TCN-GW-MC_REF

SW for MVB/CAN converter

Programmer's manual

Version 1.10

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101	4. 12. 2014	Add Chapter 2 – list of compatible hardware and add the abbreviation Target device
102	11. 12. 2014	Chapter Technical parameters added
103	18. 12. 2014	Addendum B
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Related documents

1. RB-RTM/1A011 – Operation manual
   file: rb-rtm1a_g_en_xxx.pdf
2. IEC 61375-3-1 ed1.0:2012 – Multifunction Vehicle Bus (MVB)
3. CiA Draft Standard 301 v4.02:2002 – CANopen Application Layer and Communication Profile

1. Abbreviation used in this document

ADS AMiT Domain Services

BA MVB Bus Administrator

CAN Controller Area Network – serial data bus developed by BOSCH company (ISO 11898-1).

COB Communication Object, which is made of one or more CAN frames. Any information transmitted via CANopen has to be mapped into COBs (see CiA 401, chapter 3).

COB-ID Communication Object ID. It identifies a COB uniquely in a CAN network. The identifier determines the priority of that COB in the data link layer (see CiA 301, chapter 3).

CRC Cyclic Redundancy Check

MD Message Data. Data transmitted sporadically over the bus for diagnostics, bus management etc.

MVB Multifunction Vehicle Bus. Bus used to transfer data within a TCN consist.

NMT Network Management. One of the service elements of the application layer in the CAN Reference Model. The NMT serves to configure, initialise, and handle errors in a CAN network (CiA 301, chapter 5).

NSDB Node Supervisor DataBase – includes configuration data.

PD Process Data – data intended for time-critical data exchange.

PDO Process Data Object (CiA 301, chapter 9.2.1)

SDO Service Data Object (CiA 301, chapter 9.2.2).

SHA-1 Secure Hash Algorithm-1

Target device Target hardware from list of compatible hardware

TCN Train Communication Network (IEC 61375-1).

TNM Train Network Management

2. Introduction

This manual describes the features of TCN-GW-MC_REF software. The software is running on hardware from AMiT production which is referred in the following text as target device, eventually as device. List of compatible hardware can be found in chapter Technical parameters.

The TCN-GW-MC_REF serves as a communication interface between MVB and CAN network. The TCN-GW-MC_REF enables the bi-directional transfer of process data, transfer of messages is not supported. Transfer of process data (PD) between MVB and CAN is performed through mapping of sink MVB ports to transmit PDO in one direction and mapping of receive PDO into source MVB ports in opposite direction.

The TCN-GW-MC_REF supports the CANopen protocol on the CAN bus. The TCN-GW-MC_REF can act as NMT-master or NMT-slave. The TCN-GW-MC_REF is a MVB class 2 device.

The TCN-GW-MC_REF provides access to MVB traffic store for CANopen devices. The device settings including the mapping of transmit and receives PDOs to MVB ports is configurable. The device configuration is created on PC using **TCNBridgeCfg-A01** application. The output of **TCNBridgeCfg-A01** is the NSDB domain configuration file which can be downloaded to the TCN-GW-MC_REF using PC application **ADSManager**. Alternatively, the NSDB domain configuration file can be created directly by user and moreover the NSDB domain configuration file can be downloaded using CAN SDO.

The following documentation describes usage of the **TCNBridgeCfg-A01** and the procedure for downloading of the configuration into the target device and the procedure of downloading (upgrading) a new firmware to the target device via **ADSManager** and by CAN SDO.

The prerequisite is that the user has knowledge about the TCN and CANopen network functionality and knowledge about using TCN process data and CANopen services.

2.1. Limitations of functionality

The TCN-GW-MC_REF does not work as Bus Administrator (BA) on the MVB bus side. Therefore, at least one device with BA functionality must be used on MVB bus.

Slave CANopen stations in the range of Minimal boot capability must be attached on the CAN bus.

The TCN-GW-MC_REF supports frames according the CAN 2.0A (11-bit identifier) on the CAN bus .

