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| **FUNCTIONAL SPECIFICATION** | | | | | | | | | | | | | | | | | | | | | | | | | | |  | |
| **PART/SUBSYSTEM NAME** | | | | | | | | | | | | | | | | | | **PART NUMBER** | | | | | | | |
| **LIN (Local Interconnect Network)**  **Data Link and Physical Layer Specification** | | | | | | | | | | | | | | | | | | **000603.101.AE** | | | | | | | |
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| **DATE** | | **LET** | | **FR** | **REVISIONS** | | | | | | | | | | | | | | **DR** | | **CK** | **REFERENCE** | | | |
| 4/26/2010 | |  | |  | 9th Revision of this specification. First Revision in this Format - JML | | | | | | | | | | | | | |  | |  |  | | | |
| 1/5/2015 | |  | |  | Release AB Jim Lawlis, Christian Grossmann | | | | | | | | | | | | | |  | |  | **MODIFIED BY** | | | |
| 2/17/2016 | |  | |  | Release AC Jim Lawlis & Global Netcom Group | | | | | | | | | | | | | |  | |  | James M. Lawlis | | | |
|  | |  | |  | Adding configuration schema instructions and format | | | | | | | | | | | | | |  | |  | **APPROVED BY** | | | |
| 8/17/2017 | |  | |  | Release AD Doug Oliver & Global Netcom Group | | | | | | | | | | | | | |  | |  | Netcom TDR | | | |
| 4/16/19 | |  | |  | Release AE Jim Lawlis, Doug Oliver, Gary O’Brien   1. Updated reference table 2. Aligned DLPL\_LIN\_02\_001 with review document adding specifics on clock tolerance 3. Added DLPL\_LIN\_11\_007 to align with review document and better define TX behavior during micro RESET 4. Added DLPL\_LIN\_11\_008 to improve EMC test plan definition for LIN performance 5. Added DLPL\_LIN\_11\_009 to improve definition of parametric LIN testing before and after CI-280 6. DLPL\_LIN\_13\_001    1. Defined C1 package size minimum to align with review criteria by other Ford TS’s for caps on connector pins.    2. Specified conditions for which Z1 may be de-populated aligning with review form    3. Specified conditions for which L1 current rating may be reduced from 150mA rating 7. DLPL\_LIN\_14\_001 Clarified how components should be grounded when CM chokes are used in power and ground 8. Added DLPL\_LIN\_14\_008 to specify layout location preference for TVS device. 9. DLPL\_LIN\_21\_003 clarified that ref[23] qualification is optional for transceiver approval consistent with practice. 10. DLPL\_LIN\_24\_001 clarified which testing was required and which was optional for transceiver approval consistent with practice. 11. Updated traceability table 10 for ISO 17987 | | | | | | | | | | | | | |  | |  |  | | | |
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| FRAME | | | | | | | | | REV | | | |  | | | | | | | | | | | | |
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# I. Scope

This document is a technical regulation for a multiplex network between ECU’s, an inter-systems network. In combination with a protocol standard for multiplex it is a full specification regarding communication, but all demands in the Technical Regulation for the specific ECU also has to be fulfilled.

This document shall be used to define and develop all production intent ECU’s for Ford Enterprise.

Slave non-conformances will be discussed on a case by case basis.

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# III. References

The requirements of the documents listed in the following table, form a part of this specification. The revision levels shown in the table were the latest at the time this Functional Specification was written. In the event of a conflict between the requirements of this specification and these documents, the requirements of the documents in the table shall have precedence.

| **Rev Level** | **Requirement Document Name (i.e., SDS/ARL requirements, Deviations, Engineering Specifications)** |
| --- | --- |
|  | [1] ISO 7498-1, Open Systems Interconnection - basic reference model |
| 2014 | [3] ISO 17987 Part 1-6 Road Vehicles – Local interconnect network (LIN) |
| 2012 | [10] SAE J2602-1, LIN Network for Vehicle Applications |
| 2012 | [11] SAE J2602-2, LIN Network for Vehicle Application Conformance Test |
| 2012 | [12] SAE J2602-3, LIN Network for Vehicle Application NCF File Definition |
| 25 | [13] FMC1278, Electromagnetic Compatibility Specification For Electrical/Electronic Components and Subsystems |
| AP or latest | [14] 000603.002 - Netcom Physical Layer Approved Components  <https://www.vsemweb.ford.com/tc/webclient?argument=MLUJpzWLx3NrTD> |
| AB | [15] 000603.111 - Design Verification Method for LIN |
| AB | [16] 000603.112 – Hardware Review DV |
| 2014 | [17] ISO 17987 Part 7 Road Vehicles – Local interconnect network (LIN) |
| AA | [18] FS-0000-000001 Global Start/Stop Voltage Curve Specification |
| 2019 | [19] SAE 2962-1 Communication Transceivers Qualification Requirements - LIN |
| 22 | [20] RQT-191001-009890 EC-0042 Powered At All Times And Conditioned Power Circuits |
| 24 | [21] RQT-191001-009906 EC-0058 Low/High Voltage Guaranteed Function/Performance |
| 12 | [22] RQT-002600-009624 EY-0141 E/E System and Component Operating Voltage |
|  | [23] IEC TS-62228 Integrated circuits - EMC evaluation of transceivers - Part 2: LIN transceivers |
| 14 | [24] RQT-002600-009624 (EY-0141) E/E SYSTEM & COMPONENT OPERATING VOLTAGE - Immunity to Voltage Overstress |
|  |  |

1. Definitions / Abbreviations

## General definitions

For multiplex terminology, SAE J1213/1 JUN91 "Glossary of Vehicle Networks for Multiplexing and Data Communications" shall be used in applicable cases for documentation.

|  |  |
| --- | --- |
| Dominant/recessive | The bus can have one of two complementary logical values: “dominant” or “recessive”. See ref[3] for the definition of dominant and recessive. Dur­ing simultaneous transmission of “dominant” and “recessive” bits, the resulting bus value will be “dominant”. |
| Multiplex channel | to interleave or simultaneously transmit two or more messages on a single communication media |
| Network | a set of electronic and cabling devices facilitating the multidirectional exchange of informa­tion encoded in serial form. Each electronic device (in this case: ECU) is equipped with a specific, standardized electronic interface in order to guarantee compatibility between exchanged binary items of information. |
| Normal mode | LIN node communication during operational voltages ranges and nonfaulted conditions |
| Passive mode | the LIN node does not transmit (leaves bus output recessive), but the node does still receive |
|  |  |

## Abbreviations used in document

|  |  |
| --- | --- |
| DTC | Diagnostic Trouble Code |
| ECU | Electronic Control Unit with a computer/microcontroller. |
| EMC | Electromagnetic Compatibility |
| FMC | Ford Motor Company |
| IC | Integrated Circuit |
| ISO | International Organization for Standardization |
| LIN | Local Interconnect Network |
| SAE | Society of Automotive Engineers |
| WCCA | Worst Case Circuit Analysis |

1. PRODUCT OVERVIEW

The specification addresses only the lower two layers of the ISO network reference model (see Ref[1]).

Ford LIN Supplier Code is 0007. This can be used in modules built to print for Ford.

1. REQUIREMENTS

**Data Link Layer**

## Type of Network

DLPL\_LIN\_01\_001 - LIN standard used in master node

The master for each network shall support the LIN standards in accordance with ref[3] and ref[10].

DLPL\_LIN\_01\_002 - LIN standard used in slave node

All slave modules must be compliant to the Local Interconnect Network (LIN) standards: ref[10], ref[3].

DLPL\_LIN\_01\_003 - The priority between standard documents and this specification

In case of discrepancy between the standard documents and this specification, this specification has precedence. In case of a discrepancy between ref[10] and ref[3], ref[10] has precedence

DLPL\_LIN\_01\_004 - Class C functions

The requirements in this specification support Class A & B functions by default. LIN modules that are Functional Importance Class C as defined in their Ford EMC Test Plan, see ref[13], shall fit the inductor.  
Exceptions may be granted for one of two conditions:

1. Transceivers are listed on the approved transceiver list, ref[14] with “No” indicated in column “Ind Rqd Class C”.
2. Transceivers in individual modules that have demonstrated their capability to meet the class C immunity requirements without an inductor, see ref[13] by passing Ford EMC testing to class C standards for RI-112 for LIN functionality in a Ford certified lab.

