CLIPSAL
INTEGRATED SYSTEMS

C-Bus Interface Requirements

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CHANGE HISTORY

Date	Change Reference	Comments
11 Dec 01	-	Original
7 Mar 02	Issue 1.1	Added limitation about use of serial interface at speeds below 9600 bits/s.
10 May 02	Issue 1.2	Changed C-Bus Inside references to C-Bus Enabled.
24 Jul 03	Issue 1.3	Added section on compound devices, and setup of PCI Power Up settings
1 Oct 04	Issue 1.4	Update QA logo
12 Oct 04	Issue 1.5	Warning for Transmission Retries
26 nov 08	Issue 1.6	Remove QA logo
8 Dec 08	Issue 1.7	Add safety / life support policy

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1 SCOPE

This document details the requirements that apply to all devices using the C-Bus Serial Interface and C-Bus Serial Interface Development Kit as the means of access to C-Bus.

These requirements apply to:

- Devices developed by Clipsal Integrated Systems Pty Ltd;
- Devices developed by third parties; and
- Embedded and PC based software.

This specification defines levels of compliance for C-Bus devices, with a higher value being a more complete representation of standard C-Bus devices.

This document is written for Serial Interface version 4.0.00 and later. The differences for earlier releases are shown where applicable.

2 DEFINITIONS

The following terms, when used in this document, have the meanings shown below:

Application	A well-defined set of behaviours for one or more devices connected to a C-Bus network.
CAL	Common Application Language. The information sent in a C-Bus message for use by devices on the network. Normally used for device configuration and control, and network management.
Client Device	A device attached to C-Bus via a Serial Interface.
Concatenated Commands	A series of C-Bus commands within one C-Bus message.
MMI	Multi-point to Multi-point Information. A highly efficient status reporting technique used in C-Bus.
Network Variable	A network wide control variable maintained and/or controlled by C-Bus units. Within the Lighting Application, a Network Variable is called a Group Address Variable (GAV), and its value is called a Group Address Level.
SAL	Specific Application Language. The information sent in a C-Bus message for use by a specific application. Only the relevant application is capable of interpreting the information in the message.
Unit	Something attached to a C-Bus network.

3 DOCUMENT CONVENTIONS

Mandatory requirements include the word “shall”.

Desirable (optional) requirements include the word “should”.

Statements of what is required to achieve C-Bus Enabled compliance are shown in this document inside a box, thus:

Requirement statement

4 REFERENCED DOCUMENTS

Reference	Title	Summary / Purpose
CBUS-APP	C-Bus Application Messages & Behaviour	Description of the assigned C-Bus Application Addresses, the messages permitted for each Application, and Application behaviour. Multiple chapters, each separately issued and controlled.
CBUS-NET	C-Bus Device Control and Network Management	Description of the device control and network management messages permitted on C-Bus. Multiple chapters, each separately issued and controlled.
CBUS-SIUG	Serial Interface User Guide	Describes the operation and use of the C-Bus PC Interface.

5 SAFETY / LIFE SUPPORT POLICY

Clipsal Australia Pty Ltd does not support or recommend use of C-Bus as the primary means of communicating safety related information.

Notification of safety related information using C-Bus, as a secondary function, is acceptable provided the source of the information has some other means of alerting personnel to the safety related condition.

In this context, safety related information means any information, alarm, alert or similar which if not presented could result in a hazard to personnel.

6 SERIAL INTERFACE LIMITATIONS

6.1 Buffer Space and Long C-Bus Commands

The C-Bus Serial Interface (as used in the PCI Development Kit and the C-Bus SIM) contains a buffer used to construct information for transmission onto the bus.

This buffer will hold 21 bytes (21 character pairs). However, this buffer includes the inter-network routing information (the Network PCI). Therefore, the buffer space available for the C-Bus commands depends on the number of bytes used for the Network PCI.

The Network PCI has a length of between one byte, in case of a message intended for the local network, and up to eight bytes in case when message is intended for a network separated by six network bridges.

Therefore the space available for the commands will vary between 20 bytes in case of the local network down to 14 bytes in case of a the furthest sub-network.

No Application has commands greater than 14 bytes long. When transmitting Concatenated Commands, Applications shall pack as many commands as possible into the available buffer space.

6.2 Serial Interface Data Rate

The C-Bus Serial Interface can be run at data rates of between 300 bits/s and 9600 bits/s.

The C-Bus Serial Interface contains very limited buffering of C-Bus traffic destined for the RS-232 port.