3. Technical parameters

MVB	Compatibility	IEC 61375-3-1 ed1.0:2012
	Process data	Yes
	Message data	Yes
	Class	2

CAN	Compatibility	CANOpen CiA DS301 v4.02:2002
	NMT slave	Yes
	NMT master	Yes
	CAN frames	CAN2.0A (11 bit identifier)

Configuration	Mapping definition	TCNBridgeCfg-A01
	Configuration download	ADSManager connected thru RS232
		CAN SDO by external client
		possible by TNM services on MVB by external client

Target device	MVB-CAN Converter	RB-RTM/1A011

4. Mapping

The transmission of PD from CAN to MVB bus is performed by mapping of Receive PDO(s) to the MVB source port(s). It is possible to map more PDO into one source port or one PDO into more source ports. But it is strongly recommended to map one PDO into one MVB source port only because of PD dataset consistency.

The transmission of PD from MVB to CAN bus is performed by mapping of MVB sink port(s) to the Transmit PDO(s). It is also possible to map one MVB port into more PDO(s).

5. SDO communication

The current version of NSDB configuration file can be obtained using CAN SDO. Moreover, the NSDB domain configuration file can be downloaded into the TCN-GW-MC_REF using CAN SDO too. The specifications of dictionary objects and state machine description are included in next chapters.

5.1. Dictionary object specification

Next objects on DO index 0x5f00 are supported:

Subindex	Access rights	Type	Length	Meaning
0	Read/only	Unsigned8	8-bits	Number of objects (10)
1	Write/only	Unsigned32	32-bits	Command: 0 = undefined 1 = setup parameters 2 = read information 3 = start download 4 = cancel
2	Read/write	Unsigned32	32-bits	Domain identifier: 0x000000007 = NSDB executed 0x000000008 = NSDB update
3	Read/write	Unsigned32	32-bits	Length of the domain
4	Write/only	Unsigned32	32-bits	Timeout [ms] Note: Each download operation resets automatically the timeout
5	Write/only	String	Max 128 bytes	Domain data segment first 4 bytes = segment offset
6	Read/only	Unsigned32	32-bits	State: 0 = idle 1 = setup 2 = reading information 3 = download in progress 4 = download ended 5 = wait restart
7	Read/only	Unsigned32	32-bits	Domain date and time (UNIX format)
8	Read/only	Unsigned32	32-bits	Domain CRC
9	Read/only	Unsigned32	32-bits	Domain version
10	Read/only	Unsigned32	32-bits	Length of already downloaded data

Note: Entering setup state clears automatically all attributes (domain identifier, timeout, length of domain). The user shall setup new values of these attributes before calling reading information or download start command.

5.2. State machine description

The state machine description of reading information about current NSDB domain follows:

State	Command or action	Next state
Idle	Setup parameters (cmd_code=1)	Setup
Setup	Set domain identifier (0x00000007 = NSDB executed)	Setup
	Reading information (cmd_code=2)	Read information
	Cancel (cmd_code=4)	Idle
Read information	Read domain version, date, time and CRC	Read information
	Cancel (cmd_code=4)	Idle

The state machine description of downloading NSDB domain follows:

State	Command or action	Next state
Idle	*Setup parameters (cmd_code=1)*	Setup
Setup	Set domain identifier (0x00000008 = NSDB update)	Setup
	Set domain length	
	Set download timeout	
	Start download (cmd_code=3) error	
	Start download (cmd_code=3) ok	Download in progress
	Cancel (cmd_code=4)	Idle
Download in progress	Domain data segment	Download in progress
	Read length of downloaded data	
	Last domain data segment	Download ended
	Cancel (cmd_code=4)	Idle
	Timeout (download timeout)	
Download ended	No action, system is stopping	Wait restart
	Cancel (cmd_code=4)	Idle
Wait restart	No action, system is rebooting	Idle

6. TCNBridgeCfg-A01

This PC application is used for configuration of MVB and CAN parameters, and mapping between MVB ports and CAN PDOs. The output of this application is a configuration file (NSDB) with extension **.dom**. This file can be loaded into the target device using **ADSManager**.

This chapter describes the **TCNBridgeCfg-A01** program user interface.

6.1. Elementary structuring

When configuring, it's necessary to define:

- TCN-GW-MC_REF parameters on MVB bus
- TCN-GW-MC_REF parameters on CAN bus
- Mapping of MVB ports on PDO and vice versa

TCN-GW-MC_REF configuration procedure is as follows:

1. Database creation
2. Settings of MVB and CAN buses parameters
3. Mapping of PD(s) between buses
4. Uploading NSDB file into the target device

6.2. Menu

File: Contains the standard items:

- **New** – Creation of new configuration. This action deletes the actual configuration and allows user to create the new one.
- **Load** – Loads configuration from file
- **Save** – Saves configuration with actual name. Unless the configuration has been saved, the user is prompted to entitle the file and select location for saving.
- **Save As** – Saves configuration with new name
- **Exit** – Program termination

Options:

- **Preferences** – Selection of default folder for saving / loading of configuration files

Help:

- **About** – Shows information about program

6.3. Tabs

User interface is divided into five tabs, where is can be defined parameters of each part of NSDB.