DLPL\_LIN\_01\_005 - Requirement Exception Process

Off the Shelf LIN systems that do not meet all the requirements of this document shall be evaluated and approved on a case by case basis. Additional testing must be performed to verify compliance with the level of requirements for the user function class (A, B or C).

## Oscillator tolerance definition

DLPL\_LIN\_02\_001 - Speed tolerance

The total network transmission speed tolerance shall include all causes. For crystals and resonators this shall include manufacturing tolerance, ageing and temperature. For PLL's, the tolerance shall be determined as specified by the semiconductor manufacturer, and shall include the effects of manufacturing, ageing, temperature and transmission speed. Timing tolerance must meet one of the following depending on the implementation:

1. Master Node: ≤+/-0.5%
2. Slave Node: master-slave only without autobauding ≤+/-1.5%
3. Slave Node: master-slave only with autobauding: must be able to synch with the master with an error ≤+/-2%. Absolute timer error ≤ +/- 14%
4. Slave Node: master-slave and slave-slave with autobauding: must be able to synch with the master with an error ≤+/-0.5% *(since it is not guaranteed that all slaves autobaud)*
5. Slave Node: master-slave and slave-slave without autobauding: ≤+/-1%

Note: particular care must be taken to ensure the appropriate tolerance is met when a resonator is being used with a PLL.

DLPL\_LIN\_02\_002 - PLL used as clock

When a PLL is being used to clock the LIN interface, transmission and reception are only allowed when the PLL is locked.

## Synchronization and bit sampling

DLPL\_LIN\_03\_001 - Synchronization

Synchronisation is allowed on recessive to dominant transitions only.

## UART

DLPL\_LIN\_04\_001 - Characteristics

UART characteristics shall be according to ref[10].

## Network transmission speed

DLPL\_LIN\_05\_001 - Bus speed

All standard LIN modules shall operate at the nominal bus speed of 10.417 Kbps. Special approvals for Links to run at 19.2 Kbps or 20.4 Kbps will be granted as long as all transceivers on the links have been qualified at one of the two higher speeds.

## Bus operation

DLPL\_LIN\_06\_001 - Maximum transmission time

Each frame transmission time must be within the range of TFrame\_Nominal and TFrame\_Maximum. The publisher of the frame must support a maximum frame transmission time of less than TFrame\_Maximum. See ref[3] for definition of TFrame\_Nominal and TFrame\_Maximum.

DLPL\_LIN\_06\_002 - Slave transmission time

The TResponse\_Maximum value in which a slave node can complete, ref[10], its response shall be identified in its Node Capability File. In the event a value is not provided in the Node Capability File, the Master node shall presume a value of TResponse\_Maximum as defined in ref[3].

DLPL\_LIN\_06\_003 - Inter-byte space

Each inter-byte space shall be between 0 and 8 bit times. The response space shall be between 0 and 8 bit times. The total transmission time is the sum of the header, response space and the response shall be between TFrame\_Minimum and TFrame\_Maximum as defined in ref[3].

DLPL\_LIN\_06\_004 - Header schedule jitter

The transmission of headers must follow the time schedule given by the schedule table. There will normally be a jitter in the transmission of headers, ref[3], ref[10], caused by internal processes inside the master ECU. This jitter must not delay the start of transmission of a header for more than 1.5 ms. The worst case jitter must be calculated by the supplier of the master ECU and reported to the FMC design team responsible for the ECU.

## Wake-Up Timing

DLPL\_LIN\_07\_001 - Wakeup strategy

All nodes shall follow the strategy specified in ref[3] and ref[10].

mwt

sd

First slave response

Local event (master)

t

First

header

local event at t=0, mwt<100ms, sd<100ms - For Slaves that wake from local events only.

sd<250ms - for Slaves that wake from ignition or Bus traffic only

mwt is the master wakeup time

sd is the slave wakeup delay

Figure 4.1 Master node sends wake up request.

Figure 4.1 Shows the scenario when the master node sends a wake up request (first header) due to a local event. The debouncing time is not included in the figure. The first header is sent within a specific time(mwt). After being woken up the slave node is ready to transmit valid data within a specific time(sd).

mwd

st

First header

Local event (slave)

t

Wake up request

local event at t=0, st<50ms, mwd<130ms

mwd is the master wakeup delay

st is the slave wakeup time

Figure 4.2 A slave node sends one wakeup request.

Figure 4.2 shows the scenario, for slaves that wake from local events, when a slave node wakes up the network due to a local event. The master node sends the first header mwd time after the first wake up request.

wd

wd

mwt

st

First header

Local

event (slave)

t

local event at t=0, st<50ms,

150ms <= wd <= 300 ms

mwt<130ms

st is the slave wakeup time

wd is the delay between wake

up attempts

mwt is the master wakeup time

Wake up request #1

Wake up request #2

Wake up request #3

Figure 4.3 A slave node sends three wakeup requests.

Figure 4.3 shows the scenario, for slaves that wake from local events, when a slave node wakes up the network due a local event. The master node sends the first header after 3 wake up requests.

DLPL\_LIN\_07\_002 - Timeout and sleep commands

The master shall always issue a sleep command when power down of the bus is required, ref[3] and ref[10].

All slaves must implement both the timeout and sleep command, ref[3] and ref[10].

DLPL\_LIN\_07\_003 - Local event– master sends the first header

A master node shall transmit the first header within 100 ms after a local event.

DLPL\_LIN\_07\_004 - Network event – wake up request to first header

The LIN master shall detect and begin transmission of the first header of the appropriate schedule table no longer than 130ms after the wake up request. Specific subsystems that require a faster wakeup response time can be defined in the subsystem application requirements.

DLPL\_LIN\_07\_005 - Power on – master sends the first header

A master node shall transmit the first header within 250 ms after power is applied or after a hardware reset.

DLPL\_LIN\_07\_006 - Local event –

For slaves that wake form local events only, slave sends the wake up request

A slave node shall transmit a wake up request within 50ms after a local event.

DLPL\_LIN\_07\_007 - Network event – wake up request to slave ready to communicate

The LIN slave node shall detect the wake up request and be able to transmit valid data within:

* 100ms for slaves that wake from local events
* 250ms for slaves that wake from Ignition or Bus traffic only

. Slaves shall not respond until their data is valid. Diagnostic supervision in the master shall take this delay into account. Specific subsystems that require a faster wakeup response time can be defined in the subsystem application requirements.

DLPL\_LIN\_07\_008 - Power on – slave sends the first response

A slave node shall be able to transmit valid data within

* 100ms for slaves that wake from local events
* 250ms for slaves that wake from Ignition or Bus traffic only

after power is applied or after a hardware reset. Slaves shall not respond until their data is valid. Diagnostic supervision in the master shall take this delay into account. Specific subsystems that require a faster wakeup response time can be defined in the subsystem application requirements.

**Physical Layer**

## Wiring

In order to avoid EMC problems, best wiring practices outlined below should be followed whenever possible.

Bus wiring practices to improve EMC performance

1. Avoid routing bus wires with noisy (e.g. injector drivers) and sensitive (e.g. low signal level sensors, antenna feeds) circuits.

2. Precaution shall be taken when routing wires near the vehicle antenna or antenna amplifiers to prevent inducing noise into these circuits. A shielded wire may be needed near an active antenna.

3. Avoid wire loops by locating bus wires close to the vehicle’s metal ground.

## Max length

DLPL\_LIN\_09\_001 - Bus length

The maximum wiring length shall not exceed 18m. The maximum bus length is the sum of the lengths of all the wire used to interconnect the nodes on a given network.

Special requests for a tradeoff between more nodes and shorter wire can be addressed on a case by case basis

## Number of Nodes

DLPL\_LIN\_10\_001 - Number of nodes in a network

The maximum node count for any given network shall not exceed 9 Slaves and 1 Master.

Special requests for a tradeoff between more nodes and shorter wire can be addressed on a case by case basis

## Fault Tolerant Modes

The network shall meet the requirements as defined per the following failure modes:

DLPL\_LIN\_11\_001 - ECU Power Loss

ECUs shall not interfere with normal communication among the remaining bus ECUs during a loss of power (or low voltage) condition. Upon return of power, normal operation shall resume without any operator intervention within a time specified in the "Wake-Up Timing" section.

