C-Bus Application Messages & Behaviour

Chapter 23 – Clock & Timekeeping

Document Number: CBUS-APP/23
Issue: 1.12
Date: 11 December 2008

Comments on this document should be addressed to:

Engineering Manager
Clipsal Integrated Systems
PO Box 103 Hindmarsh
South Australia 5007

TABLE OF CONTENTS

23 CLOCK AND TIMEKEEPING APPLICATION

23.1 Application ID

$DF

23.2 Description

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 Clipsal Touchscreen, a C-Bus master time server, and so on.

23.3 Document Convention

Numbers are shown in decimal (base ten) with no other special prefixes or indications.

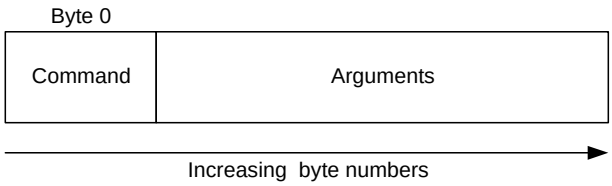
Binary numbers (base 2) are shown with the prefix %.

Hexadecimal numbers (base 16) are shown with the prefix $.

Example: 157 = %10011101 = $9D

23.4 Message Structure

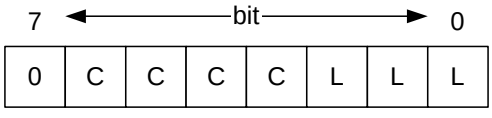
C-Bus Clock and Timekeeping messages have the form:



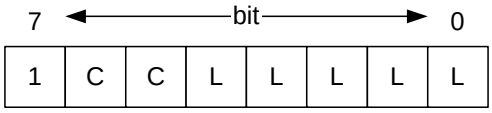
The number of arguments can be variable, dependent on the command.

The command byte is broken into bit-fields to support encoding of a command and the number of bytes following as parameters. There are two possible codings, to support a large number of commands with short arguments, and a small number of commands with long arguments.

The short argument command form is:



The long argument command form is:



Where “C” represents a bit of a command, and “L” represents a bit of the length.

This command format provides compatibility with the C-Bus lighting application, and is therefore suitable for backward compatibility with older devices and interoperability with lighting units.

23.4.1 Commands

The following commands are supported:

Short argument form (binary):

UPDATE NETWORK VARIABLE: %0 0001 LLL

REQUEST REFRESH: %0 0010 001

All others reserved.

The length field reflects the number of arguments.

Long argument form (binary):

There are currently no Long argument form commands allocated.

23.4.2 Network Variable Numbers

C-Bus Clock and Timekeeping Network Variables define the shared data items and permit synchronous update.

The following convention is used:

Network Variable Number:

Size:	8-bit byte
Range:	$00 .. $FF
Special Cases:	$00 and $FF are reserved
Usage:	$01 = Time
	$02 = Date
	$03 .. $FE reserved for future expansion

23.5 Defined Commands

Clocks and Timekeeping Application commands are typically emitted by a device with a reasonably accurate clock and a timekeeping ability, though this is not needed in all cases.

To ensure synchronisation of network variables (the Date and the Time), messages shall be received and processed by all Units operating in the Clocks and Timekeeping Application that have a C-Bus Interface level of 2 or more.

Clocks and Timekeeping Application messages are C-Bus Specific Application Language (SAL) messages.

All messages listed are mandatory for C-Bus Clock and Timekeeping Application support, unless explicitly stated otherwise. Deviation from these messages will cause C-Bus devices to be incompatible. Consult Clipsal Integrated Systems before deviating from these messages.

23.5.1 UPDATE NETWORK VARIABLE

Commands to update Network Variables are followed by the Network Variable Number, and then the information being set.

23.5.1.1 Update Time

Command: $0D

Arguments: $01, <hours>, <minutes>, <seconds>, <daylight saving>

Meaning: A device has broadcast the time. All Nodes receiving this message should set their time to value in the message.