As a consequence, the use of serial data rates less than 9600 bits/s is not recommended. Use of these lower rates could lead to occasional loss of information for devices that need to monitor C-Bus traffic.

6.3 Power Cycling and Compound Devices

A “compound device” is one which uses a C-Bus Serial Interface, and some other separate control processor, and where this control processor is powered from a non-C-Bus power source.

Great care is needed in the design of these compound devices, because each side of the C-Bus Serial Interface can separately have power applied and removed. It is important to design the compound device to ensure the C-Bus Serial Interface is correctly initialised when either C-Bus power is cycled, or when the control processor power is cycled.

This is further described in the C-Bus Serial Interface Users Guide (CBUS-SIUG).

The configuration / setup required for the C-Bus Enabled Levels, as shown in this document, ensures the C-Bus PCI will always restore the configuration settings if the C-Bus power is separately removed and re-applied.

6.4 Message Transmission Retries

Each of the C-Bus PCI, SIM and CNI devices perform retries in transmission. Up to 3 retries will be carried out by these devices after which the '#' confirmation character will be returned.

Note: It is unwise to layer additional retries over the top in the event that this failure is reported. When transmitting to an application address, it is possible that the transmit attempt will fail if there are no devices which want to accept such messages (this is possible when transmitting to any application, but more likely for the security, telephony, and date/time applications, especially on small networks).

In the event of a transmission to an application which fails (after too many retries), CIS recommend that transmission to that application be paused for a period, or until a message is received on that application address.

7 C-BUS ENABLED

"C-Bus Enabled" is an approach used by Clipsal Integrated Systems Pty Ltd to specify, test and certify that devices attached to a C-Bus network:

a. Comply with the network protocols;

b. Avoid excessive bus traffic; and

c. Have acceptable interoperability with other C-Bus devices.

The above objectives are achieved by specifying the interface requirements for C-Bus devices, and by specifying, for each application, the message traffic that may be sent over C-Bus. Finally, guidance is provided for the use of the C-Bus PC interface.

The documents and their relationships are shown in Figure 1.

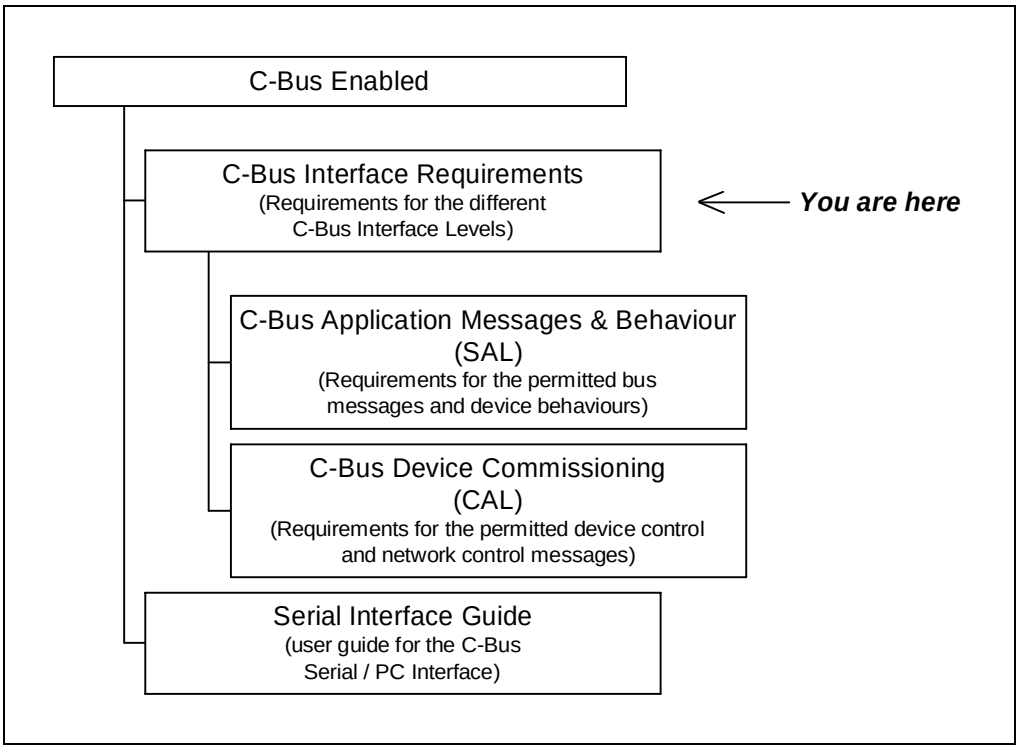

Figure 1 C-Bus Enabled Documents and Relationships

8 INTERFACE REQUIREMENTS

Client Devices attached to a C-Bus network shall comply with certain minimum requirements. To minimise the effort required to attach Client Devices to C-Bus, the requirements have been broken into a series of levels. The choice of an appropriate level will ensure that a reliable Client Device is designed and developed, without imposing excessive constraints.