DLPL\_LIN\_11\_002 - Bus Wiring Short to Ground

Network data communications may be interrupted but there shall be no damage to any ECU when the bus is shorted to ground. A network impedance of less than 50 ohms between the bus and ground shall be considered a short to ground and continued communications are not guaranteed or required. Upon removal of the fault, normal operation shall resume without any operator intervention within 1 second. This DLPL does not apply to the 27V overstress condition of ref[24].

DLPL\_LIN\_11\_003 - Bus wiring short to battery

Network data communications may be interrupted but there shall be no damage to any device when the bus is shorted to positive battery less than 26.5 volts (Vbatt < 26.5 volts). A network impedance of less than 50 ohms between the bus and battery shall be considered a short and continued communications are not guaranteed or required. Upon removal of the fault, normal operation shall resume without any operator intervention within 1 second.

DLPL\_LIN\_11\_004 - Communication persistency

A short or open in any single wiring circuit of an ECU, except for power, ground, or serial data, shall not preclude the ability to communicate with that ECU for diagnostic purposes.

DLPL\_LIN\_11\_005 - Ground offset voltage

Ground offset voltage limits at the ECU, specified as 0.1 x Vbatt ECU, must be maintained over the entire range of 8 < Vbatt ECU < 26.5 volts. See ref[10] for definition of Vbatt ECU.

DLPL\_LIN\_11\_006 – Start/Stop Voltage Profile

If the given LIN link requires continuous communication throughout the start/stop event then all modules on the link must be powered from the Voltage Stability Module.

DLPL\_LIN\_11\_007 – TX Pin During Micro Reset

The TX pin shall not be driven dominant while the microcontroller is in RESET. If a transceiver has an internal pull-down resistor, then the application must make provisions for one of the following:

1. a pull up resistor is used on TX pin and the micro is confirmed to have a high impedance state during micro RESET
2. transceiver incorporates a dominant time out feature
3. transceiver is disabled during micro RESET

DLPL\_LIN\_11\_008 – LIN Acceptance Criteria During EMC Immunity Testing

Modules with LIN should base LIN acceptance criteria for EMC testing on the minimum update rate required for each signal transmitted over LIN needed to support the system function according to the specific Functional Importance Class. This detail cannot be generically specified in this requirement and must be determined by the owners of the LIN modules. It is important that specific acceptance criteria be included in the EMC test plan. The method of simulating and monitoring the LIN operation during specific EMC tests must be sufficient for compliance with the acceptance criteria to be judged. Messages should be sent at the same rate during EMC testing as they are in the application. Do not send a message only every 250mS if the normal schedule in the application is sending the message every 15mS. Keep in mind the dwell time at each frequency during immunity testing to make sure that performance can be assessed for each step. It is recommended that Class C Functions simply require error free communication as the acceptance criterion.

DLPL\_LIN\_11\_009 – LIN Testing to Verify ESD Robustness

As documented in ref[13] evidence shall be provided that the EMC Test Plan includes parametric testing of the LIN output to verify robustness to CI-280 as part of acceptance criteria. Scope plots of the LIN bus before and after CI-280 testing shall be captured. Set the scope to 10uS/div for 19.2k baud or 20us/div for 10.4k baud horizontal and 2 V/div vertical. The plots must contain at least one dominant to recessive edge and one recessive to dominant edge. All after-test plots shall be compared with the plot taken before the test. The overlay of the before and after test plots shall not deviate by more than +/-10% of the nominal recessive voltage shown on the scope plot *(see Figure 4.4 below for an example)*

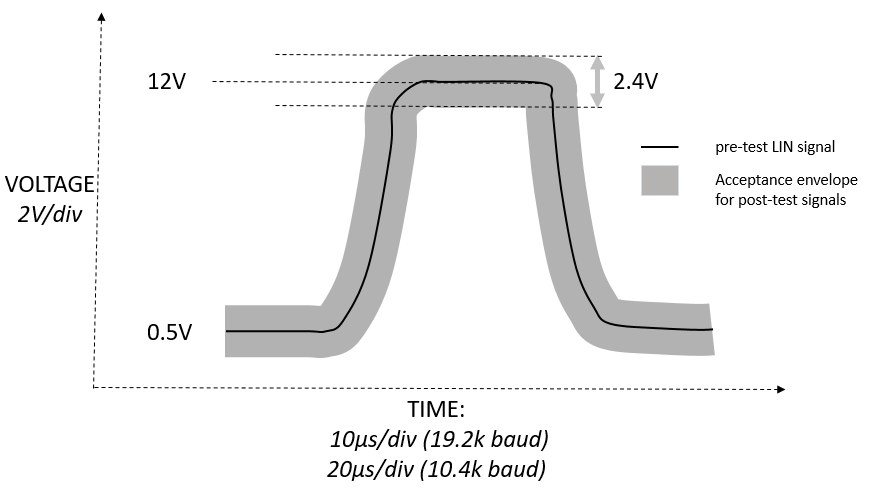


Figure 4.4: Acceptance Envelope for LIN Signal Scope Traces Post Test

## Operating Battery Power Voltage Range

DLPL\_LIN\_12\_001 - Normal battery voltage power operation

The ECU shall provide Vbatt IC to the bus transceiver within the range of 8 to 17 volts when Vbatt ECU is in the range of 9 to 18 volts.

DLPL\_LIN\_12\_002 - Normal/Passive mode at high voltage

For 18 < Vbatt ECU < 24 volts the bus may operate in either the normal or the passive mode. Nodes shall only enter the passive mode in this voltage range in order to protect themselves; they shall not shut down due to voltage alone. In the passive mode the bus shall be recessive (not be pulled or driven to ground) and TxD shall be in the Recessive state.

DLPL\_LIN\_12\_004 - Leakage current limits

Recessive state transceiver leakage current limits shall be less than or equal to 23 µA.

DLPL\_LIN\_12\_005 - Low Battery Voltage Operation

For 0 < Vbatt ECU < 8 volts the bus may operate in either the normal or the passive mode. In the Passive Mode the bus shall be recessive (not be pulled or driven to ground) and TxD shall be in the high state. Fault codes shall be suppressed below 10 volts.

DLPL\_LIN\_12\_007 – LIN Transceiver Voltage Source

The LIN transceiver voltage supply (VCC/VBAT) for all nodes and the pull-up supply for the LIN Master (R1 D1) must be powered by the vehicle battery supply. *Exceptions to this may only be granted upon approval by:*

1. *The Ford Technical Specialist responsible for the LIN master module for the network in question*
2. *The Ford Technical Specialist responsible for the module that is powered by a source other than battery*
3. *The Ford Technical Specialist responsible for any module communicating with the module that is powered by a source other than battery*
4. *The Netcom Hardware Technical Specialist.*

Mismatch in the supply voltages between nodes may result in loss of communication due to the scaling of the LIN line logic thresholds with the VCC/VBAT input of the transceiver.

**ECU Level**

## Interface implementation and physical layer circuit

DLPL\_LIN\_13\_001 - Interface implementation and physical layer circuit master and slave

The circuits defined in figure 5.1 and figure 5.2 shall be used for all designs.

VCC/VBAT

LIN

GND

TXD

RXD

Transceiver

C1

L1

Z1

R1

D1

TXD

RXD

LIN Micro

Controller

C2

see table below

R2

or

or



C3

C3

Figure 5.1 Master node

|  |  |  |
| --- | --- | --- |
| **Component ID** | **Description** | **Value** |
| C1 | Capacitor | 680 pF ±10%  ≥ 100V rating  0603 or larger package |
| C2 | CapacitorNote 2  Flexisafe or Equivalent | ≥ 90 nF  ≥ 100V rating Note 5 |
| C3 | Capacitor Note 3  Non-Flexisafe | ≥ 180 nF  ≥ 50V rating |
| D1 | Diode | ≥ 100V  ≥ 100mA |
| R1 | Resistor | 1 kOhm  Power Rating Note 6 |
| R2 | Resistor Note 1 | 0 Ohm |
| L1 | Inductor Note 1 | 45 – 105 µH  150 mA Note 7 |
| Z1 Note 4 | Dual Monolithic Avalanche Diode for ESD and over voltage protection. | 27 V breakdown voltage minimum |

Note 1 LIN links that need to be capable of Class "C" functions, see DLPL\_LIN\_01\_004

Note 2 Select Flexisafe type capacitors in accordance with ref[20]. According to ref[20], dual series capacitors are only allowed when the necessary capacitance value is not available in a single Flexisafe type device.

