

C-BUS MODULE INTERFACE SPECIFICATION

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CHANGE HISTORY

Date	Doc Issue	Comments
20 Aug 02	1	Added Master Security functions / events. Removed the Mode parameter from lighting commands.
20 Aug 02	2	Changed zone number definition.
27 Sep 02	3	Added Scope section. Corrected description of event handling. Added details of network path handling. Added Get Last Source Network Index Function. Added example of making the system non-volatile. Added details of the cbus_time_delay function. Added details of ramp rates. Added CAL Response Function. Added PCI Voltage measurement command and event. Changed formatting.
30 Sep 02	4	Changed cbus_vf_initialise to cbus_bf_initialise. Added details of C-Bus Module memory usage. Added details of how to handle serial transmit characters.
28 Jan 03	5	Corrected names for C-Bus voltage measurement. Added new reason codes for telephony application.
4 Feb 2003	6	Added more information about using CAL commands to program a C-Bus Device. CAL Programming Event Handler has been replaced by CAL Generic Write handler and CAL Generic Read handler. CAL Write Event handlers changed to return a cbus_boolean result. CAL Read Event handlers changed to return a cbus_boolean result and also to pass the read data back via a parameter. Added more details about C-Bus Module customisation. Changed Security commands and event handlers to support new specification for: Tamper, Panic, Low Battery, Arm System. Added new commands and event handlers: Mains Failure, Arm Read/Not Ready, Current Alarm Type.
12 June 03	7	Added new Security messages. Replaced some enumerated types with cbus_boolean. Combined the command, event handler and set/get status functions for Alarm, Panic, Tamper, Low Battery, Mains Failure, Line Cut, Arm Failed, Fire Alarm, Gas Alarm, Other Alarm. Removed Current Alarm Type message. Changed enumerated type naming to avoid problems with name re-use. Added some example code.
3 Sep 03	8	Added cbus_lighting_vf_clear_groups function. Added cbus_lighting_vf_initiate_MMI function. Corrected cbus_lighting_vf_register_event_handler definition.

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18 Dec 03	9	The following definitions have been changed due to name space conflicts with C++ compilers : boolean → cbus_boolean true → cbus_true false → cbus_false CBUS_TIME → CBUS_CBUS_TIME Added Network Discovery Functions. Added delay call-back function. Added Last Source Unit Address function
23 Feb 04	10	Removed cbus_security_vf_status_1_request and cbus_security_vf_status_2_request and replaced with cbus_security_vf_status_request. Fixed cbus_lighting_if_app_index function call name.
6 Apr 04	11	Added error reporting functions and codes
16 Apr 04	12	Changed C-Bus transmission failure event handler
19 Apr 04	13	Recovered lost document sections. Added to discovery process.
14 May 04	14	Adding/changing PCI initialisation functions Removed reference to redundant delay functions.
29 June 04	15	Corrected error reporting and added transmission failure/success reporting.
9 July 04	16	Changed types (eg. byte to int8u)
3 Dec 04	3.0	Re-written for C-Bus Module version 3. Added indicator kill and labelling.
20 Jan 05	3.1	Added flavours for lighting labels
14 Feb 05	3.2	Update for release 3.1. Add queue management. Corrects defects: 4123 - Level MMI reports wrong levels. 4260 - some things declared as "byte", and numerous compiler warnings on some platforms. 4333 - Database change event handler should not report target of a ramp. 4390 - Timeout needs to be increased (in heavy traffic conditions for small embedded systems). 4406 - Generic event handler only called sporadically.
3 May 05	3.3	Add explanatory definitions
15 May 05	3.4	Correct typos, add error and air conditioning.
1 Aug 05	3.5	Add error report when C-Bus is disconnected (see section 10.2.6).
15 Aug 05	3.6	Add set preferred language events
22 Aug 05	3.7	Update HVAC set plant level and error api's
30 Aug 05	3.8	Updated HVAC TYPES to a new and more complete set.
3 Nov 06	3.9	Add APIs for clock & burden control. Add API for getting serial number as a string. Add API for setting the ramp to 0 mode. Numerous corrections to Air-Conditioning API's.

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C-Bus Module Interface Specification

1 PURPOSE

This document is to define the Application Program Interfaces (API) to the C-Bus Module.

APIs are sorted by their applicable C-Bus Application, except universal APIs that are listed separately.

A section at the end of the document describes how to use the APIs for particular purposes.

2 SCOPE

This document applies to version 3 of the C-Bus Module. This document does not repeat the principles of operation for C-Bus Applications, as described in the separate protocol documents.

3 INTRODUCTION

The C-Bus Module provides a portable, scalable interface between embedded systems and C-Bus, and is used by Clipsal Integrated Systems any many released products

The C-Bus Module complies with the requirements for C-Bus Enabled, at levels 1, 2, 3 or 4 (see section 21.1.1).

At the time of writing, the C-Bus Module has been ported to at least the following processors:

- . Hitachi H8S and H8/300 (with Hitachi HEW)
- . Texas Instruments MSP430 (with IAR EW430 and GCC/MSP430)
- . Atmel AVR (With WinAVR)
- . ARM7 (With IAR EWARM and GCC)
- . Intel x86 PC / Windows (with Borland C / C++ Builder and Microsoft VC++)
- . Intel x86 PC / Linux (with GCC 3.3.2)

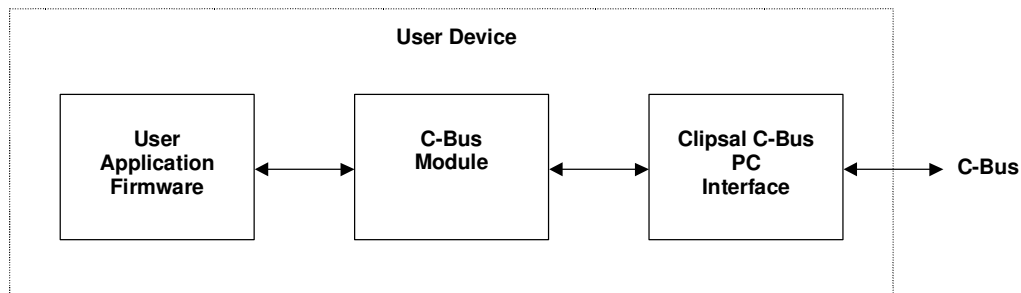
Porting is aided by careful definition of all data types, and careful adherence to the specified API. All procedures are encapsulated and have a defined C code interface.

The C-Bus Module has been designed for use in embedded systems, communicating with C-Bus via a C-Bus PC Interface as shown below. The C-Bus Module provides a programmer-friendly interface between the users Application Firmware and the C-Bus PC Interface.

For PC / Windows, a DLL allows the APIs to be called from numerous other programming languages.

For PC / Linux, an object archive allows the code to be statically linked into programs in any language that uses the standard linker.

C-Bus Module Interface Specification

**4 DEFINITIONS**

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

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.
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.

C-Bus Module Interface Specification

5 PRINCIPLES OF OPERATION

5.1 C-Bus Communication Mechanism

The C-Bus Module forms an interface to C-Bus using two queues – a transmit queue and a receive queue. This enables the low-level communication routines to be very short and fast. Time-consuming processing occurs at the higher levels in the software.

To send a C-Bus message, the appropriate function call is used. This generates the appropriate C-Bus message and places it into the transmit queue. When any previous messages have been sent successfully (or the number of retries has been exceeded), then the new message is sent.

As data is received, complete messages are placed onto a receive queue. These are processed in order as time allows.

Direct user software access to the queues is not necessary or encouraged.

5.2 Processing of Received Messages

C-Bus messages can arrive at any time. These messages are accumulated and periodically processed by the C-Bus Module. As the messages are decoded, an **event handler** is called.

Each event handler needs to have been registered before the decoded C-Bus messages can be passed to the user application firmware.

If a C-Bus message arrives for which an event handler has not been registered, then that C-Bus message will be discarded.

5.3 Models and Updates

When configured for C-Bus Enabled Level 4, the C-Bus Module builds an internal model of the state of each group in its registered Lighting Applications, and tracks all ramp operations. When used for Level 4 interfacing, the C-Bus Module **must** have its update function called at well-defined intervals.

Irrespective of the C-Bus Enabled Level with which the C-Bus Module is used, the update function needs to be called regularly to ensure normal operation.

C-Bus Module Interface Specification**6 EVENT HANDLERS**

Event Handlers may be registered for a range of C-Bus events as described in the following sections.

Where there is more than one relevant event handler for a particular C-Bus event, there are two alternatives for how the event handlers will be called:

- a. Default Mode – every relevant event handler for a particular event will be executed. They will be executed in order from the most specific to the most general; or
- b. Prioritised Mode – only the most specific of the registered event handlers for a particular event will be executed.

The mode is set using the `cbus_vf_set_prioritised_event_mode` function (see section 10.6.1).

The hierarchy / priority of the event handlers is shown below:

C-Bus Event	Applicable Event Handlers		
	⇐ More General	More Specific ⇒	
Any	Generic		
CAL	Generic	CAL Generic Programming	CAL Response CAL Generic Write CAL Generic Read CAL Write CAL Read
Lighting	Generic	Lighting	
Trigger Control	Generic	Trigger Control	
Enable Control	Generic	Enable Control	
Air Conditioning	Generic	Air Conditioning	
Error	Generic	Error	
Measurement	Generic	Measurement	
Security	Generic	Security	
Telephony	Generic	Telephony	
Time	Generic	Time	

C-Bus Module Interface Specification

For example, if the CAL Write and CAL Generic Programming Event Handlers are registered and a CAL Write event is received, how the event is handled depends on the mode:

- If the C-Bus Module is in Default Mode, both event handlers will be called.
- If Prioritised Mode is set, only the CAL Write Event Handler will be called.

In the above example, if the CAL Read event handler is not registered and a CAL Read event is received, then the CAL Generic Programming Event Handler will be called.

6.1 Data Scope / Validity in Event Handlers

Data that is passed to an event handler is only valid during the life of that event handler.

If a parameter is passed which the user needs to use at a later time (for example a character string), the event handler must copy it elsewhere.

6.2 Event Handler Duration

When an event handler is called, all other processing is suspended.
An event handler must complete and return control as quickly as possible.

C-Bus Module Interface Specification

7 NETWORKS

Section 10.11 provides further details about registering networks.

The C-Bus Module stores registered networks in an array, with a size set in the `cbus_config.h` file by the constant `CBUS_MAX_NETWORK_COUNT + 1`. The last element in the networks table is used when a message is received from an unregistered network.

When a message is received, the source network path is extracted and compared with the registered networks. The index is stored and can be obtained using the function `cbus_if_get_last_source_network_index` (see section 10.12).

If a reply needs to be sent to the source network, this function can be used to retrieve the index of the path to the network.

This approach means that networks only need to be registered once, at initialisation time. Thereafter, all references to networks are by an index into the network table, rather than by direct inclusion of a network route.

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8 RETRIES

Almost all function calls to the C-Bus Module allow specification of a number of retries.

Generally, this should be set to 0 (no retries). If a C-Bus network is not reliable and needs a higher number of retries, it usually indicates one of the following problems:

- a. Too many or too few network burdens;
- b. Insufficient voltage at some devices in the network;
- c. Too many devices attached to a single network segment;
- d. Poor wiring connections;
- e. Interference from other electrical devices or wiring - possibly caused by placing C-Bus wiring too close to other wiring.

Use of a number of retries greater than 3 is strongly discouraged.

Any network needing 3 or more retries has other serious defects that should be rectified.

C-Bus Module Interface Specification

9 QUICKSTART GUIDE

There is no excuse!

Read this whole document thoroughly and get a good understanding!

Not willing to do that? This quickstart guide should give enough information about the really important points.

9.1.1 Customisation¹

Take the following steps to customise the C-Bus Module for your use and minimise the memory usage:

- If only the lighting application(s) are needed, modify `cbus_config.h` to remove all of the other application definitions.
- Set the maximum number of networks that will be needed (10 by default) in `cbus_config.h`.
- Set the maximum number of lighting applications that will be needed (10 by default) in `cbus_config.h`.
- Set the maximum number of Group Addresses that will be needed (256 by default) per Application in `cbus_config.h`.
- Set the size of the C-Bus Command and Receive Buffers (not the length of the items, just the number of items that are stored in each buffer) in `cbus_config.h`.

9.1.2 Initialisation - suitable for Lighting Message Processing

To initialise the C-Bus Module:

- Register any networks of interest using `cbus_bf_register_network_path`.
- Register any Application Addresses of interest using `cbus_lighting_bf_register_app`.
- If you have less than 256 Group Addresses per Application, then register the Group Addresses of interest using `cbus_lighting_bf_register_group`.
- Register your C-Bus PCI Serial data transmission handler using `cbus_vf_register_serial_transmit_handler`.
- Register a Lighting Event Handler using `cbus_lighting_vf_register_event_handler`.
- If you are interested in being notified that the database has changed (for example, to store the data to non-volatile memory), register an event handler using `cbus_lighting_vf_register_database_event_handler`.

¹ Customisation is not applicable for pre-compiled Windows and Linux versions.

C-Bus Module Interface Specification

- If you want to be notified that there was an MMI discrepancy (which will cause the database to be updated automatically), register an event handler using `cbus_lighting_vf_register_MMI_event_handler`.
- Enable the transmission and reception of data from the PC Interface.
- Call `cbus_bf_initialise`.
- Wait for the state returned by `cbus_ef_get_connect_state` to change to `cbus_ce_module_normal_operation`. Use a timeout. An even better approach is to register a connect event handler, which will raise an event when a successful connection is made, or when it has been determined that a connection cannot be made.
- If any Group Address levels have been stored in non-volatile memory, restore the levels by setting them with `cbus_lighting_vf_set_database_level`.

9.1.3 Sending Commands

To send a lighting command, use `cbus_lighting_vf_set_level`.

The timer functions in section 14.4 can be used to set a Group Address to a level with a timer on it.

9.1.4 Acting on Commands

The registered event handler is called each time a Group Address changes. If the database Change Event Handler or the MMI Event Handler is registered, they will also be called as required.

9.1.5 Where next....

Read the rest of this document!

C-Bus Module Interface Specification

10 GENERAL FUNCTIONS

The following functions are not associated with any particular C-Bus Application.

10.1 Maintenance Functions

10.1.1 C-Bus Module Initialisation

```
cbus_boolean cbus_bf_initialise(void);
```

This function performs the following operations:

- Initialises the C-Bus Database;
- Initialises the C-Bus Transmit and Receive queues;
- Prepares for a connection to the C-Bus PCI.

This function always returns `cbus_true`.

***This function must always be called before any other C-Bus Module function.
If the C-Bus Module is shut down for any reason, this function must be called before re-starting.***

***²If CBUS_FILTER_APPLICATIONS is not defined, the Primary Application of the PCI will be reset to \$FF to ensure SAL messages on all applications are accepted.
If CBUS_FILTER_APPLICATIONS is defined, Primary and Secondary Applications will be loaded from the PCI and made available.***

10.1.2 Update

The update service must be executed on a regular basis (every 5ms to 200ms depending on the build configuration). The update service performs the following operations:

- Starts and initialises the connection to the C-Bus PCI, if required (see section 10.1.1);
- Updates all internal functions, process, databases and models;
- Updates any timers, each second (if a timer expires, the appropriate timeout action is performed);
- Sends messages in the transmit queue to C-Bus; and
- Processes messages from the receive queue.

² Not applicable for Windows and Linux versions.

C-Bus Module Interface Specification

The transmit and receive actions are performed either on every update call, or every alternate update call depending on the build configuration.

The update function has the interface:

```
cbus_et_module_state cbus_ef_update(void);
```

The function result is the enumerated type `cbus_et_module_state`. The following valid states can be returned:

State	Meaning
<code>cbus_ce_module_not_initialised</code>	The C-Bus module has not yet been (or completed) initialisation
<code>cbus_ce_module_pci_reset</code>	The C-Bus Module has reset the PCI as part of the initialisation process
<code>cbus_ce_module_pci_setup</code>	The C-Bus Module is setting up the PCI as part of the initialisation process
<code>cbus_ce_module_normal_operation</code>	The C-Bus Module is operating normally
<code>cbus_ce_module_initialise_fail</code>	The C-Bus Module failed to initialise the C-Bus PCI, normal operation is not possible
<code>cbus_ce_module_pci_properties_changing</code>	The C-Bus module is in the process of changing the properties of the PCI to which it is attached
<code>cbus_ce_module_ping_fail</code>	The C-Bus Module has detected that the connection to the C-Bus PCI has been broken, and it is no longer able to operate normally.

Important note: Transmission should not be attempted until the update function (or the function `cbus_ef_get_connect_state`) returns `cbus_ce_module_normal_operation`.

If transmission is attempted before this state is returned, information sent using transmit requests could be discarded.

10.1.3 Get C-Bus Module Update / Connect State

```
cbus_et_module_state cbus_ef_get_connect_state(void);
```

This function returns the current C-Bus Module operation / connection state. This state is exactly the same state that is returned by the update function described in section 10.1.1, with the same return values.

If the C-Bus Module is shut down for any reason, the values returned by this function are meaningless.

C-Bus Module Interface Specification

10.1.4 Register a C-Bus Connect Handler

```
void cbus_vf_register_connect_handler(  
    void (*f)(cbus_et_connect_result));
```

Calling this function registers a connect handler.

The connect handler will be called when the C-Bus Module has made (or failed) a connection to C-Bus.

The registered function shall be of the form:

```
void my_event_handler(cbus_et_connect_result);
```

The function is passed the enumerated type `cbus_et_connect_result`. The following valid results can be passed:

Result	Meaning
<code>cbus_ce_connect_failed_no_pci</code>	Connection failed, it appears there is no C-Bus PCI present
<code>cbus_ce_connect_failed_invalid_pci_reply</code>	Connection failed, an unexpected reply was obtained from a C-Bus PCI
<code>cbus_ce_connect_ok</code>	Normal connection was successfully achieved

C-Bus Module Interface Specification

10.2 Error Reporting And Handling

Some functions will set an error code when an invalid operation is requested. The code may be inspected or an error handler may be activated to process these errors.

There is also a mechanism to report transmission failures or success.

10.2.1 Get The Last Error Code

```
int8u cbus_if_get_last_error(void);
```

This function returns the last error code. The error code returned exists until it is overwritten by another error code with a later C-Bus Module function call.

Possible error codes are:

Symbolic Error Name	Code	Description
CBM_SUCCESS	0	No error.
CBM_CMDSTR_TOO_LONG	1	C-Bus command was too long. The command must be less than CBUS_COMMAND_STRING_LENGTH.
CBM_STRING_TOO_LONG	2	The length of the string passed as a parameter was too long.
CBM_TOO_MANY_NETWORKS	3	An attempt to register a network has failed as the space allocated for networks is used up.
CBM_CMD_TOO_LONG	4	An attempt to add a c-bus command to the output queue has failed as the command was too long.
CBM_TOO_MANY_APPLICATIONS	5	An attempt to register another application has failed as there is no more space for applications.
CBM_APPLICATION_NOT_FOUND	6	A C-bus command has failed as the requested application is not registered.
CBM_GRP_EQ_255	7	A group number of 255 is not valid for the requested operation.
CBM_BAD_PCI_VERSION	8	The requested operation requires a higher PCI version.
CBM_GROUP_NOT_FOUND	9	The requested group has not been registered in the database.
CBM_TOO_MANY_GROUPS	10	An attempt to register more groups than the available space allocated.
CBM_INIT_FAILED	11	Connection to the PCI failed.

C-Bus Module Interface Specification

10.2.2 Set The Last Error Code

```
void cbus_vf_set_last_error(int8u error);
```

This sets the C-Bus Module error code, and calls any registered error handler. This can be used to propagate errors back to user code.

10.2.3 Register an Error Handler

```
void cbus_vf_register_error_handler(void (*f)(int8u));
```

This registers an event handler for error reporting. When an error occurs, the registered handler will be called. The parameter passed is the error code.

The registered function shall be of the form:

```
void my_event_handler(int8u number);
```

10.2.4 Register a Transmit Successful Handler

```
void cbus_vf_register_tx_succeed_handler(
    void (*f)(int8u, int8u));
```

This registers a function to be called when transmission succeeds. The registered function shall be of the form:

```
void my_event_handler(int8u Unit_App,
    int8u Msg_Type);
```

10.2.5 Register a Transmit Failure Handler

```
void cbus_vf_register_failure_handler(void (*f)(int8u,
    int8u,
    int8u));
```

In the event of a transmission failure, the handler will be called. The registered function shall be of the form:

```
void my_event_handler(int8u tx_fail_code,
    int8u unit_app,
    int8u msg_type);
```

unit_app is either the unit number or the application number, depending on the message type.

tx_fail_code is one of:

Transmission Error Symbolic Name	Value	Description
<code>cbus_ce_tx_no_acknowledge</code>	0	The message transmitted to the Serial Interface with the matching Alpha was not transmitted into the local C-Bus network, due to too many re-transmissions with no acknowledgment.

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Transmission Error Symbolic Name	Value	Description
<code>cbus_ce_tx_checksum_bad</code>	1	The message transmitted to the Serial Interface with the matching Alpha was not transmitted into the local C-Bus network, due to corruption in transmission.
<code>C-Bus_ce_tx_no_clock</code>	2	The message transmitted to the Serial Interface with the matching Alpha was not transmitted into the local C-Bus network, due to Serial Interface losing C-Bus synchronising clock at any time during an attempted C-Bus transmission.
<code>cbus_ce_tx_buffer_overflow</code>	3	The PCI could not accept the data (eg too much data or checksum error).
<code>cbus_ce_tx_timeout</code>	4	There was no response in the required time.
<code>cbus_ce_tx_application_offline</code>	5	The application has been taken offline because a series of transmissions to it have failed.
<code>cbus_ce_tx_unknown_error</code>	255	Undetermined problem.

`msg_type` is one of:

Message Type Symbolic Name	Value	Description
<code>cbus_ce_mt_bridged</code>	0	Destination was a bridge.
<code>cbus_ce_mt_sal</code>	1	SAL message.
<code>cbus_ce_mt_cal</code>	2	CAL message.
<code>cbus_ce_mt_cbus_test</code>	3	An internal test was being used to test that the PCI is connected.
<code>cbus_ce_mt_unknown</code>	255	Unknown message type.

