ASAM

Association for Standardisation of
Automation and Measuring Systems

ASAM MCD-1 (XCP on Ethernet)

Universal Measurement and Calibration Protocol

Ethernet Transport Layer

Version 1.3.0

Date: 2015-05-01

Associated Standard

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1 FOREWORD

XCP is short for Universal Measurement and Calibration Protocol. The main purpose is the data acquisition and calibration access from electronic control units. Therefore a generic protocol layer is defined. As transport medium different physical busses and networks can be used. For each authorized transport medium a separated transport layer is defined. This separation is reflected in standard document structure, which looks like follows:

- One Base Standard
- Associated Standards for each physical bus or network type

The Base Standard describes the following content:

- Protocol Layer
- Interface to ASAM MCD-2 MC
- Interface to an external SEED&KEY function
- Interface to an external Checksum function
- Interface to an external A2L Decompression/Decrypting function
- Example Communication sequences

This associated standard describes the XCP on Ethernet Transport Layer.

The "X" inside the term XCP generalizes the "various" transportation layers that are used by the members of the protocol family. Because XCP is based on CCP the "X" shall also show that the XCP protocol functionality is extended in compare with CCP.

2 INTRODUCTION

This standard describes how XCP is transported on Ethernet as transport layer. It is shown how addressing shall be realized and the usage of the different communication models (see Chapter 4.2). Also the content of the control field of the XCP message frame format is described. For details about the frame format structure please refer the base standard [1]. The interface to the ASAM MCD-2 MC description file is described in chapter 7.

3 Relations to Other Standards

3.1 Backward Compatibility to Earlier Releases

3.1.1 Ethernet Transport Layer

This Transport layer uses the version number 1.3. This version number is represented as 16 bit value, where the high byte contains the major version (U) and low byte contains the minor version (V) number.

If this associated standard is modified in such a way that a functional modification in the slave's driver software is needed, the higher byte of its XCP Transport Layer Version Number will be incremented. This could be the case e.g. when modifying the parameters of an existing command or adding a new command to the specification.

If this associated standard is modified in such a way that it has no direct influence on the slave's driver software, the lower byte of its XCP Transport Layer Version Number will be incremented. This could be the case e.g. when rephrasing the explaining text or modifying the AML description.

The slave only returns the most significant byte of the XCP Transport Layer Version Number for the current Transport Layer in the response upon CONNECT.

3.1.2 The Compatibility Matrix

The Compatibility Matrix gives an overview of the allowed combinations of Protocol Layer and Transport Layer parts. For details about the Compatibility Matrix please refer the base standard [1].

3.2 References to other Standards

For details about the References to other standards please refer the base standard [1].

4 THE XCP TRANSPORT LAYER FOR ETHERNET (TCP/IP AND UDP/IP)

4.1 ADDRESSING

A slave device connected by Ethernet and TCP/IP or UDP/IP protocol is addressed by its IP(V4 or V6) Address and Port number.

4.1.1 TCP/IP

The slave device is the listener. It will only accept one connection at the time. If the socket is closed while in XCP connected state, the slave device will perform an XCP disconnect, which means that all data acquisition will be stopped.

Note for RESUME Mode:

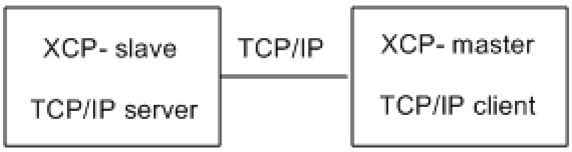

Figure 1 RESUME mode with TCP/IP

For TCP/IP the XCP master always has to actively establish a connection to the XCP slave which is passively listening for incoming connections until then. The consequence for the `RESUME` mode is that the master has to permanently try to open a connection to the slave which itself has to buffer measurement data until the connection is established. Otherwise data will be lost.

4.1.2 UDP/IP

While not connected, the slave device will answer upon a `CONNECT` command by sending the response to the IP address and port of the sender of the command. It will continue to answer to this IP address and port for all subsequent responses. When connected, it will respond only to telegrams from the IP address which has sent the `CONNECT` command even if another port is used. All other command packets will not be responded.

4.2 COMMUNICATION MODEL

XCP on TCP/IP and UDP/IP makes use of the standard communication model.

