

ASAP

Working Party on Standardisation of Application Systems

Interface Specification

Interface 3

Version 2.0 dated 7 February 1994

AVL

ECU
APPLICATION SYSTEM INTERFACE
V2.0
'SERIAL' VERSION

1 CONTENTS

1 CONTENTS	1
2 OVERVIEW	2
3 CHANGES WITH RESPECT TO V1.0	4
4 DATA FORMATS	6
5 TELEGRAM STRUCTURE	7
6 COMMUNICATION SEQUENCE	9
7 DETAILED COMMANDS	10
8 COMMAND SEQUENCES	29

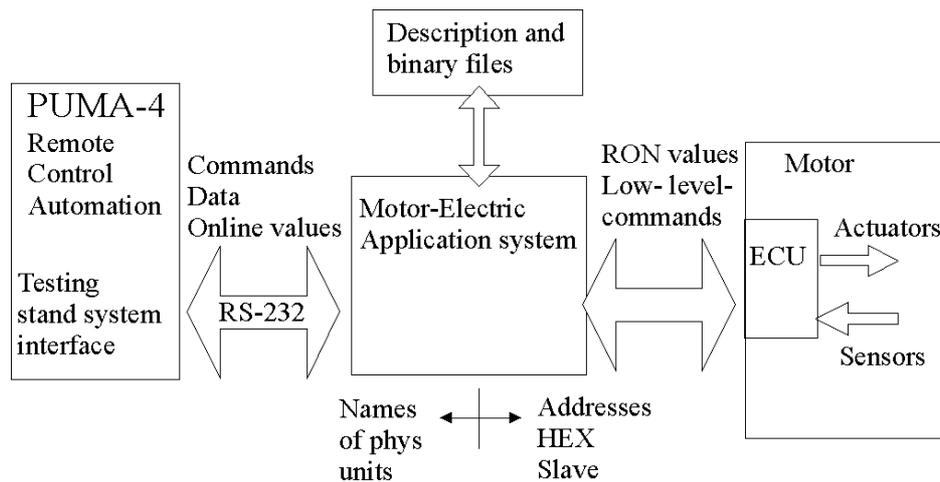
Note: These specifications may be changed without prior notice.

2 OVERVIEW

This interface description contains all the basic information about the integration of motor electronic systems in a higher-order testing stand system (PR-S) including a motor electronic application system (AP-S). The actual integration occurs using a standardised serial RS232 data connection and uses a software protocol allowing straightforward command and data exchange between the PR-S and AP-S.

Figure A shows the basic hardware structure of this integration. It clearly demonstrates that in any case the AP-S is used as an intelligent relay station between the PR-S and the motor electronic device. The various motor electronic devices can be operated via the AP-S which can also be used interactively as a stand-alone device.

In the shown solution the PR-S only communicates with the AP-S. Only dimensions in physical units (e.g. m³/h) with related logical name (e.g. AIR FLOW) are exchanged between the PR-S and AP-S. The software package used on the AP-S is consequently responsible for the preparation and conversion into hexadecimal values suitable for the motor electronic devices.



Figur 1

The connection with a standard RS232 line is based on the following basic settings:

9600 Baud (adjustable)
8 Bits
1 Stop Bit
no parity bit
no support of XON/XOFF
ALL COMMANDS ARE INITIATED BY THE PR-S
(STRICT MASTER-SLAVE PRINCIPLE)

The following pages detail all used data structures, data types and commands.

3 CHANGES WITH RESPECT TO V1.0

This version of the AVL protocol differs from the previous V1.0 version in the following points:

VERSION MECHANISM:

A version management mechanism is activated together with this version of the interface protocol. The following applies for the identification of protocol versions VX.Y:

- X:** Main protocol version number (1...255). A change of this dimension is necessary if the general data or telegram structure is modified, if the data frame of existing functions has changed, if the meaning of existing commands differs considerably from those of the previous version or if the command sequence to be respected has been modified. If a PR-S and an AP-S with an interface implementation of the same main protocol version number meet, in principle it may be assumed that they can communicate with each other.
- Y:** Sub-version number (0...255). This dimension is changed if a new function was added to the interface definition. A PR-S and AP-S with the same main protocol version number but different sub-version numbers can communicate with one another but the full range of functions may not be available.

TRANSMISSION:

The BAUD rate indicated for data transmission must be adjustable on the PR-S as well as on the AP-S. A BAUD rate of 9600 must be considered a minimum requirement.