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10.2.6 Detecting that the C-Bus PCI has been disconnected

The C-Bus Module periodically checks that the C-Bus PCI is still connected. This check is made every 4 seconds, during idle periods.

If the C-Bus Module discovers that the PCI has been disconnected, it will:

- a. activate the transmit failure event handler, with a transmit fail code of `cbus_ce_tx_timeout`, and a message type of `cbus_ce_mt_cbus_test`; and
- b. change the operating mode so that future updates will not do anything, and calls to `cbus_ef_update` will return `cbus_ce_module_ping_fail`.

After detecting that the C-Bus PCI has been disconnected, the user of the C-Bus Module should wait a reasonable period (suggest 1 minute), before attempting to reconnect.

Reconnection should be made by:

- a. calling `cbus_bf_initialise`; and then
- b. waiting for a connection event, or until `cbus_ef_update` returns `cbus_ce_module_normal_operation`.

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10.3 Queue Management

In some high traffic conditions, the receive and transmit queues can be manually processed (instead of, or as well as) automatically processed.

10.3.1 Process Receive Queue

```
void cbus_vf_process_receive_queue(void);
```

If anything is waiting in the receive queue (from C-Bus), it will be processed by the appropriate application, including calling back any event handlers if required.

This is not normally needed - automatic queue processing (during the update cycle) is normally sufficient

10.3.2 Process Transmit Queue

```
void cbus_vf_process_transmit_queue(void);
```

If anything is waiting in the transmit queue (to go to C-Bus), it will be transmitted if the C-Bus PCI is available.

This is not normally needed - automatic queue processing (during the update cycle) is normally sufficient

10.3.3 Enable / Disable Processing of C-Bus Input

```
void cbus_vf_stop_ip_processing(cbush_boolean);
```

If the parameter is `cbus_true`, then input received from C-Bus will be discarded.

If the parameter is `cbus_false`, then input received from C-Bus is queued for processing.

Normally, the only reason for disabling input from C-Bus is because the input *and* output queues fill, leading to messages sent to C-Bus being lost.

In this case, it is preferable to ensure that output messages are transmitted, to choke off input messages until the output queues are sufficiently emptied.

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10.3.4 Register a Handler For Notification of Output Queue Condition

```
cbus_vf_register_tx_queue_flow_ctl_handler(  
    void (*f)(cbus_et_flow_type));
```

When the output queue is either very full, or very empty, the registered event handler will be called. The registered function shall be of the form:

```
void my_event_handler(cbus_et_flow_type e_flow_type);
```

`e_flow_type` is one of:

Flow Control Symbolic Name	Value	Description
<code>cbus_ce_flow_lo</code>	2	The output queue has dropped below the low size threshold.
<code>cbus_ce_flow_hi</code>	3	The output queue has filled above the high size threshold.

C-Bus Module Interface Specification

10.4 Generic Send Message Functions**10.4.1 General Purpose Send**

```
void cbus_vf_send_command(char * s,  
                          int8u retries);
```

This sends a given C-Bus message string through the PC Interface with a given number of retries. The C-Bus Module does no interpretation or other processing of the message.

On success the C-bus error code is `CBM_SUCCESS`. If the message string `s` is too long the C-bus error code is set to `CBM_CMDSTR_TOO_LONG`.

This function should not be required, because functions are provided for sending all defined C-Bus message types.

10.4.2 SAL Messages

```
void cbus_vf_send_SAL_command(int8u network,  
                              int8u application,  
                              char *command,  
                              int8u retries);
```

This builds and sends a C-Bus SAL command. The C-Bus Module incorporates the header, network and application then appends the command.

The C-Bus Module may append this command to the previous command if:

1. The network and application match;
2. The previous command has not been sent;
3. There is still room at the end of the previous message buffer;
4. The previous command was not a Label command; and
5. There is more than one item in the queue OR there is one item in the queue and it has not been sent.

If the command can not be appended, a new message will be created in the output queue.

The `command` parameter is a null terminated string that does not include any C-Bus header (\05), Application Address or Network Route. If the `command` parameter is too long the function will fail and set the error code to `CBM_CMD_TOO_LONG`.

This function should not be required, since functions are provided for sending all defined C-Bus message types.

If several commands are concatenated, the number of retries used will be the greater of the retries for each of the commands sent.

C-Bus Module Interface Specification

10.5 Other Functions

The following functions are for general-purpose use.

10.5.1 Percent to Decimal Conversion

C-Bus uses a non-trivial method to convert between decimal level values and percentage levels. These conversion functions are provided as a convenience. These conversions are generally used for the C-Bus Lighting Application.

```
int8u cbus_if_dec_to_percent(int8u n);
```

This converts from a decimal value (0-255) to a percentage (0-100).

```
int8u cbus_if_percent_to_dec(int8u n);
```

This converts from a percentage (0-100) to a decimal value (0-255).

10.5.2 Is This A Lighting Application?

```
cbus_boolean cbus_bf_is_application_lighting(int8u app);
```

Returns whether an application number is a C-Bus Lighting Application (Generally, in the range \$30 - \$5F).

10.5.3 Process SAL Command Events

```
void cbus_vf_process_SAL_commands(cbush_boolean state);
```

When the device is being programmed, or during start-up, it may be desirable to disable the processing of SAL commands and C-Bus MMIs.

Use this function to enable or disable processing of SAL and MMI commands.

10.5.4 Get Application

```
int8u cbus_if_get_application(int8u i_index)
```

This returns the application at *i_index* of the available applications list.

Use this functions to retrieve the Primary and Secondary Applications of the PCI if CBUS_FILTER_APPLICATIONS is defined.

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10.6 Event Handling

Every 5 - 200ms (depending on the configuration), the message(s) at the top of the C-Bus receive queue are processed. The Application number will determine what happens to the message.

For each C-Bus Application, a set of procedures will process the message, and then call an event handler for that Application and message type. Each event handler needs to be registered. If there is no registered event handler for a particular message, then nothing is done. Finally, the generic event handler is called.

The same mechanism is used to respond to any changes made to Network Variables via other function calls. Hence if a function call is made which changes something in the C-Bus model, the event handler will be called.

10.6.1 Prioritised Event Mode

```
void cbus_vf_set_prioritised_event_mode(cbus_boolean prioritised);
```

Use this function to control how events are handled when there is more than one relevant handler.

If `prioritised` is `cbus_true`, then only the most specific of the relevant handlers will be called. If `cbus_false`, then all relevant handlers will be called.

10.6.2 Generic Event Handler

```
void cbus_vf_register_handler(void (*f)(int8u *,  
                                     int8u));
```

Use this function to register the generic event handler. A generic event handler will only be called if it has been registered. The event handler is passed the received C-Bus message as an array of bytes, and the length of the message.

The registered function shall be of the form:

```
void my_event_handler(int8u *message,  
                     int8u message_length);
```

Use of the generic event handler is strongly discouraged.

Such use requires a detailed knowledge of the C-Bus protocol, which should not be necessary when using the facilities of the C-Bus Module.

10.6.3 Continue Processing

```
void cbus_vf_register_continue_processing_call_back(  
    cbus_boolean (*f)(void));
```

Processing of received C-Bus commands may take some time, depending on what the user does in the event handlers.

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A call-back function can be registered so that at the end of processing each command, the user application is asked whether or not continue with processing more commands. This is done to avoid the situation where processing the whole queue may take more time than is allocated for some task.

If no event handler is registered, processing will continue until the receive queue is empty. The registered function shall be of the form:

```
cbus_boolean my_event_handler(void) ;
```

The call back function shall return **cbus_true** or **cbus_false**, depending on whether it wants processing of received commands to continue or not.

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10.7 C-Bus PC Interface Properties

The following functions return details of the PCI being used to make the connection to the C-Bus network.

10.7.1 Get PCI Firmware Version

```
char *cbus_cf_get_PCI_version(void);
```

This returns a pointer to a null terminated string containing the PCI firmware version, as ASCII coded text. The result will be a maximum of 17 characters (including the null terminator).

10.7.2 Get PCI Unit Address

```
int8u cbus_if_get_PCI_unit_address(void);
```

This returns the Unit Address of the C-Bus PCI.

10.7.3 Get PCI Serial Number

```
int32u cbus_if_get_PCI_serial_number(void);
```

This returns the Serial Number of the C-Bus PCI as an unsigned 32 bit integer.

10.7.4 Get PCI Serial Number as a String

```
char *cbus_pf_get_PCI_serial_string(void);
```

Returns a pointer to a null terminated string containing the Serial Number of the attached PCI, in the CIS preferred string format.

10.7.5 Start Measurement of PCI Voltage

```
void cbus_vf_measure_PCI_voltage(void);
```

This initiates a measurement of the C-Bus voltage at the attached PCI. When the voltage measurement has been returned from the PCI, a Voltage Measurement Event will be raised. The Voltage will then be able to be read using the `cbus_cf_get_PCI_voltage` function.

10.7.6 Get PCI Voltage

```
char *cbus_cf_get_PCI_voltage(void);
```

This returns a pointer to a null terminated string containing the PCI Voltage. The result will be a maximum of 6 characters (including the null terminator).

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10.8 Miscellaneous PCI Events**10.8.1 Configuration Change Event**

```
void cbus_vf_register_config_change_handler(void (*f)(void));
```

If a configuration parameter (such as unit address etc) of the PCI used to connect to C-Bus is changed (via C-Bus), an event handler can be called. It is up to the event handler to determine what has been changed and act accordingly.

Use this function to register the event handler. If no event handler is registered, this event will be ignored.

The registered function shall be of the form:

```
void my_event_handler(void);
```

10.8.2 Voltage Measurement Event

```
void cbus_vf_register_voltage_measure_handler(void (*f)(void));
```

When a command to measure the C-Bus Voltage is sent (with the function `cbus_vf_measure_PCI_voltage`, the reply from the PCI will trigger calling a Voltage Measure Event Handler. Use this function to register the event handler. If no event handler is registered, this event will be ignored.

The registered function shall be of the form:

```
void my_event_handler(void);
```

10.8.3 Power-Up Event

```
void cbus_vf_register_power_up_handler(void (*f)(void));
```

If the C-Bus power fails and is restored, the C-Bus PCI will be reset. The PCI can notify that power up has occurred, and this in turn can cause an event handler to perform any actions necessary.

The C-Bus Module detects that the PCI has powered up, and automatically restores any prior PCI setup modes or options.

Use this function to register the event handler. If no event handler is registered, this event will be ignored.

The registered function shall be of the form:

```
void my_event_handler(void);
```

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10.9 Transparent Mode

Transparent mode is used when data is to be sent to and received from the PCI directly with no buffering or interpretation. This is used to provide direct access to the PCI, for example using an additional serial port and some external device.

By convention, all C-Bus software sends “~~~<CR>” to a PCI when it starts up. If the C-Bus Module is used in a configuration where another serial port is used to make a connection (through the C-Bus Module) to the PCI, then this sequence should be used to recognise a new connection request and behave accordingly.

10.9.1 Enter/Exit Transparent Mode

To make the C-Bus module enter or exit Transparent Mode, use the following function.

```
void cbus_vf_set_transparent_mode(cbus_boolean transparent_mode);
```

Set `transparent_mode` parameter to `cbus_true`, to Transparent Mode, and `cbus_false` to clear transparent mode.

When leaving Transparent Mode, it is necessary to re-initialise the C-Bus Module.

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10.10 Serial I/O

The C-Bus Module does not include software to drive or interface to serial communication ports. Provision of this software external to the C-Bus Module provides the greatest cross-platform code portability.

Two serial ports are supported:

- The PC Interface Serial Port; and
- The Second Serial Port (generally used for communicating with a PC). This is only used when in Transparent Mode. See section 24.2 for more details.

Serial data access is performed using a transmit handler, which needs to be registered, and a character receive function.

10.10.1 Register C-Bus Output Function

```
void cbus_vf_register_serial_transmit_handler(void (*f)(char));
```

This function registers the serial transmission handler for the PCI serial data.

When the C-Bus Module wishes to send a character to the PCI, this event handler will be called. Message strings are sent one byte at a time by calling the registered function.

If no event handler is registered, this event will be ignored, and there will be no C-Bus communications. The registered function shall be of the form:

```
void my_event_handler(char transmit_character);
```

How the character is handled is up to the user. Options include:

- Send the character immediately, and return control when complete (for some types of embedded systems, this may cause a lot of “dead time” where the processor is waiting); or
- Add the character to a buffer, and send the buffer as time permits (usually using an interrupt service routine).

10.10.2 C-Bus Input

```
void cbus_vf_serial_receive_character(char character);
```

This function must to be called when a character is received from the PCI serial port.

Within the C-Bus module, the character will be added to a buffer and dealt with at the appropriate time.

10.10.3 Second Serial Port Output

```
void cbus_vf_register_serial_transmit_handler2(void (*f)(char));
```

Use this function to register the serial transmission handler for the second serial port.

C-Bus Module Interface Specification

When the C-Bus Module wishes to send a character to the second serial port, this event handler will be called. Data strings are sent one byte at a time by calling the registered function.

If no event handler is registered, this event will be ignored, and there will be no C-Bus communications with the second serial port. The registered function shall be of the form:

```
void my_event_handler(char transmit_character);
```

How the character is handled is up to the user. Options include:

- Send the character immediately, and return control when complete (for some types of embedded systems, this may cause a lot of “dead time” where the processor is waiting); or
- Add the character to a buffer, and send the buffer as time permits (usually using an interrupt service routine).

10.10.4 *Second Serial Port Input*

```
void cbus_vf_serial_receive_character2(char character);
```

This function is called when a character is received from the second serial port. Within the C-Bus module, the character will be sent to the C-Bus PCI if Transparent Mode is set.

C-Bus Module Interface Specification

10.11 Registering a Network

```
cbus_boolean cbus_bf_register_network_path(int8u network_index,
                                           char * network_path);
```

This registers the network path in the database.

If the index is out of range (\geq `CBUS_MAX_NETWORK_COUNT`) or if the length of the path is greater than 14 characters plus a null terminator (15 characters total), this will return `cbus_false` and set an error code

If no more networks can be registered, the function will fail and set the error code to `CBM_TOO_MANY_NETWORKS`.

If the network path string is too long, the function will fail and set the error code to `CBM_STRING_TOO_LONG`.

Network index 0 is always used for the local network, and must not be registered.

Note: the network path must contain the full path information. For example, in an installation with a path of bridges with address A1, A2, A3, A4, A5, the paths to each network are:

Index	Network	Path
0	Device's Local Network	"" (does not need to be registered)
1	Network 1	"A109"
2	Network 2	"A112A2"
3	Network 3	"A11BA2A3"
4	Network 4	"A124A2A3A4"
5	Network 5	"A12DA2A3A4A5"

The path to the destination network is relative to the point where the device using the C-Bus Module is installed.

This could be different to the C-Bus "local network" displayed in the C-Bus Toolkit installation software.

For example, in Figure 1, the path from the C-Bus "Local Network" to Network A3 will be "A1A2A3", the path from Device 1 to Network A3 will be "A2A3" and the path from Device 2 to Network A3 will be "A3". The path from Device 2 to Network A2 will be "" and the path from Device 2 to Network A1 will be "A1".

C-Bus Module Interface Specification

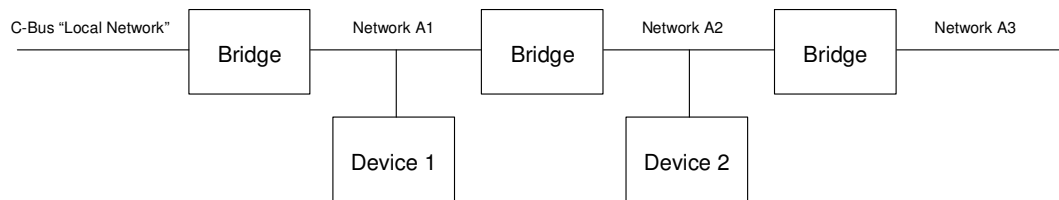


Figure 1 Network Routing Example

C-Bus Network Routing is described in more detail in the C-Bus Serial Interface Users Guide.

10.12 Get Last Source Network Index

```
int8u cbus_if_get_last_source_network_index(void);
```

This returns the index of the network of the most recently processed received message (see registering networks in section 10.11). If this function is used in an event handler, the network index relates to the event being handled.

If the received message is from a network that is not registered, the path to the network will be placed in the "spare" network slot (see section 7) and this index will be returned.

The contents of the spare network slot are only guaranteed to be valid during the life of the event handler. If this spare network slot is used (for example to send a reply), then either:

- ***The reply needs to be sent from within the event handler; or***
- ***The network path needs to be copied for later use, then registered before use.***

10.13 Get Last Source Unit Address Function

```
int8u cbus_if_get_last_source_unit(void);
```

This returns the source unit address of the most recently processed received message.

C-Bus Module Interface Specification

11 CHANGING THE SETTINGS OF THE ATTACHED PCI

Most users can ignore this section.

A C-Bus Network requires at least one Clock Generator, and a Burden. Output units such as relays and dimmers are capable of acting as clock generators, and have a software selectable burden. System units such as a PCI or a later model SIM (5500SM series) can also act as a clock generator, and have a software selectable burden.

The C-Bus Module provides a facility to find and change the states of the clock generator and burden of its attached PCI.

The facilities provided do not allow the state of the clock generator and burden to be changed in any other C-Bus units.

The state of the clock generator and burden is determined when the C-Bus Module starts, and is not checked after that time. This means an application does not get a “live” state – so changes made using Toolkit may be unknown to a running application.

If an application must know of changes made to the configuration of its attached PCI or SIM, the configuration change handler should be used to shut the C-Bus Module down and re-start it, in the event that a change to configuration is detected.

The current state of the clock generator and burden is available only after a connection has been established. The handler registered in a call to `cbus_vf_register_connect_handler` is an appropriate place to retrieve the current states.

Changing the state of a C-Bus Clock Generator or Burden can be very disruptive to an operating C-Bus network – to the point where the entire network could stop operating (for example by turned off the only clock generator, adding too much burden, etc.)

Therefore, any application that changes the state of the Clock Generator or Burden could cause significant network disruption. The state should only be changed by application developers with a thorough understanding of their attached C-Bus network characteristics, equipment, and topology.

If the state of the clock generator or burden is to be changed, the C-Bus Module will apply the changes to the attached PCI or SIM, and then shut down, within the next ½ to 1 second. The event can be detected from the return state of `cbus_ef_update` and used to re-initialise the C-Bus Module.

C-Bus Module Interface Specification

11.1 Get Clock Generator State

```
cbus_boolean cbus_bf_get_clock_enable(void);
```

Get the state of the attached PCI or SIM clock generator, as known at the last initialise. If the clock state is changed over the bus, this will NOT automatically be updated. Instead the configuration change handler should be used to re-start the C-Bus Module.

Returns `cbus_true` if the clock generator is enabled in the attached PCI or SIM.

11.2 Get Burden State

```
cbus_boolean cbus_bf_get_burden_enable(void);
```

Get the state of the attached PCI or SIM burden, as known at the last initialise. If the burden state is changed over the bus, this will NOT automatically be updated. Instead the configuration change handler should be used to re-start the C-Bus Module.

Returns `cbus_true` if the burden is enabled in the attached PCI or SIM.

11.3 Set Clock Generator and Burden State

```
void cbus_vf_set_pci_properties(cbus_boolean b_clock_enable,  
                               cbus_boolean b_burden_enable);
```

Set the state of the attached PCI or SIM clock and burden.

Changing the PCI properties can be fairly slow. During the change, calls to `cbus_ef_update` will return `cbus_ce_module_pci_properties_changing`.

Once the change is complete, calls to `cbus_ef_update` will return `cbus_ce_module_not_initialised`. At that time, the C-Bus module will not perform any further message processing until it is restarted, by a call to `cbus_bf_initialise`.

The timer, task, interrupt handler, or process used to regularly call `cbus_ef_update` should perform these checks of the C-Bus Module state, and handle them accordingly.

C-Bus Module Interface Specification

12 NETWORK DISCOVERY

A C-Bus Network contains one or more units, each identified by their unique Unit Address (0 to 255). The Network Discovery functions can be used to determine which units are installed on a network, and find some details about those units.

The Network Discovery process consists of:

- a. Setting the discovery parameters (section 12.1.1); then
- b. Initiating the Network Discovery (section 12.1.2).

Once started, network discovery causes a series of events that report the results of the discovery (see 12.2.1). These events may take from a few seconds to a minute or more depending on the number of units on the network, and the number of unit parameters requested.

The process can be repeated for each C-Bus Network of interest.

12.1 Functions

12.1.1 Set Discovery Parameters

The required unit parameters to be returned from the Network Discovery process can be set using the following function:

```
void cbus_discovery_vf_set_parameters(  
    int16u discovery_parameters);
```

discovery_parameters is a bitwise mask, where a "1" bit indicates a piece of information to be discovered, as listed below:

Bit	Parameter Value	Name	Data Returned
0	1	Unit Type	The C-Bus Unit Type (eg "KEY4" or "DIMDN8")
1	2	Manufacturer	The manufacturer of the unit
2	4	Version	The firmware version of the unit
3	8	Group Addresses	List of Group Addresses used by the unit
4	16	Group Levels	List of Group Address levels
5	32	Applications	List of Application numbers used by the unit
6	64	Serial Number	Serial Number of the unit
7	128	Status	Common Status (see Serial Interface User Guide)
8	256	Area Address	Unit Area Address

C-Bus Module Interface Specification

The following constants are defined for these parameters, and these can be added or bitwise OR'ed to produce the desired discovery parameters.

```
#define CBUS_DISCOVERY_NONE          0x0000
#define CBUS_DISCOVERY_UNIT_TYPE     0x0001
#define CBUS_DISCOVERY_MANUFACTURER 0x0002
#define CBUS_DISCOVERY_VERSION       0x0004
#define CBUS_DISCOVERY_GROUPS        0x0008
#define CBUS_DISCOVERY_LEVELS       0x0010
#define CBUS_DISCOVERY_APPLICATIONS 0x0020
#define CBUS_DISCOVERY_SERIAL_NUMBER 0x0040
#define CBUS_DISCOVERY_STATUS        0x0080
#define CBUS_DISCOVERY_AREA          0x0100
#define CBUS_DISCOVERY_CONFLICT      0x8000
```

For example, the get the Unit Type and Version parameters, use:

```
cbus_discovery_vf_set_parameters(CBUS_DISCOVERY_UNIT_TYPE |
                                CBUS_DISCOVERY_VERSION);
```

12.1.2 Initiate Network Discovery

A Network discovery is initiated using:

```
void cbus_discovery_vf_initiate(int8u network);
```

The discovery will run until all of the requested information has been found and notified (using event handlers):

C-Bus Module Interface Specification

12.2 Discovery Events**12.2.1 Network Discovery Parameter Event**

Following the initiation of the Network Discovery, a series of events will return the discovered units and their parameters.