The CAN Definition, MVB Definition, Mapping MVB to CAN and Mapping CAN to MVB tabs are described in individual chapters.

6.3.1 Database definition

In this tab it is possible to define some identifying characteristics of NSDB. Four items are filled by user:

- **Database Name** – Database user name. Maximum 31 characters long (independent on filename)
- **User Type** – Database user type. Maximum 31 characters long (without influence to functionality)
- **Date** – Database creation date. Actual date is used upon database creation. User can change the date arbitrarily. Subsequently, the entered date appears in domain parameters.
- **User Version** – Database user version. Version number subsequently appears in domain version

Following three items are read only and filled automatically by application:

- **Database Identifier** – Database numerical identifier
- **Format Version** – Database version. It has no relation to User Version
- **32-bit CRC** – CRC code calculated over the whole NSDB

6.3.2 CAN Definition

CAN bus parameters definition consists of three parts:

- General bus parameters
- Parameters of CANopen NMT-master
- CANopen NMT-slave parameters of stations, that are attached to the CAN bus

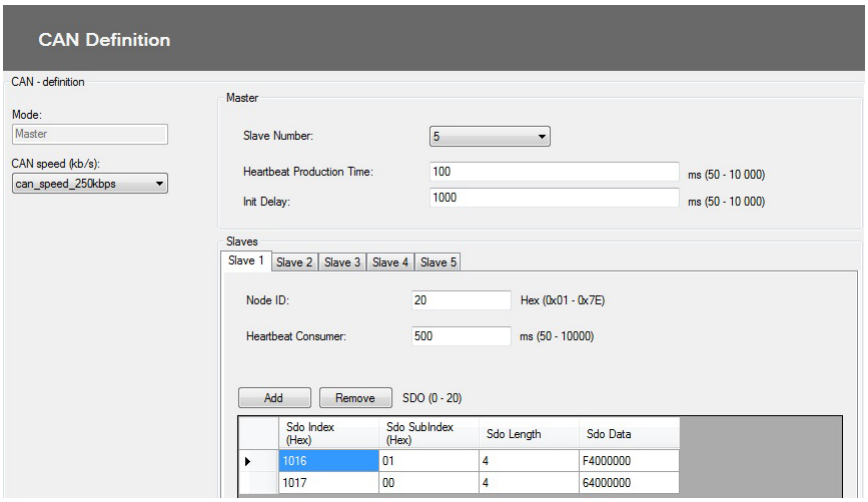

Fig. 1 - CAN Definition Tab

Bus parameters

- **Mode** – Mode, in which the CAN part of TCN-GW-MC_REF works. It is possible to configure Master or Slave mode.
- **CAN speed** – CAN bus speed rate [kbps]
- **Vendor Id** – CANopen vendor identification assigned by CiA. It is a part of the object 1018 (identify object) and it identifies the manufacturer of device.
- **Product Code** – vendor specific code (assigned by vendor). It is a part of identify object too.
- **Revision** – vendor specific revision number (assigned by vendor). It is a part of identify object too.

Slave mode parameters:

- **Node ID** – unique identification of the slave node (values between 0x01 to 0x7E)
- **Heartbeat Production Time** – period in which the Slave will send the heartbeat. It can take values from 50 ms up to 10 000 ms.
- **Heartbeat Consumer Time** – period in which the Slave checks the heartbeat from the master. It should be greater than the master heartbeat production time. The allowed interval is from 50 ms up to 10 000 ms.
- **0x1000** – optional parameter. It can specify additional capabilities of the device. The default value is 0x020001A5 which corresponds to the profile “Train vehicle control” (profile number 421), type of device “Train operating system” (device type 2). The allowed values is whole Unsigned32 interval.

Master mode parameters:

TCN-GW-MC_REF implements the CANopen NMT-master protocol. The protocol implementation is able to perform the slave stations boot-up. After the

boot-up the TCN-GW-MC_REF sends only SDO messages that are defined in the configuration.