DATA FORMATS:

- 1:** Change in the length of the 'NAME' protocol data type from the current 8 ASCII characters to the 'STRING' data type with a variable length (max. length: 'Implementation Dependent').
- 2:** Integration of an 'Integer4' data type to transmit large integral units.

DATA FRAMES:

- 1:** To avoid ambiguities in the interpretation of error statistics in the answer telegram from the AP-S to the PR-S, the AP-S may be requested by the PR-S to re-transmit the last sent telegram. However, this does not initiate a more recent version of the basic PR-S telegram.
- 2:** In addition to the answer data of the AP-S defined for each PR-S command a general error answer data frame will be introduced. This data frame will always be sent to the PR-S by the AP-S instead of the regular data frame whenever an error occurs during the processing of PR-S commands on the AP-S, and contains in addition to an error code an error message in clear text.

FUNCTIONS:

- 1: 'IDENTIFY' telegram: After initialising the communication ('INIT' command) a mutual identification is initiated in which the name of the PR-S and AP-S and of the relevant realised protocol version are exchanged. This information is necessary for compatibility checking and for the clear text output of user messages.
- 2: Introduction of a set of new telegrams making a possibly available recorder function of the application system usable for the test stand system.
- 3: An additional command to transmit a packet of on-line values has been introduced. In addition to the number of actual values contained in the packet it contains the global list of actual values. This modifies the answer telegram of the 'SWITCHING OFF LINE/ON LINE' command. No more data are transmitted with this command.
- 4: An additional telegram was introduced to activate the reset line of the command devices via the AP-S from the PR-S.
- 5: A new command to influence the representation mode allows to transfer data from the AP-S to the PR-S in the micro-controller model of the command devices.
- 6: In the data frame for the selection of the description and binary files ('SELECT DESCRIPTION-FILE AND BINARY-FILE') the destination (Emulator) is available as an additional parameter for which both file data must be valid.
- 7: In the data frame for the 'COPY BINARY FILE' command there is an additional source or target code: physical emulator board.
- 8: The interpretation of the 'PARAMETER FOR VALUE ACQUISITION' telegram was concretised. In future it will be possible to repeatedly use this telegram for a given ECU-(EP)PROM ('EMULATOR LUN'). The lists of dimensions to be recorded on line contained in these telegrams are concatenated in their entry sequence whatever the indicated ('Emulator LUN') and thus produce a final list of on line values. A telegram with an 'empty' list ('Number of values'=0) will lead to a rejection of the global list built up to that moment whatever the indicated ('Emulator LUN')('CLEAR ON LINE VALUE LIST').

STATUS:

- \$5656:** This AP-S error status explicitly informs the PR-S of the non-availability of a selected function.
- \$FFFF:** An error has occurred during the execution of a PR-S command on the AP-S. The answer telegram of the AP-S to the PR-S contains information about the error cause/error location. (Error Code) as well as an error message in clear text.

4 DATA FORMATS

All data structures used for the exchange of data between the PR-S and AP-S belong to one of 5 basic types:

Data type	Length	Comments
BYTE (0...255)	1 BYTE	---
WORD (0...65535)	2 BYTE	Motorola type
INTEGER 4	4 BYTE	Motorola type
IEEE-REAL	4 BYTE	Motorola type
STRING	2n BYTE	see definition

The 'STRING' data type is a composite data type:

Length	Character 1	Character 2	...	Character x
1 WORD	1 BYTE	1 BYTE	...	1 BYTE

Length: Number of subsequent valid characters in Byte. The maximum allowed length is implementation dependent.

Character 1,2 ... Byte value in ASCII interpretation.

Character x: Filler; if the number of valid characters in the Byte (length) is odd, a filler byte will make the effective string-length L_{off} (in Byte) even again.

$$L_{off} = 'Length' + "Length' \text{ MOD } 2 + 2$$

Please note: PC platforms usually use INTEL data types. The latter must be converted to the Motorola format ('swap').

In addition to these 5 real data types 3 logical data types may also be indicated. They are directly related to the conditions prevailing in modern motor electronics.

log. data type	structure	meaning
Identification field	field	checkpoint-oriented representation of a context $z=f(x,y)$ or $z=f(x)$; $z(ij)=f[x(i),y(j)];z(i)=f[x(i)];$ retrievable and modifiable via the AP-S
Parameter	scalar	fixed value;retrievable and modifiable via the AP-S
Actual value	scalar	values cyclically measured or calculated by the motor electronic device; retrievable but not modifiable via the AP-S

5

TELEGRAM STRUCTURE

Communication between the PR-S and AP-S occurs via 2 defined telegrams with a fixed format:

PR-S to AP-S
AP-S to PR-S

General command structure for 'PR-S to AP-S' telegrams:

Length	Command code	Data	Check sum
1 WORD	1 WORD	n WORD	1 WORD

General command structure of the 'AP-S to PR-S' telegrams:

Length	Command code	Status	Data	Check sum
1 WORD	1 WORD	1 WORD	m WORD	1 WORD

Communication control and data exchange between the PR-S and AP-S occur with these two telegrams.