To register an event handler for these events, use:

```
void cbus_discovery_vf_register_parameter_handler(
    void (*f)(int8u,
               int8u,
               int16u,
               int8u *,
               int8u));
```

The registered function is called for each unit and parameter discovered. If no event handler is registered, discovery events will be ignored.

The event handler is passed the discovery network number, unit address, the discovery parameter (see section 12.1.1), a pointer to the parameter data, and the number of bytes of parameter data. The registered function shall be of the form:

```
void my_event_handler(int8u network,
                      int8u unit_address,
                      int16u parameter,
                      int8u * parameter_data,
                      int8u byte_count);
```

When a unit is first discovered, the event handler is called with the appropriate network and unit_address, but the parameter will be 0 (CBUS_DISCOVERY_NONE, meaning no data), and the data will be NULL.

If there is a unit address conflict (ie two or more C-Bus units at the same address), the parameter will be CBUS_DISCOVERY_CONFLICT.

This first event can be used to record the existence of a unit.

As each parameter of the unit is discovered, the event handler will be called with the appropriate parameter number and data as shown below:

Parameter Value	Name	Data Returned
1	Unit Type	8 bytes of ASCII data (padded with spaces)
2	Manufacturer	8 bytes of ASCII data (padded with spaces)
4	Version	8 bytes of ASCII data (padded with spaces)
8	Group Addresses	0 - 16 Group Addresses (FF means not used)
16	Group Levels	0 - 16 Group Address levels (corresponding to the Group Addresses from above)

C-Bus Module Interface Specification

Parameter Value	Name	Data Returned
32	Applications	2 Application addresses (FF means not used)
64	Serial Number	4 bytes
128	Status	1 byte (see Serial Interface User Guide)
256	Area Address	1 Area Address (FF means not used)

The order in which parameter events appear is:

1. Unit found (no parameter data)
2. Unit Type
3. Manufacturer
4. Version
5. Applications
6. Area Address
7. Serial Number
8. Status
9. Group Addresses
10. Levels

12.2.2 Network Discovery Complete Event

Following the completion of the Network Discovery, a completion event is raised. To register an event handler for this event, use the function:

```
void cbus_discovery_vf_register_complete_handler(void (*f)(void));
```

The registered function shall be of the form:

```
void my_event_handler(void);
```

12.2.3 Discovering Levels

If the options to discover Applications, Group Addresses and Levels are selected, the Lighting Database will be updated with the levels as they are discovered, and an MMI event will be raised if the discovered level is different from that in the database.

C-Bus Module Interface Specification

13 CAL SERVICES

C-Bus CAL commands are used to address individual units on a C-Bus network, usually for loading or extracting configuration or commissioning information.

Refer to section 24.4 for more details on using CAL commands to program a C-Bus Device.

13.1 Functions**13.1.1 Generic CAL Transmission**

```
void cbus_vf_CAL_send(int8u network,
                     int8u unit_address,
                     char *message_string,
                     int8u retries);
```

Generic CAL commands can be sent using this function.

If you do not understand what a CAL command is, or how to use CAL commands, then either read the C-Bus Serial Interface Users Guide, or contact Clipsal Integrated Systems Pty Ltd for more information.

In the event of a failure to transmit, the C-Bus Module uses the specified number of retries before aborting the transmission.

Any reply will take a minimum of 100ms to be received, since the receive buffer is not checked until 100ms after the command has been sent.

If there are many commands in the transmit and/or receive buffers, it could be several seconds between transmitting a command and receiving a reply.

If a reply is received, the CAL Response event handler will be called.

Ensure that the length of the message (header + network path + message string etc) does not exceed the `CBUS_OUTPUT_STRING_LENGTH` configuration parameter (see section 24.1). The `message_string` is a null terminated string that does not include the header (\06), destination or network of the command.

On success the C-bus error code is set to `CBM_SUCCESS`.

If the `message_string` is too long the C-bus error code is set to `CBM_CMDSTR_TOO_LONG`.

13.1.2 Transmit CAL Reply

```
extern void cbus_vf_CAL_reply_send(int8u network,
                                   int8u unit_address,
                                   char *message_string,
                                   int8u retries);
```

CAL Reply commands can be sent using this function.

C-Bus Module Interface Specification

In the event of a failure to transmit, the C-Bus Module uses the specified number of retries before aborting the transmission.

The `message_string` is a null terminated string which does not include the header, destination or network of the message.

On success the C-bus error code is set to `CBM_SUCCESS`.

If the `message_string` is too long the C-bus error code is set to `CBM_CMDSTR_TOO_LONG`.

Do not use this function to return a reply to a CAL Read event. Use the special function `cbus_vf_CAL_read_response` instead.

13.1.3 Read Response

```
void cbus_vf_CAL_read_response(int8u network,  
                               int8u unit_address,  
                               int8u *data,  
                               int8u data_count);
```

Use this function to respond to CAL programming read events (see section 13.3).

`data` is a pointer to the data to be returned, `data_count` is the number of bytes to be returned.

On success the C-bus error code is set to `CBM_SUCCESS`.

If the `data` is too long the C-bus error code is set to `CBM_CMDSTR_TOO_LONG`.

C-Bus Module Interface Specification

13.2 CAL Events**13.2.1 CAL Response Handler**

```
void cbus_vf_CAL_register_response_handler(void (*f)(int8u *,
                                                    int8u));
```

Use this function to register a CAL Response event handler. If no event handler is registered, this event will be ignored.

The response event handler is called when an incoming CAL REPLY message arrives. In the normal course of events, the only way a CAL REPLY can arrive is because of a prior CAL send (typically for an Identify or Recall command). The event handler is passed the received C-Bus command as an array of bytes which includes the message header and network path.

The registered function shall be of the form:

```
void my_event_handler(int8u * command,
                      int8u command_length);
```

13.3 Device Programming Events

It is possible to load configuration data into the User Device, or extract configuration data from the User Device, both over C-Bus.

This is achieved by treating the C-Bus PCI as a bridge, and addressing the device on the other side: CAL Commands addressed to the PCI Unit address will be actioned internally by the PCI and will not be passed to the serial port. CAL commands that are addressed to a virtual unit address on the other side of the PCI "bridge" are sent to the serial port, and can be handled by the C-Bus module by calling an event handler.

13.3.1 Virtual Addressing Conventions

The memory that can be addressed through C-Bus **does not** have to reflect the internal memory map of the User Device – instead, any convention the user of the C-Bus Module chooses to apply can be used.

However, some C-Bus addressing conventions are enforced in order to provide a consistent interface to memory read and write processes:

Writing to Virtual Address 0 from C-Bus sets an address pointer. This pointer is the location at which subsequent read and write commands will access data.

Reading and writing at virtual address 1 accesses data at the location of the address pointer.

Accessing virtual address 0 and 1 is handled by the C-Bus module, generates Read and Write events, and causes the Read and Write event handlers to be called.

Accessing other virtual addresses will cause the Generic Read and Write Event Handlers to be called. Use of this method for reading and writing configuration data is STRONGLY discouraged.

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Using C-Bus CAL commands other than STORE (to write) and RECALL (to read) will result in the Generic Programming Event Handler being called.

For more details on using CAL commands to program a Device, see section 24.4.2.

13.3.1.1 Generic Programming Event

```
void cbus_vf_CAL_register_generic_programming_handler(  
    void (*f)(int8u *,  
              int8u));
```

This function registers an event handler for generic CAL programming events.

The event handler is only called when a CAL Programming command is received and no applicable event handler is registered.

The event handler is passed the received C-Bus command as an array of bytes which includes the message header and network path. The registered function shall be of the form:

```
void my_event_handler(int8u * command,  
                     int8u command_length);
```

13.3.1.2 Generic Write Event

```
void cbus_vf_CAL_register_generic_write_handler(  
    cbus_boolean (*f)(int8u,  
                     int8u,  
                     int8u,  
                     int8u *,  
                     int8u));
```

This function registers an event handler for generic CAL programming write events.

The event handler will be called when a CAL Programming STORE command to virtual address \$02 - \$FF is received. If no event handler is registered, this event is ignored.

The event handler is passed the originating network number, unit address, the virtual address, the CAL command data string (stripped of the header) and the length of the command. The registered function shall be of the form:

```
cbus_boolean my_event_handler(int8u source_network,  
                             int8u source_unit_address,  
                             int8u virtual_address,  
                             int8u * command,  
                             int8u command_length);
```

If the write operation was successful, the event handler shall return `cbus_true`, otherwise `cbus_false`.

If the event handler returns `cbus_true`, the C-Bus Module sends a CAL ACKNOWLEDGE command back to the originator of the write command.

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13.3.1.3 *Generic Read Event*

```
void cbus_vf_CAL_register_generic_read_handler(  
    cbus_boolean (*f)(int8u,  
                      int8u,  
                      int8u,  
                      int8u *,  
                      int8u));
```

This function registers the event handler for generic CAL programming read events.

The event handler will be called when a CAL Programming RECALL command to virtual address \$02 - \$FF is received. If no event handler is registered, this event is ignored.

The event handler is passed the originating network number, unit address virtual address, and the number of bytes to be read. The event handler needs to copy the correct number of bytes to the result pointer.

The registered function shall be of the form:

```
cbus_boolean my_event_handler(int8u source_network,  
                              int8u source_unit_address,  
                              int8u virtual_address,  
                              int8u *result  
                              int8u data_count);
```

If the read operation is to succeed, the event handler shall return **cbus_true**, otherwise **cbus_false**.

If the event handler returns **cbus_true**, the C-Bus Module generates and sends a C-Bus CAL REPLY command.

13.3.1.4 *Write Event*

```
void cbus_vf_CAL_register_write_handler(  
    cbus_boolean (*f)(int8u,  
                      int8u,  
                      int32u,  
                      int8u *,  
                      int8u));
```

This function registers the event handler for CAL programming write events.

The event handler will be called when a CAL Programming STORE command is received to Virtual Address \$01. If no event handler is registered, this event is ignored.

The event handler is passed the originating network number, unit address, the address of the write, a pointer to the data and the amount of data. The registered function shall be of the form:

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```
cbus_boolean my_event_handler(int8u  source_network,
                              int8u  source_unit_address,
                              int32u address,
                              int8u *data,
                              int8u  data_count);
```

If the write operation was successful, the event handler shall return **cbus_true**, otherwise **cbus_false**.

If the event handler returns **cbus_true**, the C-Bus Module sends a CAL ACKNOWLEDGE command back to the originator of the write command.

13.3.1.5 *Read Event*

```
void cbus_vf_CAL_register_read_handler(
    cbus_boolean (*f)(int8u,
                      int8u,
                      int32u,
                      int8u *,
                      int8u));
```

This function registers the event handler for CAL programming read events.

The event handler will be called when a CAL Programming RECALL command is received to Virtual Address \$01. If no event handler is registered, this event is ignored.

The event handler is passed the originating network number, unit address, the address of the read, a pointer to a data buffer and the amount of data. The event handler needs to copy the correct number of bytes to the result pointer. The registered function shall be of the form:

```
cbus_boolean my_event_handler(int8u  source_network,
                              int8u  source_unit_address,
                              int32u address,
                              int8u *result,
                              int8u  data_count);
```

If the read operation is to succeed, the event handler shall return **cbus_true**, otherwise **cbus_false**.

If the event handler returns **cbus_true**, the C-Bus Module generates and sends a C-Bus CAL REPLY command.

C-Bus Module Interface Specification

14 LIGHTING APPLICATION

The Lighting Application is used to control and monitor lighting. This is usually comprised of incandescent or fluorescent lighting and associated control devices such as switches, dimmers and relays. It can also be used for lighting messages destined to other protocols, such as DALI.

Traditionally, Lighting was the only Application available, and hence is commonly used for purposes such as curtain control, irrigation and so forth.

When built for C-Bus Enabled Level of 3 or more, the C-Bus Module includes a Lighting Application database. This provides a model of the C-Bus Lighting Application group addresses that can be interrogated to determine levels.

The number of Lighting Applications that can be stored in the database is set in the file `cbus_config.h`³. The application number is passed to the various functions, and the index of the Application (0, 1, 2, ...) is looked up by the function before the database records can be accessed.

Each Lighting Application instance includes a set of Group Records. In normal cases, there are 256 Group Address records for each Lighting Application instance. Each Group Address has a record which stores the current level along with details such as whether it is ramping and how fast, timer settings and other parameters needed for the light state machine. The state machine maintains the ramping levels and will automatically handle timer time-out actions.

For some embedded systems with tight memory constraints, the number of Group Records can be reduced. In that case, each Group of interest must be registered before it is available in the database.

The C-Bus lighting application database can only be accessed using the functions defined in the header file.

³ Pre-compiled versions of the C-Bus Module (for Windows and Linux) are built for 20 lighting Applications.

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14.1 C-Bus Lighting Ramp Rates

Where functions require a ramp rate, the value used is a ramp rate token in the range 0 – 15 (*not a duration in seconds*).

Ramp rates and their tokens are:

Ramp Rate Token	Ramp Rate
0	Instantaneous
1	4 seconds
2	8 seconds
3	12 seconds
4	20 seconds
5	30 seconds
6	40 seconds
7	1 minute
8	1.5 minutes
9	2 minutes
10	3 minutes
11	5 minutes
12	7 minutes
13	10 minutes
14	15 minutes
15	17 minutes

C-Bus Module Interface Specification

14.2 Lighting Database Functions**14.2.1 Application Registration****14.2.1.1 Register Application Number**

```
cbus_boolean cbus_lighting_bf_register_app(int8u app);
```

This registers the lighting application number in the database.

If the database cannot support any more application numbers (ie. Application count > 10), this returns `cbus_false` and sets the error code to `CBM_TOO_MANY_APPLICATIONS`.

14.2.1.2 Get Application Index

```
int16s cbus_lighting_if_app_index(int8u app);
```

This returns the index of the application in the database. It returns -1 if the Application Number was not found and sets the error code to `CBM_APPLICATION_NOT_FOUND`.

14.2.2 Group Registration

Group address registration is not required if the C-Bus Module is built using 256 groups per Lighting Application (ie. `CBUS_MAX_LIGHTING_GROUPS = 256`).⁴

14.2.2.1 Register Group Address

```
cbus_boolean cbus_lighting_bf_register_group(int8u app,  
                                             int8u group);
```

This registers the lighting group address in the database. If the database can not support any more group addresses (ie. Group count > `CBUS_MAX_LIGHTING_GROUPS`), it returns `cbus_false` and sets the error code to `CBM_TOO_MANY_GROUPS`.

If the application is not registered, the function will fail and set the error code to `CBM_APPLICATION_NOT_FOUND`.

14.2.2.2 Get Group Index

```
char cbus_lighting_if_group_index(int8u app,  
                                  int8u group);
```

This returns the index of the Group Address in the database.

The data base stores up to `CBUS_MAX_LIGHTING_GROUPS` Group Addresses per Application, with index 0 to `CBUS_MAX_LIGHTING_GROUPS - 1`.

⁴ Pre-compiled versions of the C-Bus Module (for Windows and Linux) are built for 256 groups per Lighting Application. Consequently, group registration is not required.

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If the Group Address was not found, this returns -1 and sets the error code to **CBM_GROUP_NOT_FOUND**.

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

14.2.2.3 Clear Registered Groups

```
void cbus_lighting_vf_clear_groups(void);
```

This clears all registered Group Addresses. This is only applicable when there are less than 256 Groups per Application.

14.2.3 Lighting Database Operations

14.2.3.1 Set Database Level

```
void cbus_lighting_vf_set_database_level(int8u application,  
                                         int8u group,  
                                         int8u level,  
                                         int8u ramp_rate);
```

This sets the level in the database **without** sending a corresponding C-Bus command.

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

14.2.3.2 Get Level

```
int8u cbus_lighting_if_get_level(int8u network,  
                                 int8u application,  
                                 int8u group);
```

This returns the level of a Group Address from the database (which should reflect the value on C-Bus).

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND** and return a level of 0.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND** and return a level of 0.

C-Bus Module Interface Specification

14.2.4 Lighting Database Ramp Behaviour Options

`cbus_lighting_vf_set_ramp_0_use_two_steps(cbus_boolean b_enabled);`

Sets the behaviour of the C-Bus Module for ramp to level 0 operations.

If the parameter is `cbus_true`, a ramp to level 0 operation (with a non-instant ramp rate) will be issued as a ramp to level 1, followed at the end of the ramp by an OFF command.

If the parameter is `cbus_false`, a ramp to level 0 operation will always be issued onto C-Bus as a single ramp to level 0.

Older C-Bus key units manufactured before 2001 would show only the target level of a ramp on their indicators. Thus, ramps to OFF over long durations could present misleading information on the indicators.

Many older C-Bus devices (for example, Scene Master, B&W Touchscreen) compensate for this, when a ramp to level 0 is issued with a non-instant ramp rate, by issuing a ramp to level 1 command, then, when the level gets to level 1, issuing an OFF command.

C-Bus Module releases prior to version 3.15 also had this behaviour.

C-Bus Module version 3.16 and later allow this behaviour as an option, which is disabled by default. When this option is disabled, a ramp to level 0 operation will simply issue a single ramp to level 0 command onto C-Bus.

C-Bus Module Interface Specification

14.3 C-Bus Lighting Operations**14.3.1 Set Level**

```
void cbus_lighting_vf_set_level(int8u network,  
                                int8u application,  
                                int8u group,  
                                int8u level,  
                                int8u ramp_rate,  
                                int8u retries,  
                                int8u force);
```

This sets a lighting group address to a level with a particular ramp rate. It makes a specific number of retries to get the message onto C-Bus.

force is used to re-assert the level into the network, in the event that an MMI indicates a discrepancy between the database level and the reported level. **force** is the number of times the level will be copied from the database into the network in the event of a discrepancy (and when that count is expired, the database will not be used to further update the network).

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

The function will fail if the group is set to 255. The error code will be set to **CBM_GRP_EQ_255** in this case.

C-Bus Module Interface Specification

14.4 Timer Operations

The following functions are used for timers on the lighting application. All times are in seconds.

14.4.1 Set Timer

```
void cbus_lighting_vf_set_timer(int8u network,  
                               int8u application,  
                               int8u group,  
                               int16s duration,  
                               int16s expiry_level);
```

Set a timer to expire after **duration** seconds. On expiry, send a C-Bus command to set the level to **expiry_level**. If **expiry_level** is -1, the current level will be restored on timer expiry.

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

14.4.2 Get Amount Of Time Left On A Timer

```
int16s cbus_lighting_if_get_timer(int8u application,  
                                  int8u group);
```

This returns the amount of time left on a Group's timer, in seconds.

14.4.3 Stop Timer and Execute Action

```
void cbus_lighting_vf_terminate_timer(int8u application,  
                                       int8u group);
```

This stops the timer and executes the associated C-Bus action.

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

C-Bus Module Interface Specification

14.4.4 Stop Timer with No Action

```
void cbus_lighting_vf_reset_timer(int8u application,  
                                int8u group);
```

This stops the timer without executing the C-Bus action.

If the application is not registered, the function will fail and set the error code to **CBM_APPLICATION_NOT_FOUND**.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

C-Bus Module Interface Specification

14.5 MMI Operations**14.5.1 Initiate MMI**

```
void cbus_lighting_vf_initiate_MMI(int8u network,
                                   int8u application);
```

This executes a C-Bus MMI on the selected Network and Application.

If connected through a version 1-3 PCI, it will initiate a status MMI; for a version 4+ PCI, it will initiate a series of level MMI(s), which will synchronise the database to the C-Bus Group Address levels.

This function can be used to re-synchronise the database with C-Bus in exceptional circumstances. During normal operation, the C-Bus Module interacts with C-Bus to maintain synchronisation

It is not necessary, or desirable, to use regular MMIs to synchronise the database to the C-Bus levels.

14.5.2 Initiate Status MMI

```
void cbus_lighting_vf_initiate_status_MMI(int8u network,
                                           int8u application);
```

This starts a status MMI on the selected Network and Application.

This function is not normally expected to be used.

14.5.3 Initiate Level MMI

```
void cbus_lighting_vf_initiate_level_MMI(int8u network,
                                          int8u application,
                                          int8u start_group);
```

This starts a level MMI on the selected Network and Application, at the specified starting group.

The level MMI will cause the database levels to be updated for the block of 32 groups, beginning at `start_group`.

The value of `start_group` must be one of 0x00, 0x20, 0x40, 0x60, 0x80, 0xA0, 0xC0 or 0xE0. Operation of C-Bus equipment with other values is not guaranteed.

C-Bus Module Interface Specification

14.6 Labels**14.6.1 Apply Lighting Label**

```
void cbus_lighting_vf_label(int8u network,  
                           int8u application,  
                           int8u group,  
                           int8u flavour  
                           cbus_et_label_type type,  
                           int8u language,  
                           int8u length,  
                           int8u *text);
```

Labels can be applied to lighting groups and trigger control group / action selectors in DLT switches.

To label a group, set:

application:	lighting application you wish to use
group:	group to be labelled
flavour:	0, 1, 2 or 3 depending on the group button flavour to be labelled (normally 0)
type:	cbus_lighting_ce_label_text
language:	the language code (see cbus_lighting.h)
length:	the length of the label string
text:	pointer to the label string (16 chars max)

More sophisticated labelling using dynamic icons is also possible - refer to the C-Bus lighting application documentation for more details.

14.6.2 Set Preferred Language for Labels