Note 3 Alternative to using Flexisafe capacitor only permitted if conditions of ref[20] are met. Capacitors C3 must be perpendicular from each other.

Note 4 Z1 should be placed as close as possible to the module connector. Z1 shall be from ref[14] COM\_CAN\_LIN\_02\_002 unless passing data is provided for the specific module according to ref[19] for ESD and according to ref[24] for Voltage Overstress. Insure that a representative master pull-up network(1k resistor and diode) is included in the LIN setup for the ref[24] Voltage Overstress test if the module is a LIN slave. Parametric testing is required before and after the ref[24] Voltage Overstress testing to verify that the TVS was not damaged. In addition to testing, a WCCA must be provided to show that Z1 will not be damaged by the ref[24] Voltage Overstress. Z1 shall exhibit a capacitance <30pF while under 2.5V reverse bias. This may be proven via measurement or by data sheet analysis. Once the test documentation has been presented to, and accepted by the Netcom authority, the component will become FMC qualified ESD protection components for the specific module tested.

The Z1 Zener diode may be depopulated if all of the following conditions are met

1. the LIN transceiver has passed SAE J2962-2 ref[19] without a Zener placed and is listed in ref[14] with ‘No’ in the column ‘Zener Stack Rqd’
2. Inductor L1 is NOT populated
3. The LIN trace length from the connector to the transceiver pin is less than 3 inches

The layout shall still protect for the Zener diode.

Note 5 On-board filtering or clamping may allow lower rated devices based on approval from Ford Netcom

Note 6 The power rating of R1 must be selected to survive a short to ground at the maximum operational supply voltage and temperature of the module. Consider CI-220 and CI-222 of ref[13], ref[21],ref[22], and ref[24] Voltage Overstress. A WCCA shall be provided to verify the performance of R1. Any overcurrent or overvoltage protection in the master pull-up circuit should be considered in the WCCA. The ambient temperature assumption for the ref[24] Voltage Overstress condition shall be 55C.

Note 7 An inductor with a worst case current rating lower than 150mA may be used if the following testing/analysis is provided and passed:

1. The module is tested according to ref[13] while monitoring the temperature rise of the inductor. The rise over ambient plus the worst case internal temperature is less than the maximum temperature rating for the inductor,
2. A WCCA shows that during a LIN bus short to battery external to the module, the temperature rise of the inductor plus the worst case internal temperature is less than the maximum temperature rating for the inductor. The WCCA should assume the worst case dominant bit density which will be different for Masters vs. Slaves since the current pulled through the inductor in a given module during an external short to battery is only based on that transceiver driving the bus. Worst case short circuit current limits for the transceiver output shall be used in the analysis.
3. A WCCA shows that there is no loss of inductance during worst case operation of the LIN bus during maximum ambient temperature, worst case dominant bit density (self heating of inductor), and maximum battery voltage while LIN is operational (without shut down mechanism this may be as high as 27V for ref[24] Voltage Overstress conditions)
4. Verification of WCCA: Chamber testing is conducted at the maximum ambient temperature for the module while it is running normal bus traffic with an external short to battery on the LIN line. The temperature of the inductor shall be monitored during the test and it must confirm the conclusions of item 2.

VCC/VBAT

LIN

GND

TXD

RXD

Transceiver

C1

L1

Z1

TXD

RXD

LIN Micro

Controller

see table below

R2

or

C2

or



C3

C3

Figure 5.2 Slave node

|  |  |  |
| --- | --- | --- |
| **Component ID** | **Description** | **Value** |
| C1 | Capacitor | 220 pF±10%  100V rating  0603 or larger package |
| C2 | Capacitor Note 2  Flexisafe or Equivalent | ≥ 90 nF  ≥ 100V rating Note 5 |
| C3 | Capacitor Note 3  Non-Flexisafe | ≥ 180 nF  ≥ 50V rating |
| R2 | Resistor Note 1 | 0 Ohm |
| L1 | Inductor Note 1 | 45 – 105 µH  150 mA Note 6 |
| Z1 Note 4 | Dual Monolithic Avalanche Diode for ESD and over voltage protection. | 27 V breakdown voltage minimum |

Note 1 LIN links that need to be capable of Class "C" functions, see DLPL\_LIN\_01\_004

Note 2 Select Flexisafe type capacitors in accordance with Ref[20]. According to Ref[20], dual series capacitors are only allowed when the necessary capacitance value is not available in a single Flexisafe type device.

Note 3 Alternative to using Flexisafe capacitor only permitted if conditions of Ref[20] are met. Capacitors C3 must be perpendicular from each other.

Note 4 Z1 should be placed as close as possible to the module connector. Z1 shall be from ref[14] COM\_CAN\_LIN\_02\_002 unless passing data is provided for the specific module according to ref[19] for ESD and according to ref[13] for ref[24] Voltage Overstress. Insure that a representative master pull-up network(1k resistor and diode) is included in the LIN setup for the ref[24] Voltage Overstress test if the module is a LIN slave. Parametric testing is required before and after the ref[24] Voltage Overstress testing to verify that the TVS was not damaged. In addition to testing, a WCCA must be provided to show that Z1 will not be damaged by the ref[24] Voltage Overstress. Z1 shall exhibit a capacitance <30pF while under 2.5V reverse bias. This may be proven via measurement or by data sheet analysis. Once the test documentation has been presented to, and accepted by the Netcom authority, the component will become FMC qualified ESD protection components for the specific module tested.

The Z1 Zener diode may be depopulated if all of the following conditions are met

1. the LIN transceiver has passed SAE J2962-2 ref[19] without a Zener placed and is listed in ref[14] with ‘No’ in the column ‘Zener Stack Rqd’
2. Inductor L1 is NOT populated
3. The LIN trace length from the connector to the transceiver pin is less than 3 inches

The layout shall still protect for the Zener diode.

Note 5 On-board filtering or clamping may allow lower rated devices based on approval from Ford Netcom

Note 6 An inductor with a worst case current rating lower than 150mA may be used if the following testing/analysis is provided and passed:

1. The module is tested according to ref[13] while monitoring the temperature rise of the inductor. The rise over ambient plus the worst case internal temperature is less than the maximum temperature rating for the inductor,
2. A WCCA shows that during a LIN bus short to battery external to the module, the temperature rise of the inductor plus the worst case internal temperature is less than the maximum temperature rating for the inductor. The WCCA should assume the worst case dominant bit density which will be different for Masters vs. Slaves since the current pulled through the inductor in a given module during an external short to battery is only based on that transceiver driving the bus. Worst case short circuit current limits for the transceiver output shall be used in the analysis.
3. A WCCA shows that there is no loss of inductance during worst case operation of the LIN bus during maximum ambient temperature, worst case dominant bit density (self heating of inductor), and maximum battery voltage while LIN is operational (without shut down mechanism this may be as high as 27V for ref[24] Voltage Overstress conditions)
4. Verification of WCCA: Chamber testing is conducted at the maximum ambient temperature for the module while it is running normal bus traffic with an external short to battery on the LIN line. The temperature of the inductor shall be monitored during the test and it must confirm the conclusions of item 2.

## General Layout Design requirements

DLPL\_LIN\_14\_001 - Grounding of the LIN transceiver

The Ground of the LIN transceiver and all directly connected components shall be made to the same ECU ground with a low inductance path to the module connector ground pin. Intentional ground separation in the layout between signal ground and connector ground shall be avoided. Exceptions to this shall only be allowed with the approval of the appropriate Netcom design authority. In the case of exceptions, all the LIN components shall have the same ground (e.g. Zener, caps, transceiver)

DLPL\_LIN\_14\_002 - Capacitors

C1 and C2, see figure 5.1 and 5.2, shall be shall be monolithic ceramic capacitors.