For communication control there are 3 variants of these general telegrams, the command telegrams:

Repeat request to the AP-S
Repeat request from the AP-S
Acknowledgement message of the AP-S

Repeat request to the AP-S:

Length	Command code	Check sum
6	0	1 WORD

Repeat request from the AP-S:

Length	Command code	Status	Check sum
8	0	\$EEEE	1 WORD

Acknowledgement message from the AP-S:

Length	Command code	Status	Check sum
8	1 WORD	\$AAAA	1 WORD

The repeat request is intended to prompt the AP-S or PR-S to re-transmit the last telegram sent ('PR-S to AP-S' or 'AP-S to PR-S') (*the last sent telegram was not correctly received or interpreted by the AP-S/PR-S*). A 'repeat request to the AP-S' will not, however, result in a more recent version of the commands to the AP-S in the basic 'PR-S to the AP-S' telegram. The acknowledgement message informs the PR-S of the correct reception of the 'PR-S to AP-S' telegram (*the last telegram was received and processing has started on the AP-S*).

The individual telegram inputs have the following meaning:

Length: Length of the global telegram in Bytes (including length-WORDS, command code, data record and check sum; for the AP-S answer 'AP-S to PR-S' obviously the status is included). The length is always an even number. The minimum length for the 'PR-S to AP-S' telegrams is of 6 Bytes, that of the 'AP-S to PR-S' answer is 8 Bytes.

Command: Fixed number; the command code of the AP-S answer 'AP-S to PR-S' always corresponds with the original 'PR-S to AP-S' telegram sent by the PR-S.

Status: This value serves to transfer error information in the 'AP-S to PR-S' answer telegram.

Status	Meaning
\$0000	Faultless execution of the last command
\$1232	Faultless execution of the last command
\$2343	Value \$2343 indicates that the last sent telegram was not processed and that the testing system must again set up communication, as interactively major changes have been made to the AP-S configuration predefined by the PR-S. The successful execution of the 'INIT' command (Code 2) resets this status (see 'User command "START"' in the section on 'some command sequences').
\$3454	A \$3454 status informs the PR-S that the AP-S is in simulation mode. The status is interpreted in the subsequent processing as an '0' or '\$1232' status (faultless command execution).
\$5656	This status informs the PR-S of the non-availability of the function of the last sent command.
\$FFFF	An error occurred during the processing of the last PR-S command sent to the AP-S . An error number and a detailed error message in clear text are sent by the AP-S to the PR-S.
all others	reserved.
\$AAAA	This status is considered as an acknowledgement of the last command by the PR-S. The final answer of the AP-S occurs after the command has been processed (see telegram above).
\$EEEE	In conjunction with command code 0 in the PR-S RETRY telegram, this status may be considered as a command repeat request (see telegram above).

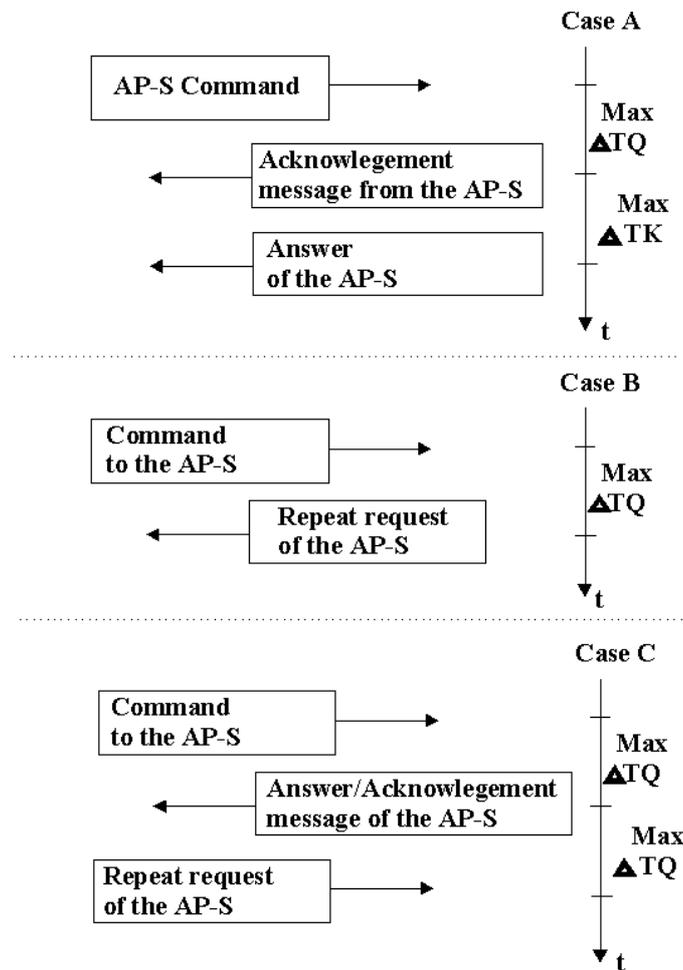
Data: The length and structure of the data records - described further - depend on the actual command. They may differ for the 'PR-S to AP-S' telegrams and for the 'AP-S to PR-S' telegrams. A length 0 for the data record is allowed.

