CiA® 802

Application note

CAN remote frames: Avoiding of usage

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HISTORY

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2010-12-07	*Publication of version 1.1 as* application note
	- Minor editorial changes
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CONTENTS

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1 Scope

This application note provides recommendations for substituting CAN remote frames by other CANopen communication services. It should be regarded as a clear statement to avoid the usage of CAN remote frames.

2 Normative references

The following referenced documents are indispensable for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

/CiA301/	CiA 301, CANopen Application layer and communication profile
/CiA302-2/	CiA 302-2, CANopen Additional application layer functions — Part 2: Network management
/ISO11898-1/	ISO 11898-1, Road vehicles — Controller area network (CAN) — Part 1: Data link layer and physical signalling

3 Terms and definitions

For the purpose of this document, the following terms and definitions and those given in /CiA301/, /CiA302-2/ and /ISO11898-1/ apply.

4 Symbols and abbreviated terms

For the purpose of this document, the following symbols and abbreviated terms and those given in /CiA301/, /CiA302-2/ and /ISO11898-1/ apply.

5 Remote frame

5.1 General

The CAN data link layer services, as specified in /ISO11898-1/, include the CAN data frame remotely requested by means of the corresponding CAN remote frame (see Figure 1). The CAN remote frame is structured in the same way as the CAN data frame. The CAN remote frame differs from data frame as follows:

RTR bit is of recessive value;

Data field does not exist at all.

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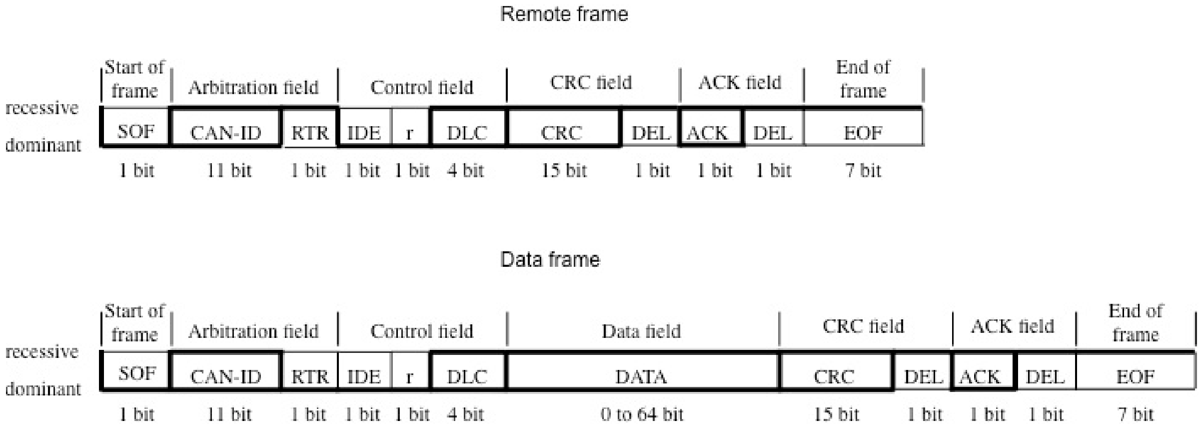

LEGEND

DATA User data or payload
DEL Delimiter
r reserved

Figure 1 – Format of the CAN data and remote frame with 11-bit CAN-ID

The CAN remote frame requests the transmission of the corresponding CAN data frame with the very same CAN identifier (CAN-ID). Due to the fact that the RTR bit is always dominant in CAN data frames, the CAN data frame wins bus arbitration in the case that one or more CAN remote frame with the very same CAN-ID are transmitted at the very same moment.

The CAN data link layer as provided in /ISO11898-1/ does not specify the implementation of CAN remote frames. There are two main implementations on the market:

The CAN controller responds to CAN remote frames immediately and independent of the micro-controller;

The CAN controller passes the CAN remote frame via interrupt to the micro-controller, which sends the corresponding data frame.

Some CAN controller implements both behaviours, which are selectable by the device designer.