DLPL\_LIN\_14\_003 - Ground plane

An unobstructed ground plane is required under the transceiver chip on the same layer as the transceiver.

DLPL\_LIN\_14\_004 - Location of the transceiver

Transceiver should be located as close to edge connector as possible. There may be exceptions when the transceiver is part of an SBC and other functions of the SBC drive placement in another area of the board. For example, an SBC with an integrated power supply should be located nearest the micro.

LIN traces shall not be routed underneath or on close proximity to other ICs unless they are shielded by a ground plane.

DLPL\_LIN\_14\_005 - Circuit board tracks

The LIN circuits’ tracks between connector and transceiver should be as short as possible.

DLPL\_LIN\_14\_006 - Location of the decoupling capacitor

The decoupling capacitor C2, see figure 5.1 and 5.2, shall be placed as close as possible to the transceiver in order to minimize the trace length to the power pin.

DLPL\_LIN\_14\_007 – Capacitor Ratings

The 100V and Flexisafe requirement is only for transceivers that are connected to battery power.

DLPL\_LIN\_14\_008 – Location of Transient Suppression

The transient suppression (Zener (Z1) or Varistor) shall be placed as close as possible to the module connector LIN pin.

**Ford Generic LIN Networking**

This section will serve as an interface spec. It defines the behavior of the LIN Master and LIN Slave, as well as defining the signal names used by the Master and Slave.

## Ford Standard Error Reporting

One means of simplifying the LIN Master is to distinctly categorize the error reporting technique use by the LIN Slaves. After analysis of the SAE J2602 Status bits, we decided that most of these errors can be caused by multiple LIN Slaves using worst-case baud rate clocks (one on the extreme high end, another on the extreme low end. Therefore, we decided to not report DTCs due to the standard J2602 LIN Status bits (ERR0, ERR1 and ERR2).

DLPL\_LIN\_15\_002 – Ford Standard J2602 Extension

All Slaves are required to report the Ford Standard J2602 Error Handling Extension

### Ford Standard J2602 Error Handling Extension

Even though APINFO4 is called out by J2602, it is included in this list because Ford expects that all slaves continue to report these errors as long as the error exists.

Even though APINFO0 is designated as unused it should be set to zero in all reported status bytes

Table 0‑1 – Ford Standard Extension of LIN J2602 Status Byte

| **APINFO4** | **APINFO3** | **APINFO2** | **APINFO1** | **APINFO0** | **Meaning** |
| --- | --- | --- | --- | --- | --- |
| 0 | 0 | 0 | 0 | unused | No failure to report |
| 1 | Don't care | Don't care | Don't care | unused | Slave not configured |
| Don't care | 0 | 1 | Don't care | unused | Output disabled temporarily due to environmental issue (temperature, voltage), no short. Do not use this for load shedding. Note that this case should be used when the disabling of the output is not due to a vehicle repairable fault. The service manual should indicate that the condition was due to the capacity of the output being exceeded. |
| Don't care | 1 | 0 | Don't care | unused | One or more outputs disabled temporarily due to short-circuit. |
| Don't care | 1 | 1 | Don't care | unused | ECU fault (can be any internal fault or an output driver fault) |
| Don't care | Don't care | Don't care | 1 | unused | One or more input faults detected.  Note that this is unreliable when the slave reports ECU fault. |

**Note:** ECU fault can be used to indicate other major faults besides output FET and 3/3 life.

Table 0‑2 – LIN Slave Error Reporting Requirement

| **Rqm't Num.** | **Ford LIN Error Handling Requirement** |
| --- | --- |
| DLPL\_LIN\_15\_003 | All LIN slaves shall use the standard J2602 LIN Status byte as the first byte of all transmitted messages |
| DLPL\_LIN\_15\_004 | Diagnostic Trouble Codes (DTCs) will not be set based on the state of the ERR0, ERR1 and ERR2 SAE J2602 status byte flags |
| DLPL\_LIN\_15\_005 | All LIN slaves shall report errors using the J2602 LIN status bits. |
| DLPL\_LIN\_15\_006 | The LIN status bits APINFO4, APINFO3, APINFO2 and APINFO1 shall report errors whenever an error is detectable (don't report it only once). |
| DLPL\_LIN\_15\_007 | LIN slaves shall support a simplified version of the FET Protection (Output Fault Management) specification:   * Whenever an output is disabled due to a short circuit, set APINFO3/APINFO2 to binary 10. Slave increments internal FET Life count * Reactivate the output when a customer re-requests circuit activation (could be hardwired to slave or LIN signal) * Stop allowing reactivation once 3/3 life is reached and set APINFO3/APINFO2 to binary 11. These bits shall never change after this. |
| DLPL\_LIN\_15\_008 | A LIN Slave implementation may not even need to report an error via the LIN Status Byte. However, the LIN Status Byte must still be transmitted because it will be used to ensure that the all LIN Slaves are present. |

### DLPL\_LIN\_15\_009 – Slave Behavior in the Presence of Errors When Transmitting

* When the Slave detects a Framing error, Data error, or invalid Checksum, the Slave will cease transmission prior to transmission of the next byte field, unless the error occurs during the transmission of the checksum byte, and return to the “Dormant” state of waiting for the next break/synch sequence from the master node.  The Slave will also set the appropriate error flags within LINStatus signal.

### DLPL\_LIN\_15\_010 – Slave Behavior in the Presence of Errors When Receiving

* When the Slave detects an ID Parity error, Framing error, or Invalid Checksum, the Slave will discard any data buffered from the current frame and return to the “Dormant” state of waiting for the next break/synch sequence from the master node.  The Slave will also set the appropriate error flags within LINStatus signal.

## Schedule Table Names

FNOS Schedule Table Operation

* **On network wakeup:** the NULL schedule table is used
* **On network sleep:** FNOS switch to the NULL schedule table and then issues the Sleep command
* **When the application requests the Master LIN Drivers to use schedule table XXX:** The current LIN message is completed and then the XXX schedule table is selected. Note that request XXX when XXX is already running, it restarts the schedule table at the beginning.

### Schedule Table Selection in the Master

In the Master, a schedule table is selected whenever:

* Ignition\_Status changes to OFF, ACC or RUN/START
* Network is awakened
* At the start of and the end of LIN Configuration (run diag service $31, $203A).

When a new schedule table is selected, the current LIN message completes and then the requested schedule table is started – even if the requested schedule table is the same as the current schedule table.

### Standard Schedule Table Names

Table 0‑3 – LIN Schedule Table Name Requirement

| **Rqm't Num.** | **Requirement** |
| --- | --- |
| DLPL\_LIN\_16\_001 | Only schedule table names listed in Table 0‑4 – LIN Schedule Table Names shall be used in the specified ECU. |

Table 0‑4 – LIN Schedule Table Names

Note: the table below contains the required naming convention for a Master with 4 LIN links. It does not imply that a Master cannot contain more than 4 LIN links. The pattern of assignments below can be expanded to cover as many LIN links as are defined for the Master

| **Rqm't Num.** | **LIN Master** | **LIN Subnet** | **Schedule Table Name** | **Description** |
| --- | --- | --- | --- | --- |
| DLPL\_LIN\_16\_002 | Any | Any | (null) | No traffic on the LIN subnet – slaves cannot "wake" the subnet. |
|  |  |  |  |  |
| DLPL\_LIN\_16\_003 | SPDJB/BCM | LIN\_01 | "LIN11" | Normal use |
| DLPL\_LIN\_16\_004 | "LIN12" | Normal use |
| DLPL\_LIN\_16\_005 | "LIN13" | Normal use |
| DLPL\_LIN\_16\_006 | "LINConfig1" | Used only for Slave configuration & Slave part number collection |
|  |  |  |  |
| DLPL\_LIN\_16\_007 | LIN\_02 | "LIN21" | Normal use |
| DLPL\_LIN\_16\_008 | "LIN22" | Normal use |
| DLPL\_LIN\_16\_009 | "LIN23" | Normal use |
| DLPL\_LIN\_16\_010 | "LINConfig2" | Used only for Slave configuration & Slave part number collection |
|  |  |  |  |
| DLPL\_LIN\_16\_011 | LIN\_03 | "LIN31" | Normal use |
| DLPL\_LIN\_16\_012 | "LIN32" | Normal use |
| DLPL\_LIN\_16\_013 | "LIN33" | Normal use |
| DLPL\_LIN\_16\_014 | "LINConfig3" | Used only for Slave configuration & Slave part number collection |
|  |  |  |  |
| DLPL\_LIN\_16\_015 | LIN\_04 | "LIN41" | Normal use |
| DLPL\_LIN\_16\_016 | "LIN42" | Normal use |
| DLPL\_LIN\_16\_017 | "LIN43" | Normal use |
| DLPL\_LIN\_16\_018 | "LINConfig4" | Used only for Slave configuration & Slave part number collection |
|  |  |  |  |  |