Checksum: Is obtained by adding all telegram WORD dimensions and contains the 'Least Significant WORD' of this sum.

6

COMMUNICATION SEQUENCE

A command sequence PR-S → P-S and AP-S → PR-S is always introduced by the PR-S with a 'PR-S to AP-S' telegram and is concluded by the AP-S with the 'AP-S to PR-S' telegram. Between them the command telegrams 'Repeat request to AP-S', 'Repeat request from the AP-S' or 'Acknowledgement message of the AP-S' may be used. This results in the following diagram :



Following a PR-S command either an acknowledgement message, a repeat request or the final answer telegram must be sent by the AP-S within a predetermined time range ΔTQ . If this time range is exceeded the line between PR-S and AP-S will be considered as non-operational and corresponding error messages will be issued and reactions will occur on the PR-S.

If a PR-S command is answered by the acknowledgement message the final answer telegram must be sent within a command-dependent timeout ΔTK without a new prompt from the AP-S to the PR-S.

DETAILED COMMANDS

Version V2.0 includes the following command groups:

Initialisation, identification, emergency
EMERGENCY
INIT
IDENTIFY

Configuration
SELECT DESCRIPTION FILE AND BINARY FILE
COPY BINARY FILE
CHANGE BINARY FILE NAME

Identification field manipulation
SELECT LOOK-UP TABLE
PUT LOOK-UP TABLE TO AP-S
GET LOOK-UP TABLE FROM AP-S
GET LOOK-UP TABLE VALUE
INCREASE LOOK-UP TABLE
SET LOOK-UP TABLE

Parameter manipulation
GET PARAMETER FROM AP-S
SET PARAMETER ON AP-S

Measurement data recording
PARAMETER FOR VALUE ACQUISITION
SWITCHING OFF LINE/ON LINE
GET ON LINE VALUE

Recorder
DEFINE RECORDER PARAMETERS
DEFINE TRIGGER PARAMETERS
ACTIVATE RECORDER
GET RECORDER STATUS
GET RECORDER RESULT HEADER
GET RECORDER RESULT
SAVE RECORDER FILE
LOAD RECORDER FILE

Miscellaneous
SET GRAPHIC MODE
RESET DEVICE
SET FORMAT

GENERAL

The following described data frames of the AP-S answers to the individual commands are related to the faultless execution on the AP-S. If during the execution of the command on the AP-S an error occurs, a fixed data frame will be transmitted to the PR-S for error analysis. It replaces the data frame for the faultless execution.

Data from the AP-S

Entry	Data type
Error code	WORD
Error text	STRING

Initialisation, Identification, Emergency

EMERGENCY	Code	1
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This command may be sent to the AP-S during active communication in an emergency situation. ECU-specific emergency reactions may be initiated on the AP-S. A definition of such a situation, the value allocated to the 'Event' and how it must be dealt with, depends on the actual realisation of the AP-S.

Data to the AP-S

Entry	Data type
Event	WORD

Data from the AP-S

NO DATA

INIT	Code	2
------	------	---

This command is the first to be sent by the testing system and starts communication with the AP-S. The AP-S performs all the necessary initialisations. After this command the AP-S is ready for REMOTE operation with the PR-S.

Data to the AP-S:

NO DATA

Data from the AP-S:

NO DATA

IDENTIFY	Code	20
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After initialising the connection (Command 'INIT') a randomly attributable name and the current protocol version number of the communication partner must be exchanged with this command. If this command is acknowledged by an error message from the AP-S, it may be assumed by the PR-S that a protocol version V1.x has been implemented on the AP-S.