```
void cbus_lighting_vf_set_language(int8u network,  
                                   int8u application,  
                                   int8u language);
```

Sets the preferred language for label display. If the language has no labels loaded, the English labels will be displayed.

C-Bus Module Interface Specification

14.7 Events**14.7.1 Database Change Event**

```
void cbus_lighting_vf_register_database_event_handler(  
    void (*f)(int8u,  
               int8u,  
               int8u));
```

This function registers the event handler for the Lighting Database change events. If the database is changed due to an external event or due to an internal operation, then this event handler will be called (if registered).

This handler may also be compile time enabled to be called every time the level changes due to a database level changing due to a ramping event.

Every time the `cbus_lighting_vf_set_database_level` function is called, this event handler will be called.

The event handler can be used to save the data to non-volatile memory for recall after power failures. The parameters passed are the Application Number, the Group Address and the new target level. The registered function shall be of the form:

```
void my_event_handler(int8u application,  
                      int8u group,  
                      int8u level);
```

14.7.2 Lighting Event

```
void cbus_lighting_vf_register_event_handler(  
    void (*f)(int8u,  
               int8u,  
               int8u,  
               int8u));
```

If a Lighting message is received, the database will be automatically updated and the event handler will be called (if registered).

This registers an event handler for Lighting Application messages. When any event on the Lighting Application is received, the registered event will be called. The parameters passed are the Application Number, the Group Address, the new level and the ramp rate index (see section 14.1).

The registered function shall be of the form:

```
void my_event_handler(int8u application,  
                      int8u group,  
                      int8u level,  
                      int8u ramp_rate);
```

C-Bus Module Interface Specification

14.7.3 Alternate Lighting Event

```
void cbus_lighting_vf_register_event_handler2(  
    void (*f)(int8u,  
               int8u,  
               int8u,  
               int8u,  
               cbus_boolean));
```

If a Lighting message is received, the database will be automatically updated and this event handler will be called (if registered).

This registers an event handler for Lighting Application messages. The parameters passed are the Application Number, the Group Address, the new level, the ramp rate index (see section 14.1), and whether the received command was an ON/OFF command (as opposed to a ramp to level command).

This event handler will not normally be required, the previous one is preferred.

The registered function shall be of the form:

```
void my_event_handler(int8u application,  
                      int8u group,  
                      int8u level,  
                      int8u ramp_rate,  
                      cbus_boolean on_off_command);
```

14.7.4 Additional Alternate Lighting Event

```
void cbus_lighting_vf_register_event_handler3(  
    void (*f)(int8u,  
               int8u,  
               int8u,  
               int8u,  
               cbus_lighting_et_source_type));
```

If a Lighting message is received, the database will be automatically updated and this event handler will be called (if registered).

This registers an event handler for Lighting Application messages. The parameters passed are the Application Number, the Group Address, the new level, the ramp rate index (see section 14.1), and an enumerated type indicating the source of the change to the lighting group.

This event handler will not normally be required, the previous one is preferred.

Possible source types are:

C-Bus Module Interface Specification

Enumerant	Meaning
<code>cbus_lighting_ce_source_cbus</code>	A command was received from C-Bus which caused this even
<code>cbus_lighting_ce_source_MMI</code>	An MMI discrepancy was corrected and caused this event
<code>cbus_lighting_ce_source_ramp</code>	A ramping group caused this event
<code>cbus_lighting_ce_source_self</code>	A function call by the user caused this event

The registered function shall be of the form:

```
void my_event_handler(int8u application,
                     int8u group,
                     int8u level,
                     int8u ramp_rate,
                     cbus_lighting_et_source_type source);
```

14.7.5 MMI Event

```
void cbus_lighting_vf_register_MMI_event_handler(
    void (*f)(int8u,
              int8u,
              int8u,
              int8u));
```

This function registers the event handler for the Lighting Application MMI correction messages.

If there is a discrepancy between the state of a group reported in an MMI and the state in the database, the database will be corrected. When the MMI mechanism corrects a Lighting Group Address level, the registered event will be called. The parameters passed are the Application Number, the Group Address and the new level.

The ramp rate is always zero, but is included to make the interface identical to the lighting event handler, so that the one event handler can be registered for BOTH events if required.

The registered function shall be of the form:

```
void my_event_handler(int8u application,
                     int8u group,
                     int8u level,
                     int8u ramp_rate);
```

C-Bus Module Interface Specification

14.7.6 Label Event

```
cbus_lighting_vf_register_label_handler(  
    void (*f)(int8u,  
              int8u,  
              int8u,  
              cbus_et_label_type,  
              int8u,  
              int8u,  
              int8u *));
```

This function registers the event handler for the received Label commands.

The registered function shall be of the form:

```
void my_event_handler(int8u application,  
                     int8u group,  
                     int8u flavour,  
                     cbus_et_label_type label_type,  
                     int8u language,  
                     int8u label_length,  
                     int8u *text);
```

Meanings of these parameters are described in section 14.6.1.

14.7.7 Preferred Language Event

```
cbus_lighting_vf_register_pref_language_handler(  
    void (*f)(int8u,  
              int8u));
```

This function registers an event handler for received "Set Preferred Language" commands.

The registered function shall be of the form:

```
void my_event_handler(int8u application,  
                     int8u language);
```

Meanings of these parameters are described in section 14.6.1.

C-Bus Module Interface Specification

15 TRIGGER CONTROL APPLICATION

The Trigger Control Application is used to cause a number of actions in response to a single C-Bus message.

Devices that respond to Trigger Control Application Messages causes a defined set of actions to occur, one time only, each time the trigger message is received.

Devices that respond to Trigger Control Messages can generally be programmed in some manner, so that the exact trigger message and the actions taken can be set up at the time the device is installed.

The actions taken are typically to emit one or more new C-Bus messages (generally on another Application), or to output information on some other medium (for example, simple Infra-Red codes to control Televisions, VCRs, etc).

Typical devices that respond to Trigger Control Application messages are the Clipsal Scene Controller or the C-Bus Touchscreen (to set specific lighting conditions), and the Clipsal IR output unit (to control simple Infra-Red devices).

15.1 Network Variables

The Trigger Control Application network variables are stored in a database and the values are automatically maintained.

15.2 C-Bus Functions

Note that registering groups is not required if using 256 groups per Application (ie. `CBUS_MAX_LIGHTING_GROUPS = 256`).

If less than 256 groups per Application are used, the Trigger Groups must be registered using the lighting group registration functions, with application `CBUS_TRIGGER_APP`.

15.2.1 Set Trigger Group

```
void cbus_trigger_vf_set_group(int8u network,
                              int8u trigger_group,
                              int8u action_selector,
                              int8u retries);
```

This activates a Trigger Group/Action Selector combination. It makes a specific number of retries to get the message onto C-Bus.

If the `trigger_group` is not registered, the function will fail and set the error code to `CBM_GROUP_NOT_FOUND`.

The function will fail if the `trigger_group` is set to 255. The error code will be set to `CBM_GRP_EQ_255` in this case.

C-Bus Module Interface Specification

15.2.2 Indicator Kill

```
void cbus_trigger_vf_indicator_kill(int8u network,
                                   int8u trigger_group,
                                   int8u retries);
```

This transmits a C-Bus Indicator Kill message on the Trigger Group. This is used to switch off the indicators for any units that have a scene active on that Trigger Group.

The Trigger Group does not have to be registered.

The function will fail if the `trigger_group` is set to 255. The error code will be set to `CBM_GRP_EQ_255` in this case.

15.3 Labels

15.3.1 Apply Trigger Label

```
void cbus_trigger_vf_label(int8u network,
                           int8u group,
                           int8u action_selector,
                           int8u flavour,
                           cbus_et_label_type type,
                           int8u language,
                           int8u length,
                           int8u *text);
```

Labels can be applied to scene trigger keys, by trigger group + action selector in DLT switches.

To label a Trigger Control group/action selector pair used for a scene, set:

group:	trigger group to be labelled
action_sel:	action selector to be labelled
flavour:	0
type:	<code>cbus_ce_label_text</code>
language:	the language code (see <code>cbus_lighting.h</code>)
length:	the length of the label string
text:	pointer to the label string (16 chars max)

More sophisticated labelling using dynamic icons is also possible - refer to the C-Bus lighting application documentation for more details.

15.3.2 Set Preferred Language for Labels

```
void cbus_trigger_vf_set_language(int8u network,
                                  int8u language);
```

Sets the preferred language for control trigger label display. If the language has no labels loaded, the English labels will be displayed.

C-Bus Module Interface Specification

15.4 Database Functions

Note that registering groups is not required if using 256 groups per Application (ie. `CBUS_MAX_LIGHTING_GROUPS = 256`).

If less than 256 groups per Application are used, the Trigger Groups must be registered using the lighting group registration functions, with application `CBUS_TRIGGER_APP`.

15.4.1 Set Database Level

```
void cbus_trigger_vf_set_database(int8u trigger_group,  
                                int8u action_selector);
```

This sets the Trigger Group in the database without sending a corresponding C-Bus command.

If the `trigger_group` is not registered, the function will fail and set the error code to `CBM_GROUP_NOT_FOUND`.

15.4.2 Get Trigger

```
int8u cbus_trigger_if_get_group(int8u trigger_group);
```

This returns the value of a Trigger Group from the database (which should reflect the value on C-Bus).

C-Bus Module Interface Specification

15.5 Timer Functions

The following functions are used for timers on the trigger control application. All times are in seconds.

15.5.1 Set Timer

```
void cbus_trigger_vf_set_timer(int8u network,  
                              int8u trigger_group,  
                              int16s duration,  
                              int16s expiry_level);
```

Set a timer to expire after **duration** seconds. On expiry, send a C-Bus command to set the level to **expiry_level**. If **expiry_level** is -1, the current level will be restored on timer expiry.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

15.5.2 Get Amount Of Time Left On A Timer

```
int16s cbus_trigger_if_get_timer(int8u trigger_group);
```

This returns the amount of time left on a Group's timer, in seconds.

15.5.3 Stop Timer and Execute Action

```
void cbus_trigger_vf_terminate_timer(int8u trigger_group);
```

Stop the timer and execute the C-Bus action.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

15.5.4 Stop Timer with No Action

```
void cbus_trigger_vf_reset_timer(int8u trigger_group);
```

This stops the timer without executing the C-Bus action.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

C-Bus Module Interface Specification

15.6 Events**15.6.1 Trigger Events**

```
void cbus_trigger_vf_register_handler(void (*f)(int8u,  
                                              int8u));
```

This registers the event handler for the Trigger Control Application messages. If a Trigger Control message is received, the database will be automatically updated and the event handler will be called (if registered). The parameters passed are the Trigger Group and the new action selector.

The registered function shall be of the form:

```
void my_event_handler(int8u trigger_group,  
                      int8u action_selector);
```

15.6.2 Indicator Kill Events

```
void cbus_trigger_vf_register_indicator_kill_handler(  
    void (*f)(int8u))
```

This registers the event handler for the Indicator Kill messages arriving on the Trigger Control messages. If an Indicator Kill message is received the event handler will be called (if registered). The parameter passed is the Trigger Group for which any active indicator should be turned off.

The registered function shall be of the form:

```
void my_event_handler(int8u trigger_group);
```

15.6.3 Label Events

```
cbus_trigger_vf_register_label_handler(  
    void (*f)(int8u,  
              int8u,  
              int8u,  
              cbus_et_label_type,  
              int8u,  
              int8u,  
              int8u *));
```

This function registers the event handler for the received Label commands.

The registered function shall be of the form:

C-Bus Module Interface Specification

```
void my_event_handler(int8u group,  
                      int8u action_selector,  
                      int8u flavour,  
                      cbus_et_label_type label_type,  
                      int8u language,  
                      int8u label_length,  
                      int8u *text);
```

Meanings of these parameters are described in section 15.3.1.

15.6.4 Preferred Language Event

```
cbus_trigger_vf_register_pref_language_handler(  
    void (*f)(int8u));
```

This function registers an event handler for received "Set Preferred Language" commands received on the Trigger Control Application.

The registered function shall be of the form:

```
void my_event_handler(int8u language);
```

Meanings of these parameters are described in section 15.3.1.

C-Bus Module Interface Specification

16 ENABLE CONTROL APPLICATION

The Enable Control Application is used to set one or more shared C-Bus Network Variables. Devices on the bus (and which can accept Enable Control Messages) take some defined set of actions, based on the value of the shared Network Variable(s). These actions are dependent on the device using the Network Variable. They may lead to the generation of other C-Bus messages.

Devices which respond to Enable Control Application Messages can generally be programmed in some manner, so that exact values of the Network Variables and the actions taken can be set up at the time the device is installed.

A typical device using the Event Control Application is a scheduling system, where different schedules can be selected using the Network Variables. Complex scheduling can be created using several of these devices on the same network.

16.1 Network Variables

The Enable Control Application network variables are stored in a database and the values are automatically maintained.

16.2 C-Bus Functions

Note that registering groups is not required if using 256 groups per Application (ie. `CBUS_MAX_LIGHTING_GROUPS = 256`).

If less than 256 groups per Application are used, the Enable Groups must be registered using the lighting group registration functions, with application `CBUS_ENABLE_APP`.

16.2.1 Set Enable Group

```
void cbus_enable_vf_set_group(int8u network,  
                             int8u enable_group,  
                             int8u value,  
                             int8u retries);
```

This sets the Enable Group to a particular value. It makes a specific number of retries to get the message onto C-Bus.

If the `enable_group` is not registered, the function will fail and set the error code to `CBM_GROUP_NOT_FOUND`.

The function will fail if the `enable_group` is set to 255. The error code will be set to `CBM_GRP_EQ_255` in this case.

C-Bus Module Interface Specification

16.3 Database Functions

Note that registering groups is not required if using 256 groups per Application (ie. `CBUS_MAX_LIGHTING_GROUPS = 256`).

If less than 256 groups per Application are used, the Enable Groups must be registered using the lighting group registration functions, with application `CBUS_ENABLE_APP`.

16.3.1 Set Database Level

```
void cbus_enable_vf_set_database(int8u enable_group,  
                                int8u value);
```

This sets the Enable Group in the database without sending a corresponding C-Bus command.

If the `enable_group` is not registered, the function will fail and set the error code to `CBM_GROUP_NOT_FOUND`.

16.3.2 Get Enable

```
int8u cbus_enable_if_get_group(int8u network,  
                                int8u enable_group);
```

This returns the value of an Enable Group from the database (which should reflect the value on C-Bus).

C-Bus Module Interface Specification

16.4 Timer Functions

The following functions are used for timers on the Enable control application. All times are in seconds.

16.4.1 Set Timer

```
void cbus_enable_vf_set_timer(int8u network,  
                             int8u enable_group,  
                             int16s duration,  
                             int16s expiry_level);
```

Set a timer to expire after **duration** seconds. On expiry, send a C-Bus command to set the level to **expiry_level**. If **expiry_level** is -1, the current level will be restored on timer expiry.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

16.4.2 Get Amount Of Time Left On A Timer

```
int16s cbus_enable_if_get_timer(int8u enable_group);
```

This returns the amount of time left on a Group's timer, in seconds.

16.4.3 Stop Timer and Execute Action

```
void cbus_enable_vf_terminate_timer(int8u enable_group);
```

Stop the timer and execute the C-Bus action.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

16.4.4 Stop Timer with No Action

```
void cbus_enable_vf_reset_timer(int8u enable_group);
```

This stops the timer without executing the C-Bus action.

If the group is not registered, the function will fail and set the error code to **CBM_GROUP_NOT_FOUND**.

C-Bus Module Interface Specification

16.5 Events

```
void cbus_enable_vf_register_handler(void (*f)(int8u,  
                                              int8u));
```

This registers the event handler for the Enable Control Application messages. If an Enable Control message is received, the database will be automatically updated and the event handler will be called (if registered). The parameters passed are the Enable Group and the value.

The registered function shall be of the form:

```
void my_event_handler(int8u trigger_group,  
                      int8u value);
```


C-Bus Module Interface Specification

17.1.1 Zone HVAC Network Variables

The Zone HVAC Network variables characterise the Heating, Cooling or Ventilation state of a individual zone. There is a set of Zone Network variables for each individual zone on the system.

Variable	Function
HVAC Mode	Mode of operation in the zone
HVAC Set Level	Set temperature or operating level
HVAC Setback Level	The allowable variation from the set level
HVAC Type	Type of HVAC plant
HVAC Flags	Defines how the zone is to be controlled
HVAC Guard Maximum	Maximum allowable temperature
HVAC Guard Minimum	Minimum allowable temperature
HVAC Output Level	The HVAC output required of the plant for that zone
HVAC Auxiliary Level	A second level needed for some plant types
Current Temperature	The temperature in the zone
Status	Information on the system function
Error	A code representing the highest severity error

17.1.2 Zone Humidity Network Variables

The Zone Humidity Network variables characterise the Humidity Control state of a individual zone. There is a set of Zone Network variables for each individual zone on the system.

Variable	Function
Humidifier Mode	Mode of operation in the zone
Humidifier Set Level	Set humidity or operating level
Humidifier Setback Level	The allowable variation from the set level
Humidifier Type	Type of Humidity plant
Humidifier Flags	Defines how the zone is to be controlled
Humidifier Guard Maximum	Maximum allowable humidity
Humidifier Guard Minimum	Minimum allowable humidity
Humidifier Output Level	The HVAC output required of the plant for that zone
Humidifier Auxiliary Level	A second level needed for some plant types
Current Humidity	The humidity in the zone
Status	Information on the system function
Error	A code representing the highest severity error

17.1.3 Conventions**Temperature**

Temperature is transferred as a signed 2's complement integer using two bytes. The value represents the temperature in °C, expressed in 256th of a degree. The following examples indicate the conventions:

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Temperature = 25.3°C

Value = Integer(25.3 * 256) = \$194C Hex

Temperature = -37.9°C

Value = Integer(-37.9 * 256) = \$DA1A Hex

To use with °F, the following conversions can be used:

$$^{\circ}\text{F} = ^{\circ}\text{C} * 9 / 5 + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) * 5 / 9$$

Humidity

Humidity values are transferred over C-Bus in %, expressed as a two bytes representing the Humidity (0 = 0% to 65535 = 100%).

Raw Levels

If a raw level is used instead of a Temperature in °C or Humidity in percent, then the level is expressed as a fraction of the capacity of the plant, using 2 bytes as a signed 2's complement number⁵:

In this case:

Raw Level = 50%

Value = Integer(0.5 * 32767) = \$3FFF Hex

Raw Level = -10%

Value = - Integer(0.1 * 32768) = \$F334 Hex

The Auxiliary Level

When HVAC Mode or Level is set, each command carries the level and an Auxiliary Level. The meaning of the Auxiliary Level is dependant on the plant type.

The Auxiliary Level is normally used to convey a manual setting of some part of the plant. The Auxiliary Level is not normally used in automatic operating modes, where a plant controller works out how to run based on the demand placed upon it.

Typical uses for the Auxiliary Level are:

- Set a manual fan speed
- Set a manual over-ride on HVAC plant (for example, heater normal and heater boost)

When the Flags indicate that the Auxiliary Level is not used, it means that whatever is controlled by the Auxiliary Level is to operate automatically.

⁵ Raw Level is used (for example) for Evaporative control in non-thermostatic mode.

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Zones

A Zone List is made up of a list of zones (to which a command or setting is applied). A Zone List is made by adding the constants:

CBUS_AIR_CON_M_ZONE_0
CBUS_AIR_CON_M_ZONE_1
CBUS_AIR_CON_M_ZONE_2
CBUS_AIR_CON_M_ZONE_3
CBUS_AIR_CON_M_ZONE_4
CBUS_AIR_CON_M_ZONE_5
CBUS_AIR_CON_M_ZONE_6

Zone 0 also has the special name CBUS_AIR_CON_M_ZONE_UNSWITCHED.

Flags

The Flags are used to represent single pieces of information about the state or operation of Zones.

The purpose of each flag is self-explanatory. When a Flags parameter is needed, it is built by adding as appropriate the constants:

CBUS_AIR_CON_M_LEVEL_IS_RAW
CBUS_AIR_CON_M_SETBACK_ENABLED
CBUS_AIR_CON_M_GUARD_ENABLED
CBUS_AIR_CON_M_AUX_LEVEL_USED

HVAC Mode

The HVAC mode is specified by an enumerated type defined as follows:

cbus_air_con_et_hvac_mode

Enumerant	Meaning
cbus_air_con_ce_hvac_mode_off	The HVAC system is Off
cbus_air_con_ce_hvac_mode_heat_only	The HVAC system is heating
cbus_air_con_ce_hvac_mode_cool_only	The HVAC system is cooling
cbus_air_con_ce_hvac_mode_heat_and_cool	The HVAC system is heating or cooling with automatic changeover
cbus_air_con_ce_hvac_mode_vent_fan_only	The HVAC system is running a fan only

HVAC Type

The HVAC type is used to specify the plant type being controlled. It is normally fixed by an installation. Messages that transmit an HVAC Type must use a type that matches the installed equipment or the commands will be ignored. The HVAC type is an enumerated type defined as:

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cbus_air_con_et_hvac_type

Enumerant	Meaning
cbus_air_con_ce_hvac_type_none	No type.
cbus_air_con_ce_hvac_type_furnace	Gas / Oil / Electric furnace
cbus_air_con_ce_hvac_type_evaporative	Evaporative Cooler
cbus_air_con_ce_hvac_type_heat_pump_rc	Heat pump (reverse cycle)
cbus_air_con_ce_hvac_type_heat_pump_heat_only	Heat pump (heat only)
cbus_air_con_ce_hvac_type_heat_pump_cool_only	Heat pump (cool only)
cbus_air_con_ce_hvac_type_furnace_evaporative	Furnace heating / evaporative cooling
cbus_air_con_ce_hvac_type_furnace_heat_pump_cool	Furnace heating / heat pump cooling
cbus_air_con_ce_hvac_type_hydronic	Hydronic heating
cbus_air_con_ce_hvac_type_hydronic_heat_pump_cool	Hydronic heating / heat pump cooling
cbus_air_con_ce_hvac_type_hydronic_evaporative	Hydronic heating / evaporative cooling
cbus_air_con_ce_hvac_type_any	Intelligent selection of one of the above

HVAC Error Codes

The HVAC Error is used to report fault conditions in the plant being controlled. The HVAC Error is an enumerated type defined as:

cbus_air_con_et_hvac_error

Enumerant	Meaning
cbus_air_con_ce_hvac_error_no_error	No Error
cbus_air_con_ce_hvac_error_heater_total	Heater total failure
cbus_air_con_ce_hvac_error_cooler_total	Cooler total failure
cbus_air_con_ce_hvac_error_fan_total	Fan total failure
cbus_air_con_ce_hvac_error_temp_sensor	Temperature Sensor failure
cbus_air_con_ce_hvac_error_heater_temporary	Heater temporary problem
cbus_air_con_ce_hvac_error_cooler_temporary	Cooler temporary problem
cbus_air_con_ce_hvac_error_fan_temporary	Fan temporary problem

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Enumerant	Meaning
<code>cbus_air_con_ce_hvac_error_heater_service</code>	Heater service required
<code>cbus_air_con_ce_hvac_error_cooler_service</code>	Cooler service required
<code>cbus_air_con_ce_hvac_error_fan_service</code>	Fan service required
<code>cbus_air_con_ce_hvac_error_filer_replacement</code>	Filter replacement required

HVAC Status

The HVAC Status is used to represent single pieces of information about the state or operation of the HVAC system.

The HVAC Status is made by adding as appropriate the constants:

```
CBUS_AIR_CON_M_HVAC_STATUS_COOLING_ON
CBUS_AIR_CON_M_HVAC_STATUS_HEATING_ON
CBUS_AIR_CON_M_HVAC_STATUS_FAN_ACTIVE
CBUS_AIR_CON_M_HVAC_STATUS_DAMPER_OPEN
CBUS_AIR_CON_M_HVAC_STATUS_BUSY
CBUS_AIR_CON_M_HVAC_STATUS_ERROR
CBUS_AIR_CON_M_HVAC_STATUS_EXPANSION
```

Humidity Mode

The Humidity mode is specified by an enumerated type defined as follows:

`cbus_air_con_et_humidity_mode`

Enumerant	Meaning
<code>cbus_air_con_ce_humidity_mode_off</code>	The Humidity Control system is off
<code>cbus_air_con_ce_humidity_mode_humidify_only</code>	The Humidity Control system is humidifying
<code>cbus_air_con_ce_humidity_mode_dehumidify_only</code>	The Humidity Control system is dehumidifying
<code>cbus_air_con_ce_humidity_mode_humidity_control</code>	The Humidity Control system is maintaining humidity between limits

Humidity Type

The Humidity type is used to specify the plant type being controlled. It is normally fixed by an installation. Messages that transmit a Humidity Type must use a type that matches the installed equipment or the commands will be ignored. The Humidity type is an enumerated type defined as:

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cbus_air_con_et_humidity_type

Enumerant	Meaning
<code>cbus_air_con_ce_humidity_type_none</code>	No type
<code>cbus_air_con_ce_humidity_type_evaporator</code>	Evaporator equipment
<code>cbus_air_con_ce_humidity_type_refrigerative</code>	Refrigerative equipment
<code>cbus_air_con_ce_humidity_type_combined</code>	Evaporator / Refrigerative equipment
<code>cbus_air_con_ce_humidity_type_any</code>	Intelligent selection of one of the above

Humidity Error Codes

The Humidity Error is used to report fault conditions in the plant being controlled. The Humidity Error is an enumerated type defined as:

cbus_air_con_et_humidity_error

Enumerant	Meaning
<code>cbus_air_con_ce_humidity_error_no_error</code>	No Error
<code>cbus_air_con_ce_humidity_error_humidifier_total</code>	Humidifier total failure
<code>cbus_air_con_ce_humidity_error_dehumidifier_total</code>	Dehumidifier total failure
<code>cbus_air_con_ce_humidity_error_fan_total</code>	Fan total failure
<code>cbus_air_con_ce_humidity_error_humidity_sensor</code>	Humidity Sensor failure
<code>cbus_air_con_ce_humidity_error_humidifier_temporary</code>	Humidifier temporary problem
<code>cbus_air_con_ce_humidity_error_dehumidifier_temporary</code>	Dehumidifier temporary problem
<code>cbus_air_con_ce_humidity_error_fan_temporary</code>	Fan temporary problem
<code>cbus_air_con_ce_humidity_error_humidifier_service</code>	Humidifier service required
<code>cbus_air_con_ce_humidity_error_dehumidifier_service</code>	Dehumidifier service required
<code>cbus_air_con_ce_humidity_error_fan_service</code>	Fan service required

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Enumerant	Meaning
<code>cbus_air_con_ce_humidity_error_filer_replacement</code>	Filter replacement required

Humidity Status

The Humidity Status is used to represent single pieces of information about the state or operation of the Humidity control system.

The Humidity Status is made by adding as appropriate the constants:

`CBUS_AIR_CON_M_HUMIDITY_STATUS_HUMIDIFY_ON`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_DEHUMIDIFY_ON`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_FAN_ACTIVE`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_DAMPER_OPEN`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_BUSY`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_ERROR`
`CBUS_AIR_CON_M_HUMIDITY_STATUS_EXPANSION`

Schedule Formats

When thermostat schedule entries are being transmitted, the entry contains a format describing how it fits into the schedule.

Schedule formats are an enumerated type, as follows:

`cbus_air_con_et_schedule_fmt`

Enumerant	Meaning
<code>cbus_air_con_ce_schedule_fmt_4_all_same</code>	Four periods per day, all days the same
<code>cbus_air_con_ce_schedule_fmt_4_week_weekend</code>	Four periods per day, week / weekend format
<code>cbus_air_con_ce_schedule_fmt_4_days_different</code>	Four periods per day, each day different
<code>cbus_air_con_ce_schedule_fmt_6_all_same</code>	Six periods per day, all days the same
<code>cbus_air_con_ce_schedule_fmt_6_week_weekend</code>	Six periods per day, week / weekend format
<code>cbus_air_con_ce_schedule_fmt_6_days_different</code>	Six periods per day, each day different
<code>cbus_air_con_ce_schedule_fmt_no_fixed_periods</code>	No fixed number of periods

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Fan Modes

Fan Modes are used to set the operation of a fan. The fan modes are an enumerated type, as follows:

`cbus_air_con_et_fan_mode`

Enumerant	Meaning
<code>cbus_air_con_ce_fan_mode_automatic</code>	The fan will automatically be switched on and off as the climate control is maintained/
<code>cbus_air_con_ce_fan_mode_continuous</code>	The fan will run continuously.

Sensor Status

Used by a sensor to indicate the operating state of the sensor. The sensor status is an enumerated type, as follows:

`cbus_air_con_et_sensor_statusmode`

Enumerant	Meaning
<code>cbus_air_con_ce_sensor_no_error</code>	The sensor is operating normally
<code>cbus_air_con_ce_sensor_relaxed</code>	The sensor is operating in a relaxed accuracy band
<code>cbus_air_con_ce_sensor_out_of_cal</code>	The sensor is out of calibration
<code>cbus_air_con_ce_sensor_total_failure</code>	The sensor has had a total failure

C-Bus Module Interface Specification

17.2 C-Bus Functions**17.2.1 HVAC Schedule Entry**

```
cbus_air_con_vf_hvac_schedule_entry(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int8u i_entry,  
    cbus_air_con_et_schedule_fmt e_format,  
    cbus_air_con_et_hvac_mode e_mode,  
    int16s i_temp,  
    int8u i_flags,  
    int16u i_start_time,  
    int8u i_retries);
```

Broadcasts a change to an HVAC Schedule entry (if coming from a thermostat), or load a change to an HVAC Schedule entry (if not coming from a thermostat).

The start time is in minutes since 12am Sunday Morning, or CBUS_AIR_CON_M_SCHEDULE_NULL which indicates a NULL entry.

The temperature is in degrees C * 256 (if not raw), or a fraction of plant capacity (if raw).

17.2.2 Humidity Schedule Entry

```
cbus_air_con_vf_humidity_schedule_entry(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int8u i_entry,  
    cbus_air_con_et_schedule_fmt e_format,  
    cbus_air_con_et_humidity_mode e_mode,  
    int16u i_humidity,  
    int8u i_flags,  
    int16u i_start_time,  
    int8u i_retries);
```

Broadcasts a change to an Humidity Schedule entry (if coming from a thermostat), or load a change to a Humidity Schedule entry (if not coming from a thermostat).

The start time is in minutes since 12am Sunday Morning, or CBUS_AIR_CON_M_SCHEDULE_NULL which indicates a NULL entry.

The Humidity is either an unsigned percentage (if not raw format), or a fraction of plant capacity (if raw).

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17.2.3 Refresh

```
cbus_air_con_vf_refresh(int8u i_network,  
                        int8u i_zone_group,  
                        int8u i_retries);
```

Request the services in control of the specified Zone Group to issue commands describing its current schedule, operating state, and mode.

To prevent excessive C-Bus network bandwidth being consumed this command shall not be issued more frequently than once per 5 minutes. This limitation must be enforced in the users software.

17.2.4 Set HVAC Mode

```
cbus_air_con_vf_set_hvac_mode(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_hvac_mode e_mode,  
    cbus_air_con_et_hvac_type e_type,  
    int16s i_temp,  
    int8u i_flags,  
    cbus_air_con_et_fan_mode e_fan_mode,  
    int8u i_fan_speed,  
    int8u i_retries);
```

Broadcast a request (from user interface devices, or a schedule service, or a cbus thermostat schedule service) to indicate that the required HVAC mode and / or level for the Zone(s) has changed.

The Zone Manager(s) that are servicing the Zone(s) will react accordingly.

17.2.5 Set Humidity Mode

```
cbus_air_con_vf_set_humidity_mode(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_humidity_mode e_mode,  
    cbus_air_con_et_humidity_type e_type,  
    int16u i_humidity,  
    int8u i_flags,  
    cbus_air_con_et_fan_mode e_fan_mode,  
    int8u i_fan_speed,  
    int8u i_retries);
```

Broadcast a request (from user interface devices, or a schedule service, or a cbus thermostat schedule service) to indicate that the required Humidity mode and / or level for the Zone(s) has changed.

The Zone Manager(s) that are servicing the Zone(s) will react accordingly.

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17.2.6 HVAC Plant Status

```
cbus_air_con_vf_hvac_plant_status(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_hvac_type e_type,  
    int8u i_hvac_status,  
    cbus_air_con_et_hvac_error e_error,  
    int8u i_retries);
```

Issued by an HVAC plant controller whenever the Status of the system changes, or whenever an error needs to be reported by the plant controller.

17.2.7 Humidity Plant Status

```
cbus_air_con_vf_humidity_plant_status(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_humidity_type e_type,  
    int8u i_humidity_status,  
    cbus_air_con_et_hvac_error e_error,  
    int8u i_retries);
```

Issued by a Humidity plant controller whenever the Status of the system changes, or whenever an error needs to be reported by the plant controller.

17.2.8 Temperature

```
cbus_air_con_vf_zone_temperature(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16s i_temp,  
    cbus_air_con_et_sensor_status e_status,  
    int8u i_retries);
```

A temperature sensor can use this to send an update of the temperature it measures on a Zone, or Zones.

A thermostat or controller with integral temperature sensor also use this function to send the temperature of the Zone in which it is placed.

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17.2.9 Humidity

```
cbus_air_con_vf_zone_humidity(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16u i_humidity,  
    cbus_air_con_et_sensor_status e_status,  
    int8u i_retries);
```

A temperature sensor can use this to send an update of the temperature it measures on a Zone, or Zones. A thermostat or controller with integral temperature sensor can also use this.

17.2.10 Zone Group Off

```
cbus_air_con_vf_set_zone_group_off(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_retries);
```

Switch off all plant in all of the Zones of the specific Zone Group

17.2.11 Zone Group On

```
cbus_air_con_vf_set_zone_group_on(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_retries);
```

Switch on all plant in all of the Zones of the specific Zone Group, and restore their previous operational state.

17.2.12 Set HVAC Upper Guard

```
cbus_air_con_vf_set_hvac_upper_guard(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16s i_temp,  
    int8u i_flags,  
    int8u i_retries);
```

Set the upper guard temperature limit for a zone group. The flags are only used to specify if the temperature is in degrees or raw.

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17.2.13 *Set HVAC Lower Guard*

```
cbus_air_con_vf_set_hvac_lower_guard(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16s i_temp,  
    int8u i_flags,  
    int8u i_retries);
```

Set the lower guard temperature limit for a zone group. The flags are only used to specify if the temperature is in degrees or raw.

17.2.14 *Set HVAC Setback Limit*

```
cbus_air_con_vf_set_hvac_setback_limit(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16s i_temp,  
    int8u i_flags,  
    int8u i_retries);
```

Set the setback temperature limit for a zone group. The flags are only used to specify if the temperature is in degrees or raw.

17.2.15 *Set Humidity Upper Guard*

```
cbus_air_con_vf_set_humidity_upper_guard(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16u i_humidity,  
    int8u i_flags,  
    int8u i_retries);
```

Set the upper guard humidity limit for a zone group. The flags are only used to specify if the humidity is in percent or raw.

17.2.16 *Set Humidity Lower Guard*

```
cbus_air_con_vf_set_humidity_lower_guard(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16u i_humidity,  
    int8u i_flags,  
    int8u i_retries);
```

Set the lower guard humidity limit for a zone group. The flags are only used to specify if the humidity is in percent or raw.

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17.2.17 *Set Humidity Setback Limit*

```
cbus_air_con_vf_set_humidity_setback_limit(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    int16u i_humidity,  
    int8u i_flags,  
    int8u i_retries);
```

Set the setback humidity limit for a zone group. The flags are only used to specify if the humidity is in percent or raw.

17.2.18 *Set HVAC Plant*

```
cbus_air_con_vf_set_hvac_plant(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_hvac_mode e_mode,  
    cbus_air_con_et_hvac_type e_type,  
    int8u i_flags,  
    int8s i_plant_level,  
    cbus_air_con_et_fan_mode e_fan_mode,  
    int8u i_fan_speed,  
    int8u i_retries);
```

Sets the demand on a plant controller, based on calculations done in a thermostat.

17.2.19 *Set Humidity Plant*

```
cbus_air_con_vf_set_humidity_plant(  
    int8u i_network,  
    int8u i_zone_group,  
    int8u i_zone_list,  
    cbus_air_con_et_humidity_mode e_mode,  
    cbus_air_con_et_humidity_type e_type,  
    int8u i_flags,  
    int8s i_plant_level,  
    cbus_air_con_et_fan_mode e_fan_mode,  
    int8u i_fan_speed,  
    int8u i_retries);
```

Sets the demand on a plant controller, based on calculations done in a thermostat.

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17.3 Events**17.3.1 HVAC Schedule Event**

```
cbus_air_con_vf_register_hvac_schedule_handler(  
    void (*f)(int8u,  
              int8u,  
              int8u,  
              cbus_air_con_et_schedule_fmt,  
              cbus_air_con_et_hvac_mode,  
              int16s,  
              int8u,  
              int16u));
```

Event handler for a newly arrived HVAC Schedule entry message.

The start time is in minutes since 12am Sunday Morning, or
CBUS_AIR_CON_M_SCHEDULE_NULL which indicates a NULL entry.

The temperature is in degrees C * 256 (if not raw), or a fraction of plant capacity (if raw).

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int8u i_entry,  
                      cbus_air_con_et_schedule_fmt e_format,  
                      cbus_air_con_et_hvac_mode e_mode,  
                      int16s i_temp,  
                      int8u i_flags,  
                      int16u i_start_time)
```

17.3.2 Humidity Schedule Event

```
cbus_air_con_vf_register_humidity_schedule_handler(  
    void (*f)(int8u,  
              int8u,  
              int8u,  
              cbus_air_con_et_schedule_fmt,  
              cbus_air_con_et_humidity_mode,  
              int16u,  
              int8u,  
              int16u));
```

Event handler for a newly arrived Humidity Schedule entry message.

The start time is in minutes since 12am Sunday Morning, or
CBUS_AIR_CON_M_SCHEDULE_NULL which indicates a NULL entry.

The Humidity is either an unsigned percentage (if not raw format), or a fraction of plant capacity (if raw).

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The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int8u i_entry,  
                      cbus_air_con_et_schedule_fmt e_format,  
                      cbus_air_con_et_humidity_mode e_mode,  
                      int16u i_humidity,  
                      int8u i_flags,  
                      int16u i_start_time)
```

17.3.3 Refresh Event

```
cbus_air_con_vf_register_refresh_handler(  
    void (*f)(int8u));
```

Event handler for a newly arrived Refresh message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group)
```

17.3.4 Set HVAC Mode Event

```
cbus_air_con_vf_register_set_hvac_mode_handler(  
    void (*f)(int8u,  
              int8u,  
              cbus_air_con_et_hvac_mode,  
              cbus_air_con_et_hvac_type,  
              int16s,  
              int8u,  
              cbus_air_con_et_fan_mode,  
              int8u));
```

Event handler for a newly arrived Set HVAC Mode message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_hvac_mode e_mode,  
                      cbus_air_con_et_hvac_type e_type,  
                      int16s i_temp,  
                      int8u i_flags,  
                      cbus_air_con_et_fan_mode e_fan_mode,  
                      int8u i_fan_speed)
```

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17.3.5 Set Humidity Mode Event

```
cbus_air_con_vf_register_set_humidity_mode_handler(  
    void (*f)(int8u,  
               int8u,  
               cbus_air_con_et_humidity_mode,  
               cbus_air_con_et_humidity_type,  
               int16u,  
               int8u,  
               cbus_air_con_et_fan_mode,  
               int8u));
```

Event handler for a newly arrived Set Humidity Mode message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_humidity_mode e_mode,  
                      cbus_air_con_et_humidity_type e_type,  
                      int16u i_humidity,  
                      int8u i_flags,  
                      cbus_air_con_et_fan_mode e_fan_mode,  
                      int8u i_fan_speed)
```

17.3.6 HVAC Plant Status Event

```
cbus_air_con_vf_register_hvac_plant_status_handler(  
    void (*f)(int8u,  
               int8u,  
               cbus_air_con_et_hvac_type,  
               int8u,  
               cbus_air_con_et_hvac_error));
```

Event handler for a newly arrived HVAC Plant Status message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_hvac_type e_type,  
                      int8u i_hvac_status,  
                      cbus_air_con_et_hvac_error e_error)
```

17.3.7 Humidity Plant Status Event

```
cbus_air_con_vf_register_humidity_plant_status_handler(  
    void (*f)(int8u,  
               int8u,  
               cbus_air_con_et_humidity_type,  
               int8u,  
               cbus_air_con_et_humidity_error));
```

Event handler for a newly arrived Humidity Plant Status message.

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The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_humidity_type e_type,  
                      int8u i_humidity_status,  
                      cbus_air_con_et_humidity_error e_error)
```

17.3.8 Zone Temperature Event

```
cbus_air_con_vf_register_zone_temperature_handler(  
    void (*f)(int8u,  
              int8u,  
              int16s,  
              cbus_air_con_et_sensor_status));
```

Event handler for a newly arrived Zone Temperature message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int16s i_temp,  
                      cbus_air_con_et_sensor_status e_status)
```

17.3.9 Zone Humidity Event

```
cbus_air_con_vf_register_zone_humimidity_handler(  
    void (*f)(int8u,  
              int8u,  
              int16u,  
              cbus_air_con_et_sensor_status));
```

Event handler for a newly arrived Zone Humidity message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int16u i_humidity,  
                      cbus_air_con_et_sensor_status e_status)
```

17.3.10 Zone Group Off Event

```
cbus_air_con_vf_register_zone_off_handler(  
    void (*f)(int8u));
```

Event handler for a newly arrived Zone Group Off message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group)
```

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17.3.11 *Zone Group On Event*

```
cbus_air_con_vf_register_zone_on_handler(  
    void (*f)(int8u));
```

Event handler for a newly arrived Zone Group On message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group)
```

17.3.12 *Set HVAC Upper Guard Event*

```
cbus_air_con_vf_register_hvac_upper_guard_handler(  
    void (*f)(int8u,  
               int8u,  
               int16s,  
               int8u));
```

Event handler for a newly arrived Set HVAC Upper Guard message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int16s i_temp,  
                      int8u i_flags);
```

17.3.13 *Set HVAC Lower Guard Event*

```
cbus_air_con_vf_register_hvac_lower_guard_handler(  
    void (*f)(int8u,  
               int8u,  
               int16s,  
               int8u));
```

Event handler for a newly arrived Set HVAC Lower Guard message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      int16s i_temp,  
                      int8u i_flags);
```

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17.3.14 *Set HVAC Setback Limit Event*

```
cbus_air_con_vf_register_hvac_setback_handler(  
    void (*f)(int8u,  
              int8u,  
              int16s,  
              int8u));
```

Event handler for a newly arrived Set HVAC Setback message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                     int8u i_zone_list,  
                     int16s i_temp,  
                     int8u i_flags);
```

17.3.15 *Set Humidity Upper Guard Event*

```
cbus_air_con_vf_register_humidity_upper_guard_handler(  
    void (*f)(int8u,  
              int8u,  
              int16u,  
              int8u));
```

Event handler for a newly arrived Set Humidity Upper Guard message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                     int8u i_zone_list,  
                     int16u i_humidity,  
                     int8u i_flags);
```

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17.3.16 *Set Humidity Lower Guard Event*

```
cbus_air_con_vf_register_humidity_lower_guard_handler(  
    void (*f)(int8u,  
              int8u,  
              int16u,  
              int8u));
```

Event handler for a newly arrived Set Humidity Lower Guard message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                     int8u i_zone_list,  
                     int16u i_humidity,  
                     int8u i_flags);
```

17.3.17 *Set Humidity Setback Limit Event*