The block transfer communication is optional.
The interleaved communication model is optional.

4.3 HEADER AND TAIL

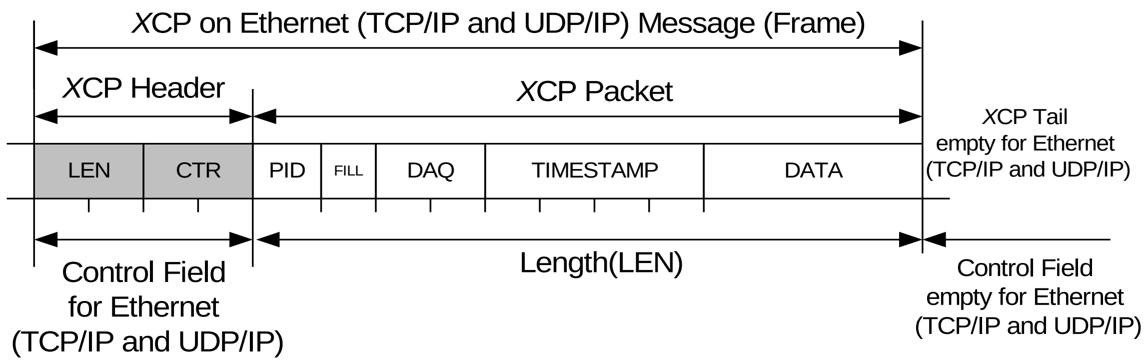

Figure 2 Header and tail for XCP on Ethernet (TCP/IP and UDP/IP)

4.3.1 HEADER

For XCP on Ethernet (TCP/IP and UDP/IP) the Header consists of a Control Field containing a **LEN**gth (LEN) and a **C**oun**T**e**R** (CTR).
Both LEN and CTR always are WORDs in Intel byte order (little endian).
To make optimal use of UDP/IP, multiple XCP Frames may be combined into a single UDP/IP frame, but an XCP Frame may not cross a UDP/IP frame boundary.
The same XCP Frame format is used for the stream oriented protocol TCP/IP to simplify decoding the original XCP messages.

4.3.1.1 LENGTH

LEN is the number of bytes in the original XCP Packet.

4.3.1.2 COUNTER

The CTR value in the XCP Header allows detection of missing Packets.

For each point to point connection, the master has to generate a CTR value for all packets that are sent to the slave. This CTR value has to be increased for each packet regardless of the type (CMD, STIM).
For XCP Multicast messages based on IP multicast, the master has to set the CTR field to 0.

The slave has to generate a (second, independent) CTR value for all packets that are sent to the master. This CTR value is to be increased for each packet regardless of the type (RES, ERR, EV, SERV, DAQ).

4.3.2 TAIL

For XCP on Ethernet (TCP/IP and UDP/IP) there’s no Tail (empty Control Field).

4.4 THE LIMITS OF PERFORMANCE

The upper limit of `MAX_CTO` and `MAX_DTO` depends on protocol stack (TCP/IP and UDP/IP) of the host system.

Table 1 CTO and DTO range

Name	Type	Representation	Range of value
`MAX_CTO`	Parameter	BYTE	0x08 – 0xFF
`MAX_DTO`	Parameter	WORD	0x0008 – 0xFFFF

5 Specific Commands for XCP on Ethernet (TCP/IP and UDP/IP)

Table 2 Command codes overview

Command	Code	Timeout	Remark
GET_SLAVE_ID	0xFF	irrelevant	optional
GET_DAQ_CLOCK_MULTICAST	0xFA	irrelevant	optional

5.1 Slave Detection on Ethernet

Category Ethernet only, Multicast (UDP/IP only), optional
Mnemonic GET_SLAVE_ID

Table 3 GET_SLAVE_ID command structure

Position	Type	Description
0	BYTE	Command Code = TRANSPORT_LAYER_CMD = 0xF2
1	BYTE	Sub Command Code = 0xFF
2	WORD	Port – used for response
4	BYTE	IP multicast address – used for response most significant byte (1st octet)
5… 6	Multi-BYTE	IP multicast address – used for response (byte significance in descending order)
7	BYTE	IP multicast address – used for response least significant byte (4th octet)
8…19	Multi-BYTE	Reserved (e.g. for IPv6)
20	BYTE	IP_VERSION 0 = IPv4 Others = reserved

The master can use GET_SLAVE_ID command to detect XCP slaves on Ethernet. Therefore, the master sends an IPv4 multicast message using IPv4 address 239.255.0.0 and port 5556. The counter field in the transport layer Ethernet specific XCP header type shall not be processed by the slave. Independent of the connection state, a slave has to process the command and send a response to the master.