If, however, this command is not sent by the PR-S, then the AP-S may assume that a protocol version V1.x has been implemented on the PR-S.

Data to the AP-S

Entry	Data type
Protocol version number	WORD
PR-S name	STRING

Data from the AP-S

Entry	Data type
Protocol version number	WORD
AR-S name	STRING

For a protocol version VX.Y : 'Protocol Version Number' = $256 * X + Y$ applies.

CONFIGURATION

SELECT DESCRIPTION FILE AND BINARY FILE

Code

3

In general for each ECU-(EP)ROM there is a binary data file and a description file containing the structure information of the binary file and of the ECU-RAM structure. In the description file there are also links of identification field addresses, parameter addresses and actual value addresses with logical names and labels, e.g. the identification field SP_ADV (end identification field) is linked to start address \$06F0 or parameter MAX-N (maximum speed) is in address \$780A or actual value AKT_N (actual engine speed) is in RAM address \$0030, etc. As concerns the integration of an AP-S in the PR-S it is recommended that these files - and hence the basic configuration - can be preset by the higher-order PR-S.

This command may only be transmitted to the AP-S after a successful execution of the 'INIT' command. A 'Binary data file' and a related 'Description file' are jointly linked to a logical Unit Number (EMULATOR LUN). Both files are local to the AP-S. the path and file extension correspond with the default settings of the AP-S.

With the indication of a destination number agreed by the PR-S and AP-S the PR-S can define the valid location (multiple of a control device) for the allocation of the description file and binary file. This is required if a corresponding indication is not present in the description file. The destination number and the 'Emulator LUN' need not correspond.

Data for the AP-S

Entry	Data type
Description file name	STRING
Binary file number	STRING
Destination	WORD

Destination: 0...destination is automatically defined by the AP-S; 1, 2, ... final allocation to destinations 1, 2,... by the PR-S.

Data from the AP-S:

Entry	Data type
Emulator LUN	WORD

COPY BINARY FILE

Code

4

After an automatic move and modification of the motor electronics data via the PR-S - AP-S link, it is recommended to save the modified binary data in a file on the hard disk. This command must only be executed if the 'Emulator LUN' dimension has already been determined with the 'SELECT DESCRIPTION FILE AND BINARY' command. This command transfers the current binary file of the specified emulator from the specified source to the specified target, e.g. from the emulator board to a file on the hard disk.

Data for the AP-S

Entry	Data type
Target	WORD
Source	WORD
Emulator LUN	WORD

Data from the AP-S:

NO DATA

Source, target: 1... EPROM, 2... file, 3... virtual emulator board, 4... physical emulator board.

The board from which the control device obtains its current data is considered as the physical emulator board . As opposed to this the virtual emulator board is a representation of the contents of the physical emulator board on the AP-S without having to have the same contents as the latter at all times.

The minimum requirement is the realisation of the copy command with the 'virtual Emulator Board' as a source and 'File' as a target. This allows to store the binary file of the indicated emulator on the hard disk under its current name.

CHANGE BINARY FILE NAME**Code****5**

This command is only sent by the PR-S after the successful definition of the 'Emulator LUN' by the 'SELECT DESCRIPTION FILE AND BINARY FILE' command. It is used to change the binary file name of the designated emulator in the prescribed manner. A subsequent 'COPY BINARY FILE' will store the binary file under this new name. This allows to save modified binary file contents without losing the original data.

Data for the AP-S

Entry	Data type
New Binary File Name	STRING
Emulator LUN	WORD

Data from the AP-S:

NO DATA

Identification field manipulation

SELECT LOOK-UP TABLE

Code

6

This command is only sent by the PR-S after a successful definition of the 'Emulator LUN' by the 'SELECT DESCRIPTION FILE AND BINARY FILE' command. This command combines a specific identification field with the 'Emulator LUN' into an unambiguous 'Identification field number'.

Further basic information about the identification field dimensions (nx, ny) will be requested by the AP-S. A function $z=f(x,y)$ expands in the x direction as well as in the y direction, i.e. $n_x > 1$ and $n_y > 1$. A function $z=f(x)$, however, only expands in the x direction, i.e. $n_x > 1$ and $n_y=1$. Each identification field to be addressed by the PR-S must be notified to the AP-S in this manner. Subsequently, each identification field shall only be addressed with the 'Identification field number'. the maximum allowed dimensions for the identification fields depends on the implementation.