- **Slave Number** – number of slave devices. User can choose from 1 to 5.
- **Heartbeat Production Time** – period in which the Master will send the heartbeat. It can have the value from 50 ms up to 10 000 ms.
- **Init Delay** – initial delay for slave device startup. Up to this time the gateway will not communicate with slave station. Meaningful for slave stations, which have longer startup after restart.

Slave station parameters

This sub-tab defines parameters for single slave station.

- **Node ID** – unique identification of the slave node (values between 0x01 to 0x7E)
- **Heartbeat Consumer Time** – period in which the slave station checks the master's heartbeat (values from 50 ms up to 10 000 ms).
- **SDO table** – list of SDO for the slave. SDO are sent in the order as in the table (max. 20 rows).

Items defined for each SDO are as follows:

- **SDO Index** – Object Dictionary index.
- **SDO SubIndex** – Object Dictionary subindex.
- **SDO Length** – SDO length in bytes (0 up to 32). If the value is equal to 0, length of SDO is assumed to be 4 bytes.
- **SDO Data** – User defined binary data.

Note: Data are entered in little-endian order. The SDO Length item must be consistent with entered SDO data. If the SDO Length is greater than number of entered bytes, SDO Data is completed with relevant number of 0.

6.3.3 MVB Definition

MVB parameters and ports are described this tab.

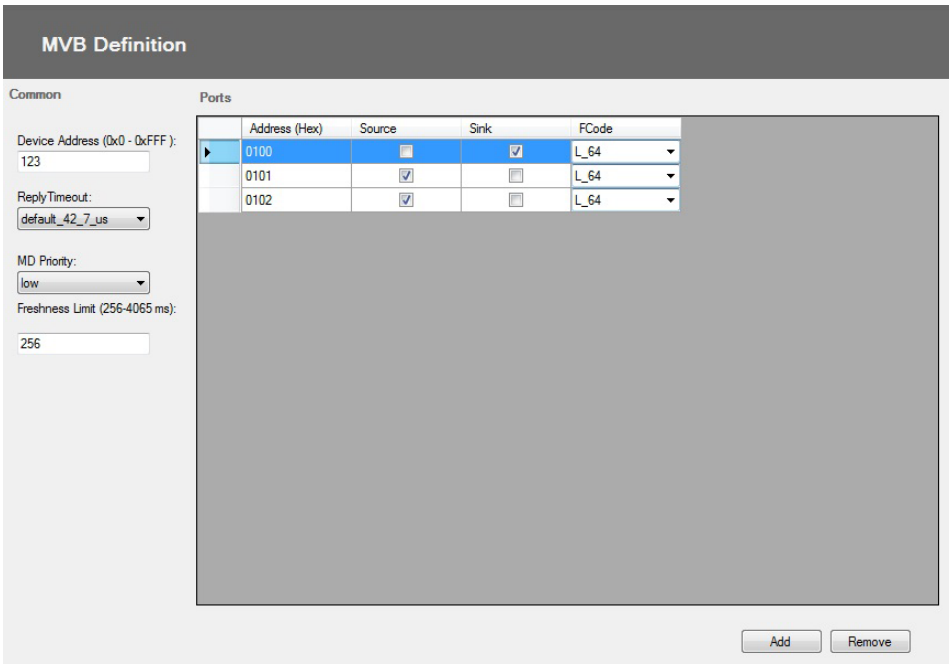

Fig. 2 - MVB Definition Tab

General parameters

Parameter	Meaning
Device Address	Device address on MVB bus.
Reply Timeout	Time in which must be received the slave frame: 0 = default time 42.7 µs 1 = 10.7 µs, 2 = 21.4 µs 3 = 32 µs, 4 = 42.7 µs, 5 = 53.4 µs 6 = 64 µs, 7 = 74.7 µs, 8 = 85.4 µs
MD Priority	Priority (Low/High) of MVB messages
Freshness Limit	Time in (ms) which determines the interval after elapsing of whose the data in port are considered to be invalid.

Definition of ports

User defines the individual MVB ports in ports-table.

Each port is defined by following parameters:

Address	Unique 12-bit number, that specifies the port address. The limit values (0, 4095) are reserved and must not be assigned to any port.
Source	Port is configured as producer; data from port are transmitted to MVB bus.
Sink	Port is configured as consumer; data are received into port from MVB bus.
Fcode	Size of port in bits. Minimum 16 bits and maximum 256 bits

Note: At least one MVB port must be defined. User cannot save configuration, where the ports-table does not contain any port.