8.1 Summary of Compliance Levels

The levels of compliance to the C-Bus Specification are summarised in Table 1 and Table 2. A full description is presented in sections 8.2 onwards.

Table 1 Capability by Compliance Level

	Level					
Capability	**1**	**2**	**3**	**4**	**5**	**6**
Transmit SAL	✓	✓	✓	✓	✓	✓
Receive SAL		✓	✓	✓	✓	✓
Receive device re-programming (CAL) messages		✓	✓	✓	✓	✓
Manipulate devices and perform network management functions (Transmit CAL)			✓	✓	✓	✓
Initiate C-Bus status messages (MMIs) and interpret responses			✓	✓	✓	✓
Internal model of network variables			✓	✓	✓	✓
Active maintenance of model of network variables				✓	✓	✓
Rules for determining and correcting discrepancies in a network				✓	✓	✓
Can monitor responses to C-Bus status messages (MMIs) initiated by other Units				✓	✓	✓
Can monitor device control and network management messages initiated by other Units				✓	✓	✓
Learn network variable relationships					✓	✓
Contribute status information to MMIs						✓

Table 2 Requirements Summary by Compliance Level

Level	Requirements Summary
1	Shall transmit C-Bus SAL messages (as appropriate to the Application) and wait for acknowledgment of the message. In applications where messages are not issued as a result of user input the messages shall be re-transmitted on failure. Shall support internetwork routing of messages across C-Bus bridges. Shall send Concatenated Commands to reduce network traffic if more than one command is to be sent in response to a single event (eg. Button Press, Timer Expiry). CAL commands shall not be used or supported in any form. MMI shall not be used or supported in any form.
2	Shall support all of Level 1, and also: Shall receive C-Bus SAL Commands (as appropriate) and act on them. Shall interpret Concatenated Commands. Shall interpret commands received across C-Bus bridges. CAL commands shall not be transmitted. CAL commands can be received for the purpose of setting up or programming a device. MMI shall not be used or supported in any form.
3	Shall support all of Level 2, and also: The device shall incorporate and maintain an internal model of the Network Variables it controls. The device shall determine Network Variable settings on power-up to synchronise its internal model with the C-Bus network. Transmission of CAL commands permitted (in addition to reception of CAL). MMI permitted.
4	Shall support all of Level 3, and also: Shall actively maintain Network Variables, by: a. monitoring SAL messages and (if required) generating periodic MMIs to determine Network Variable levels; and b. incorporating rules for the application to act on reported discrepancies between the internal model of Network Variables and the actual value of the Network Variables, making corrections where required.
5	Shall support all of Level 4, and also: Shall have and participate in a Learn function to establish new relationships between devices and Network Variables. (For lighting devices, participates in Learn Mode to establish or modify Group Address assignments.)

Level	Requirements Summary
6	Shall support all of Level 5, and also: Shall contribute status information to MMIs. Shall function as an output unit. *Note: This level cannot be achieved using the standard C-Bus Serial Interface.*
7+	Reserved for future use

8.2 Level 1 Interface Implementation Requirements

8.2.1 Purpose

A Level 1 Interface is a limited capability Transmit-only interface to C-Bus.

Level 1 Client Devices:

a. Transmit information into a C-Bus network, and await acknowledgment from the Serial Interface;

b. May transmit information across C-Bus bridges, if appropriate;

c. Have no ability to read or extract information from a C-Bus network;

d. Cannot perform device configuration, control or network management operations;

e. Cannot be programmed, configured or set up over C-Bus using CAL commands; and

f. Cannot transmit or receive MMI (status requests).

8.2.2 Applicability

Level 1 Client Devices **shall** meet the requirements of section 8.2 and its sub-sections.

[Note: These requirements ensure the highest possible reliability of transmission to C-Bus networks via the Serial Interface. It provides a positive confirmation mechanism for all outgoing messages.]

8.2.3 Interaction with C-Bus

Level 1 Client Devices **shall** transmit to Applications on C-Bus.

[Note: Level 1 Client Devices never receive any information from C-Bus, and never manipulate the configuration of Units or perform network management operations.