Data for the AP-S

Entry	Data type
Emulator LUN	WORD
Identification field name	STRING

Data from the AP-S

Entry	Data type
Identification field number	WORD
y dimension (ny)	WORD
x dimension (nx)	WORD
Address (logging info)	WORD

PUT LOOK-UP TABLE TO AP-S

Code

7

This command is only sent after the 'Identification field number' has been defined with 'SELECT LOOK-UP TABLE'. This command transmits the entire identification field content to the AP-S. The identification field structure defined by means of the 'SELECT LOOK-UP TABLE' command remains unchanged. Depending on the AP-S software this command may not only change the z body but also the axle definition (position of the support points).

Data for the AP-S

Entry	Data type
Identification field number	WORD
Identification field length	WORD
Y(1)	REAL
Y(2)	REAL
:	:
Y(ny)	REAL
X(1)	REAL
X(2)	REAL
:	:
X(nx)	REAL
Minimum Z(ij)	REAL
Maximum Z(ij)	REAL
Minimum increment	REAL
Z[X(1),Y(1)]	REAL
Z[X(2),Y(1)]	REAL
Z[X(3),Y(1)]	REAL
:	:
Z[X(2),Y(5)]	REAL
:	:

The same format is used for functions $z=f(x)$. In this case the entry will be Y(1) followed by a random dummy value!

Data from the AP-S:

NO DATA

The entry 'Identification field length' states the number of REAL values of the identification field ($\text{Length} = n_y + n_x + (n_y * n_x) + 3$); the maximum length is thus obtained for a maximum identification field definition of 20×20 by $20 + 20 + (20 * 20) + 3 = 443$ or for 32×32 identification fields by $32 + 32 + (32 * 32) + 3 = 1091$) and must obviously correspond with the identification field dimensions of the answer telegram to command 6. The entries 'Minimum Z(ij)' and 'Maximum Z(ij)' are global limits for the z body of the identification field, accordingly the 'minimum increment' entry is dependent upon the definition of the data type used in the ECU.

These 3 dimensions are defined by the AP-S in the answer telegram to command 8 and only serve to inform the PR-S about these global identification field restrictions.

GET LOOK-UP TABLE FROM AP-S	Code	8
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This command is only sent after the 'Identification field number' has been defined with 'SELECT LOOK-UP TABLE' command. This command transmits the entire identification field content from the AP-S to the PR-S. A copy of the identification field is thus available on the PR-S and can be archived or manipulated.

Data for the AP-S

Entry	Data type
Identification field number	WORD

Data from the AP-S

Entry	Data type
Identification field length	WORD
Y(1)	REAL
Y(2)	REAL
:	:
Y(ny)	REAL
X(1)	REAL
X(2)	REAL
:	:
X(nx)	REAL
Minimum Z(ij)	REAL
Maximum Z(ij)	REAL
Minimum increment	REAL
Z[X(1),Y(1)]	REAL
Z[X(2),Y(1)]	REAL
Z[X(3),Y(1)]	REAL
:	:
Z[X(2),Y(5)]	REAL
:	:

The same format is used for functions $z=f(x)$. In this case the entry will be Y(1) followed by a random dummy value!

The entry 'Identification field length' states the number of REAL values of the identification field ($\text{Length} = n_y + n_x + (n_y * n_x) + 3$); the maximum length is thus obtained for a maximum identification field definition of 20 x 20 by $20 + 20 + (20 * 20) + 3 = 443$ or for 32 x 32 identification fields by $32 + 32 + (32 * 32) + 3 = 1091$) and must obviously correspond with the identification field dimensions of the answer telegram to command 6. The entries 'Minimum Z(ij)' and 'Maximum Z(ij)' are global limits for the z body of the identification field, accordingly the 'minimum increment' entry is dependent upon the definition of the data type used in the ECU.

GET LOOK-UP TABLE FROM AP-S	Code	9
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This command is only sent after the 'Identification field number' has been defined with 'SELECT LOOK-UP TABLE' command. This command makes the AP-S transmit a single identification field value defined by the indication of the support point location to the PR-S.

Data for the AP-S

Entry	Data type
Identification field number	WORD
Y index	WORD
X index	WORD

Data from the AP-S

Entry	Data type
Value	REAL

INCREASE LOOK-UP TABLE	Code	10
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This command is only sent after the 'Identification field number' has been defined with 'SELECT LOOK-UP TABLE' command. This command makes the AP-S add an offset to the specified identification field. The relative form of the identification field remains unchanged in all identification field areas meeting the restrictions of the z body. All other areas receive the corresponding limit value (Maximum Z(ij), Minimum Z(ij)). The identification field area to be changed is indicated by the start index and the delta range.