## Standard LIN Signal Names

Standard LIN Signal Names are used to in the listed ECUs. For more information on how LIN Slave Configuration and Part Number Reporting work, refer to section *3.18*. Configuring LIN Slaves / Collecting Slave Part Numbers

Table 0‑5 – Standard LIN Signal Names

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rqm't Num.** | **LIN Slave** | **Signal Type** | **Who Transmits** | **Signal Name** |
| DLPL\_LIN\_17\_001 | xxx | LIN Status | Slave | xxxLINStatus |
|  |  |  |  |
| DLPL\_LIN\_17\_002 | PartNum Index | Slave | xxxPartNumIndex |
| DLPL\_LIN\_17\_003 | PartNum Data | Slave | xxxPartNumData0  xxxPartNumData1  xxxPartNumData2  xxxPartNumData3  xxxPartNumData4  xxxPartNumData5 |
|  |  |  |  |  |
| DLPL\_LIN\_17\_004 | xxx | Config Index | Master (SPDJB/BCM) | xxxConfigIndex |
| DLPL\_LIN\_17\_005 | Config Data | Master (SPDJB/BCM) | xxxConfigData0  xxxConfigData1  xxxConfigData2  xxxConfigData3  xxxConfigData4  xxxConfigData5  xxxConfigData6 |
|  |  |  |  |  |

## Configuring LIN Slaves / Collecting Slave Part Numbers

DLPL\_LIN\_18\_001 – LIN Slave Configuration

LIN Slaves are not dynamically configured since this can cause random latency issues and TGWs. So, configuration is only done when startRoutine $203A is requested from a test tool.

Once a slave detects that the subnet as switched to Configuration Mode then any configurable slave shall immediately start reporting "Not Configured" until the next requirement is met. The configurable LIN Slave must transmit the "Not Configured" status at least one time

The LIN Master then switches to the *LINConfigX* schedule table and transmits any LIN Slave configuration information via a normal functional message per Slave. At the same time, it collects the LIN Slave's part number information (if supported). After all LIN Slave configuration information has been transmitted and all the part number information has been collected for all slaves on a subnet, the master switches back to a "normal" schedule table. In case of problems, the maximum amount of time spent in the *LINConfigX* schedule table is 4 seconds.

DLPL\_LIN\_18\_002 – Flashing Application Code

Updating Application Code in a LIN Slave is NOT SUPPORTED

DLPL\_LIN\_18\_003 – Part Number Reporting Options

Part Number Index and Part Number Data signals should not force the slave into configuration mode.

Table 0‑6 – When are LIN Slaves Configured and their Part Numbers Collected Requirements

| **Rqm't Num.** | **Rule** |
| --- | --- |
| DLPL\_LIN\_18\_004 | The LIN Master shall only transmit configuration information and collect part number information when:   * The ignition is in RUN * AND the LIN Master is in the Extended Diagnostic Session * AND a test tool requests diagnostic service $31 startRoutine $203A |
| DLPL\_LIN\_18\_005 | When the LIN Master receives a valid diagnostic request for service $31 startRoutine $203A (see above), it will first switch to the *LINConfigX* schedule table (as defined in Table 0‑4 – LIN Schedule Table Names) and transmit it for a maximum of 4 seconds and then it will switch back to the "normal" schedule table. |
| DLPL\_LIN\_18\_006 | LIN Master will attempt to communicate with the LIN Slave for a minimum of 1 second and a maximum of 4 seconds |
| DLPL\_LIN\_18\_007 | The maximum size of a configuration file can be no larger than 255 bytes |
| DLPL\_LIN\_18\_008 | Once a slave detects that the subnet as switched to *Configuration Mode* then any configurable slave shall immediately start reporting "Not Configured" until the next requirement is met. The configurable LIN Slave must transmit the "Not Configured" status at least one time. |

DLPL\_LIN\_18\_010 – Slave Configuration Schema

Ford uses the XML format to receive supplier LIN configuration data. The XML Schema (defined in Appendix A) is the only Ford accepted XML schema.

The XML Schema, as shown in Appendix A, describes all XML element data types. The supplier must enter all byte data in decimal format.

**LIN Master Requirements**

## DTCs Set by the LIN Master

Table 0‑7 –DTCs Set by the LIN Master

|  |  |  |  |
| --- | --- | --- | --- |
| **Rqm't Num.** | **DTC** | **LINStatus Byte (binary)** | **Meaning** |
| DLPL\_LIN\_19\_001 | $zzzz55 | xxx1 xxxx | Slave Not Configured  APINFO4 set to 1 |
| DLPL\_LIN\_19\_002 | $zzzz9A | xxxx 01xx | Output Disabled (no short) – one or more outputs are/were disabled due to environmental reasons (temperature, operating voltage…)  APINFO2+ APINFO3 = 01 |
| DLPL\_LIN\_19\_003 | $zzzz01 | xxxx 10xx | Output Fault (short) – one or more outputs have reported that a short exists  APINFO2+ APINFO3 = 10 |
| DLPL\_LIN\_19\_004 | $zzzz49 | xxxx 11xx | Replace Slave – slave indicates that it can no longer function normally  APINFO2+ APINFO3 = 11 |
| DLPL\_LIN\_19\_005 | $zzzz02 | xxxx xx1x | Input Fault – one or more input circuits indicate a fault exists  APINFO1 set to 1 |
| DLPL\_LIN\_19\_006 | $zzzz08 | (missing) | Missing slave |

Table 0‑8 –DTC Example Base Numbers for LIN Slaves

|  |  |  |
| --- | --- | --- |
| **LIN Master ECU** | **LIN Slave ECU** | **DTC Base Number (Hex)** |
| SPDJB/BCM | DC/AC Inverter | zzzz = $9330 |
| Compass/Mirror Module | zzzz = $9331 |
| Rear Video Camera Module | zzzz = $915E |

**Configuring the SPDJB Master**

## Configuration Mode – LIN Master Requirements

Table 0‑9 – Configuring LIN Slaves – LIN Master Requirements

|  |  |
| --- | --- |
| **Rqm't Num.** | **Requirement** |
| DLPL\_LIN\_20\_001 | When Diagnostic service $31 requests startRoutine = $203A,   * Set LIN\_ConfigMode = CONFIG * For each slave ECU - set *LINSlavePartNum[n]* = NULL for all n |
| DLPL\_LIN\_20\_002 | For each LIN subnet, when:   * LINConfigX schedule table has been gone through at least once, * ConfigIndex = 0 has been transmitted **twice** for each LIN Slave, * LIN Status Bit APINFO4 indicates that the all LIN Slaves are configured, * and part number has been collected for all LIN Slaves (received the same *PartNumIndex* twice)   Set LIN\_ConfigMode = NULL. |
| DLPL\_LIN\_20\_003 | When LIN\_ConfigMode = CONFIG for a maximum of 4 seconds,  set LIN\_ConfigMode = NULL. |

## REQUIREMENTS - Transceiver Qualification Process

DLPL\_LIN\_21\_001 - Approved components

Components approved for use in ECU’s connected to LIN networks are listed in ref[14].

DLPL\_LIN\_21\_002 - Qualification testing

All FMC approved transceivers need to pass the SAE J2602 Conformance test in ref[11].

DLPL\_LIN\_21\_003 - EMC testing

The transceiver supplier must demonstrate conformance to FMC EMC requirements with their transceiver laid out on a circuit board following all FMC layout requirements. EMC testing requirements are defined in ref[19] SAE 2962-1 Communication Transceivers Qualification Requirements – LIN.

If the transceiver has been tested to prove conformance to ref[23] those results should be provided to Ford.

All test results must be released to Ford Motor Company and will be kept confidential.

