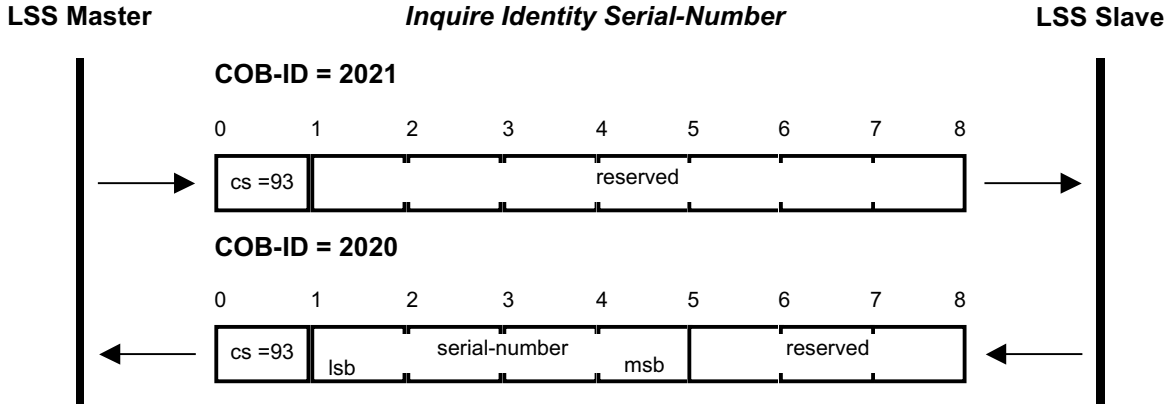


- **cs**:
  LSS command specifier
  92 for Inquire Serial Number

- **revision-number**:
  The revision-number (see /2/) of the selected module.

- **reserved**: reserved for further use by CiA.

5.5.1.4 Inquire Identity Serial-Number Protocol



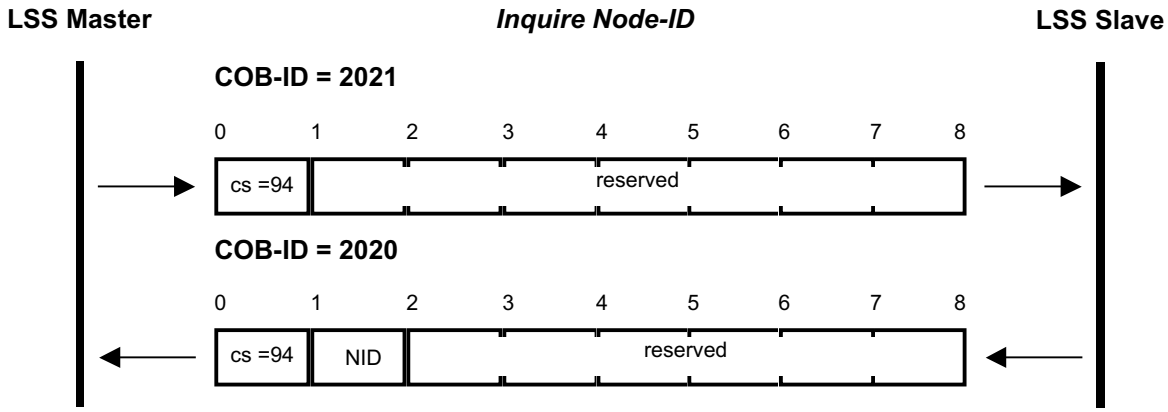
- **cs**:
  LSS command specifier
  93 for Inquire Serial Number

- **serial-number**:
  The serial-number (see /2/) of the selected module.

- **reserved**: reserved for further use by CiA.

5.5.2 Inquire Node-ID Protocol

This protocol is used to implement the 'Inquire Node-ID' service.