Data for the AP-S

Entry	Data type
Identification field number	WORD
Y index	WORD
X index	WORD
Y Delta	WORD
X Delta	WORD
Offset	REAL

Data from the AP-S

NO DATA

SET LOOK-UP TABLE	Code	11
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This command is only sent after the 'Identification field number' has been defined with 'SELECT LOOK-UP TABLE' command. This command makes the AP-S set the contents of the selected identification field in the specific range to a constant value. In this range the identification field will be brought to a horizontal level.

Data for the AP-S

Entry	Data type
Identification field number	WORD
Y index	WORD
X index	WORD
Y Delta	WORD
X Delta	WORD
Value	REAL

Data from the AP-S

NO DATA

MEASUREMENT DATA ACQUISITION

PARAMETER FOR VALUE ACQUISITION

Code

12

This command is only sent by the PR-S after the 'Emulator LUN' has been defined by the 'SELECT DESCRIPTION FILE AND BINARY FILE'. This command informs the AP-S of the actual values, their sequence and the acquisition rate at which they must be transmitted to the PR-S. Scanning periods (scanning frequencies) in the 10000 ms (0,1 Hz) to 500 ms (2 Hz) range are provided. This command can be repeated a number of times for each 'Emulator LUN'. In this case the transmitted lists are concatenated in their access sequence, whatever the indicated 'Emulator LUN'. If a number of emulators are available from the AP-S or if the command was repeatedly sent, the entry of the scanning rate of the last telegram will apply.

If the PR-S does not require any actual values from the AP-S an empty list with 'Number of values'=0 may also be sent to the AP-S. An empty list furthermore entails a rejection of the actual value list compiled until that moment, whatever the indicated 'Emulator LUN' ('CLEAR ON LINE VALUE LIST').

Data for the AP-S

Entry	Data type
Emulator LUN	WORD
Scanning time (ms)	WORD
Number of values	WORD
Name of the 1st value	STRING
Name of the 2nd value	STRING
:	:

Data from the AP-S

NO DATA

SWITCHING OFF LINE/ON LINE

Code

18

If any actual values are to be collected this command will only be sent after the command 'PARAMETER FOR VALUE ACQUISITION' has been processed.

With the first execution of this command with Mode=1 the AP-S will subsequently also transfer all current and future modifications of the identification fields and parameters on the AP-S to the motor electronic device (transparent operation). Moreover, from then onwards the PR-S may request data packets with lists of the current actual values (command 'GET ON LINE VALUE'). This transparent type of operation is again de-activated with Mode=0 and all subsequent identification field and parameter changes will again only occur locally on the AP-S. At the same time, the AP-S is informed of the setting of the cyclical actual value acquisition.

Data for the AP-S

Entry	Data type
Mode	WORD

Mode: 0... OFF-LINE, 1...ON-LINE

Data from AP-S:

NO DATA

GET ON LINE VALUE	Code	13
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In the event actual values are to be acquired this command will only be sent after the 'SWITCHING OFF LINE/ON LINE' command has been processed with Mode=1. This command prompts the AP-S to transfer to the PR-S a packet with the current actual values (in accordance with the list definition of the 'PARAMETER FOR VALUE ACQUISITION' command).

Data for the AP-S:

NO DATA

Data from the AP-S:

Entry	Data type
Number of actual values	WORLD
Value of the 1st actual value	REAL
Value of the 2nd actual value	REAL
:	:

PARAMETER MANIPULATION

GET PARAMETER FROM AP.S

Code

14

This command is only sent by the PR-S after the 'Emulator LUN' has been defined by the 'SELECT DESCRIPTION FILE AND BINARY FILE COMMAND'. This command transmits the specified parameter from the AP-S to the PR-S.

Data to the AP-S:

Entry	Data type
Emulator LUN	WORD
Parameter name	STRING

Data from the AP-S:

Entry	Data type
Value	REAL
Minimum value	REAL
Maximum value	REAL
Minimum increment	REAL

The entries 'Minimum value' and 'Maximum value' are global limits for this parameter. The entry 'Minimum increment' is dependent on the resolution of the data type used for this parameter in the ECU.

SET PARAMETER ON AP.S

Code

15

This command is only sent by the PR-S after the 'Emulator LUN' has been defined by the 'SELECT DESCRIPTION FILE AND BINARY FILE COMMAND'. This command transmits the specified parameter with the defined value from the PR-S to the AP-S.

Data for the AP-S

Entry	Data type
Emulator LUN	WORD
Parameter name	STRING
Value	REAL

Data from the AP-S

NO DATA

RECORDER**DEFINE RECORDER PARAMETERS****Code****41**

This command is only sent by the PR-S after the 'Emulator LUN' has been defined by the 'SELECT DESCRIPTION FILE AND BINARY FILE COMMAND'. This command defines the necessary parameters for the recorder function on the AP-S.