5.2 Usage problems

Several general usage problems occur in some CAN controllers during processing of the CAN remote frames. These problems are listed as follows:

The number of transmit messages that support CAN remote frames is limited due to the fact that the global receive buffer in some CAN controllers are not able to handle all RTR-requests, therefore only a few RTR-messages are handled. (e.g. up to 14 or sometimes even less RTR-messages are processed);

The implementation effort of the CAN software driver is more complex because the CAN remote frame is relatively complex to handle in some CAN controllers. In some CAN controllers with single message buffering capability, CAN remote frames are transmitted via a receive buffer and not via a transmit buffer. If there are more CAN remote frames to be handled than receive buffers available, the CAN remote frame is either received in the buffer, which transmitted the CAN remote frame or received in the global receive buffer;

When two or more devices request the CAN data frame at the very same moment, a bus collision occurs when the data length codes are different as for arbitration only the CAN identifier bits and the RTR bit are used. From this it follows, e.g. when two or more devices request the same CAN data frame, all receive message buffers linked to this CAN data frame shall have the same data length,

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Furthermore, some CAN controllers with single message buffer capability respond to a CAN remote frame with the corresponding message with the same data length code received by the CAN remote frame and not with the data length provided when the message was configured;

In case the application crashes, some CAN controller may still answer remote frames with old data.

5.3 Usage avoidance and substitution by other CANopen services

5.3.1 General

From the beginning, the usage of CAN remote frame was restricted in CANopen. CAN remote frames are only allowed in the error control service, node-guarding function and for remotely requested PDO.

5.3.2 Network management

It is recommended to use the Heartbeat mechanism to supervise CANopen NMT slave devices.

With the node-guarding mechanism the device with NMT master functionality supervises all CANopen NMT slave devices in the network. Therefore the NMT master transmits periodically the node-guarding request as CAN remote frame to each slave, which responds with its corresponding node-guarding response as CAN data frame (see Figure 2).

The node-guarding response message contains the NMT FSA (finite state automaton) status information plus an additional toggle-bit. The toggle-bit is necessary to detect that the micro-controller is not more updating the status information if the CAN controller responds automatically without interference of the micro-controller. The node-guarding mechanism has the disadvantage that only the device with NMT master functionality receives the node-guarding messages. The further disadvantage is that after sending the CANopen boot-up message, the transmit message buffer on CAN controller chips with single message buffers needs to be reloaded with the new data for node-guarding. When however the node-guarding message has already been requested by the NMT-master by means of a CAN remote frame before the transmit message buffer is updated, the previous buffer transmits the boot-up message again.

Due to these disadvantages of the node-guarding mechanism, the CiA 301 version 4.0 introduced the heartbeat mechanism. With the NMT Heartbeat mechanism any CANopen device is able to supervise other CANopen devices in the network (see Figure 3). The heartbeat message contains the current NMT FSA state but without the toggle bit. The CANopen device with NMT master functionality supervises all CANopen NMT slave devices in the network using the heartbeat. In this case the NMT slaves (act as heartbeat producer) send periodically their heartbeat message as CAN data frame and NMT master (acts as heartbeat consumer) receives these heartbeat messages (see /CiA301/). NMT master checks whether the heartbeat from each device is received within the time interval, configured for this CANopen device in the heartbeat consumer object (see /CiA301/). If it is not the case, the heartbeat event occurs. This event indicates that the node is not capable for communication in the network. In the same way one or more CANopen NMT slaves may monitor the condition of CANopen device with NMT master capability or other CANopen NMT slaves. CANopen slave devices with NMT master functionality also monitor the heartbeat of the active NMT master in order to detect the NMT master failure (see flying master procedure in /CiA 302-2/).

It is recommended to choose heartbeat consumer time higher than the heartbeat producer time, in order to ensure the reception of the heartbeat message in time, even in case the time jitters occur.