Date and Time Master Devices that receive this command shall reset their periodic waiting time used for priority determination to the device's full interval, and cancel any pending start-up transmissions. Refer to section 23.9.

Originator: Anywhere

Notes: Time arguments shall be presented in a format suitable for direct display, using single bytes, as follows:

<hour> = 0 .. 23

<minute> = 0 .. 59

<second> = 0 .. 59

<daylight saving> =

0 if the time has no daylight saving offset applied

1 if the time includes an advance by 1 hour for daylight saving[1]

2 .. $FE are reserved

$FF if the daylight saving offset is unknown[2]

[1] Therefore the unadjusted time can be found by subtracting 1 hour. A further adjustment may need to be made for the date.

[2] Devices that receive a time update with UNKNOWN daylight saving offset should preserve whatever daylight saving offset they currently apply.

23.5.1.2 Update Date

Command: $0E

Arguments: $02, <year high>, <year low>, <month>, <day>, <day of week>

Meaning: A device has broadcast the date. All Nodes receiving this message should set their date to the value in the message.

Date and Time Master Devices that receive this command shall reset their periodic waiting time used for priority determination to the device's full interval, and cancel any pending start-up transmissions. Refer to section 23.9.

Originator: Anywhere

Notes: Date arguments shall be presented as single bytes, as follows:

<year high> = the high order byte representing the year number

<year low> = the low order byte representing the year number

(For 2001, year high = $07, year low = $D1)

<month> = 1 .. 12 (1 = January, 2 = February, etc)

<day> = 1 .. 31

<day of week> = 0 .. 6 (0 = Monday, 1 = Tuesday, …, 6 = Sunday)

23.5.2 REQUEST REFRESH

Command: $11

Arguments: $03

Meaning: A device is requesting the date and time be provided in one or more "Update Network Variable" messages by the currently active *Date and Time Master Device*..

The timing requirements for responses to this command are described in section 23.9.

Originator: Anywhere

23.6 Message Priority

Clock and Timekeeping Application messages shall always be transmitted at the lowest priority (Class 4), unless otherwise noted.

Thus, to send a Class 4 message, use a message header of (for example) $05.

23.7 Internetwork Routing

Clock and Timekeeping Application messages may be routed via one or more C-Bus bridges or gateway devices. Such messages will be received with a message type indicating point-multipoint, but will have a non-zero Network routing.

The Network routing information is irrelevant, as responses to Clock and Timekeeping Application messages are sent to the local network for routing via bridges or gateways as described above.

23.8 Application Behaviour

23.8.1 Concatenated Commands

A Clock and Timekeeping Application device may receive a message containing more bytes than a single command. This permits a single C-Bus transmission to contain multiple commands for a single application.

Devices using C-Bus Clock and Timekeeping Application messages must process all received bytes. This is achieved by placing the received bytes in a buffer, and using the following simple algorithm:

```
WHILE the buffer contains bytes LOOP
    The first byte defines the command type and argument
    count (refer section 23.4).
    Process the first (command) byte and its arguments
    Once processed, remove the command and argument bytes
    from the buffer
END LOOP
```

23.8.2 Reception of Unknown or Unsupported Commands

Devices receiving a message containing a command header that is not supported shall:

1. Ignore the command, and use the length bits to determine the number of subsequent bytes to skip; and
2. Resume checking for commands after skipping the unknown or unsupported command.

23.8.3 Transmission of Date and Time Updates

When a device is to transmit both a date and a time update, it is preferred if both updates are transmitted in the same C-Bus message as two concatenated commands.

23.9 Date and Time Master Time Devices

A C-Bus Date and Time Master Device is one that is capable of regularly transmitting UPDATE NETWORK VARIABLE messages on the C-Bus Clocks and Timekeeping Application.

These regular transmissions keep all devices on a network synchronised to a common date and time clock.