Commands sent to applications are Point to Multipoint, or Point to Point to Multipoint. The byte following the "\" of a Serial Interface transmission encodes the message type and priority. The least significant 3 bits encode the message type. These bits may only be "011" or "101". This means transmissions begin "\x3" or "\x5". The value of "x" is generally 0 but could be different for higher priority transmissions.]

8.2.4 Serial Interface Initialisation

Level 1 Client Devices **shall** ensure high reliability for communication between a Client Device and the C-Bus Serial Interface by using:

a. checksums for all information passed over the Serial Interface; and

b. use of a confirmation mechanism to report success / failure of message transmission on the C-Bus medium.

[Note: By default, the Serial Interface has checksum control enabled only in the incoming direction (from C-Bus).

Checksums are calculated over all bytes in a transmission, including the checksum byte, such that the sum (modulo 256) always equals 0.]

To ensure high reliability communication, Level 1 Client Devices **shall** set at least the following options as part of their initialisation, including after power failures:

- SMART mode: prevents echo of characters sent to the Interface, SAL messages will include complete source path information
- IDMON option: consistent data format for all communications
- SRCHK option: enable checksum for communications towards the Interface
- LOCAL_SAL option: enable SAL message to appear as if from a simple unit

This can be achieved using the following commands (Note all characters are in ASCII format)[1]:

```
~~~<cr>
@A3420002<cr>
@A3410058<cr>
@A3300058<cr>
```

[Note: The above commands reset the Serial Interface to Basic Mode, then activate the specific options. Following this mode-set command, all further transmission to the Serial Interface must include the checksum as two characters on the end of the transmission, just before the <CR>.

A NACK character ("!") will be sent from the Serial Interface if the checksum test fails, and the message will be ignored.

Messages that pass the checksum test are processed by the Serial Interface and transmitted to the C-Bus network.]

8.2.5 Confirmation of Transmission

Level 1 Client Devices **shall** include a request for confirmation with every transmission to the Serial Interface.

This **shall** be achieved by attaching a lower case ASCII character in the range 'g'-'z' (excludes lower case character in the range a-f that can be interpreted as hex numbers) to the end of every transmission to the Serial Interface.

For example:

```
\0538000121A1g<cr>
```

[Note: When the Serial Interface detects the lower case letter in the range 'g'-'z', it enters the SMART mode if it was not previously in this mode, proceeds to transmit the C-Bus command within the message. It then uses the lower case character supplied within the message to report the success or failure of the C-Bus transmission. The reply is only sent following a completion of the C-Bus transaction. So the mechanism can be used to time the transmissions based on the command-response pairing.

In case of the above command the response would be one of the following:

[1] This command format applies for C-Bus Serial Interface version 4.0.00 and later. Earlier versions need to drop the "@" symbol. The syntax for setting parameters of the Serial Interface is described fully in CBUS-SIUG.

g. success

g! failure: checksum failure

g# failure: too many re-transmissions

g$ failure: corruption in transmission

g% failure: no system clock]

Level 1 Client Devices **shall** analyse the response received from the Serial Interface following a transmission, and re-transmit as required up to three times following a failure.

Re-transmissions **shall** be separated by a minimum time delay of 0.250 seconds.

[Important Notes:

1. *The Serial Interface automatically re-transmits C-Bus messages which fail, up to a limit designed to minimise network congestion. The additional re-transmission is at the discretion of the Client Device connected to the Serial Interface.*
2. *It is not mandatory to re-transmit if the command is initiated by direct user input, for instance as a consequence of a key press.]*

8.2.6 Concatenated Commands

Level 1 Client Devices wishing to send multiple commands to a single application, in response to a single event, **shall** concatenate the multiple commands into a single C-Bus message up to the maximum length of the C-Bus message buffer, and send them in a single transmission.

[Note: An example might be sending Lighting commands to multiple Group Addresses in response to a single key press. In that case, as many commands as possible must be concatenated and sent as a single C-Bus transmission.

Refer to section 0 for limitations on the number of concatenated commands which can be sent at one time.]

8.2.7 Internetwork Routing

Level 1 Client Devices transmitting messages for delivery into the local C-Bus network **shall not** contain Network Routing information.

Level 1 Client Devices transmitting messages intended for delivery into a remote C-Bus network, via one or more C-Bus bridges, **shall** include an appropriate source routing stack in the Network PCI field.

8.3 Level 2 Interface Implementation Requirements

8.3.1 Purpose

A Level 2 Interface is a limited capability Transmit / Receive interface to C-Bus.

Level 2 Client Devices generally perform all functions of a Level 1 Client Device, with the following changes:

a. Receive SAL commands via the Serial Interface;

b. Act on received SAL commands;

c. Interpret Concatenated Commands;

d. Understand and decode commands received across C-Bus bridges;

e. Cannot perform device configuration, control or network management operations using CAL commands;

f. Can be programmed, configured or set up over C-Bus using CAL commands; and

g. Cannot transmit or receive MMI (status requests).

8.3.2 Applicability

Level 2 Client Devices **shall** meet the requirements of section 8.3 and its sub-sections.

8.3.3 Interaction with C-Bus

Level 2 Client Devices **shall** only

a. transmit to Applications on C-Bus; and

b. receive information from C-Bus.

[Note: Level 2 devices never manipulate the configuration of Units or perform network management operations. Refer to the Notes of section 8.2.3 for more details.

Level 2 device can receive SAL and CAL commands.]

8.3.4 Serial Interface Initialisation

Level 2 Client Devices **shall** ensure high reliability for communication between a Client Device and the C-Bus Serial Interface by using:

a. checksums for all information passed over the serial interface;

b. use of a confirmation mechanism to report success / failure of message transmission on the C-Bus medium; and

c. configuration of the Serial Interface for bi-directional communication.

[Note: By default, the Serial Interface has checksum control enabled only in the incoming direction (from C-Bus).]

To ensure high reliability communication, Level 2 Client Devices **shall** set at least the following options as part of their initialisation, including after power failures:

- SMART mode: prevents echo of characters sent to the Interface, SAL messages will include complete source path information
- CONNECT option: enable monitoring of specific application language (SAL) messages passed over the local C-Bus network
- IDMON option: consistent data format for all communications
- SRCHK option: enable checksum for communications towards the Interface
- LOCAL_SAL option: enable SAL message to appear as if from a simple unit

This can be achieved using the following commands (Note all characters are in ASCII format) [2]:

~~~<cr>
<insert any applicable filter settings here. See section 8.3.5>
@A3420002<cr>
@A3410059<cr>
@A3300059<cr>

[Note: The above commands reset the Serial Interface to Basic Mode, then activate the specific options. Following this mode-set command, all further transmission to the Serial Interface must include the checksum as two characters on the end of the transmission, just before the <CR>.

A NACK character ("!") will be sent from the Serial Interface if the checksum test fails, and the message will be ignored.

Messages that pass the checksum test are processed by the Serial Interface and transmitted to the C-Bus network.

The additional CONNECT configuration flag relays SAL messages on the local network to the serial port. By default the Interface will pass all SAL messages regardless of their application.]

8.3.5 Programming the Serial Interface to Filter SAL message traffic

Level 2 Client Devices **should** use the Serial Interface to filter C-Bus traffic to only those applications which are of interest, by programming the application numbers of interest into the Serial Interface filter parameters.

[The applications of interest can be selected by programming the two available application filter parameters $21 and $22. By setting parameter $21 to the value of $FF the filtering is disabled. In order to receive only commands on one application set parameter $21 to the application number. To add a second application, program its number into parameter $22.

If more than two applications are of interest, the Serial Interface should be programmed with parameter $21 set to $FF. All SAL messages will then be passed and the device will have to select those of interest to it.