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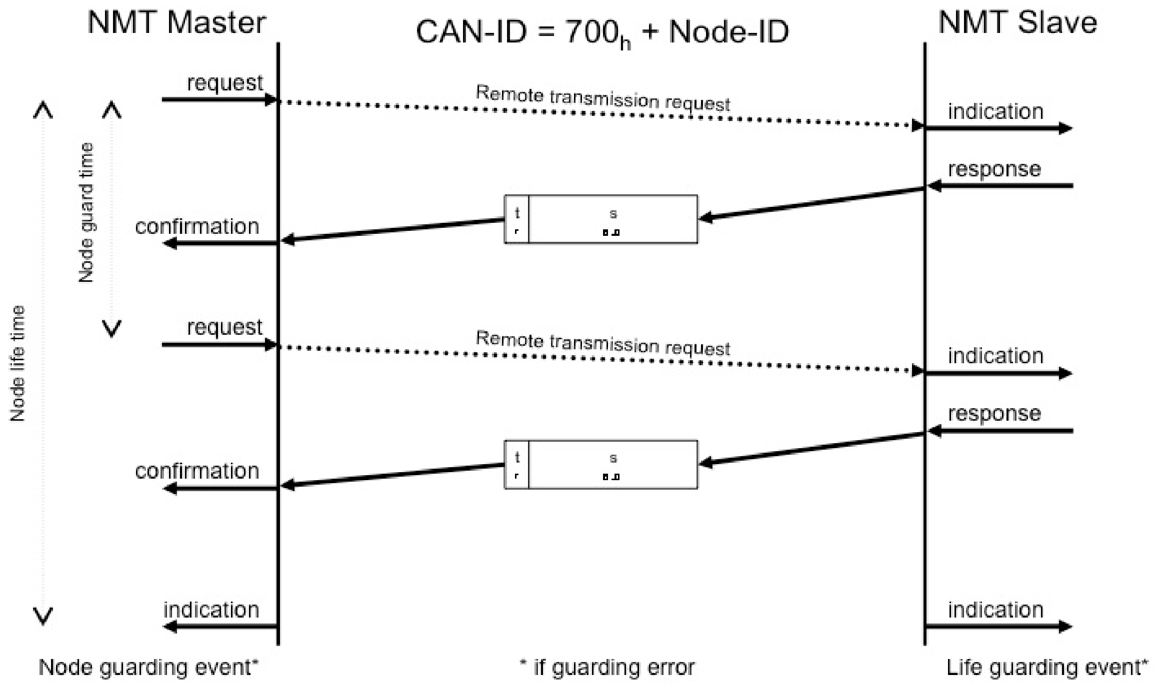

LEGEND
s: State of the NMT slave
4: Stopped
5: Operational
127: Pre-operational
t: Toggle bit

NOTE The value of the toggle bit shall alternate between two consecutive responses from the NMT slave. The value of the toggle-bit of the first response after the guarding protocol becomes active shall be 0. The toggle bit in the guarding protocol shall be reset to 0 when the NMT sub-state reset communication is passed (no other change of NMT state resets the toggle bit). If a response is received with the same value of the toggle-bit as in the preceding response then the new response is handled as if it was not received.