Two MVB ports with the same port address can be configured as source and as sink as well.

6.3.4 MVB to CAN mapping

Mapping of MVB ports to CAN PDO is defined in this tab. Sink MVB ports are mapped into Transmit PDO according the table. Each PDO can be sent periodically, on event (port data received), or combined.

More ports can map their data onto single PDO, but it is not recommended because of PD consistency.

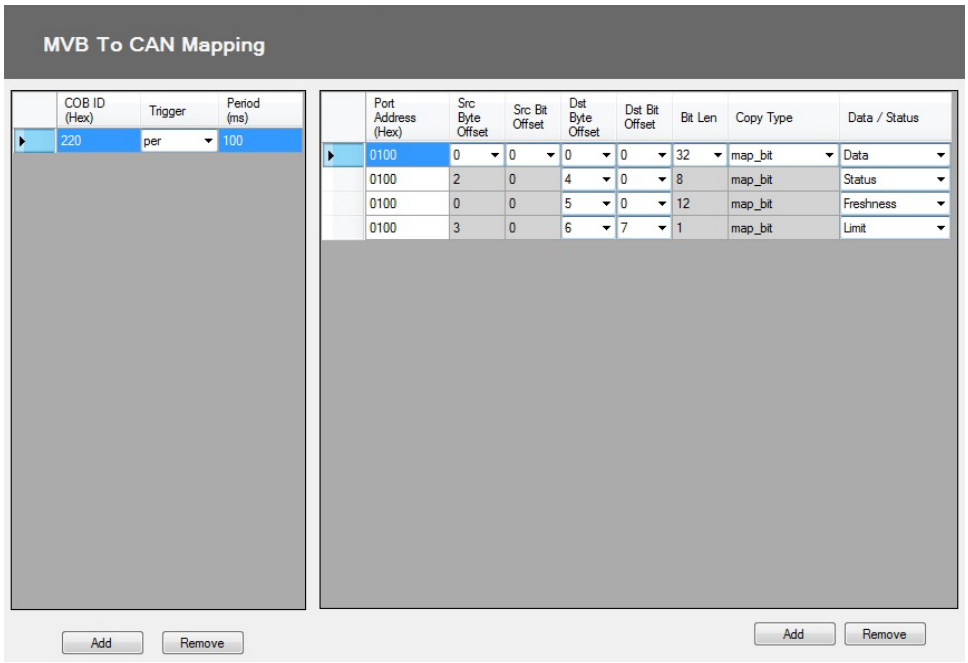

Fig. 3 - Mapping of MVB ports onto CAN frames.

PDO Definition

- **COB-ID** – 11-bit object identifier. The standard COB-ID classification is stated in appendix A.
- **Trigger** – CAN frame transmission mode:
  - **Periodic** – periodic transmission, period determined in relevant table column – see below.
  - **Events** – transmission triggered by MVB port PD reception (new data value is not determined).
  - **Combined** – combination of both previous forms: Periodic and Events. Data are transmitted periodically and at the time of MVB port PD reception in addition.

- **Period** – Period in (ms) with which the ports are transmitted to network if the trigger type Periodic or Combined is selected.

Mapping of MVB port onto PDO

- **Port Address** – Mapped port address
- **Src Byte Offset** – Byte offset in MVB port.
- **Src Bit Offset** – Bit offset in the port Src Byte.
- **Dst Byte Offset** – Byte offset in PDO.
- **Dst Bit Offset** – Bit offset in Dst Byte.
- **Bit Len** – Number of transferred bits.
- **Copy Type** – PD copying method.
- **Data/Status** – Port data or information about freshness, status etc.

Copy Type Data can be copied from MVB port to CAN PDO in the four following ways:

CopyType	Description
map_byte	Whole bytes are copied. Copy length in bits (Bit Len) is automatically rounded to the nearest higher multiple of eight.
map_bit	Bitwise copy
map_inv_byte	Inverse byte copy (order of bytes is reverted).
map_inv_bit	Inverse bitwise copy (order of bites is reverted).

Data/Status It defines the meaning of the transferred data. Except process data, it is also possible to map information about MVB port freshness, status and freshness above limit indication. Process data is a default value.

- **Data** – Process data
- **Status** – MVB port status.

Bit 3	Bit 2	Bit 1	Bit 0
Src	Snk	Twc	Frc
Current configuration			

In general, there can be any combination of bit flags stated in table.