[2] This command format applies for C-Bus Serial Interface version 4.0.00 and later. Earlier versions need to drop the "@" symbol. The syntax for setting parameters of the Serial Interface is described fully in CBUS-SIUG.
~~~

For example, the following command will select only the lighting application[3]:

@A3210038<cr>

In addition command:

@A3220088<cr>

selects the heating application as the second application.

Following the above two commands, only SAL commands intended for the lighting and heating applications are transmitted to the Serial Interface. These two filter settings must be programmed before the Serial Interface mode is changed. Refer to section 8.3.4.

Because the Serial Interface is reset to BASIC mode, the SRCHK option will be off, so checksums do no apply to the commands that select the filter settings.]

8.3.6 Confirmation of Transmission

Level 2 Client Devices **shall** include a request for confirmation with every transmission to the Serial Interface, and **shall** analyse responses and request re-transmission, as described in section 8.2.5.

8.3.7 Confirmation of Reception

Level 2 Client Devices **shall** validate the checksum of all information received from the Serial Interface.

Level 2 Client Devices **shall** discard any information received from the Serial Interface that has an invalid checksum.

[Note: The Client Device is responsible for correct processing of the received messages and can respond to some or all of the messages.

If the Client Device detects a checksum failure in information received from the Serial Interface, it should discard the information. Whilst it is possible to request a re-transmission from the Serial Interface, this is not encouraged.]

8.3.8 Concatenated Commands

Level 2 Client Devices **shall** transmit Concatenated Commands as described in section 8.2.6.

When a Level 2 Client Device receives a message containing Concatenated Commands, it **shall** process all commands in the message.

[Note: For this level of interface, it is not essential for the client device to maintain the states of C-Bus variables between the commands. However, it is mandatory that all relevant C-Bus commands are processed consistently and reliably.

Refer to section 0 for limitations on the length of Concatenated Commands.]

[3] This command format applies for C-Bus Serial Interface version 4.0.00 and later. Earlier versions need to drop the "@" symbol. The syntax for setting parameters of the Serial Interface is described fully in CBUS-SIUG.

8.3.9 Inter Network Routing

Level 2 Client Devices **shall** interpret the full C-Bus network path for every received C-Bus SAL message.

[Note: Refer to the Serial Interface Specification for details of the format of monitored SAL messages.

In general, the simplest way to determine the position of the first character pair of the SAL commands contained in the message is to calculate it as follows:

4 + (NPCI_Header AND 7) = number of character pairs to skip]

8.4 Level 3 Interface Implementation Requirements

8.4.1 Purpose

A Level 3 Interface is a flexible Transmit / Receive interface to C-Bus, with power up synchronisation between the network and its internal state model.

Level 3 Client Devices generally perform all functions of a Level 2 Client Device, with the following changes:

a. on power up only an MMI request is issued (either status or level as appropriate), to determine the setting of network variables of interest;

b. incorporates an internal model of the network variables of interest, and updates the model in response to its own actions (transmitting to C-Bus), and also in response to messages it monitors from other devices on C-Bus; and

c. transmission of device configuration, control and network management operations (CAL commands) are permitted.

8.4.2 Applicability

Level 3 Client Devices **shall** meet the requirements of section 8.4 and its sub-sections.

8.4.3 Interaction with C-Bus

Level 3 Client Devices **shall**

a. transmit to Applications on C-Bus;

b. receive information from C-Bus;

c. if required for their operation, transmit device control and network management (CAL) messages; and

d. If required for their operation, after power up transmit MMI status requests and receive and decode MMI status responses.

8.4.4 Serial Interface Initialisation and SAL message filtering

Level 3 Client Devices **shall** ensure high reliability for communication between a Client Device and the C-Bus Serial Interface by using the initialisation processes described in sections 8.3.4 and 8.3.5.

[Note: Minimum acceptable interface settings are LOCAL_SAL, IDMON, SMART, SRCHK & CONNECT. Filtering, if required, should be set as described in section 8.3.5.]