```
cbus_air_con_vf_register_humidity_setback_handler(  
    void (*f)(int8u,  
              int8u,  
              int16u,  
              int8u));
```

Event handler for a newly arrived Set Humidity Setback message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                     int8u i_zone_list,  
                     int16u i_humidity,  
                     int8u i_flags);
```

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17.3.18 *Set HVAC Plant Event*

```
cbus_air_con_vf_register_hvac_plant_handler(  
    void (*f)(int8u,  
               int8u,  
               cbus_air_con_et_hvac_mode,  
               cbus_air_con_et_hvac_type,  
               int8u,  
               int8s,  
               cbus_air_con_et_fan_mode,  
               int8u));
```

Event handler for a newly arrived Set HVAC Plant message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_hvac_mode e_mode,  
                      cbus_air_con_et_hvac_type e_type,  
                      int8u i_flags,  
                      int8s i_plant_level,  
                      cbus_air_con_et_fan_mode e_fan_mode,  
                      int8u i_aux_level)
```

17.3.19 *Set Humidity Plant Event*

```
cbus_air_con_vf_register_humidity_plant_handler(  
    void (*f)(int8u,  
               int8u,  
               cbus_air_con_et_humidity_mode,  
               cbus_air_con_et_humidity_type,  
               int8u,  
               int8s,  
               cbus_air_con_et_fan_mode,  
               int8u));
```

Event handler for a newly arrived Set Humidity Plant message.

The handler should be declared as:

```
void my_event_handler(int8u i_zone_group,  
                      int8u i_zone_list,  
                      cbus_air_con_et_humidity_mode e_mode,  
                      cbus_air_con_et_humidity_type e_type,  
                      int8u i_flags,  
                      int8u i_plant_level,  
                      cbus_air_con_et_fan_mode e_fan_mode,  
                      int8u i_aux_level)
```

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18 DATE AND TIME APPLICATION

The Clock & Timekeeping Application is used to broadcast date and time information to devices on a network. This application allows changes to date and time made on a C-Bus device to be synchronously propagated to all other interested devices on the C-Bus network.

Devices which could use the Clock and Timekeeping Application include Security Systems, the C-Touch Touchscreen, a C-Bus master time server, and so on.

18.1 Network Variables

The Date and Time Application has two Network Variables: the Date and the Time.

These variables are automatically updated in response to received C-Bus messages and are maintained in real-time, therefore providing calendar services.

The storage format for the date and time are defined in the header file.
These variables are exported as a structure and can be read directly.
Direct update of these variables is not supported, and could cause unpredictable results.

18.2 General Purpose Functions**18.2.1 Days In Month**

```
int8u cbus_time_if_days_in_month(int8u m,
                                int16u y);
```

This returns the number of days in month *m* of year *y*.

18.2.2 Day Number

```
int16u cbus_time_if_calculate_day_number(
    cbus_time_st_time_type *time);
```

This calculates the day number. This is the number of days (inclusive) that have elapsed since 1 January 2000.

18.2.3 Day Number to Day Of Week

```
int8u cbus_time_if_day_number_to_day_of_week(int16u day_number);
```

This calculates the day of the week from the day number. Sunday = 0 ... Saturday = 6.

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18.2.4 Day of Week

```
int8u cbus_time_if_calculate_day_of_week(  
    cbus_time_st_time_type *time);
```

This calculates the day of the week from the date. Sunday = 0 ... Saturday = 6.

18.2.5 Copy Time

```
void cbus_time_vf_copy_time(cbus_time_st_time_type *source_date,  
    cbus_time_st_time_type *dest_date);
```

This copies the date and time from the `source_date` structure to the `dest_date` structure.

18.2.6 Get Time

```
void cbus_time_vf_get_time(cbus_time_st_time_type *user_time);
```

This gets the current time, as an alternative to using or copying the exported time / date structure.

18.2.7 Set Time

```
void cbus_time_vf_set_time(cbus_time_st_time_type * new_time);
```

This sets the current time.

<p><i>This function updates the local copy of the date & time, but does not make a transmission onto C-Bus.</i></p>
--

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18.3 C-Bus Functions**18.3.1 Send Date**

```
void cbus_time_vf_send_date(int8u network);
```

This transmits the current date onto C-Bus.

18.3.2 Send Time

```
void cbus_time_vf_send_time(int8u network);
```

This transmits the current time onto C-Bus.

18.3.3 Send Date and Time

```
void cbus_time_vf_send_date_time(int8u network);
```

This transmits the current date and time onto C-Bus.

18.4 Events

```
void cbus_time_vf_register_handler(  
    void (*f)(cbus_boolean),  
    cbus_time_st_time_type,  
    cbus_time_st_time_type);
```

This registers the event handler for the Date/Time Application messages.

If a Date/Time message is received, the database will be automatically updated and the event handler will be called (if registered).

The parameter passed indicates whether the date changed (otherwise the time has changed).

The registered function shall be of the form:

```
void my_event_handler(cbus_boolean date_changed,  
    cbus_time_st_time_type *initial_date_time,  
    cbus_time_st_time_type *adjusted_date_time);
```

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19 ERROR REPORTING APPLICATION**19.1 Description**

The C-Bus Error Reporting Application is used to report error or fault information detected or generated by C-Bus units over the C-Bus network.

A **Monitored Event** is an event or value that is watched to determine the presence or absence of a failure.

An **Error Monitoring Device** watches Monitored Events and transmits their status to a C-Bus network.

An **Error Receiving Device** accepts status information from a C-Bus network but does not watch Monitored Events directly.

Transmissions shall be separated by at least five seconds to ensure the C-Bus network is not overloaded.

Errors may be acknowledged on an individual basis. If an error has been acknowledged this information will be included in any further refreshes of the error status.

Messages on the C-Bus Error Reporting Application effect composite network variables for the System Category, Latched Flag, Acknowledge Flag, Severity, Unit Number and Error Data.

Error severity is one of the following values from the enumerated type:

`cbus_error_et_severity`

Enumerant	Meaning
<code>cbus_error_ce_severity_all_ok</code>	A unit has no failures to report for anything that it is watching
<code>cbus_error_ce_severity_ok</code>	A unit reports that a Monitored Event is OK
<code>cbus_error_ce_severity_minor_failure</code>	A unit reports that a Monitored Event has a minor failure
<code>cbus_error_ce_severity_general_failure</code>	A unit reports that a Monitored Event has a general failure
<code>cbus_error_ce_severity_extreme_failure</code>	A unit reports that a Monitored Event has an extreme failure

The exact meanings associated with severity is at the discretion of the Error5 Receiving device, though generally the following guidance should apply:

- A Minor Failure is something that is reported but for which there are no serious consequences, for example, a blown lamp in the middle of a large room;

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- A General Failure is more serious than a minor failure;
- An Extreme Failure is very serious. Practical examples include a blown lamp in a public access stairway, or a complete breakdown of an air-conditioning system.

19.2 Functions

```
void cbus_error_vf_send_report(int8u i_network,  
                               int16u i_system_category,  
                               cbus_boolean b_latch_shortcut,  
                               cbus_boolean b_acknowledged,  
                               cbus_boolean b_latched,  
                               cbus_error_et_severity e_severity,  
                               int8u i_unit_identifier,  
                               int8u i_error_data_1,  
                               int8u i_error_data_2,  
                               int8u i_retries);
```

This function transmits an error report, or acknowledges a report, or is used to clear a latched error report.

For example when an error report is received, it can be acknowledged by sending the same error again (from the receiving device) with the "b_acknowledged" parameter set to cbus_true.

Similarly, a latched error is cleared by sending the same error again (from the receiving device) with the severity set to OK.

If the flag "b_latch_shortcut" is set, it means the latched error and current error are the same, so a separate latched error message should not be sent.

19.3 Events

```
void cbus_error_vf_register_handler(  
    void (*f)(int16u i_system_category,  
               cbus_boolean b_latch_shortcut,  
               cbus_boolean b_acknowledged,  
               cbus_boolean b_latched,  
               cbus_error_et_severity e_severity,  
               int8u i_unit_identifier,  
               int8u i_error_data_1,  
               int8u i_error_data_2));
```

This registers the event handler for the Error Reporting messages.

If an Error Report message is received the event handler will be called (if registered). The parameters passed to the handler are the system category, acknowledged and latched flags, the severity, the originating unit identification, and two pieces of error information specific to that system category.

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19.4 Important Notes

System categories and the error data items are allocated from a register maintained by Clipsal Integrated Systems as part of the documentation of the C-Bus Error Reporting Application.

These items must be allocated and used in consultation with Clipsal Integrated Systems.

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20 MEASUREMENT APPLICATION

20.1 Network Variables

The Measurement Application has network variables corresponding to the value of each channel of each measurement device.

The number and type of measurement devices is highly flexible and at the discretion of an installer. Consequently, the C-Bus Module does not maintain the value of these variables internally. It just sends and receives the commands.

Measurements have units (of measurement), which are described using the following enumerated type:

`cbus_measurement_et_unit_type`

Enumerant	Meaning
<code>cbus_measurement_ce_centigrade</code>	Temperature
<code>cbus_measurement_ce_amp</code>	Current
<code>cbus_measurement_ce_degree</code>	Angular displacement
<code>cbus_measurement_ce_coulomb</code>	(Electric) charge
<code>cbus_measurement_ce_true_false</code>	Boolean stuff
<code>cbus_measurement_ce_farad</code>	Capacitance
<code>cbus_measurement_ce_henry</code>	Inductance
<code>cbus_measurement_ce_hertz</code>	Frequency
<code>cbus_measurement_ce_joule</code>	Energy
<code>cbus_measurement_ce_katal</code>	Rate of catalytic activity
<code>cbus_measurement_ce_kg_m3</code>	Density
<code>cbus_measurement_ce_kg</code>	Mass
<code>cbus_measurement_ce_litre</code>	Volume
<code>cbus_measurement_ce_litre_h</code>	Very slow flow rates
<code>cbus_measurement_ce_litre_m</code>	Slow flow rate
<code>cbus_measurement_ce_litre_s</code>	Flow rate
<code>cbus_measurement_ce_lux</code>	Light level
<code>cbus_measurement_ce_metre</code>	Distance
<code>cbus_measurement_ce_metre_m</code>	Slow speed
<code>cbus_measurement_ce_metre_s</code>	Speed
<code>cbus_measurement_ce_metre_s2</code>	Acceleration
<code>cbus_measurement_ce_mole</code>	Quantity of substance

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Enumerant	Meaning
cbus_measurement_ce_newton_metre	Torque
cbus_measurement_ce_newton	Force
cbus_measurement_ce_ohm	Resistance
cbus_measurement_ce_pascal	Pressure
cbus_measurement_ce_percent	Humidity, generic percentages & linear ratios
cbus_measurement_ce_decibel	Logarithmic ratio
cbus_measurement_ce_ppm	Concentrations
cbus_measurement_ce_rpm	Angular speed
cbus_measurement_ce_second	Elapsed Time
cbus_measurement_ce_minute	Elapsed Time
cbus_measurement_ce_hour	Elapsed Time
cbus_measurement_ce_sievert	Radiation
cbus_measurement_ce_steradian	Units of solid angle
cbus_measurement_ce_tesla	Magnetic field strength
cbus_measurement_ce_volt	Voltage
cbus_measurement_ce_watt_hour	Power consumption
cbus_measurement_ce_watt	Power
cbus_measurement_ce_weber	Magnetic Flux
cbus_measurement_ce_no_unit	Unitless quantities
cbus_measurement_ce_custom	User defined

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20.2 Functions**20.2.1 Send Measurement Data**

```
void cbus_measurement_vf_send_data(  
    int8u network,  
    int8u device_id,  
    int8u channel,  
    int32s mantissa,  
    int8s exponent,  
    cbus_measurement_et_unit_type units);
```

This function sends a Measurement Application message, where

channel is the measurement channel number

mantissa is the numeric value of the measured parameter.

exponent is the multiplier (power of ten)

units is the units of the measured parameter, as selected from the table in section 20.1.

20.3 Events

```
void cbus_measurement_vf_register_handler(  
    void (*f)(int8u,  
        int8u,  
        int32s,  
        int8s,  
        cbus_measurement_et_unit_type));
```

This registers the event handler for the Measurement Application messages.

If a Measurement Application message is received, the event handler will be called (if registered). The parameters passed are the Device Identifier, the Channel number, the mantissa and exponent of the measured value and the Unit Type, as defined in section 20.1.

The registered function shall be of the form:

```
void my_event_handler(int8u device_id,  
    int8u channel,  
    int32s mantissa,  
    int8s exponent,  
    cbus_measurement_et_unit_type units);
```

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21 SECURITY APPLICATION

The Security Application is used to control and monitor a security system.

A security system usually makes use of proprietary devices such as sensors, keypads, and a monitor panel, but can also respond to C-Bus messages and announce status onto C-Bus for other devices to use if they desire.

The Security Application module usage depends on whether the device using the module is a Security Panel or some other device.

For example, an "Arm System" command will be transmitted by a Security Panel as a command, but other devices would only receive "Arm System" commands as an event.

Any device can use any of the functions or events, but they are separated in this document for clarity.

21.1 Network Variables

The Security Application maintains the following model of the security system as network variables:

- Zone Isolation (`cbus_true` / `cbus_false`)
- State of Tamper, Panic, Alarm, Low Battery, Main, Line Cut, Arm Fail, Fire Alarm, Gas Alarm, Other Alarm (`cbus_true` / `cbus_false`)
- Zone State, as the enumerated type:

`cbus_security_et_zone_state_type`

Enumerant	Meaning
<code>cbus_security_ce_zone_sealed</code>	Zone is sealed
<code>cbus_security_ce_zone_unsealed</code>	Zone is unsealed
<code>cbus_security_ce_zone_open</code>	Zone is open circuit
<code>cbus_security_ce_zone_short</code>	Zone is short circuit

- System Arm State, as the enumerated type:

`cbus_security_et_arm_code_type`

Enumerant	Meaning
<code>cbus_security_ce_disarmed</code>	Security system is disarmed
<code>cbus_security_ce_fully_armed</code>	Security system is completely armed
<code>cbus_security_ce_partially_armed</code>	Security system is partly armed

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21.2 Security Database Functions

Values are automatically set when sending or receiving C-Bus Commands.

Setting these values (using a ..._set... call) does NOT cause a C-Bus message to be sent.

All status variables (except Zone Status) are reset when a System Disarm command is sent or received.

21.2.1 Get Zone State

```
cbus_security_et_zone_state_type  
cbus_security_ef_get_zone_state(int8u zone_number);
```

This returns the state of a zone.

21.2.2 Set Zone State

```
void cbus_security_vf_set_zone_state(  
    int8u zone_number,  
    cbus_security_et_zone_state_type zone_state);
```

This sets the state of a zone.

21.2.3 Get Zone Isolation

```
cbus_boolean cbus_security_bf_get_zone_isolation(  
    int8u zone_number);
```

This returns `cbus_true` if the zone is isolated.

21.2.4 Set Zone Isolation

```
void cbus_security_vf_set_zone_isolation(  
    int8u zone_number,  
    cbus_boolean zone_isolated);
```

This sets zone to isolated if `cbus_true`, or non-isolated otherwise.

21.2.5 Get System Armed Status

```
cbus_security_et_arm_code_type  
cbus_security_ef_get_armed_status(void);
```

This returns the system armed state.

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21.2.6 Set System Armed Status

```
void cbus_security_vf_set_armed_status(
    cbus_security_et_arm_code_type armed_status);
```

This sets the system armed state.

21.2.7 Get System State

```
cbus_boolean cbus_security_bf_get_status(
    cbus_security_et_status_message_type status_item);
```

This returns the status of *item*, which is an enumerated type. The state returned is *cbus_true* (meaning that item is active) or *cbus_false* (meaning that the item is not active). The possible items to query are:

cbus_security_et_status_message_type

Enumerant	Meaning
<i>cbus_security_ce_status_alarm</i>	If <i>cbus_true</i> , an alarm is active
<i>cbus_security_ce_status_tamper</i>	If <i>cbus_true</i> , tamper is active
<i>cbus_security_ce_status_panic</i>	If <i>cbus_true</i> , panic is active
<i>cbus_security_ce_status_low_battery</i>	If <i>cbus_true</i> , low battery is active
<i>cbus_security_ce_status_mains_failure</i>	If <i>cbus_true</i> , mains has failed
<i>cbus_security_ce_status_line_cut</i>	If <i>cbus_true</i> , a telephone line has been cut
<i>cbus_security_ce_status_arm_failed</i>	If <i>cbus_true</i> , an arm failed
<i>cbus_security_ce_status_fire_alarm</i>	If <i>cbus_true</i> , a fire alarm is active
<i>cbus_security_ce_status_gas_alarm</i>	If <i>cbus_true</i> , a gas alarm is active
<i>cbus_security_ce_status_other_alarm</i>	If <i>cbus_true</i> , some other alarm type is active

21.2.8 Set System Status

```
void cbus_security_vf_set_status(
    cbus_security_et_status_message_type item,
    cbus_boolean state);
```

This sets the state of the parameter in the database. The items are as described above.

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21.3 Non-Security Panel (Slave) Usage

These functions and events are used to interact with a C-Bus security system.

21.3.1 Functions

21.3.1.1 Status Request

```
void cbus_security_vf_status_request(int8u network);
```

This requests an update of the status of the attached security system, by sending Status 1 & 2 Request messages onto C-Bus. The security panel will reply with Status 1 and Status 2 messages. Any changes to the armed, tamper, panic or zone states will cause the appropriate event handlers to be called.

21.3.1.2 Arm System

```
void cbus_security_vf_arm_system(
    int8u network,
    cbus_security_et_arm_type arm_mode);
```

This sends a command to arm the security system. The Arm Mode is an enumerated type:

`cbus_security_et_arm_type`

Enumerant	Meaning
<code>cbus_security_ce_away_mode</code>	Arm in away mode
<code>cbus_security_ce_night_mode</code>	Arm in night mode
<code>cbus_security_ce_day_mode</code>	Arm in day mode
<code>cbus_security_ce_vacation_mode</code>	Arm in vacation mode
<code>cbus_security_ce_highest_level</code>	Arm to the highest level of protection possible

21.3.1.3 Set / Drop Tamper

```
extern void cbus_security_vf_tamper_status(
    int8u network,
    cbus_boolean tamper_status);
```

This requests that the security system raise (if `tamper_state = cbus_true`) or drop its tamper state.

21.3.1.4 Raise Alarm

```
void cbus_security_vf_raise_alarm(int8u network);
```

This requests that the security system raise an alarm condition.

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21.3.1.5 *Emulate Keypad*

```
void cbus_security_vf_emulate_keypad(int8u network,  
                                     char key);
```

This sends an Emulate Keypad security command onto C-Bus. The key parameter is an ASCII character (see the Security Application Documentation). This will be interpreted by the security system however is appropriate for its current mode and type of operation (normal entry of a password).

21.3.1.6 *Display Message*

```
void cbus_security_vf_display_message(int8u network,  
                                     char * message);
```

This requests that the security system display the supplied message⁶.

21.3.1.7 *Request Zone Name*

```
void cbus_security_vf_request_zone_name(int8u network,  
                                       int8u zone_number);
```

This requests that the security system return the name of the specified zone⁷.

⁶ Not all security systems support display of messages.

⁷ Not all security systems support returning zone names.

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21.3.2 Events

If a message is received (from a security system), the relevant event handler will be called.

When a Status Report message is received, it may trigger a Zone Status, System Arm Status, Tamper Status or Panic Status event.

An event handler will only be called if the received message sets a state different to that stored in the database.

21.3.2.1 System Armed Event

```
void cbus_security_vf_system_armed_handler(  
    void (*f)(cbus_security_et_arm_code_type));
```

This registers an event handler for the Security Application Armed message.

When a System Armed or System Disarmed message is received on the Security Application, the registered handler will be called. The Arm Code Type as defined in section 21.1, is passed as a parameter.

The registered function shall be of the form:

```
void my_event_handler(  
    cbus_security_et_arm_code_type arm_code_type);
```

21.3.2.2 Exit Delay Started Event

```
void cbus_security_vf_exit_delay_started_handler(void (*f)(void));
```

This registers an event handler for an Exit Delay Started message on the Security Application. When such a message is received, the registered handler will be called.

The registered function shall be of the form:

```
void my_event_handler(void);
```

21.3.2.3 Entry Delay Started Event

```
void cbus_security_vf_entry_delay_started_handler(  
    void (*f)(void));
```

This registers an event handler for an Entry Delay Started message on the Security Application. When such a message is received, the registered handler will be called.