C-Bus Date And Time Master Devices shall:

a. Have a long term accuracy of 50 ppm (26.3 minutes per year) or better. This accuracy refers to the maximum permissible error over time[3].

b. Have a battery or supercapacitor back-up for the date and time keeping function, capable of maintaining the required accuracy through power failures lasting up to 4 hours.

c. Receive and accept Update Network Variable commands on the C-Bus Clocks and Timekeeping Application, and use these to adjust the internal date and time keeping settings. ***Acceptance and handling of time and date commands from the network requires special consideration for the highest priority master time devices which have an external source of high-accuracy date and time information. This is described elsewhere in this document***

d. Periodically output Update Network Variable commands on the C-Bus Clocks and Timekeeping Application, at intervals determined by their Priority and Mastership State.

Date and Time Master Devices must avoid creating an excessive network load. For this reason, the periodic updates are only frequent enough to correct devices with poor short term accuracy.

Arbitration Between Multiple Master Time Devices

In the event that multiple Date and Time Master Devices are attached to the same bus, it is important that only one such device issues regular messages (is in the ACTIVE state), and that if this device fails for any reason the other device(s) then take over.

The States, Timers and Priorities described below, ensure this behaviour.

[3] 50 ppm accuracy is readily available from common crystal-based real-time clocks. For little additional cost, 30 and even 20 ppm is readily available, and preferred.

Priorities of Master Time Devices

Where multiple Date and Time Master Devices exist on a network, the one with the most precise clock shall always operate in the ACTIVE state. Classifying the devices into categories helps ensure this result.

Date and Time Master Devices have the following priority order:

1. High Precision / Calibrated device (for example, atomic clock, GPS, devices synchronised to NTP);

   Such devices shall

   a. ***Be normalised or referenced to Coordinated Universal Time (UTC, previously known as Greenwich Mean Time, GMT); and***

   b. ***Use a long waiting period of approximately 30 minutes; and***

   c. ***Use a short waiting period of approximately 10 seconds.***

2. Devices with a crystal oscillator or other local time source with an accuracy of 20 ppm (10.5 minutes per year) or better, **AND** the ability to store and maintain the date **AND** the ability to understand and store daylight saving settings:

   Such devices shall

   a. ***Use a long waiting period of approximately 70 minutes; and***

   b. ***Use a short waiting period of approximately 30 seconds.***

3. Devices that do not qualify as Priority 2 but which do have crystal oscillator or other local time source with an accuracy of 50 ppm or better.

   Such devices shall

   a. ***Use a long waiting period of approximately 150 minutes; and***

   b. ***Use a short waiting period of approximately 50 seconds.***

Devices with a time source accuracy of worse than 50 ppm are not permitted to act as Date and Time Master Devices, and consequently do not have a priority.

States and Timers

C-Bus Date and Time Master Devices shall maintain their clocks internally, and across power failures.

Each Date and Time Master Device shall maintain a state variable that is in one of the following states:

START-UP;

ACTIVE; or

PASSIVE.

Each Date and Time Master Device shall maintain an internal transmission timer.

[Note: If multiple Date and Time Master devices exist on the same network, the arbitration method ensures the device with the shortest timer shall act as the ACTIVE Date and Time Master Device. All others shall be PASSIVE.

The timer is reset on power up, and on the reception or transmission of a Clocks & Timekeeping Application Update Network Variable message. The value that the timer is set to depends on the priority of the device and the device's unit address.]

Operation of Date and Time Master Devices After Power Up

When power is applied, any Date and Time Master Devices shall:

a. If possible, retrieve or otherwise acquire the current date and time – usually from a battery or supercap backed real time clock, or from an operating system;

b. If it does not have or can not retrieve or acquire a valid date and time, it shall set its internal clock to midnight on January 1st, 2008;

c. set its state to START-UP; and

d. set its transmission timer to their short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately).

A Date and Time Master Device that does not have a valid time, for example due to a back-up power supply failure, shall use a short waiting period of 70 seconds in the above procedure, regardless of priority.

[Examples:

a priority 2 device with a valid initial time and a unit address of 075 would use an initial waiting period of 41 seconds.

a priority 2 device with no valid initial time and a unit address of 075 would use an initial waiting period of 81 seconds.]