To establish a simple way of communication between a slave and the master, i.e. to simplify slave side subnetting when a slave does not have a valid IP address, the slave sends the response using IP multicast as well. The IP version that has to be used for the response is given by the IP_VERSION field. The IP multicast address and port the slave has to use are given as part of the command sent by the master.

For each port, to which one or more XCP instances are bound, the slave sends a positive response carrying the payload as given in Table 4. In case that a slave does not have a valid IPv4 address, the IPv4 address has to be invalidated using IPv4 address “0.0.0.0”. Similarly, if the slave does not support `GET_ID` with parameter “requested identification type” = 0, the identification field has to be filled up with „0“.

All values of the command and positive response structure are encoded in Intel byte order.

Table 4 GET_SLAVE_ID positive response structure

Position	Type	Description
0	BYTE	Slave’s IP address - most significant byte (1st octet)
1… 2	BYTE	Slave’s IP address (byte significance in descending order)
3	BYTE	Slave’s IP address - least significant byte (4th octet)
4… 15	Multi-BYTE	Reserved
16	WORD	Slave’s port
18	BYTE	`STATUS`
19	BYTE	`RESOURCE` (must match `RESOURCE` parameter bit mask coding as send as part of positive response to command `CONNECT`)
20	DWORD	Length [BYTE]
24… 24+Length-1	Multi-BYTE	Identification, as sent as part of positive response on command `GET_ID` with parameter “requested identification type” = 0

Table 5 STATUS parameter bit mask structure

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	SLV_AVAILABILITY	IP_VERSION	IP_TRANSPORT_PROTOCOL_II	IP_TRANSPORT_PROTOCOL_I

Table 6 STATUS parameter bit mask coding

Flag	Description
IP_TRANSPORT_PROTOCOL	0 = TCP only 1 = UDP only 2 = both 3 = reserved
IP_VERSION	0 = IPv4 1 = Reserved
SLV_AVAILABILITY	0 = XCP slave free 1 = XCP slave already in use

5.2 DAQ Clock Multicast on Ethernet

Category Ethernet only, Multicast (UDP/IP only), optional
Mnemonic GET_DAQ_CLOCK_MULTICAST

Table 7 GET_DAQ_CLOCK_MULTICAST command structure

Position	Type	Description
0	BYTE	Command Code = TRANSPORT_LAYER_CMD = 0xF2
1	BYTE	Sub Command Code = 0xFA
2	WORD	Cluster Identifier (Intel byte order = little endian)
4	BYTE	Counter (allows for consistency checks at XCP master)

Transmission of XCP multicast commands on Ethernet relies on the IP multicast technique. Within the IPv4 multicast address scope, the site-local scope address range is used for XCP multicast command transmission, i.e. IP addresses 239.255.0.0 to 239.255.255.255.

The address an XCP slave observes for XCP multicast reception is derived from the `CLUSTER_AFFILIATION` parameter, which is part of `TIME_SYNCHRONIZATION_PROPERTIES` command. The mapping from the `CLUSTER_AFFILIATION` parameter to an IPv4 multicast address is based on little endian interpretation of the `CLUSTER_AFFILIATION` parameter (depicted by index *LE*) and is given as follows:

IPv4-Multicast-Addr. = 239.255.UPPER_BYTE_OF_CLUSTER_AFFILIATION$_{LE}$.
LOWER_BYTE_OF_CLUSTER_AFFILIATION$_{LE}$

The port an XCP slave observes is 5557. The counter field of the transport layer Ethernet specific XCP header (see chapter 4.3.1) shall not be processed by the slave.

When an XCP master makes use of `GET_DAQ_CLOCK_MULTICAST` command on transport layer Ethernet, a `GET_DAQ_CLOCK_MULTICAST` command must be sent every two seconds at the latest.