- **cs**:
  LSS command specifier
  94 for Inquire Node-ID

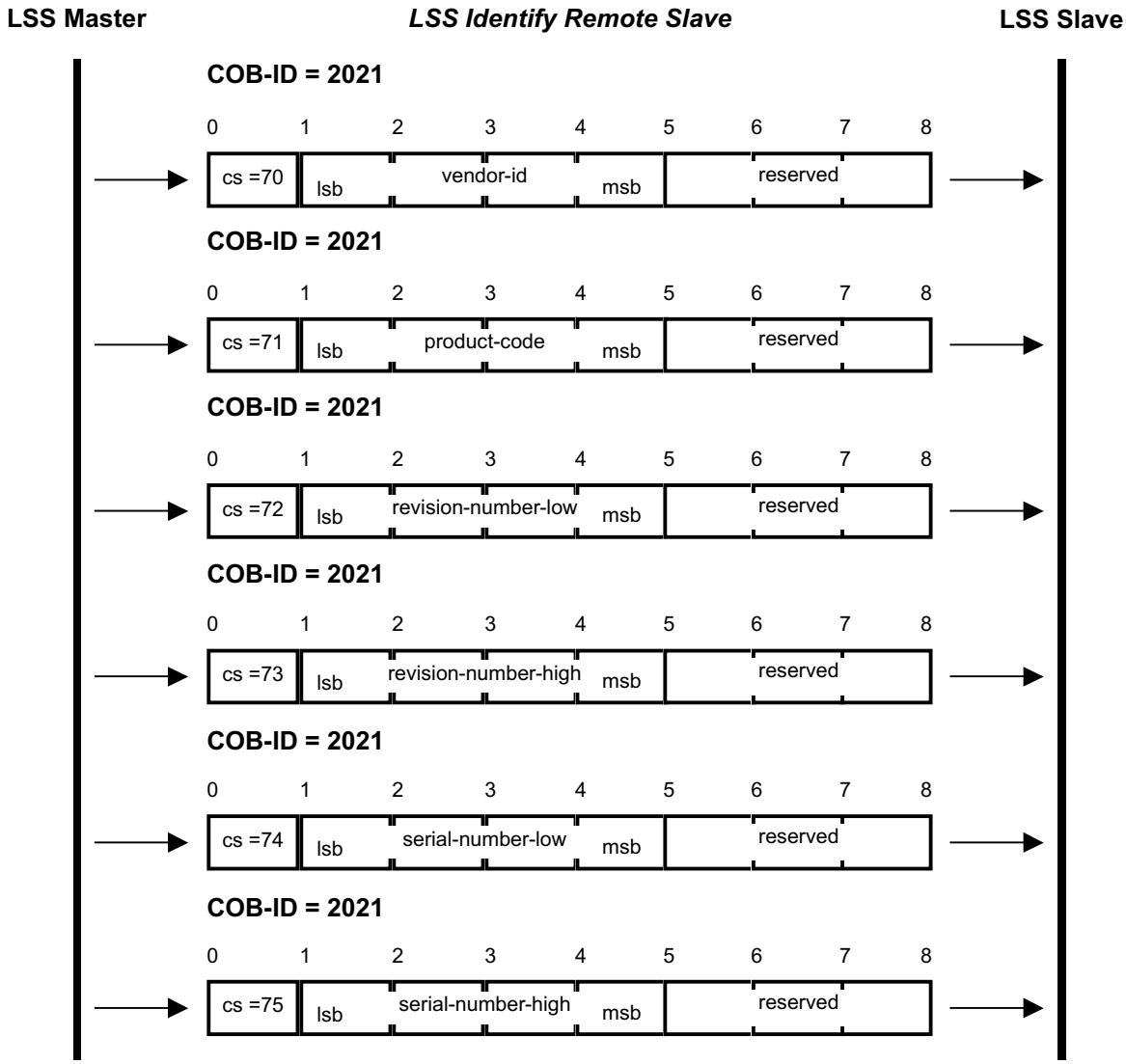
- **NID**:
  The Node-ID of the selected module. If the Node-ID has been changed by means of previous Configure Node-ID service the original Node-ID is returned until the next power on reset. A value of FFh is returned if the Node-ID is not configured, which is only possible if the slave is in ‘LSS Init State’.

- **reserved**: reserved for further use by CiA.

5.6 IDENTIFICATION PROTOCOLS

5.6.1 LSS Identify Remote Slaves

This protocol is used to implement the 'LSS Identify Remote Slaves' service.

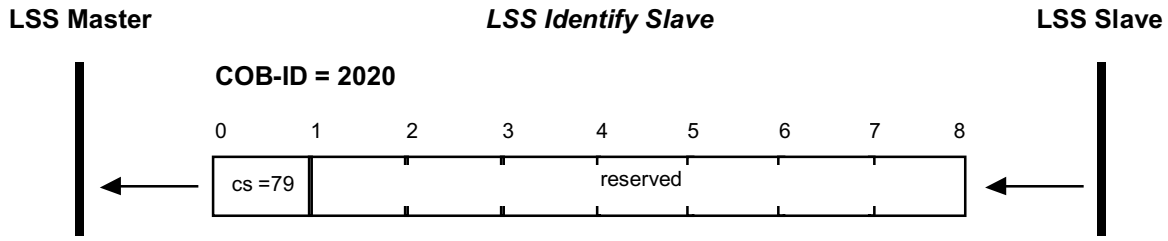


- **cs**:
  LSS command specifier
  70 to 75 for LSS Identify Remote Slaves
- **vendor-id**:
  The manufacturer name part of the LSS Address
- **product-code:**
  The product name part of the LSS Address
- **revision-number-low:**
  The lower boundary of the requested revision numbers range. The Minor range must be set to 0000h.
- **revision-number-high:**
  The higher boundary of the requested revision numbers range. The Minor range must be set to FFFFh.
- **serial-number-low:**
  The lower boundary of the requested serial numbers range
- **serial-number-high:**
  The higher boundary of the requested serial numbers range

The boundaries are included in the interval. All LSS Slaves with matching vendor-id and product-code whose major revision-number and serial-numbers lie within the given ranges, are requested to identify themselves with the LSS Identify Slave service.