Transmission Timer Expiry in Date and Time Master Devices

START-UP State

If any Date and Time Master Device is in the START-UP state and its transmission timer expires, it shall:

a. transmit a REQUEST REFRESH message; and

b. set its state to PASSIVE; and

c. If it did have a valid time when started, set its transmission timer to its short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately), in seconds (as for After Power Up above);

d. If it did not have a valid time when started, set its transmission timer to 70 seconds, regardless of its priority.

[A possible cause for an invalid time is the failure of a backup battery or power supply.]

ACTIVE or PASSIVE State

If any Date and Time Master Device is in the ACTIVE or PASSIVE state and its transmission timer expires, it shall:

a. transmit UPDATE NETWORK VARIABLE messages to set the date (if it knows the date) and time; and

b. set its transmission timer to its long waiting period plus its unit address (in seconds); and

c. set its state to ACTIVE.

Whenever the UPDATE NETWORK VARIABLE messages are transmitted:

The Daylight Saving field in the UPDATE NETWORK VARIABLE time message sent by a Date and Time Master Device shall contain $FF if the device is unable to maintain the daylight saving setting in non-volatile or battery backed up storage.

[By this means, an Active state device stays active, and should a passive state device cause a transmission it will then become active.

Setting of the timer durations means that a Passive device will only become Active if the formerly Active device does not transmit an update.]

Reception of UPDATE NETWORK VARIABLE Messages by Date and Time Master Devices at Priority 2 and 3

START-UP or ACTIVE State

If any Date and Time Master Device is in the START-UP or ACTIVE state and it receives an UPDATE NETWORK VARIABLE message, it shall:

a. set its transmission timer to its long waiting period plus its unit address (in seconds); and

b. set its state to PASSIVE.

PASSIVE State

If any Date and Time Master Devices is in the PASSIVE state and it receives an UPDATE NETWORK VARIABLE message, it shall:

a. set its transmission timer to 2 times its long waiting period, plus its unit address (in seconds); and

b. retain its state as PASSIVE.

[By setting its transmission timer to 2 x the long waiting period, a Passive state device ensures it will only transmit an update in the event that some other Active state device does not transmit.]

Reception of UPDATE NETWORK VARIABLE Messages by Date and Time Master Devices at Priority 1

Priority 1 Date and Time Master Devices (those which have an external time source) must maintain a time zone setting, usually as an offset from UTC. This setting is further adjusted for any local Daylight Saving Offset.

Priority 1 Devices with a User Interface

A Priority 1 device with a user interface for setting the UTC offset (Time Zone and possibly Daylight Saving State) has special handling.

Priority 1 Devices with a User Interface force a user to make changes to the Time Zone using that user interface only. Bus messages to change the time or date are only used to set the active Daylight Saving Offset.

A change to date or time must be corrected by the Active Date and Time Master Device, whilst maintaining arbitration between several different devices.

When a Priority 1 device with a user interface receives an UPDATE NETWORK VARIABLE message, it shall:

a. calculate a new temporary displayable time and date based on the current UTC time, current Time Zone, and the newly received daylight saving setting (if this is not 0xFF); and then

b. if the newly calculated displayable time and date differ by more than 10 seconds from the time and date in the received message:

    A. if in Start-Up or Active states, store and then transmit the newly calculated time and date immediately; or

    B. if in the Passive state, store the newly calculated time and date, then set the transmission timer to its short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately).

c. if the newly calculated displayable time and date do not differ by more than 10 seconds from the time and date in the received message:

    A. set the transmission timer to 2 times the long waiting period plus unit address (in seconds); and

    B. change to the Passive State.

[A first received date/time message will cause the Active Priority 1 master to re-calculate the display time. If this changes materially, the updated time is transmitted. Allowance needs to be made for Passive state device to take over.

This second transmission will be accepted by Passive devices, resulting in no known change and so normal arbitration times will then apply.]

Priority 1 Devices without a User Interface

A Priority 1 device without a user interface for setting the UTC offset (Time Zone and possibly Daylight Saving State) has special handling.