Figure 2 – Node guarding protocol

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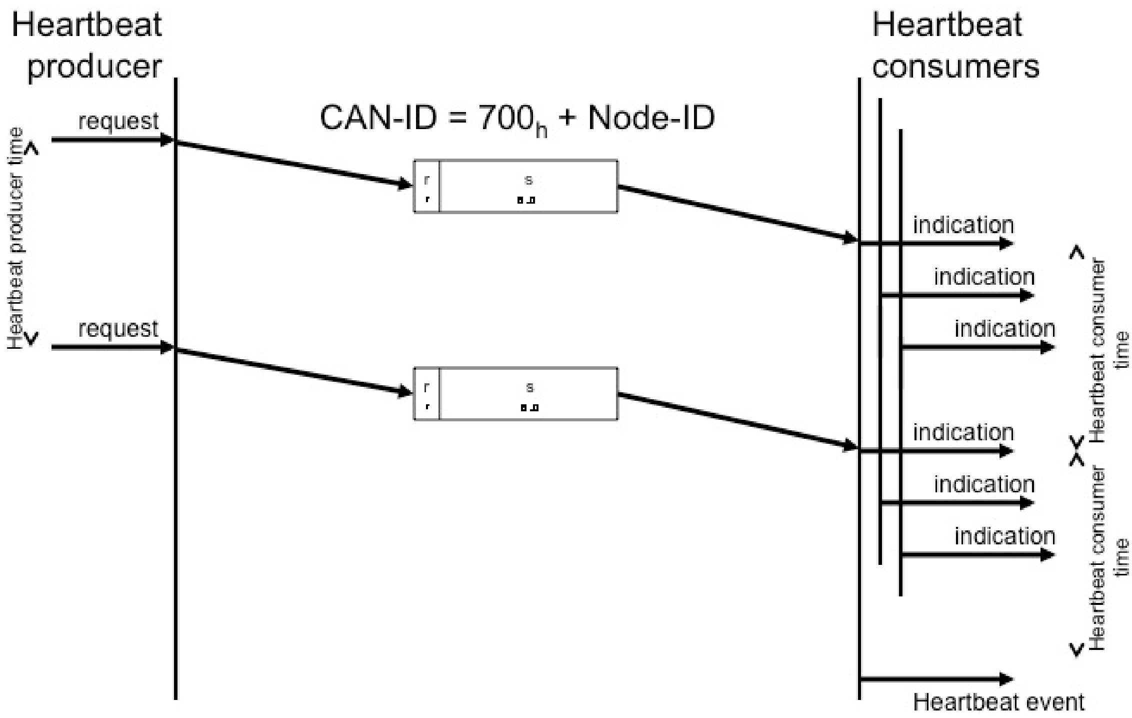

LEGEND
r: reserved (always 0)
s: State of the heartbeat producer

- 0: Boot-up
- 4: Stopped
- 5: Operational
- 127: Pre-operational

Figure 3 – Heartbeat protocol

The advantages of the heartbeat in comparison to the node-guarding protocol are listed as follows:

Reduced busload as no CAN remote frame is necessary;

CANopen NMT slaves monitor directly other CANopen devices (faster reaction time compared to the NMT-master, reporting node failures to the remaining slaves);

Decentralized monitoring is better than centralized monitoring in case the device with NMT master functionality fails.

5.3.3 Handling of the PDOs

5.3.3.1 General

In particular in PLC-based control systems, the transmission of PDOs should be scheduled by the progression of time in defined frequency. CANopen provides several scheduling mechanism to achieve such behavior. It is not recommended to use CAN remote frames for this purpose.

5.3.3.2 Centralized scheduling of PDOs

If a centralized scheduling of PDOs is required, it is recommended to use synchronous PDOs. The Sync message is than the trigger for updating the mapped objects as well as for the PDO transmission. The system designer has the possibility to define that the synchronous PDO serves all received Sync messages or only every second, every third etc. The lowest frequency is to serve every 240th Sync message.

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In order to reduce busloads, the system designer may use the acyclic transmission of PDOs. Acyclic transmission means that in addition to the reception of the Sync message an internal event (e.g. change of state) has to be occurred in order to cause a PDO transmission.

5.3.3.3 Decentralized scheduling of PDO

If a decentralized scheduling of PDOs is required, it is recommended to use event-timer triggered PDOs. A typical application for requesting PDOs by CAN remote frames would be when a newly connected HMI (human machine interface) device immediately retrieves all necessary process data from the other CANopen NMT slaves in the network. This is especially important if the PDOs are only transmitted “on change” (event-triggered) of the input value. This may take some time.

In order to retrieve the process data on one side but to avoid the use of CAN remote frames on the other side, it is recommended to use the PDO event timer. With the event timer individual time is configurable for each TPDO. The PDO is re-transmitted even if the corresponding process data has not changed.

5.3.4 Handling of MPDOs

According to /CiA301/, MPDOs are not allowed to be requested remotely by means of CAN remote frames.

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