Note: To help with this requirement Ford has designed a standard test module, reference FMC US, Department Netcom T407. Using the test module as a base will reduce both hardware and software design time. Suppliers have the option to design their own test module to demonstrate conformance.

## Message Identifiers

### Slave Supplier Test Modes

* DLPL\_LIN\_22\_001 - All LIN IDs used for supplier end of line testing and/or verification must be documented in the module’s NCF file provided to the Master ECU Design and Release activity

## Diagnostic/Manufacturing Mode Limitations

### Protection Override Timeout

* DLPL\_LIN\_23\_001 – Any LIN enabled diagnostic or manufacturing modes that override a LIN module’s internal protections must time out in 4s or less unless the command instruction is repeated

1. VERIFICATION METHODS

### Nodes

DLPL\_LIN\_24\_001 - Node conformance test

The node must demonstrate conformance to the applicable tests defined in the table below.

|  |  |
| --- | --- |
| Protocol | Conformance test |
| ISO 17987 or J2602 as determined by the LIN protocol the node has implemented | Ref[17] or Ref[11] |
| Ford DV (mandatory) | Ref[15], ref[16] |

## Verification traceability

The following matrix itemizes all requirements specified herein and cross-references them to one of several means for verification. Due the criticality of a requirement there may be more than one procedure identified for verification. Below is a brief description of each of the verification methods:

* ECU Level T.P.'s DV test where requirement is verified.
* Vehicle Level T.P.'s DV test where requirement is verified.
* Hardware Review Inspection Inspection where requirement is verified ref[5], ref[6].
* Application Testing Testing performed by (sub)system engineering verifies the requirement.

Table 10: Trace-ability Matrix

| **Requirement No.** | **SAE J2602-2 Testing** | **Ford LIN DV** | **Ford HW Review** | **Link Description File (LDF)** | **ISO 17987** |
| --- | --- | --- | --- | --- | --- |
| DLPL\_LIN\_01\_001 | **X** |  |  | **X** | **X** |
| DLPL\_LIN\_01\_002 | **X** |  |  | **X** | **X** |
| DLPL\_LIN\_01\_003 | **X** |  | **X** | **X** | **X** |
| DLPL\_LIN\_01\_004 |  |  | **X** |  |  |
| DLPL\_LIN\_01\_005 | **X** |  | **X** | **X** | **X** |
| DLPL\_LIN\_02\_001 | **X** |  | **X** |  | **X** |
| DLPL\_LIN\_02\_002 | **X** |  | **X** |  | **X** |
| DLPL\_LIN\_03\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_04\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_05\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_06\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_06\_002 | **X** |  |  |  | **X** |
| DLPL\_LIN\_06\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_06\_004 |  |  |  | **X** |  |
| DLPL\_LIN\_07\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_07\_002 | **X** |  |  |  | **X** |
| DLPL\_LIN\_07\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_07\_004 |  | **X** |  |  |  |
| DLPL\_LIN\_07\_005 |  | **X** |  |  |  |
| DLPL\_LIN\_07\_006 |  | **X** |  |  |  |
| DLPL\_LIN\_07\_007 |  | **X** |  |  |  |
| DLPL\_LIN\_07\_008 |  | **X** |  |  |  |
| DLPL\_LIN\_09\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_10\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_11\_001 | **X** |  |  |  | **X** |
| DLPL\_LIN\_11\_002 | **X** |  |  |  | **X** |
| DLPL\_LIN\_11\_003 | **X** |  |  |  | **X** |
| DLPL\_LIN\_11\_004 |  | **X** |  |  |  |
| DLPL\_LIN\_11\_005 |  | **X** |  |  |  |
| DLPL\_LIN\_11\_006 |  | **X** |  |  |  |
| DLPL\_LIN\_11\_007 |  |  | **X** |  |  |
| DLPL\_LIN\_11\_008 |  |  | **X** |  |  |
| DLPL\_LIN\_11\_009 |  |  | **X** |  |  |
| DLPL\_LIN\_12\_001 | **X** |  | **X** |  | **X** |
| DLPL\_LIN\_12\_002 | **X** |  |  |  | **X** |
| DLPL\_LIN\_12\_004 | **X** |  |  |  | **X** |
| DLPL\_LIN\_12\_005 | **X** |  |  |  | **X** |
| DLPL\_LIN\_12\_007 |  |  | **X** |  |  |
| DLPL\_LIN\_13\_001 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_001 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_002 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_003 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_004 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_005 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_006 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_007 |  |  | **X** |  |  |
| DLPL\_LIN\_14\_008 |  |  | **X** |  |  |
| DLPL\_LIN\_15\_001 | **X** |  |  | **X** | **X** |
| DLPL\_LIN\_15\_002 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_003 | **X** |  |  | **X** | **X** |
| DLPL\_LIN\_15\_004 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_005 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_006 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_007 |  | **X** |  | **X** |  |
| DLPL\_LIN\_15\_008 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_009 | **X** |  |  |  | **X** |
| DLPL\_LIN\_15\_010 | **X** |  |  |  | **X** |
| DLPL\_LIN\_16\_001 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_002 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_003 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_004 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_005 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_006 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_007 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_008 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_009 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_010 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_011 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_012 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_013 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_014 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_015 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_016 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_017 |  |  |  | **X** |  |
| DLPL\_LIN\_16\_018 |  |  |  | **X** |  |
| DLPL\_LIN\_17\_001 |  |  |  | **X** |  |
| DLPL\_LIN\_17\_002 |  |  |  | **X** |  |
| DLPL\_LIN\_17\_003 |  |  |  | **X** |  |
| DLPL\_LIN\_17\_004 |  |  |  | **X** |  |
| DLPL\_LIN\_17\_005 |  |  |  | **X** |  |
| DLPL\_LIN\_18\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_002 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_004 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_005 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_006 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_007 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_008 |  | **X** |  |  |  |
| DLPL\_LIN\_18\_010 |  | **X** |  | **X** |  |
| DLPL\_LIN\_19\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_19\_002 |  | **X** |  |  |  |
| DLPL\_LIN\_19\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_19\_004 |  | **X** |  |  |  |
| DLPL\_LIN\_19\_005 |  | **X** |  |  |  |
| DLPL\_LIN\_19\_006 |  | **X** |  |  |  |
| DLPL\_LIN\_20\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_20\_002 |  | **X** |  |  |  |
| DLPL\_LIN\_20\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_21\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_21\_002 |  | **X** |  |  |  |
| DLPL\_LIN\_21\_003 |  | **X** |  |  |  |
| DLPL\_LIN\_22\_001 |  | **X** |  |  |  |
| DLPL\_LIN\_23\_001 |  |  | **X** |  |  |
| DLPL\_LIN\_24\_001 | **X** | **X** | **X** |  | **X** |
|  |  |  |  |  |  |

1. INSTRUCTIONS AND NOTES (List special instructions)

## Hardware Review Naming Convention

CAN Reviews <special condition>\_<year>\_<vehicle usage>\_<bus>\_<Termination>\_<node name>\_<supplier>

LIN Reviews <special condition>\_<year>\_<vehicle usage>\_<bus>\_<Master/Slave>\_<node name>\_<supplier>

Example:

2015\_S550\_P552\_HSCAN\_termination\_IPC\_Continental.docx

2015\_S550\_P552\_LIN\_Master\_Valeo\_.docx

Special Condition =

(1)‘DEV’ for reviews that are officially a ‘fail’ but cover modules that have permitted deviation for certain vehicle programs under the E-Deviation system

(2)‘EXC’ for reviews that are approved with some exception(s) that pose no risk to the vehicle application reviewed but should not be universally used as carryover without review for future programs.

(3)’PASS’ for reviews that meet the CAN specification with no reservation. These modules may be used as carryover.

Year = model year for the first introduction of the module

Vehicle Usage = List of vehicles where this module will be used. Note file is stored under the directory created for the first vehicle in the list

Bus = HSCAN, MSCAN, LIN (should we go further to specify ICAN, HSCAN(1,2), LIN (Master, Slave))

Node Name = Supplier usually designates this name. Need to discuss how to be more consistent

Termination = Specify if the module is a termination node If it is a non-termination node leave this field blank (CAN reviews only)

Master/Slave = Specify if the LIN node is a Master or Slave node. (LIN reviews only)

Node Name = Supplier usually designates this name. Need to make sure of alignment with the Global naming Convention

Supplier = Supplier name

# Appendix A – LIN Slave Configuration Schema

## A.1 LIN Slave Configurations

LIN slave configurations are used to configure a LIN slave. The configurations allow for the LIN device to alter its functionality based on different configurations that reside inside the LIN device.