Priority 1 Devices without a User Interface need to determine the active local Time Zone. Their only means of doing this is to accept a bus message which is then used to calculate an offset from UTC.

UTC offsets, world-wide, are normally (in the majority) in increments of 1 hour. There are some countries which have UTC offsets of 30 minutes and 15 minutes. To handle all peculiarities, the UTC offset must allow a resolution of 15 minutes and a range of +/- 14 hours. This suits Nepal (UTC+5:45) and Christmas Island (UTC+14).

Receipt of a bus message by a device with accurate UTC means that the local Time Zone can be calculated – and rounded to the nearest 15 minutes to ensure accuracy with respect to the UTC reference.

A change to date or time (and thence local Time Zone) must be corrected by the Active Date and Time Master Device, whilst maintaining arbitration between several different devices.

If a Priority 1 device does not have a user interface for setting the UTC offset (Time Zone and possible Daylight Saving State), then when it receives an UPDATE NETWORK VARIABLE message, it shall:

a. calculate a new UTC offset based on the current value of UTC, and the Daylight Saving Offset and local display time in the UPDATE NETWORK VARIABLE message. The UTC offset should be calculated with a 15-minute resolution and a range of at least ±14 hours from UTC; and

b. if the newly calculated displayable time and date differ by more than 10 seconds from the time and date in the received message:

    A. if in Start-Up or Active states, store the newly calculated time, date, UTC offset and Daylight Saving Offset and then transmit the time and date immediately; or

    B. if in the Passive state, store the newly calculated time, date, UTC offset and Daylight Saving Offset, then set the transmission timer to its short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately).

c. if the newly calculated displayable time and date do not differ by more than 10 seconds from the time and date in the received message:

    A. set the transmission timer to 2 times the long waiting period, plus unit address (in seconds); and

    B. change to the Passive state.

Handling a REQUEST REFRESH Message in Date and Time Master Devices

ACTIVE State

If any Date and Time Master Device is in the ACTIVE state and receives a REQUEST REFRESH message, it shall:

a. immediately transmit UPDATE NETWORK VARIABLE messages for date and/or time (as for Timer Expiry above); and

b. set its transmission timer to its long waiting period plus its unit address (in seconds); and

c. retain its state as ACTIVE.

PASSIVE State

If any Date and Time Master Devices is in the PASSIVE state and receives a REQUEST REFRESH message, it shall:

a. set its transmission timer to its short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately), in seconds (as for After Power Up above); and

b. set its state to PASSIVE.

START-UP State

If any Date and Time Master Devices is in the START-UP state and receives a REQUEST REFRESH message, it shall:

a. either:

   A. if the device was not able to determine a valid time at start up, set its transmission timer to a short waiting period of 70 seconds, regardless of priority; or

   B. if the device was able to determine a valid time at start up, set its transmission timer to its short waiting period plus a delay of a random period in the range 0 .. 15 seconds (approximately), in seconds;

   and then

b. set its state to PASSIVE.

[Note: PASSIVE devices use a short waiting period so that they will take over if there is no ACTIVE master. If there is an ACTIVE master, it will respond to the REQUEST and consequently cause the timers in the PASSIVE devices to be set to the long waiting period.]

Daylight Savings Time Adjustments in Priority 1 Devices

Automatic Adjustments

Priority 1 Devices, for example, using NTP or similar can often automatically make adjustments to the time to account for Daylight Saving Time starting or finishing.

Priority 1 Devices shall only make these automatic Daylight Saving Time adjustments if they have a regular, reliable source of updates to the rules, tables or system files used to make such adjustments[4].