Upon reception of a `GET_DAQ_CLOCK_MULTICAST` command, the XCP slave will respond an `EV_TIME_SYNC` event packet as defined in XCP Protocol Layer.

All values of the command structure are encoded in Intel byte order.

5.3 Communication Error Handling

This chapter describes transport layer specific error handling. It extends the error handling concepts specified in the chapter “Communication Error Handling” of the base standard [1]. Please refer to the base standard for obtaining fundamentals on XCP error handling.

5.3.1 Error code handling

Table 8 Transport Layer Ethernet subcommands error handling

Command	Error	Pre-Action	Action
GET_SLAVE_ID	-	-	-
GET_DAQ_CLOCK_MULTICAST	-	-	-

6 SPECIFIC EVENTS FOR XCP ON ETHERNET (TCP/IP AND UDP/IP)

There are no specific events for XCP on Ethernet (TCP/IP and UDP/IP) at the moment.

7 DATA TRANSFER ON THE ETHERNET

7.1 LIMIT OF BUS BANDWIDTH USED FOR DATA TRANSFER

The bandwidth of a TCP/IP or UDP/IP connection is limited by the Ethernet controller but this information is not available in the transport layer description because this limit can change from pc to pc.

The calculation of the used bandwidth is different to the calculation for the CAN transport layer because it is possible to have multiple XCP frames within one UDP/IP or TCP/IP frame. For the Ethernet transport layer, it is only possible to limit the bandwidth based on the net data transfer (XCP header and XCP packet). It cannot be calculated, how many overhead is needed for UDP/IP or TCP/IP.

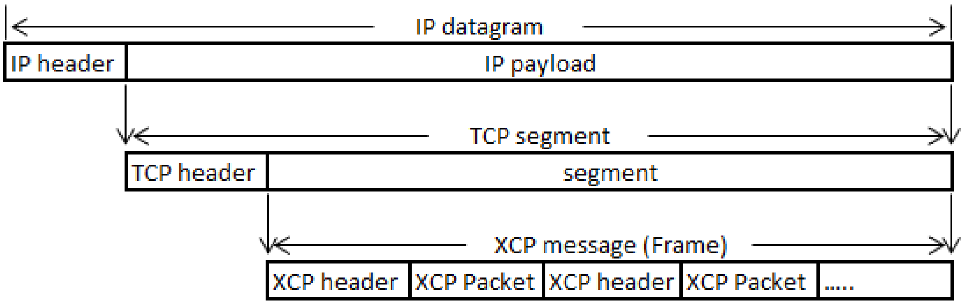

Figure 3 XCP frames with TCP/IP

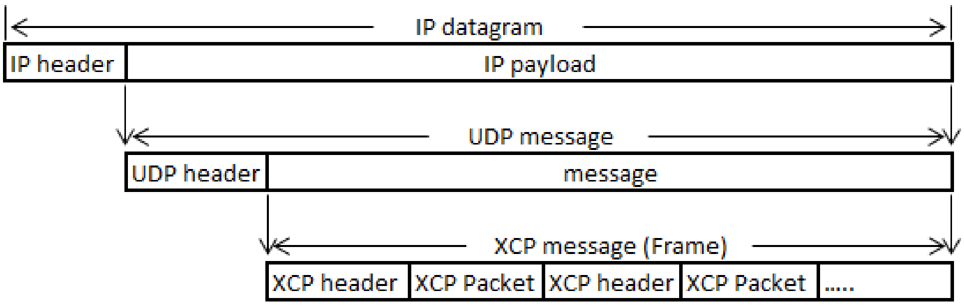

Figure 4 XCP frames with UDP/IP

With the MAX_BUS_LOAD limit, it is possible to limit the data transfer in general for XCP.
MAX_BIT_RATE defines the base bandwidth of the Ethernet network which is used in Mbit.
With these parameters it is possible for the XCP master to calculate the reserved bandwidth (100% - MAX_BUS_LOAD) * MAX_BIT_RATE.