```
void my_event_handler(void);
```

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21.3.2.4 Status Event

```
void cbus_security_vf_status_message_handler(  
    void (*f)(cbus_security_et_status_message_type,  
              cbus_boolean));
```

This registers an event handler for Status messages on the Security Application. When status messages are received, the registered handler will be called.

The handler is passed the system state that has changed, and what it has changed to. Possible system states are shown in section 21.2.7.

The registered function shall be of the form:

```
void my_event_handler(  
    cbus_security_et_status_message_type message_type,  
    cbus_boolean status);
```

21.3.2.5 Zone State Event

```
void cbus_security_vf_zone_handler(void (*f)(int8u));
```

This registers an event handler for the Zone state change messages on the Security Application. When a Zone Unsealed, Zone Sealed, Zone Open, Zone Short, Zone Isolated or Status Report message is received on the Security Application, the registered handler will be called. The zone number is passed as a parameter.

Use the `cbus_security_ef_get_zone_status` function to find what the zone state changed to.

The registered function shall be of the form:

```
void my_event_handler(int8u zone_number);
```

Special Cases: If a Status Report 1 is received, the Zone number parameter will be \$FE. If a Status Report 1 is received, the Zone number parameter will be \$FF.

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21.3.2.6 *Battery Charging Event*

```
void cbus_security_vf_battery_charging_handler(
    void (*f)(cbus_security_et_battery_charging_type));
```

This registers an event handler for Battery Charge messages on the Security Application. When a Battery Charging message on the Security Application is received, the registered handler will be called. The battery charge state is an enumerated type, and is passed as a parameter:

cbus_security_et_battery_charging_type

Enumerant	Meaning
cbus_security_ce_charging_stopped	Battery charging has stopped (was previously charging)
cbus_security_ce_charging_started	Battery charging has started (was previously not charging)

The registered function shall be of the form:

```
void my_event_handler(
    cbus_security_et_battery_charging_type state);
```

21.3.2.7 *Zone Name Event*

```
void cbus_security_vf_zone_name_handler(void (*f)(int8u,
    char *));
```

This registers an event handler for Zone Name Security Application messages. When a Zone Name message on the Security Application is received, the registered handler will be called. The zone number and the name of the zone are passed as parameters. The registered function shall be of the form:

```
void my_event_handler(int8u zone_number,
    char * zone_name);
```

21.3.2.8 *Password Entry Event*

```
void cbus_security_vf_password_entry_status_handler(
    void (*f)(cbus_security_et_password_entry_type));
```

This registers an event handler for the Password Entry Security Application messages. When a Password Entry message on the Security Application is received, the registered handler will be called. The password entry state is passed as a parameter and is an enumerated type:

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cbus_security_et_password_entry_type

Enumerant	Meaning
cbus_security_ce_password_succeeded	Password entry succeeded
cbus_security_ce_password_failed	Password entry failed
cbus_security_ce_password_disabled	Password entry has been disabled (was previously enabled)
cbus_security_ce_password_enabled	Password entry has been enabled (was previously disabled)

The registered function shall be of the form:

```
void my_event_handler(cbsecurity_et_password_entry_type code);
```

21.3.2.9 Arm Ready / Not Ready Event

```
void cbus_security_vf_arm_status_handler(void (*f)(int8u));
```

This registers an event handler for Arm Ready / Not Ready messages on the Security Application. When an Arm Ready / Not Ready message on the Security Application is received, the registered handler will be called.

The applicable zone code is passed as a parameter. The registered function shall be of the form:

```
void my_event_handler(int8u zone_number);
```

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21.4 Security Panel (Master) Usage

The following functions and event handlers are only applicable to Security Panels, and should not be used by any other devices.

21.4.1 Functions

The following functions provide the means of transmitting Security commands.

21.4.1.1 System Arm / Disarm

```
void cbus_security_vf_system_arm_status(  
    int8u network,  
    cbus_security_et_arm_code_type arm_code);
```

This sends a System Armed or System Disarmed Security Application command onto C-Bus.

21.4.1.2 Exit Delay Started

```
void cbus_security_vf_exit_delay_started(int8u network);
```

This sends an Exit Delay Started Security Application command onto C-Bus.

21.4.1.3 Entry Delay Started

```
void cbus_security_vf_entry_delay_started(int8u network);
```

This sends an Entry Delay Started Security Application command onto C-Bus.

21.4.1.4 System State

```
void cbus_security_vf_status_message(  
    int8u network,  
    cbus_security_et_status_message_type message_type,  
    cbus_boolean status);
```

This sends a Security Application status command onto C-Bus. The `message_type` is described in section 21.2.7.

21.4.1.5 Zone State

```
void cbus_security_vf_zone_state(  
    int8u network,  
    int8u zone_number,  
    cbus_security_et_zone_state_type zone_state);
```

This sends a Zone Unsealed, Zone Sealed, Zone Open or Zone Short Security Application command onto C-Bus. The zone state is described in section 21.1.

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21.4.1.6 Zone Isolated

```
void cbus_security_vf_zone_isolated(int8u network,  
                                   int8u zone_number);
```

This sends a Zone Isolated Security Application command onto C-Bus.

21.4.1.7 Battery Charging

```
void cbus_security_vf_battery_charging(  
    int8u network,  
    battery_charging_type battery_status);
```

This sends a Battery Charging Security Application command onto C-Bus.

21.4.1.8 Zone Name

```
void cbus_security_vf_zone_name(int8u network,  
                                int8u zone_number,  
                                char * zone_name);
```

This sends a Zone Name Security Application command onto C-Bus.

The zone name shall be an 11 character ASCII string, padded with spaces if necessary, and null terminated (null terminator is the 12th byte).
This shall ONLY be sent in response to a received Request Zone Name command.

21.4.1.9 Status Report 1

```
void cbus_security_vf_status_report_1(int8u network);
```

This sends a Status Report 1 Security Application command onto C-Bus.

This shall only be sent in response to a Status 1 Request command.

21.4.1.10 Status Report 2

```
void cbus_security_vf_status_report_2(int8u network);
```

This sends a Status Report 2 Security Application command onto C-Bus.

This shall only be sent in response to a Status 2 Request command.

21.4.1.11 Password Entry Status

```
void cbus_security_vf_password_entry_status(  
    int8u network,  
    cbus_security_et_password_entry_type password_status);
```

This sends a Password Entry Status Security Application command onto C-Bus.

The password status is described in section 21.3.2.8.

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21.4.1.12 *Arm Ready / Not Ready*

```
void cbus_security_vf_arm_ready(int8u network,  
                                int8u zone_number);
```

This sends an Arm Ready or Arm Not Ready Security Application command onto C-Bus. The zone number of any unsealed zone is passed as a parameter.

The zone number is 0 if the system has armed correctly.

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21.4.2 Events

If a Security message is received, the appropriate event handler will be called (if registered).

21.4.2.1 Status 1 Request Event

```
void cbus_security_vf_status_1_request_handler(void (f)(void));
```

This registers an event handler for the Status 1 Request Security Application message. When a Status Request 1 command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(void);
```

21.4.2.2 Status 2 Request Event

```
void cbus_security_vf_status_2_request_handler(void (f)(void));
```

This registers an event handler for the Status 2 Request Security Application message. When a Status Request 2 command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(void);
```

21.4.2.3 Arm System Event

```
void cbus_security_vf_arm_system_handler(  
    void (*f)(cbus_security_et_arm_type));
```

This registers an event handler for the Arm System Security Application message. When an Arm System command on the Security Application is received, the registered handler will be called. The arm type is passed as a parameter, and is described in section 21.3.1.2.

The registered function shall be of the form:

```
void my_event_handler(cbus_security_et_arm_type arm_mode);
```

21.4.2.4 Alarm Event

```
void cbus_security_vf_alarm_handler(void (*f)(cbus_boolean));
```

This registers an event handler for the Alarm Security Application message. When an Alarm command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

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```
void my_event_handler(cbus_boolean alarm_status);
```

21.4.2.5 Tamper Event

```
void cbus_security_vf_tamper_handler(void (*f)(cbus_boolean));
```

This registers an event handler for Tamper Security Application messages. When a Tamper command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(cbus_boolean tamper_status);
```

21.4.2.6 Emulate Keyboard Event

```
void cbus_security_vf_emulate_keypad_handler(void (f)(char));
```

This registers an event handler for Emulate Keypad Security Application messages. When an Emulate Keypad event on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(char key);
```

21.4.2.7 Display Message Event

```
void cbus_security_vf_display_message_handler(void (f)(char *));
```

This registers an event handler for the Display Message Security Application command. When a Display Message command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(char * message);
```

21.4.2.8 Request Zone Name Event

```
void cbus_security_vf_request_zone_name_handler(void (f)(int8u));
```

This registers an event handler for the Request Zone Name Security Application command. When a Request Zone Name command on the Security Application is received, the registered handler will be called. The registered function shall be of the form:

```
void my_event_handler(int8u zone_number);
```

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22 TELEPHONY APPLICATION

The Telephony Status & Control Application is used by C-Bus Telephone Devices to broadcast status onto C-Bus, and to enable other devices to control a C-Bus Telephone Device.

For example, a "Divert" command will be received by a Telephone Interface as an event to trigger some action, but other devices would only send "Divert" commands, and would not care about the event.

Any device can use any of the functions or events, but they are separated in this document for clarity.

22.1 Network Variables

The Telephony Application does not have Network Variables. The only interfaces to the Telephony Application are function calls and events.

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22.2 Non-Telephone Interface (Slave) Usage

22.2.1 Functions

The following functions provide the means of transmitting telephony commands (usually to a C-Bus Telephone Interface).

22.2.1.1 *Isolate Secondary Output*

```
void cbus_telephony_vf_isolate_secondary_outlet (
    int8u network,
    cbus_telephony_et_isolate_secondary_type isolate_status);
```

This sends a command to set the isolation of the secondary outlet of a C-Bus Telephone Interface. The `isolate_status` variable definition is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_normal</code>	Set the secondary outlet to a normal connection.
<code>cbus_telephony_ce_isolated</code>	Isolate the secondary outlet from the incoming telephone line.

22.2.1.2 *Recall Last Number*

```
void cbus_telephony_vf_recall_last_number (
    int8u network,
    cbus_telephony_et_recall_number_type type);
```

This sends a command to retrieve the last incoming or outgoing telephone number. The returned value indicates if the command was successful. The `type` variable definition is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_outgoing</code>	Ask the telephone interface to retrieve and return the telephone number of the last outgoing call.
<code>cbus_telephony_ce_incoming</code>	Ask the telephone interface to retrieve and return the telephone number of the last incoming call ⁸ .

⁸ Retrieving the telephone numbers of incoming calls from a C-Bus telephone interface requires the customer to have Calling Line Identification enabled on their telephone line, and that the line identification operate in a supported format.

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22.2.1.3 *Reject Incoming Calls*

```
void cbus_telephony_vf_reject_incoming_call(int8u network);
```

This causes the current incoming call to be rejected.

22.2.1.4 *Divert*

```
void cbus_telephony_vf_divert(int8u network,  
                             char * number);
```

This sends a command the telephone interface, requesting that it divert incoming calls to another telephone number.

22.2.1.5 *Clear Diversion*

```
void cbus_telephony_vf_clear_diversion(int8u network);
```

This sends a command the telephone interface, requesting that it cancel the diversion of phone numbers.

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22.2.2 Events

The relevant event handler will be called when a Telephony message is received from a C-Bus Telephone interface.

22.2.2.1 On/Off Hook Event

```
void cbus_telephony_vf_hook_handler(void (*f) (
    cbus_boolean,
    cbus_telephony_et_off_hook_type,
    char *));
```

This registers the event handler for the Telephony Application on/off hook messages.

When an On Hook or Off Hook event on the Telephony Application is received, the registered handler will be called. The data passed is whether the event is an on-hook or off-hook event, and if it is an off-hook, the reason and the telephone number (16 characters max). The reason variable definition is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_incoming_voice</code>	Telephone interface has answered an incoming voice call in voice mode
<code>cbus_telephony_ce_incoming_data</code>	Telephone interface has answered an incoming voice call in data mode
<code>cbus_telephony_ce_incoming_other</code>	The incoming call has unknown mode
<code>cbus_telephony_ce_outgoing_voice</code>	The telephone interface is making an outgoing voice call
<code>cbus_telephony_ce_outgoing_data</code>	The telephone interface is making an outgoing data call
<code>cbus_telephony_ce_outgoing_other</code>	An outgoing call has unknown mode
<code>cbus_telephony_ce_setting_diversion</code>	The telephone interface is setting a diversion
<code>cbus_telephony_ce_clearing_diversion</code>	The telephone interface is clearing a diversion

The registered function shall be of the form:

```
void my_event_handler(
    cbus_boolean on_hook,
    cbus_telephony_et_off_hook_type reason,
    char * number);
```

If `on_hook` is `cbus_true`, then the event is an on-hook event, otherwise it is an off-hook event.

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22.2.2.2 Dial-Out Failure Event

```
void cbus_telephony_vf_dial_out_failure_handler(
    void (*f)(cbus_telephony_et_dial_out_failure_type));
```

This registers the event handler for the Telephony Application failure messages.

When a Dial-Out Failure event on the Telephony Application is received, the registered handler will be called. The data passed is the reason for the failure. The **reason** variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_no_dial_tone</code>	Dial out failed because there was no dial tone found
<code>cbus_telephony_ce_no_answer</code>	Dial out failed because there was no answer
<code>cbus_telephony_ce_no_ack</code>	Dial out failed because the called party did not acknowledge the message
<code>cbus_telephony_ce_number_unobtainable</code>	Dial out failed because the number is unobtainable
<code>cbus_telephony_ce_number_busy</code>	Dial out failed because the number is busy
<code>cbus_telephony_ce_internal_failure</code>	Dial out failed for some unknown reason

The registered function shall be of the form:

```
void my_event_handler(
    cbus_telephony_et_dial_out_failure_type reason);
```

22.2.2.3 Dial-In Failure Event

```
void cbus_telephony_vf_dial_in_failure_handler(
    void (*f)(cbus_telephony_et_dial_in_failure_type));
```

This registers the event handler for the Telephony Application failure messages. When a Dial-In Failure event on the Telephony Application is received, the registered event will be called. The data passed is the reason for the failure. The **reason** variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_stopped_ringing</code>	An incoming call failed because it stopped ringing before it was answered

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The registered function shall be of the form:

```
void my_event_handler(  
    cbus_telephony_et_dial_in_failure_type reason);
```

22.2.2.4 Ringing Event

```
void cbus_telephony_vf_ringing_handler(void (*f)(char *));
```

This registers an event handler for the Telephony Application Ringing message.

When a Ringing event on the Telephony Application is received, the registered event will be called. The data passed is the calling telephone number.

The registered function shall be of the form:

```
void my_event_handler(char * number);
```

22.2.2.5 Internet Connection Request Event

```
void cbus_telephony_vf_internet_connection_handler(  
    void (*f)(void));
```

This registers an event handler for the Telephony Application Internet Connection message.

When an Internet Connection Request event on the Telephony Application is received, the registered event will be called. The registered function shall be of the form:

```
void my_event_handler(void);
```

It is expected that this event could be used by a device to establish an Internet connection, normally after the current telephone call has completed.

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22.3 Telephone Interface (Master) Usage

The following functions and event handlers are only applicable to the Telephone Interface, and should not be used by any other devices.

22.3.1 Functions

The following functions provide the means of transmitting telephony commands.

22.3.1.1 Line On Hook

```
void cbus_telephony_vf_line_on_hook(int8u network);
```

This sends a Line On Hook telephony command onto C-Bus.

22.3.1.2 Line Off Hook

```
void cbus_telephony_vf_line_off_hook(  
    int8u network,  
    cbus_telephony_et_off_hook_type reason,  
    char * number);
```

This sends a Line Off Hook telephony command onto C-Bus, including the reason code and the telephone number (16 characters max). The reason variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_incoming_voice</code>	Telephone interface has answered an incoming voice call in voice mode
<code>cbus_telephony_ce_incoming_data</code>	Telephone interface has answered an incoming voice call in data mode
<code>cbus_telephony_ce_incoming_other</code>	The incoming call has unknown mode
<code>cbus_telephony_ce_outgoing_voice</code>	The telephone interface is making an outgoing voice call
<code>cbus_telephony_ce_outgoing_data</code>	The telephone interface is making an outgoing data call
<code>cbus_telephony_ce_outgoing_other</code>	An outgoing call has unknown mode
<code>cbus_telephony_ce_setting_diversion</code>	The telephone interface is setting a diversion
<code>cbus_telephony_ce_clearing_diversion</code>	The telephone interface is clearing a diversion

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22.3.1.3 *Dial-Out Failure*

```
void cbus_telephony_vf_dial_out_failure(
    int8u network,
    cbus_telephony_et_dial_out_failure_type reason);
```

This sends a Telephony dial-out failure command onto C-Bus, including the reason. The reason variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_no_dial_tone</code>	Dial out failed because there was no dial tone found
<code>cbus_telephony_ce_no_answer</code>	Dial out failed because there was no answer
<code>cbus_telephony_ce_no_ack</code>	Dial out failed because the called party did not acknowledge the message
<code>cbus_telephony_ce_number_unobtainable</code>	Dial out failed because the number is unobtainable
<code>cbus_telephony_ce_number_busy</code>	Dial out failed because the number is busy
<code>cbus_telephony_ce_internal_failure</code>	Dial out failed for some unknown reason

22.3.1.4 *Dial-In Failure*

```
void cbus_telephony_vf_dial_in_failure(
    int8u network,
    cbus_telephony_et_dial_in_failure_type reason);
```

This sends a Telephony dial-in failure command onto C-Bus, including the reason. The reason variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_stopped_ringing</code>	An incoming call failed because it stopped ringing before it was answered

22.3.1.5 *Ringin*

```
void cbus_telephony_vf_ringing(int8u network,
                               char * number);
```

This sends a Ringing telephony command onto C-Bus with the telephone number.

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22.3.1.6 *Recall Number Response*

```
void cbus_telephony_vf_recall_number_response(  
    int8u network,  
    cbus_telephony_et_recall_number_type type,  
    char * number);
```

This sends a response to the telephony Recall Last Number Request command onto C-Bus with the type and the telephone number. The type variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_outgoing</code>	The telephone is returning the number of the last outgoing call.
<code>cbus_telephony_ce_incoming</code>	The telephone interface is returning the number of the last incoming call.

22.3.1.7 *Request Internet Connection*

```
void cbus_telephony_vf_internet_connection_request(int8u network);
```

This sends a command to request that an Internet connection be made (by another device).

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22.3.2 Events

If a telephony message is received, the appropriate event handler will be called.

22.3.2.1 Isolate Secondary Outlet Event

```
void cbus_telephony_vf_isolate_secondary_handler(  
    void (*f)(cbus_telephony_et_isolate_secondary_type));
```

This registers an event handler for the Telephony Application Isolate Secondary messages.

When an Isolate Secondary Outlet message on the Telephony Application is received, the registered handler will be called. The parameter passed is the Isolation Status. The status variable is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_normal</code>	Set the secondary outlet to a normal connection.
<code>cbus_telephony_ce_isolated</code>	Isolate the secondary outlet from the incoming telephone line.

The registered function shall be of the form:

```
void my_event_handler(  
    cbus_telephony_et_isolate_secondary_type status);
```

22.3.2.2 Recall Last Number Request Event

```
void cbus_telephony_vf_recall_last_number_handler(  
    void (*f)(cbus_telephony_et_recall_number_type));
```

This registers an event handler for the Telephony Application Request Last Number messages.

When a Recall Last Number message on the Telephony Application is received, the registered handler will be called. The parameter passed is the type. The type variable definition is an enumerated type:

Enumerant	Meaning
<code>cbus_telephony_ce_outgoing</code>	The telephone interface has been asked to retrieve and return the telephone number of the last outgoing call.
<code>cbus_telephony_ce_incoming</code>	The telephone interface has been asked to retrieve and return the telephone number of the last incoming call.

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The registered function shall be of the form:

```
void my_event_handler(cbus_telephony_et_recall_number_type type);
```

22.3.2.3 *Reject Incoming Call Event*

```
void cbus_telephony_vf_reject_call_handler(void (*f)(void));
```

This registers an event handler for the Telephony Application Reject Incoming Call message.

When a Reject Incoming Call message on the Telephony Application is received, the registered handler will be called.

The registered function shall be of the form:

```
void my_event_handler(void);
```

22.3.2.4 *Divert Event*

```
void cbus_telephony_vf_divert_handler(void (*f)(char *));
```

This registers an event handler for the Telephony Application Divert message.

When a Divert message on the Telephony Application is received, the registered handler will be called. The parameter passed is the telephone number the diversion should be set to.

The registered function shall be of the form:

```
void my_event_handler(char * number);
```

22.3.2.5 *Clear Diversion Event*

```
void cbus_telephony_vf_clear_diversion_handler(void (*f)(void));
```

This registers an event handler for the Telephony Application Clear Diversion message.

When a Clear Diversion message on the Telephony Application is received, the registered handler will be called.

The registered function shall be of the form:

```
void my_event_handler(void);
```

C-Bus Module Interface Specification

23 C-BUS STRING FUNCTIONS

The following functions are provided in the `cbus_str` unit. They are required for the other parts of the C-Bus Module, and have been provided for general use also.

23.1 *Is Hexadecimal Char*

```
cbus_boolean cbus_str_is_hex_char(char c);
```

This function returns `cbus_true` if the character is a hexadecimal character.

23.2 *Hexadecimal Char to Number*

```
int8u cbus_str_hex_char_to_number(char c);
```

This function converts hexadecimal character `c` into a number.

23.3 *Hexadecimal Pair to Number*

```
int8u cbus_str_hex_pair_to_number(char *s);
```

This function converts hexadecimal pair of characters into a byte.

23.4 *Hexadecimal String to Number*

```
int32s cbus_str_hex_string_to_number(char *s);
```

This function converts string of hexadecimal characters into a number.

23.5 *Number to Hexadecimal Char*

```
char cbus_str_number_to_hex_char(int8u n);
```

This function converts a number to a hexadecimal digit.

23.6 *Append an Integer to a String*

```
void cbus_str_add_integer_to_string(char * s,  
                                   int32s n,  
                                   int8u digits);
```

This function adds an integer number to the end of a string (including sign). If the number of digits is non-zero, it puts in that many digits and pads with zeros. If the number of digits is zero, it leaves off leading zeros.

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23.7 Append a Hex Number to a String

```
void cbus_str_add_hex_to_string(char * s,  
                               int32s n,  
                               int8u digits);
```

This function adds a hexadecimal number to the end of a string. If the number of digits is non-zero, it puts in that many digits and pads with zeros. If the number of digits is zero, it leaves off leading zeros.

23.8 Percent String

```
void cbus_str_percent_string(char * s,  
                             int8u Level);
```

This function converts a level to a percentage string.

23.9 Append Carriage Return

```
void cbus_str_add_CR_to_string(char * s);
```

This function appends a carriage return to a string.

23.10 Convert a String to a Hex String