8.4.5 Confirmation of Reception and Transmission

Level 3 Client Devices **shall** confirm transmission and reception, as described in sections 8.3.6 and 8.3.7.

8.4.6 Concatenated Commands

Level 3 Client Devices **shall** transmit Concatenated Commands as described in section 8.2.6.

When a Level 3 Client Device receives a message containing Concatenated Commands, it **shall** process all commands in the message.

8.4.7 Inter Network Routing

Level 3 Client Devices **shall** receive and transmit message which include Inter Network routing, as described in section 8.3.9.

8.4.8 Network Variable Model

Level 3 Client Devices **shall,** as appropriate to their application, internally establish and maintain its own representation of the states of C-Bus Network Variables.

[Note: The process of establishing the initial variable states will depend on the type of C-Bus installation to which the client device is attached.

Level 3 devices may use techniques such as the MMI to initially establish its internal representation of Network Variables states.

Level 3 devices do not see or take any action due to MMIs initiated by other Units.

Following establishment of the states, Level 3 Client Devices monitor C-Bus network Application message traffic to keep the model up to date. They do not perform periodic re-establishment of states.

Specifically for Lighting, installations which consist only of units with the firmware version 1.1 or higher support a new status report mechanism called Level MMI, which can be used to quickly retrieve the network variable information from all units on the network.

C-Bus units prior to version 1.1 do not support the Level MMI so the process of establishing the initial states of the network variables is more complex. The procedure is based on modelling the C-Bus units in software. Contact CIS for more information.]

8.5 Level 4 Interface Implementation Requirements

8.5.1 Purpose

A Level 4 Interface is a flexible Transmit / Receive interface to C-Bus, with power up and periodic synchronisation between the network and its internal state model.

Level 4 Client Devices generally perform all functions of a Level 3 Client Device, with the following additions:

a. periodically interrogate the network to check the consistency between its internal state model and the reported Network Variables;

b. monitor the MMI status requests and status responses of other Units in the same application(s);

c. actively correct any discrepancies detected between its internal state model and the reported Network Variables.

8.5.2 Applicability

Level 4 Client Devices **shall** meet the requirements of section 8.5 and its sub-sections.

8.5.3 Interaction with C-Bus

Level 4 Client Devices **shall**

a. transmit to Applications on C-Bus;

b. receive information from C-Bus;

c. if required for their operation, transmit device control and network management (CAL) messages;

d. If required for their operation, periodically transmit MMI status requests; and

e. If required for their operation, receive and decode MMI status responses, either due to its own request or the request of other Units.

8.5.4 Serial Interface Initialisation and SAL message filtering

Level 4 Client Devices **shall** ensure high reliability for communication between a Client Device and the C-Bus Serial Interface by using:

a. checksums for all information passed over the serial interface;

b. use of a confirmation mechanism to report success / failure of message transmission on the C-Bus medium; and

c. configuration of the Serial Interface for bi-directional communication.

[Note: By default, the Serial Interface has checksum control enabled only in the incoming direction (from C-Bus).]

To ensure high reliability communication, Level 4 Client Devices **shall** set at least the following options as part of their initialisation, including after power failures:

- SMART mode: prevents echo of characters sent to the Interface, SAL messages will include complete source path information

- IDMON option: consistent data format for all communications
- SRCHK option: enable checksum for communications towards the Interface
- CONNECT option: enable monitoring of specific application language (SAL) messages passed over the local C-Bus network
- MONITOR option: enable monitoring of MMIs occurring on the local network
- LOCAL_SAL option: enable SAL message to appear as if from a simple unit
- EXSTAT option: extended format Status Replies

This can be achieved using the following commands (Note all characters are in ASCII format) [4]:

~~~<cr>
<insert any applicable filter settings here. See section 8.3.5>
@A342000A<cr>
@A3410079<cr>
@A3300079<cr>

[Note: The above commands reset the Serial Interface to Basic Mode, then activates the specific options. Following this mode-set command all further transmission to the Serial Interface must include the checksum as two characters, on the end of the transmission, just before the <CR>.

A NACK character ("!") will be sent from the Serial Interface if the checksum test fails, and the message will be ignored.

Messages that pass the checksum test are processed by the Serial Interface and transmitted to the C-Bus network.

At Level 4, the MONITOR configuration flag is used to enable passing of all C-Bus MMIs, irrespective of where they originated. This allows the Client Device to see MMI status reports initiated by other devices.

If Application filtering of SAL messages is required, see section 8.3.5.]

8.5.5 Confirmation of Reception and Transmission

Level 4 Client Devices **shall** confirm transmission and reception, as described in sections 8.3.6 and 8.3.7.

8.5.6 Concatenated Commands

Level 4 Client Devices **shall** transmit Concatenated Commands as described in section 8.2.6.

When a Level 4 Client Device receives a message containing Concatenated Commands, it **shall** process all commands in the message.

[4] This command format applies for C-Bus Serial Interface version 4.0.00 and later. Earlier versions need to drop the "@" symbol. The syntax for setting parameters of the Serial Interface is described fully in CBUS-SIUG.
~~~

8.5.7 Inter Network Routing

Level 4 Client Devices **shall** receive and transmit message which include Inter Network routing, as described in section 8.3.9.

8.5.8 Initial Network Variable Model

Level 4 Client Devices **shall,** as appropriate to their purpose, internally establish their own representation of the states of C-Bus Network Variables.

[Note: The process of establishing the initial variable states will depend on the type of C-Bus installation to which the client application is attached.

Level 4 devices may use techniques such as the MMI to initially establish an internal representation of Network Variable states.]

8.5.9 Network Variable Model Maintenance

Level 4 Client Devices **shall,** as appropriate to their purpose, actively maintain their representation of the states of C-Bus Network Variables.

[Note: The process of maintaining the variable states will depend on the type of C-Bus installation to which the client device is attached.

Level 4 devices may use techniques such as the MMI to periodically re-synchronise an internal model with the Network Variable states.

Level 4 devices also see MMIs initiated by other Units, and should use this information to compare the reported state information with their internal model.

Client Devices need to ensure that the internal model is only modified if 3 or more discrepancies in a row are detected between the internal model and the MMI reported status. (C-Bus MMIs are fast and efficient, but do not have any protocol error checking. Consequently, a single discrepancy could be due to a bus transmission error. Two discrepancies in a row does not allow a determination one way or the other of the correct state. Three discrepancies in a row indicates that there is a problem, and what the internal model should be changed to.)

Level 4 device may also issue CAL commands to devices to aid in maintaining their internal model.]

Level 4 Client Devices **shall** ensure that C-Bus status is requested no more often than once per 3 seconds, whether issued by itself or other devices on the same application.

---- Longer intervals are encouraged. ----

[Note: Where a Level 4 Client Device initiates periodic MMIs, it must do so no more frequently than specified. Other devices on the same application may also initiate MMIs. If the Level 4 device sees these MMIs, it must use the information supplied and postpone its own next scheduled MMI request.

This is easily achieved by running an MMI timer. When the timer expires an MMI is requested. If an MMI response is seen before the timer has expired, the timer is reset.]

Level 4 Client Devices **shall** correct Network Variable state information found to be incorrect.

Level 4 Client Devices **shall** arbitrate amongst themselves to determine which Unit interrogates the network to find state information.

[Note: C-Bus Lighting units perform arbitration by having one unit designated an MMI MASTER. This unit initiates the MMI requests. All other input units use the MMI response to check for discrepancies between their internal state record and the state reported in an MMI.

If the MMI MASTER fails for some reason, another unit will take over the function transparently.

A similar scheme is used for other application types. The defined Application Messages & Behaviours specify in more precise detail the behaviour required for C-Bus Applications.]

8.6 Level 5 Interface Implementation Requirements

8.6.1 Purpose

A Level 5 Interface is a flexible Transmit / Receive interface to C-Bus, with power up and periodic synchronisation between the network and its internal state model, as for Level 4, and adding support for built-in determination and allocation of the Network Variable relationships between units.

Level 5 is the highest level of integration with C-Bus networks possible using the C-Bus Serial Interface.

Level 5 Client Devices for the Lighting Application fully support C-Bus Learn Mode.

8.6.2 Applicability

Level 5 Client Devices **shall** meet the requirements of section 8.6 and its sub-sections.

8.6.3 Interaction with C-Bus

Level 5 Client Devices **shall** interact with C-Bus as described in section 8.5.3.

8.6.4 Serial Interface Initialisation and SAL message filtering

Level 5 Client Devices **shall** ensure high reliability for communication between a Client Device and the C-Bus Serial Interface by using the initialisation processes described in section 8.5.4.

8.6.5 Confirmation of Reception and Transmission

Level 5 Client Devices **shall** confirm transmission and reception, as described in sections 8.3.6 and 8.3.7.

8.6.6 Concatenated Commands

Level 5 Client Devices **shall** transmit Concatenated Commands as described in section 8.2.6.

When a Level 5 Client Device receives a message containing Concatenated Commands, it **shall** process all commands in the message.

8.6.7 Inter Network Routing

Level 5 Client Devices **shall** receive and transmit message which include Inter Network routing, as described in section 8.3.9.

8.6.8 Initial Network Variable Model

Level 5 Client Devices **shall** establish an initial network variable model as described in section 8.5.8.

8.6.9 Network Variable Model Maintenance

Level 5 Client Devices **shall** maintain their network variable model as described in section 8.5.9.

8.6.10 Network Variable Relationships

Level 5 Client Devices **shall** include a facility to determine or participate in the determination of the relationships between Network Variables.

Level 5 Client Devices operating in the C-Bus Lighting Application **shall** participate in the C-Bus 2 Learn Mode.

[Note: Level 5 devices which are not in the Lighting Application include support for a technique similar to C-Bus 2 Learn Mode: this allows the devices to automatically allocate and link Network Variables (Group Addresses) between units.

Where commands have been defined in "C-Bus Application Messages and Behaviour", the client devices must honour those commands. This particularly applies to support for the C-Bus 2 Lighting Application Learn Mode.

Applications not defined or specified by Clipsal Integrated Systems Pty Ltd support similar behaviour.]

8.7 Level 6 Interface Implementation Requirements

8.7.1 Purpose

Level 6 devices can report their state in response to a C-Bus MMI request.

Level 6 devices are typically used for C-Bus output units, receiving messages from the bus, acting upon those messages, and reporting their state in response to an MMI request.

In addition to responding to MMI, a Level 6 device ***optionally*** supports some or all of the capabilities of a Level 5 device.

Level 6 devices can only be constructed using the C-Bus core, which is not presently released to third parties.

At the time of writing, there are no plans for further description of Level 6 interfaces.