The network interface card can have an impact on the available bandwidth therefore the XCP master has to check if the available network bandwidth is identical to the A2l file configuration MAX_BIT_RATE. If the available bandwidth is lower than MAX_BIT_RATE the XCP master has to check if it will be possible to start a measurement without disturbing the Ethernet communication.
For the offline check without a connected network the XCP master has to use the parameters from the A2L file.
The XCP master can monitor this limit while configuring the data transfer. For this the master has to use the current DAQ configuration in combination with the cycle time of the assigned EVENTs. With this information the XCP master can calculate the resulting TOTAL_BUSLOAD for the current configuration. For certain EVENTS a minimum cycle time (MIN_CYCLE_TIME) has to be defined in the a2l file additionally. For all EVENT which have no defined cycle time e.g. configuration with 0-0 in the EVENT description it is possible to add a minimum cycle time for this EVENT so that the XCP master can make a worst case calculation.

The calculation is the sum of all configured EVENTs. And in detail the update rate of an EVENT will be multiplied with the needed space for all ODTs in the related EVENT.

$$Total\_Busload\ Consumption =$$

$$\sum_{k=0}^{n} \left(\frac{1}{\mathrm{MIN\_CYCLE\_TIME\ (k)}} * \sum_{k,i=0}^{k,m} frame\_length[header + packet](k,i)\right)$$

(k = EVENT_CHANNEL_NUMBER, n = MAX_EVENT_CHANNEL)

Example: A measurement configuration with 2 ODT`s running in a 2 ms EVENT XCP packet length 40 and 17 bytes and a 100ms EVENT with 6 ODT`s with the length of 40, 40, 40, 40, 40 and 2 bytes. The MAX_BUS_LOAD is set to 12 % and MAX_BIT_RATE is 10 Mbit.

$$Total\_Busload\ Consumption =$$

$$\frac{1}{2\ ms} * (\ 2 * 4\ byte\ header + 40\ byte\ packet + 17\ byte\ packet) +$$
$$\frac{1}{100\ ms} * (6 * 4\ byte\ header + 5 * 40\ byte\ packet + 2\ byte\ packet)$$

$$= 34780\ byte/s$$

$$\frac{Total\_Busload\ \ Consumption}{MAX\_BITRATE * MAX\_BUS\_LOAD} = \frac{34780\ byte/s}{1{,}2\ Mbit} = 23{,}18\ \%$$

MAX_BUS_LOAD limits only the traffic for DAQ and STIM but not for command, response, error or event messages.

8 Interface to ASAM MCD-2 MC Description File

The following chapter describes the parameters that are specific for XCP on Ethernet.

8.1 ASAM MCD-2 MC AML for XCP on Ethernet (TCP/IP and UDP/IP)

The AML for the XCP on UDP IP transport layer specific properties is defined in the file named XCP_vX_Y_on_UDP_IP.aml where vX_Y is the current protocol layer version.
The AML for the XCP on TCP IP transport layer specific properties is defined in the file named XCP_vX_Y_on_TCP_IP.aml where vX_Y is the current protocol layer version.

8.2 IF_DATA Example for XCP on Ethernet (TCP/IP and UDP/IP)

The file XCP_vX_Y_IF_DATA_example.a2l where vX_Y is the current protocol layer version gives an IF_DATA example for a XCP on TCP IP and XCP on UDP IP transport layer (see section beginning with `“/begin XCP_ON_TCP_IP”` or `“/begin XCP_ON_UDP_IP`).

9 Symbol and Abbreviated Terms

A2L	ASAM MCD-2 MC Language File
CAN	Controller Area Network
CCP	CAN Calibration Protocol
CMD	Command
CTO	Command Transfer Object
CTR	Counter
DAQ	Data Acquisition
DLC	Data Length Code
DTO	Data Transfer Objects
ECU	Electronic Control Unit
ERR	Error
EV	Event
IP	Internet Protocol
LEN	Length
RES	Responses
SCI	Serial Communication Interface
SERV	Service
SPI	Serial Peripheral Interface
STIM	Synchronous Data Stimulation
SxI	Serial X Interface
TCP	Transfer Control Protocol
TS	Time Stamp
UDP	User Datagram Protocol
USB	Universal Serial Bus
XCP	Universal Measurement and Calibration Protocol

10 BIBLIOGRAPHY

[1] ASAM AE MCD-1 XCP BS Protocol-Layer BS Version V1.3.0

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