```
void cbus_str_add_hex_string_to_string(char * DestString,  
                                       char * SourceString);
```

This function converts each character of an ASCII string to hexadecimal character pairs and appends them to a string. eg. `cbus_str_add_hex_string_to_string(s, "Test")` where `s` is "1234" will convert "Test" to hex pairs ("54657374") and append it, leaving `s` at "123454657374".

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24 USAGE NOTES**24.1 C-Bus Module Customisation⁹**

The C-Bus Module can be customised to suit user application requirements and processor capability. All customisation is performed in the `cbus_config.h` file using `#define` statements. No changes should be made to any of the other C-Bus Module files.

A default `cbus_config.h` file (`cbus_config_default.h`) is provided and should be copied to the file name `cbus_config.h` and then customised. This is done so that when a new version of the C-Bus Module files is issued, your `cbus_config.h` file will not be over-written.

Users of versions of the C-Bus module prior to version 3 will see that the format of the `cbus_config.h` file has changed very substantially. When upgrading it will be necessary to use the new format, and make tailorings based on the old file.

The `cbus_config.h` file includes extensive comments about which sections can be changed, and which cannot. It also includes consistency checking to ensure that only mutually compatible options are selected.

The optional customisations that can be made are:

- Selection of which C-Bus Applications are to be supported.
- Selection of whether the C-Bus Lighting Database is required (this provides you with the ability to interrogate levels, to support MMIs and to enable C-Bus timers).
- If the C-Bus Database is implemented, you have the options to select how many Applications and Group Addresses you will support within the database.
- Selection of the C-Bus Enabled Level (1 – 5).
- Selection of the “tick” rate.
- Selection of whether the C-Bus queues are processed on every “tick” or on alternating “ticks”.
- Enabling or disabling support for labelling C-Bus DLT units.
- Selection of C-Bus queue lengths.
- Selection of the C-Bus queue item and buffer lengths.

⁹ For customers who receive the C-Bus Module in pre-compiled form, the `cbus_config.h` file used during compilation is supplied. However changes to this file should **not** be made, and will have no effect.

C-Bus Module Interface Specification

24.1.1 C-Bus Enabled Level

Setting the C-Bus Enabled Level automatically sets several other options, but some can be overridden if desired. The features that are included at each of the levels are shown in the table below. Higher levels include the features of all lower levels. For more details, refer to the C-Bus Enabled Program documentation.

Note that the features do not exactly match the C-Bus Enabled Program features at each level.

C-Bus Enabled Level	Features Introduced at this level
1	Transmit SAL Commands
2	Receive SAL Commands Receive CAL Commands Transmit CAL Responses
3	Transmit CAL Commands C-Bus Database
4	Handle MMI messages and maintain Database

24.1.2 Application Selection

Various C-Bus Applications can be selected, as required. The `cbus_config.h` file should be customised (see section 9.1.1) as appropriate.

24.1.3 Tick Rate

The Tick Rate is set in the `cbus_config.h` file. This is the rate at which the `cbus_ef_update` function gets called (see section 10.1). This must execute an update to the C-Bus Database (if the Lighting Application is being used) every 200ms. Consequently, the Tick Rate must be a divisor of 200ms (for example, 5ms, 10ms, 20ms, 25ms, 50ms, 100ms or 200ms).

The other constraint on the Tick Rate depends on how the C-Bus transmit data is handled:

- If transmit data is sent to a queue and handled by an interrupt handler, then there is no problem;
- Alternatively, it is possible that each time the Transmit Event Handler (see section 10.10.1) is called, the character is sent to a serial port, but control is not returned until transmission is complete. To send a whole string could take up to 45ms (45 characters x 1 ms (approx) / character) to send. This means that the `cbus_ef_update` function should not be called more often than every 100ms (to allow some margin of error), and hence the tick rate should be 100ms or 200ms.

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24.1.4 C-Bus Module Queues

The C-Bus Module queue (buffer) lengths are set in the `cbus_config.h` file.

The transmit queue length depends on several factors:

- How fast items can be put into the queue (for example, scenes with lots of commands)
- How fast the queue is emptied (the Tick Rate)
- How busy C-Bus is (this controls how many retries are required).

The receive queue length depends on:

- How fast items can be put into the queue (one every 16ms worst case – this is unlikely to be sustained for very long).
- How fast the queue is emptied (the Tick Rate).
- Whether the queue is allowed to be processed completely every tick (see section 10.6.3).

Calculation of the queue lengths is difficult, and trial and error may be required.

24.1.5 Memory Usage

The amount of RAM used by the C-Bus Module depends on:

- The C-Bus Enabled Level
- The C-Bus Applications Used
- The configuration of the C-Bus Database (if used)

Approximate RAM usage with various options is shown in the table below. For these examples, the Lighting, Trigger and Enable Applications were active.

When using the Lighting Database, the incremental memory usage is 12 bytes per Group Address per Application

Hence having an additional Lighting Application of 256 Group Addresses will require an additional 3K of RAM.

C-Bus Enabled Level	Options	RAM Usage
1	3 Applications x 10 Group Addresses, Transmit Queue length = 5	0.6K
1	3 Applications x 256 Group Addresses, Transmit Queue length = 50	2.5K
2	3 Applications x 10 Group Addresses, Transmit Queue length = 5, Receive Queue length = 2	0.8K
2	3 Applications x 256 Group Addresses, Transmit Queue length = 50, Receive Queue length = 20	4.7K

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C-Bus Enabled Level	Options	RAM Usage
3	3 Applications x 10 Group Addresses, Transmit Queue length = 5, Receive Queue length = 2	1.2K
3	3 Applications x 256 Group Addresses, Transmit Queue length = 50, Receive Queue length = 20	14.2K
4	3 Applications x 10 Group Addresses, Transmit Queue length = 5, Receive Queue length = 2	1.2K
4	3 Applications x 256 Group Addresses, Transmit Queue length = 50, Receive Queue length = 20	14.2K

The amount of program memory required depends on:

- The C-Bus Enabled Level
- The C-Bus Applications Used
- The target processor

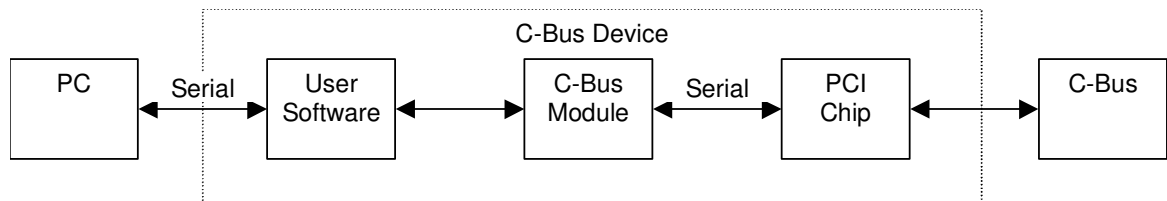
Typical program memory usage for a Hitachi H8S processor (with no optimisation) compiled with various options are shown below.

C-Bus Enabled Level	Options	Program Memory Used
1	Lighting, Enable and Trigger Applications	6.0K
1	Lighting, Enable, Trigger, Time, Measurement, Security and Telephony Applications	9.2K
2	Lighting, Enable and Trigger Applications	8.8K
2	Lighting, Enable, Trigger, Time, Measurement, Security and Telephony Applications	17.9K
3	Lighting, Enable and Trigger Applications	12.3K
3	Lighting, Enable, Trigger, Time, Measurement, Security and Telephony Applications	21.5K
4	Lighting, Enable and Trigger Applications	12.3K
4	Lighting, Enable, Trigger, Time, Measurement, Security and Telephony Applications	21.5K

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24.2 Transparent Mode

In Transparent Mode, the C-Bus module passes data directly between the PCI and a second serial port. This provides direct access to C-Bus if needed. This is typically used where there is a device that contains a PCI chip (such as C-Touch, CBTI etc), and a PC wants to use this device as if it were a PCI.

**24.2.1 Entering Transparent Mode**

To enter or exit Transparent Mode, use the `cbus_vf_set_transparent_mode` function.

The standard method for resetting a C-Bus PCI is to send the string `~~~<CR>` it, and this sequence is used by all current Clipsal software packages. If a C-Bus device sees this string, it can assume that a software package is expecting it to behave as a PCI, and set transparent mode.

24.2.2 Registering Event Handlers

The event handlers to transmit data from the C-Bus module to the PCI and the second serial port need to be registered. For example:

```

void transmit_cbus_character(char transmit_character)
{
    /* put code in here to transmit the character to the
       C-Bus PCI Chip */
}

void transmit_serial_character(char transmit_character)
{
    /* put code in here to transmit the character to the
       second serial port */
}

void main(void)
{
    /* register the event handlers */

    cbus_vf_register_serial_transmit_handler(transmit_cbus_character);
    cbus_vf_register_serial_transmit_handler2(
        transmit_serial_character);
}
  
```

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24.2.3 Transmit Data to C-Bus

To Transmit Data to C-Bus:

- Call `cbus_vf_serial_receive_character2` to send each character
- The character will be sent to the function registered to handle data transmission to the PCI (`transmit_cbus_character` in the example above).

24.2.4 Receive Data From C-Bus

To Receive Data from C-Bus:

- Call `cbus_vf_serial_receive_character` for each character received from the PCI
- The character will be sent to the function registered to handle data transmission to the PC (`transmit_serial_character` in the example above).

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24.3 Use With Other C-Bus Applications

The `cbus_config.h` file needs to be edited to enable the Applications that are required, and disable the rest.

Applications that are not required are removed from the definitions, usually by commenting out. Any source code file for an application that is not used can optionally be deleted.

Use is the same as the lighting case, except that the number of lighting applications and groups is not relevant for non-lighting application support.

24.4 Programming Configuration Data**24.4.1 PCI Configuration Data**

If the PCI chip configuration data is changed via C-Bus, the Configuration Change Event Handler is called if it has been registered. It is up to the user application to read any PCI configuration data of interest to determine what has been changed.

24.4.2 C-Bus Device Specific Configuration Data

When a C-Bus device is programmed using its corresponding Graphical User Interface (GUI), a series of CAL commands will be sent across C-Bus. These will be interpreted by the C-Bus Module and passed onto the user application as a series of events.

The most common events are the Write Event and Read Event. If event handlers are registered for these, they will be called by the C-Bus Module.

The Write Event Handler is responsible for writing the received data to the appropriate address.

The Read Event Handler has to read the required number of bytes from the appropriate address, and send the data back using `cbus_vf_CAL_read_response`.

For details of the other, more specialised, functions, refer to section 13.

24.4.2.1 Virtual Memory Addresses

The document CBUS-VMA "C-Bus System Virtual Addressing for Compound Devices" describes the methods for writing to and reading from compound C-Bus devices, and describes the rationale of the addressing scheme used.

24.4.2.2 Writing the Address Pointer

When a C-Bus STORE command is sent to the C-Bus device at Virtual Address 00 (the Address Pointer), the address is stored within the C-Bus Module, and an ACKNOWLEDGE is sent back to the Programming Device. No event is generated.

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24.4.2.3 *Writing to the C-Bus Device*

When a C-Bus STORE command is sent to the C-Bus device at Virtual Address 01 (the read / write address), the Write Event Handler (see 13.3.1.4) will be called with the write address (the Address Pointer) and the data.

When the user returns control to the C-Bus Module, an ACKNOWLEDGE will be sent to originator (the programming unit) if the result of the event handler is `cbus_true`.

24.4.2.4 *Reading from the C-Bus Device*

When a C-Bus RECALL command is sent to the C-Bus device to Virtual Address 01 (the read / write address), the Read Event Handler (see 13.3.1.5) will be called with the read address (the Address Pointer) and the number of bytes to be read.

The user needs to copy the read data to the `result` parameter. When the user returns control to the C-Bus Module, a REPLY will be sent to the originator (the programming or interrogating unit) containing the read data if the result of the event handler is `cbus_true`.

24.4.2.5 *Using Other Virtual Addresses*

When a C-Bus STORE command is sent to the C-Bus device to Virtual Address 02 - FE, the Generic Write Event Handler (see 13.3.1.2) is called with the details of the source of the command, the destination of the command (ie. Virtual Address), and the data.

The format of the data is up to the user to determine. When the user returns control to the C-Bus Module, an ACKNOWLEDGE will be sent to the Programming Device if the result of the event handler is `cbus_true`.

When a C-Bus RECALL command is sent to the C-Bus device to Virtual Address 01 (the read / write address), the Generic Read Event Handler (see 13.3.1.3) is called with the details of the source of the command, the destination of the command (ie. Virtual Address), and the number of bytes to be read.

The user needs to copy the read data to the `result` parameter. When the user returns control to the C-Bus Module, a REPLY will be sent to the Programming Device containing the read data if the result of the event handler is `cbus_true`.

<i>Use of this method for reading and writing configuration data is strongly discouraged.</i>
--

By convention, writing to virtual address FF is used for execution of some kind of command. The exact nature and purpose of commands (if any) is at the discretion of the equipment designer.

24.4.2.6 *Other CAL Commands*

Any other CAL commands will cause the Generic Programming Event Handler (see 13.3.1.1) to be called (if registered).

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24.4.2.7 Examples

In the following examples, the C-Bus Device unit address is CC. A Programming Device is controlling the C-Bus Device.

24.4.2.7.1 Set Address Pointer

To set the Address Pointer to \$12345678, a STORE command is sent to virtual address 00:

```
\06CC0900A6000078563412
```

There will be no events raised.

24.4.2.7.2 Store Data

To store data \$AABB to the address pointed to by the Address Pointer (\$12345678 in the example above), a STORE command is sent to virtual address 01:

```
\06CC0900A40100AABB
```

This will result in the Write Event Handler being called with the following data:

source_network: depends on the source and the networks configuration (see section 7).

source_unit_address: 0

address: \$12345678

data: pointer to array {0xAA, 0xBB}

data_count: 2

This data should be stored, as appropriate, and the function return value should be set to **cbus_true** so that the C-Bus Module sends an ACKNOWLEDGE to the programming device.

24.4.2.7.3 Read Data

To read 2 bytes of data from address \$12345678, it will be necessary to reset the Address Pointer first as described above. Then a RECALL command is sent to virtual address 01:

```
\06CC09001A0102
```

This will result in the Read Event Handler being called with the following data:

source_network: depends on the source and the networks configuration (see section 7).

source_unit_address: 0

address: \$12345678

result: pointer to an array of bytes to store the read result

data_count: 2

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The user then needs to read the data and copy it to the `result` parameter. The function return value should be set to `cbus_true` so that the C-Bus Module sends a REPLY to the programming device.

24.4.2.7.4 Execute Command

To send a command \$5245534554 (ASCII for "RESET") to the C-Bus Device, a STORE command is sent to virtual address \$FF (Control):

```
\06CC0900A7FF005245534554
```

This will result in the Generic Write Event Handler being called with the following data :

`source_network`: depends on the source and the networks configuration (see 7).

`source_unit_address`: 0

`virtual address`: \$FF

`command`: pointer to string "5245534554"

`command_length`: 5

The user needs to interpret the string "5245534554" and act on it. The function return value should be set to `cbus_true` so that the C-Bus Module sends an ACKNOWLEDGE to the programming device.

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24.5 Creating a System with Non-Volatile Behaviour

To create a system with non-volatile behaviour (ie. it restores its state on power-up to how it was before the power-failure), it is necessary to save the values of the C-Bus databases to non-volatile memory (eg EEPROM, FLASH, FRAM, battery backed-up SRAM etc).

A typical way to implement the storing of the data is:

- When a Lighting Database Change Event is received (see section 14.7.1), save the new level.
- When a Security Application Zone Status Event is received (see section 21.3.2.5), save the state.
- When a Time event is received (see section 18.4), update the Real Time Clock (if one is available).
- Store any other data of interest on power-failure (assuming you have time).

When power is applied, the reverse process is applied:

- Read the stored Lighting Database levels and set them in the C-Bus module (see section 14.2.3).
- Read the Security Zone status and set them in the C-Bus Module (see section 0).
- Read the time and set the C-Bus Module time (see section 18.1).
- Restore any other data of interest.

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25 EXAMPLE APPLICATION**25.1 Introduction**

In the example below, a device has an LCD Display and a connection to C-Bus to enable it to perform some simple functions:

- If the Control Group 1 is set to level 0xFF, a lighting scene is triggered (ie. several Lighting groups are set to pre-defined levels)
- If the telephone rings, the number is displayed and a light is switched on
- If the Security status changes, the details are displayed
- If the Security alarm is triggered, a light is switched on
- The outside temperature is displayed

The device also has EEPROM memory that is used to store configuration data. The configuration data can be accessed via C-Bus. The memory map is shown below:

Address	Usage
0	Number of Groups in the scene
1	Scene Group Address 1
2	Scene Level 1
3	Scene Group Address 2
4	Scene Level 2
5	Scene Group Address 3
6	Scene Level 3
7	Scene Group Address 4
8	Scene Level 4
9	Scene Group Address 5
10	Scene Level 5
11	Scene Group Address 6
12	Scene Level 6
13	Telephone Light Group Address
14	Security Light Group Address

25.2 Code

The initialisation function is called following power-up. The various event handlers will be called automatically.

The functions that write to the serial port, write to the LCD display and read/write the EEPROM are not shown.

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```
/*
** Initialise the C-Bus Module and register call-back functions
*/
void initialisation(void)
{
    /* Register the handler to write a character to the C-Bus PCI */
    cbus_vf_register_serial_transmit_handler(
        transmit_cbus_character);

    /* Register the second network */
    cbus_bf_register_network_path(1, "A2");

    /* Register the Trigger Control event handler */
    cbus_trigger_vf_register_handler(trigger_event_handler);

    /* Register the Telephone Ringing event handler */
    cbus_telephony_vf_ringing_handler(
        telephony_ringing_event_handler);

    /* Register the Security Status event handler */
    cbus_security_vf_status_message_handler(
        security_status_handler);

    /* Register the Measurement event handler */
    cbus_measurement_vf_register_handler(measurement_handler);

    /* Register the CAL event handlers for programming EEPROM */
    cbus_vf_CAL_register_write_handler(CAL_write_event_handler);
    cbus_vf_CAL_register_read_handler(CAL_read_event_handler);

    /* Initialise the C-Bus Module */
    cbus_bf_initialise();
    while (cbus_ef_get_connect_state() !=
           cbus_ce_module_normal_operation)
    {
        delay(1);
    }
}

/*
** Send a character of data to the C-Bus PCI via serial port 3
*/
void transmit_cbus_character(char transmit_character)
{
    send_serial_character(PORT3, char);
}

/*
** If Trigger Group 1 is set to level 0xFF, then switch on
** some lights
*/
void trigger_event_handler(int8u group,
                           int8u level)
```

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```

{
    int i;
    if ((group == 1) && (level == 0xFF))
    {
        /* read the Group Addresses and Levels from EEPROM and
           set the scene */
        for (i=0; i<get_EEPROM(0); i++)
            cbus_lighting_vf_set_level(0, 0x38, get_EEPROM(i*2+1),
                                       get_EEPROM(i*2+2), 1, 0, 0);
    }
}

/*
** If the telephone rings, display the number on the second
** line of the LCD display and switch on a light
*/
void telephony_ringing_event_handler(char * number)
{
    char s[50];
    strcpy(s, "Telephone number : ");
    strcat(s, number);
    display_message(2, s);
    cbus_lighting_vf_set_level(0,
                              0x38,
                              get_EEPROM(13),
                              255,
                              1,
                              0,
                              0);
}

/*
** If a Security Alarm status message is received, display
** a message on the second line of the LCD display.
** If the Alarm is on, switch a light on.
*/
void security_status_handler(
    cbus_security_et_status_message_type message_type,
    cbus_boolean status)
{
    char s[80];
    switch (message_type)
    {
        case cbus_security_ce_status_alarm :
            strcpy(s, "Alarm");
            break;
        case cbus_security_ce_status_tamper :
            strcpy(s, "Tamper");
            break;
        case cbus_security_ce_status_panic :
            strcpy(s, "Panic");
            break;
        case cbus_security_ce_status_low_battery :
            strcpy(s, "Low Battery");
    }
}

```

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```

        break;
    case cbus_security_ce_status_mains_failure :
        strcpy(s, "Main Failure");
        break;
    case cbus_security_ce_status_line_cut :
        strcpy(s, "Line Cut");
        break;
    case cbus_security_ce_status_arm_failed :
        strcpy(s, "Arm Failed");
        break;
    case cbus_security_ce_status_fire_alarm :
        strcpy(s, "Fire Alarm");
        break;
    case cbus_security_ce_status_gas_alarm :
        strcpy(s, "Gas Alarm");
        break;
    case cbus_security_ce_status_other_alarm :
        strcpy(s, "Other Alarm");
        break;
    }

    /* build command string */
    if (status == cbus_true)
        strcat(s, " ON");
    else
        strcat(s, " OFF");
    display_message(2, s);

    /*
    ** If the alarm is on, switch on the light on the remote
    ** network
    */
    if (cbus_security_if_get_status(cbus_security_ce_status_alarm))
        cbus_lighting_vf_set_level(1,
                                0x38,
                                get_EEPROM(14),
                                255,
                                0,
                                0,
                                0);
}

/*
** Display the outside air temperature on line 1 of the LCD.
** The temperature is broadcast on device 1, channel 3
*/
void measurement_handler(int8u device_id,
                        int8u channel,
                        int32s mantissa,
                        int8s exponent,
                        cbus_measurement_et_unit_type units)
{
    char s[50];
    if ((device_id == 1) && (channel == 3))
    {

```

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```
        strcpy(s, "Outside Temperature ");
        cbus_str_add_integer_to_string(s, (long int)mantissa, 0);
        strcat(s, "C");
        display_message(1, s);
    }
}

/*
** Allow the user to write to the EEPROM via C-Bus
*/
cbus_boolean CAL_write_event_handler(int8u source_network,
                                     int8u source_unit_address,
                                     int32u address,
                                     int8u * data,
                                     int8u data_count)
{
    int8u i;
    if (address + data_count <= 16)
    {
        for (i=0; i<data_count; i++)
            set_EEPROM(address++, *data++);
        return cbus_true;
    }
    else
        return cbus_false;
}

/*
** Allow the user to read from the EEPROM via C-Bus
*/
cbus_boolean CAL_read_event_handler(int8u source_network,
                                    int8u source_unit_address,
                                    int32u address,
                                    int8u * result,
                                    int8u data_count)
{
    int8u i;
    if (address + data_count <= 16)
    {
        for (i=0; i<data_count; i++)
            *result++ = get_EEPROM(address++);
        return cbus_true;
    }
    else
        return cbus_false;
}
```