5.6.2 LSS Identify Slave Protocol

This protocol is used to implement the 'LSS Identify Slave' service.

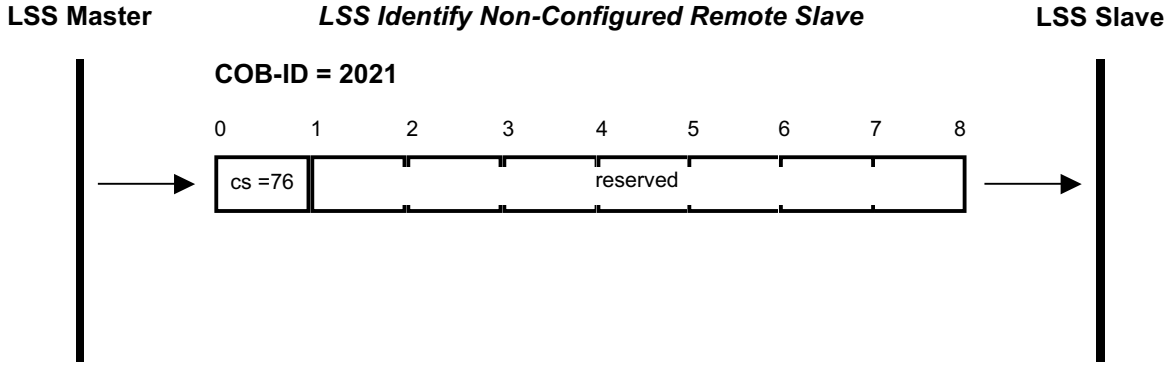


- **cs:**
  LSS command specifiers
  79 for Identify Slave

- **reserved**:
  all bytes set to '0'

5.6.3 LSS Identify Non-Configured Remote Slaves

This protocol is used to implement the 'LSS Non-Configured Remote Slaves' service.

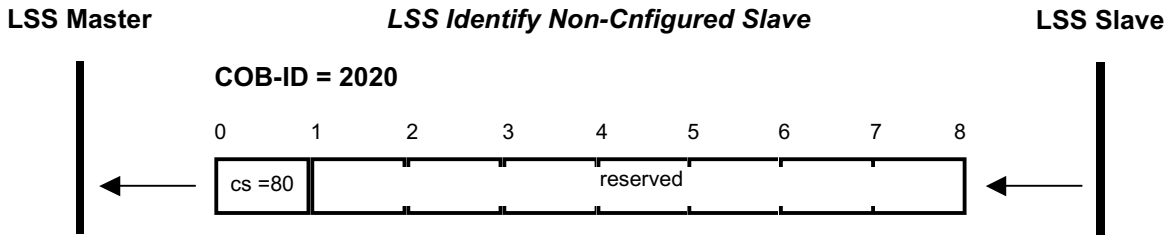


- **cs**:
  LSS command specifier
  76 for LSS Identify Non-Cconfigured Remote Slaves

All LSS Slaves whose Node-ID is not configured (FFh) are requested to identify themselves with the ‘LSS Identify Non-Configured Slave’ service.

5.6.4 LSS Identify Non-Configured Slave Protocol

This protocol is used to implement the 'LSS Identify Non-Configured Slave' service.



- **cs:**
  LSS command specifiers
  80 for Identify Non-Configured Slave

reserved:
all bytes set to '0'

6 IMPLEMENTATION RULES

When implementing the LSS protocols, the following rules have to be followed to guarantee inter-operability. The rules deal with the following implementation aspects:

CAL Layer Management (LMT)

To distinguish between LMT and LSS, all for LSS services used command specifiers are fixed to a range from 040h – 07fh.

Invalid COB's

A COB is invalid if it has a COB-ID that is used by the LSS Protocol, but contains invalid parameter values according to the LSS Protocol. This can be caused by errors in the data link layer (see /1/) or implementaton errors. Invalid COB's must be handled locally in an implementation specific way that does not fall within the scope of the /2/. As far as the LSS Protocol is concerned, an invalid COB must be ignored.

Time-Outs

Since COB's may be ignored, the response of a confirmed LSS service may never arrive. To resolve this situation, an implementation may, after a certain amount of time, indicate this to the service user (time-out). A time-out is not a confirm of the LSS service. A time-out indicates that the service has not completed yet. The application must deal with this situation. Time-out values are considered to be implementation specific and do not fall within the scope of the /2/. However, it is recommended that an implementation provides facilities to adjust these time-out values to the requirements of the application.