- **Src** – Source port.
- **Snk** – Sink port.
- **Twc** – Transfer of process data with checksum (for debugging only)
- **Frc** – Forced port – In the port is stored the replacement data (for debugging only)

In our case, the right status value is always 4 – Snk port. Other combinations are reserved.

- **Freshness** – 16-bit value of port freshness.
- **Limit** – 1 bit. This flag determines whether Freshness already expired or not (value above the Freshness Limit given in MVB definition tab).

6.3.5 CAN to MVB mapping

Process data are copied into relevant MVB ports at the PDO with defined COB-ID reception.

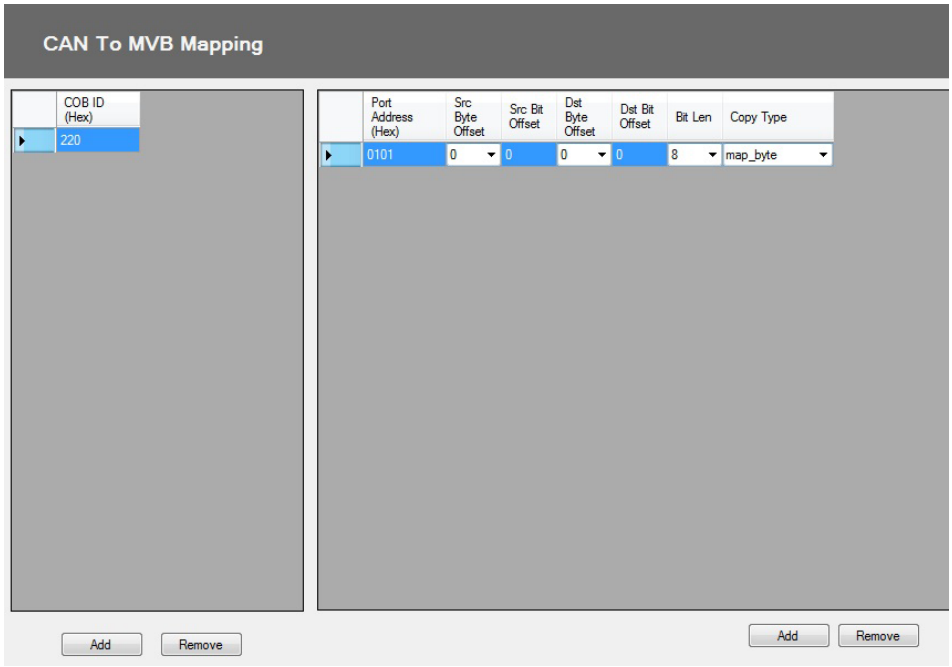

Fig. 4 - Mapping of CAN frames onto MVB ports.

PDO Definition

PDO is defined by only one item.

- **COB-ID** – 11-bit Communication Object ID The standard COB-ID classification is stated in appendix A.

Mapping of PDO onto port

Mapping of PDO onto port(s) is determined by following items:

- **Port Address** – Destination MVB port address
- **Src Byte Offset** – Byte offset in source PDO.
- **Src Bit Offset** – Bit offset in Src Byte.
- **Dst Byte Offset** – Destination byte in MVB port.
- **Dst Bit Offset** – Bit offset in Dst Byte.
- **Bit Len** – Number of transferred bits.
- **Copy Type** – PD copying method (see table Copy Type in the chapter Mapping of MVB port onto PDO)

6.4. Communication status

It is possible to detect status of process data communication on the MVB and CAN bus.

MVB When PDO transmit drops-out, the relevant MVB source ports are automatically disabled. Subsequently, corresponding MVB ports are not transferred on the MVB bus. This situation is then processed in other MVB devices with standard procedure relevant for MVB sink ports (freshness).

CAN The drop-out on the side of MVB is possible to detect by tools stated in chapter **Mapping of MVB port onto PDO**. Handling of this information depends on target CANopen device.

7. Loading domains into TCN-GW-MC_REF

This chapter describes how to load the actual domain version into a new device, or how to perform the domain upgrade for used device. Domain can be considered as contiguous memory block.