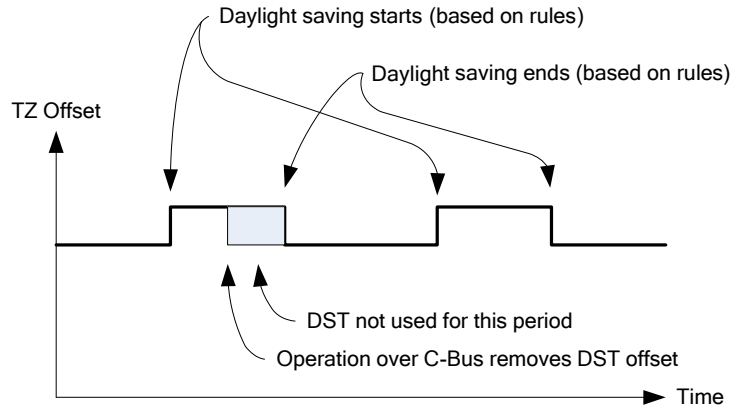
[For example, a Linux or Windows System with a reliable internet connection and unattended automatic updates would be suitable. An embedded Linux system with no ability to automatically update the rules must not use its static, non-existant, or out-of date rules to calculate and set daylight saving time.]

Where Priority 1 Devices do not have a regular, reliable source of updates to the Daylight Saving rules, those devices shall make adjustments to the setting from received C-Bus messages as described above, or by a schedule which can be easily updated by a human user.

Duration of an Externally Applied Change to Daylight Saving Offset

When a Priority 1 Device is making automatic changes to the Daylight Saving Offset, any override of that Offset made over the bus should remain active only until the next automatic Daylight Saving Offset Transition. Subsequent Daylight Saving Offset transitions will be made as normal.

This is shown graphically by example below:



[4] Governments have a habit of regularly changing the start and finish times for Daylight Saving Time.

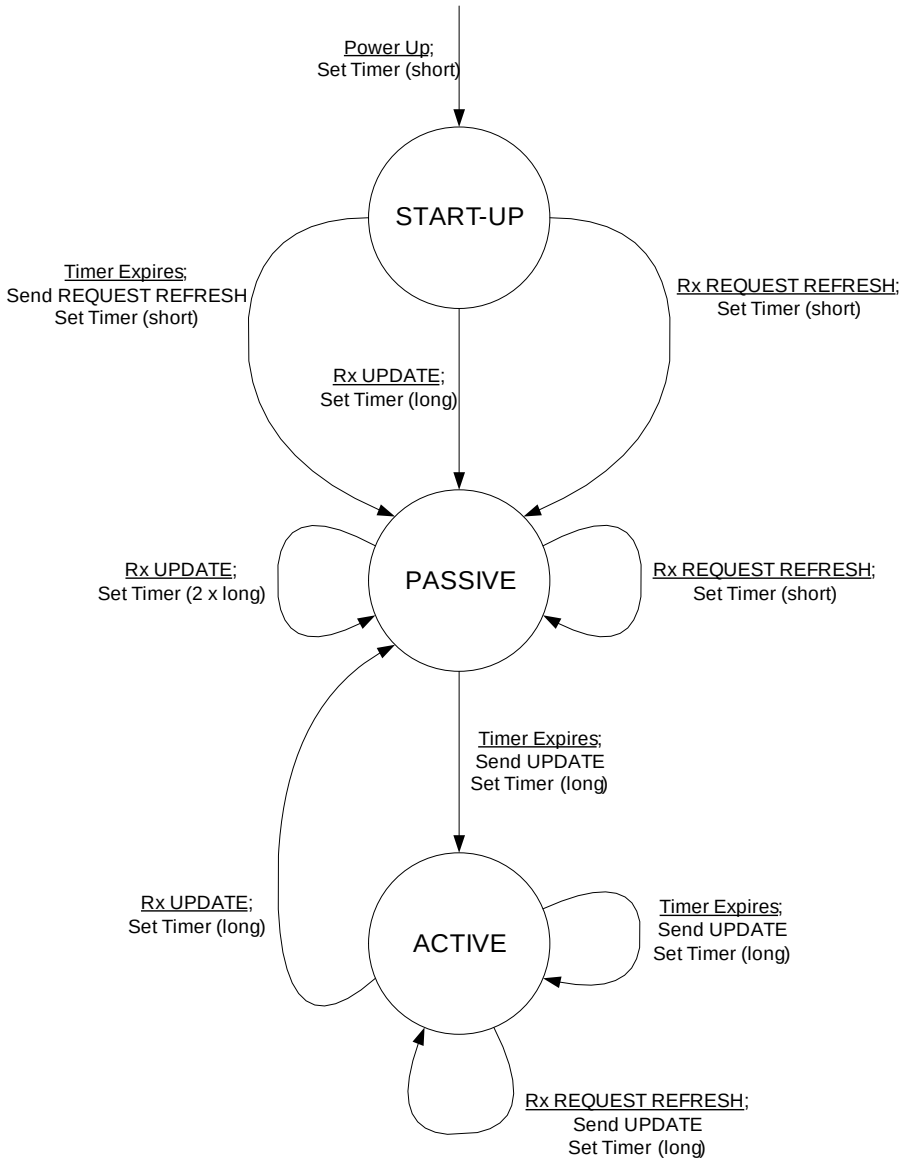
Date and Time Master Device Operation Close to Midnight