For example, vehicles may be equipped with an intrusion sensor (used in the vehicle perimeter alarm system) that detects an intrusion event when the vehicle is locked. Since the vehicle can be built with different interiors (e.g. cloth seats vs. leather seats, or car volume vs. truck volume) different calibrations sets are needed, per vehicle interior, such that the sensor reacts properly in each vehicle variant.

The LIN configuration data is solely supplier based. Ford provides no guidance in the content and meaning of the calibrations. The reason being the calibrations are usually very specific to the supplier’s algorithm’s running in the LIN slave.

There are two important terms a supplier must be aware of,

a) RECORDS

b) BYTES per RECORD

RECORDS

A RECORD is a complete set of slave configuration data the supplier has defined that allows adjustment or configuration of the functional algorithm running on the LIN slave. A RECORD is **not** a set of data bytes used to reprogram a LIN salve algorithm. The RECORD allows the supplier to adjust the slave functionality due to vehicle build variations.

BYTES per RECORD

This is a supplier defined parameter that defines how many bytes are needed to properly configure the LIN slave.

Table 1 and 2 shows the relationship between RECORD and BYTES/RECORD.

|  |  |  |
| --- | --- | --- |
| **# Records = 3** | | |
| **Bytes/ Rec = 2** | | |
| **Record #** | **Byte 1** | **Byte 2** |
| Record 1 | 03 | 02 |
| Record 2 | 11 | 23 |
| Record 3 | 22 | 44 |

Table 1: In this example the LIN slave only needs 2 bytes of data for configuration.

|  |  |
| --- | --- |
| **# Records = 4** | |
| **Bytes/ Rec = 1** | |
| **Record #** | **Byte 1** |
| Record 1 | 1 |
| Record 2 | 11 |
| Record 3 | 22 |
| Record 4 | 45 |

Table 2: In this example, the LIN slave only needs 1 byte of data for configuration.

Should the supplier require special functionality from the BCM – regarding the LIN slave configuration data, the supplier must contact the appropriate BCM Ford Feature owner and discuss the special functionality needed.

An example of special functionality with regards to LIN configurations would be if the supplierwanted to use the first or second byte (of the LIN slave configuration RECORD) to represent the configuration RECORD number loaded in the slave. Since the BCM master can hold many LIN slave configuration RECORDS, it is possible that the BCM is configured to use a calibration set that’s different than the one currently flashed in the LIN slave.

The LIN slave recognizes the difference in the configuration RECORD number received from the BCM master, assuming the BCM is communicating the configuration record it is using. The LIN slave would then report back to the Master that it’s not configured causing the BCM to activate a misconfigured DTC against the LIN slave.

**IMPORTANT:** A LIN slave will only store one RECORD. The BCM Master can hold many LIN slave configuration RECORDS (within BCM NVM storage limits). A BCM method 2 configuration parameter LINsel\_XXX\_Cfg, where XXX is LIN slave name, selects the LIN configuration RECORD the BCM will communicate to the LIN slave.

The BYTES per RECORD must be constant for each RECORD. For example, if a RECORD is defined to have a max size of 10 bytes then each subsequent record must have 10 bytes. It is forbidden to have one RECORD which is 10 bytes in size and another RECORD which is 8 bytes in size and another which is 6 bytes in size.

## A.2 Supplier Requirements

### A.2.1 BYTES PER RECORD and RECORDS

The supplier must work with appropriate Ford BCM feature owner to define how many RECORDS, and BYTES per RECORD the program will need. Usually the number or RECORDS correlates to the number of build variants a vehicle line or program line will have. For example, the HFM (hands free module) has a LIN salve located in the rear bumper of the vehicle. Based on vehicle trim level the rear fascia may be different. This can affect the sensing ability of the HFM LIN slave. Therefore the supplier will define a calibration set for each possible variant of rear fascia design.

Since each RECORD for a LIN slave resides in BCM NVM memory there is a storage limit. The total storage a LIN slave will have is equal to the number of BYTES see equation 1. The supplier must work with the Ford BCM feature owner to ensure there is BCM NVM space to handle the maximum number of LIN slave RECORDS the BCM needs to store.

### LIN SLAVE IDENTIFIER and SIZE

Each slave has a unique name and size requirements. The unique name is a requirement and must be entered when the supplier generates the XML file. The Column title “XML required name” is the Ford approved LIN slave name that must be entered when creating the XML file.

If a supplier cannot locate their “XML required name” contact the appropriate Ford Feature owner and request addition of the LIN slave.

A supplier cannot exceed the Max Bytes Allowed in the table below. Should the supplier require more storage space the appropriate Ford Feature owner must be contacted to evaluate if a size change can be allowed.

|  |  |  |  |
| --- | --- | --- | --- |
| LIN Node Name | XML required Name | Max Bytes Allowed | Functional Description |
| Rear View Camera | RVC | 256 | Rear camera LIN node |
| Combined Sensor Module | CSM | 640 | Intrusion and Inclination sensing LIN node |
| Signal Driver Module | SXDM | 900 | Signal XDM (Smart LED Driver Module / LDM) used in Front Headlamp / Signature Lamp / Park / Turn lamp applications. |
| Fade Control Module | FCM | 300 | Fade Control Module (Extra LED Driver Module) Used to control Fade ON / Fade OFF or Rear Lamps(Park / Tail) |
| Hands Free module | HFM | 800 | Rear Bumper kick sensor LIN node for rear hatch opening. |

### A.2.2 XML Schema file

<?xml version="1.0" encoding="Windows-1252"?>

<xs:schema attributeFormDefault="unqualified" elementFormDefault="qualified" xmlns:xs="http://www.w3.org/2001/XMLSchema">

<xs:element name="LIN\_Node\_Configuration\_data">

<xs:complexType>

<xs:sequence>

<xs:element name="Slave\_Name">

<xs:complexType>

<xs:attribute name="Name" type="xs:string" use="required" />

</xs:complexType>

</xs:element>

<xs:element name="Slave\_Header">

<xs:complexType>

<xs:attribute name="Separator" type="xs:string" use="required" />

<xs:attribute name="Slave\_ID" type="xs:string" use="required" />

<xs:attribute name="Num\_Of\_Record" type="xs:unsignedByte" use="required" />

<xs:attribute name="Record\_Size" type="xs:unsignedByte" use="required" />

</xs:complexType>

</xs:element>

<xs:element maxOccurs="unbounded" name="Slave\_Data">

<xs:complexType>

<xs:attribute name="Record\_Number" type="xs:unsignedByte" use="required" />

<xs:attribute name="Record\_Data" type="xs:integer" use="required" />

</xs:complexType>

</xs:element>

</xs:sequence>

</xs:complexType>

</xs:element>

</xs:schema>

### A.2.3 Example: XML File (\*.XML) with data

**#RECORDS =3**

**Bytes/Rec = 3**

<?xml version="1.0" encoding="UTF-8" standalone="yes"?>

<LIN\_Node\_Configuration\_data>

<Slave\_Name Name="HFM"/>

<Slave\_Header Separator="" Slave\_ID="" Num\_Of\_Record="3" Record\_Size="3"/>

<Slave\_Data Record\_Number="1" Record\_Data="1"/>

<Slave\_Data Record\_Number="1" Record\_Data="2"/>

<Slave\_Data Record\_Number="1" Record\_Data="3"/>

<Slave\_Data Record\_Number="2" Record\_Data="1"/>

<Slave\_Data Record\_Number="2" Record\_Data="2"/>

<Slave\_Data Record\_Number="2" Record\_Data="3"/>

<Slave\_Data Record\_Number="3" Record\_Data="1"/>

<Slave\_Data Record\_Number="3" Record\_Data="2"/>

<Slave\_Data Record\_Number="3" Record\_Data="3"/>

</LIN\_Node\_Configuration\_data>