7.1. TCN-GW-MC_REF domains

TCN-GW-MC_REF on target device contains the following domains:

Domain	Manufacturing status	Description / Upgrade
Loader	Loaded	Loader Upgrade: No
Executed application	Free	Information about running application Read only
Application update	Free	Valid application Ugrade: Yes
Safe application	Loaded	Safe application, no TCN-GW-MC_REF functionality Ugrade: Yes
MVB controller	Free	FPGA data in device Upgrade: Yes
MVB controller safe	Loaded	FPGA safe data Upgrade: Yes
NSDB	Free	Configuration database Created by user Upgrade: Yes

All domains with exception of NSDB are supplied by AMiT company. Actual versions are available here:

http://imp.amit.cz/www/mvb/rb-rtm1a01/index.htm

The NSDB domain is created by user through **TCNBridgeCfg-A01** program.

Only correct domain file can be loaded into appropriate domain. When loading, the data header is checked, therefore incorrect data cannot be loaded.

Domain filenames:

Domain	File
Loader	mvb10_l_xxx.bin
Application update	mvb1a01_1_a_xxx.dom
Safe application	mvb1a01_1_s_xxx.dom
MVB controller	mvb1a01a_1_f_xxx.dom (hw version 1020) or mvb1a01b_1_f_xxx.dom (hw version 1030 and higher)
MVB controller safe	mvb1a01a_1_e_xxx.dom (hw version 1020) or mvb1a01b_1_e_xxx.dom (hw version 1030 and higher)
NSDB	Created by user

7.2. Loading of new device

By manufacturer it is loaded only Loader (Loader, Safe Application, Safe MVB Controller) in target device. Therefore before first start is necessary to load the MVB controller and an Application.

To load the new device, it is necessary to download the **ADSManager**, actual versions of application program and MVB controller from web site stated in chapter 5.1.

Procedure

- Attach the target device to the PC COM port.
- Launch the **ADSManager** program.
- Set in the Menu – Option – Preferences

  COM port

  directories with *.dom files.
- Turn-on the target device power supply.
- In the List of devices appears the target device item; (if not, press the Search button).
- Launch the Domain services by click on device (context menu is activated by right mouse button).
- Click on Application update domain and start the Download domain service.
- **Don't reset the device** after domain download.
- Click on MVB controller domain and start the Download domain service.
- **Reset the device** after domain download.

Now the device is ready for loading domain with configuration, created by **TCNBridgeCfg-A01** program.

7.3. Loading of configuration domain

Procedure

- Attach the target device to the PC COM port.
- Launch the **ADSManager** program.
- Set in the Menu – Option – Preferences

  COM port

  directories with *.dom files.
- Turn-on the target device power supply.
- In the List of devices appears the target device item; (if not, press the Search button).
- Launch the Domain services by click on device (context menu is activated by right mouse button).
- Click on NSDB domain and start the Download domain service.
- **Reset the device** after domain download.

Now the device is completely ready to work.

7.4. Domain upgrade

When any domain needs to be upgraded on device in operation, follow the procedure below:

Procedure

- Attach the target device to the PC COM port.
- Launch the **ADSManager** program.
- Set in the Menu – Option – Preferences

  COM port

  directories with *.dom files.
- Turn-on the target device power supply.
- In the List of devices appears the target device item, (if not, press the Search button).
- Launch the Domain services by click on device (context menu is activated by right mouse button).
- Click on domain which is to be upgraded and start the Download domain service.
- **Reset the device** after domain download.

8. Appendix A – CANopen COB-ID range

COB-ID ranges given in CANopen, see CiA 301 for detail information.

Object	Function code	COB-ID range	
EMERGENCY	0001	81	FF
PDO1(tx)	0011	181	1FF
PDO1(rx)	0100	201	27F
PDO2(tx)	0101	281	2FF
PDO2(rx)	0110	301	37F
PDO3(tx)	0111	381	3FF
PDO3(rx)	1000	401	47F
PDO4(tx)	1001	481	4FF
PDO4(rx)	1010	501	57F
SDO(tx)	1011	581	5FF
SDO(rx)	1100	601	67F
NMT Error	1110	701	77F

9. Appendix B – MVB classes

The following table describes device classes in MVB according the standard IEC 61375-3 (class 1,2,4) and AMiT extension (class 3).

Class	PD	MD	BA	Note
1	Yes	No	No	
2	Yes	Yes	No	
3	Yes	No	Yes, only PD	1)
4	Yes	Yes	Yes	
5	Yes	optional	optional	Gateway with optional BA

1) Class 3 according IEC 61375-3 as a device is very rare. So this indication was used for specific functionality of Bus Administrator. In this case BA administrate only traffic of process data, which is on the contrary very often situation.