To prevent problems with roll-over of date and time near midnight, C-Bus Date and Time Master Devices shall not send updates in the period 10 minutes either side of midnight.

[Note: This problem occurs if a device (say) sent a C-Bus message setting the date at 11:59:30 but the receiving device though that the time was 11:59:59. Then the receiving device would have the correct date (briefly), but the wrong time. Sending the correct time a couple of seconds later, then the receiving device would have already rolled the date over to the next day. The time would be set back to 11:59:32 and shortly after, the date would roll over again. The same sort of problem could happen if the date was sent first, then the time. The simplest and most generic solution is to avoid sending any updates for a brief period either side of midnight.]

State Diagram

The following figure shows the above processes as a state transition diagram, when applied for Priority 2 and 3. Priority 1 is similar in principle, the text should be consulted.



23.10 Date and Time Slave Device Operation

Devices that participate in the Clock & Timekeeping Application but do not have battery or supercapacitor backup or lack sufficient accuracy to be Date and Time Master Devices are known as Date and Time Slave Devices. These devices may only send UPDATE NETWORK VARIABLE messages when a user has changed the time or date on the device's user interface.

The daylight saving field in the UPDATE NETWORK VARIABLE time message sent by a Date and Time Slave Device should contain $FF unless the unit is capable of storing the daylight saving value received from the network in non-volatile storage, or the user indicates the daylight saving offset while changing the time.

In response to UPDATE NETWORK VARIABLE messages, a Date and Time Slave Device should immediately update its internal clock to match the value in the message.

Date and Time Slave Devices may optionally send a REQUEST REFRESH message, 90 or more seconds after power-up, if a UPDATE NETWORK VARIABLE message has not been received in that time. If there are any Date and Time Master Devices on the network, the Date and Time Slave Device will receive a response within a further 90 seconds. If it does not receive a response within this time, the Date and Time Slave Device shall not perform any operations that rely on knowing the date or time.

Date and Time Slave Devices shall not respond to REQUEST REFRESH messages.

23.11 Status Reporting

The C-Bus Clock and Timekeeping Application shall not use C-Bus status request (MMI) messages.

23.12 Limitations

None.

23.13 Examples

These examples assume a clock or timekeeping device interfaced to C-Bus using the C-Bus Serial Interface, which is described in more detail in CBUS-SIUG.

The examples assume the Serial Interface SRCHK option is set, so data transfer both to and from the Serial Interface uses a checksum.

23.13.1 Output a Time command

Refer to section 23.5.1.1 (Page 5). To set the network time to 10:43:23, with no daylight saving offset, a device could issue:

To PCI: \05DF000D010A2B1700C2

23.13.2 Output a Date command

Refer to section 23.5.1.2 (Page 6). To set the network date to 25 Feb 2005 (a Friday), a device could issue:

To PCI: \05DF000E0207D502190411

23.13.3 Output a Request Refresh command

Refer to section 23.5.2 (Page 6). To request that the network time be transmitted, a device could issue:

To PCI: \05DF00100C