This command can be repeated for each 'Emulator LUN'. In this case the transmitted lists of dimensions to be included are concatenated in their access sequence, whatever the indicated 'Emulator LUN'. If a number of emulators are available from the AP-S or if the command was repeatedly sent, the entries for the 'Recording type', 'Scanning time' and 'Divider factor' of the last telegram will apply. An empty list furthermore entails a rejection of the list of dimensions to be recorded compiled until that moment, whatever the indicated 'Emulator LUN' ('CLEAR RECORDER LIST').

Data to the AP-S:

Entry	Data type
Emulator LUN	WORD
Recording type	WORD
Scanning time (ms)	REAL
Divider factor	WORD
Number of values	WORD
Name of 1st value	STRING
Name of 2nd value	STRING
:	:

Recording type: 0... equidistant in time; 1... synchronous to the system interval time.

Data from the AP-S**NO DATA**

In the event of time synchronous recording (Recording type=0) the 'scanning time' value will apply as time between two subsequent scanings. If the recording is synchronous to the system interval time of the control device that time interval between two scanings may change. Often the system interval time is linked to the position of the crankshaft and is thus crank angle synchronous. In this case the division factor indicates the number of scanings per system interval time.

DEFINE TRIGGER CONDITION**Code****42**

This command is only sent by the PR-S after the Recorder parameter has been determined by the 'DEFINE RECORDER PARAMETERS'. It includes as transition parameters the conditions for starting and stopping the recorder. These conditions are to be considered as logical functions capable of supplying the answer 'TRUE' or 'FALSE'. The structure and type of the allowed nodes are implementation dependent. For repeated transmission the settings of the last sent telegram apply. If no trigger condition is defined for the Start or Stop (empty string), starting and stopping will occur manually, i.e. the maximum sample number will generate a stop of the recorder.

'Start delay' and 'Stop delay' generate a shift in the starting or stopping of the recording of the indicated samples. The 'max. sample number' is the measure for the max. global length of the recording. A negative value for the start delay is possible in view of the possibly available Post Mortem operating mode of the AP-S recorder.

Data to the AP-S:

Entry	Data type
Trigger START	STRING
Trigger STOP	STRING
max. sample number	INTEGER4
Start delay	INTEGER4
Stop delay	INTEGER4

Data from the AP-S

NO DATA

ACTIVATE RECORDER**Code****43**

This command is only sent by the PR-S after the trigger conditions have been defined in the 'DEFINE TRIGGER CONDITION' command. The sending of this command starts the recording, activates the defined conditions for starting the recorder or stops a possibly ongoing recording process.

Data to the AP-S:

Entry	Data type
Mode	WORD

Mode = 0 ... recorder stop (independent of 'Trigger STOP'); Mode = 1 ... activated recorder;
Mode = 2 ... start recorder start ('independent of 'Trigger START')

Data from the AP-S

NO DATA

GET RECORDER STATUS**Code****44**

This command allows to query the current status of the ongoing recording and the number of already collected samples using the command 'ACTIVATE RECORDER' once the recorder has been activated. Moreover, information on stopping the recorder is given in a clear text message.

Data to the AP-S:

NO DATA

Data from the AP-S:

Entry	Data type
Recorder Status	WORD
Current Samples	INTEGER4
Stop Condition	WORD
Stop Information	STRING

Recorder status

'Recorder on':..... 1
 'Recorder off':.....2
 'Recorder ready':.....3

Stop condition

'Manual':.....1
 'Trigger Stop':..... 2
 'End of Recording': 3
 'Stop due to error': 256

GET RECORDER RESULT HEADER	Code	45
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This command allows to transmit general information via the recording from the AP-S to the PR-S upon completion of the current recording (the last valid recording following the 'INIT' command) or after the successful execution of the 'LOAD RECORDER FILE' command.

Data to the AP-S:

NO DATA

Data from the AP-S:

Entry	Data type
Start time (Trigger Start)[s]	STRING
Recording type	WORD
Scanning time [ms]	REAL
Divider Factor	WORD
Number of samples	INETGER4
Start Delay	INTEGER4
Stop Delay	INTEGER4
Lost Samples	INTEGER4
max. Phase Errors	INTEGER4

The 'Start Time' dimension defines the time at which the trigger condition occurs for the start or the time of the manual start. It is given as the absolute time of day of the AP-S and at least corresponds with the first 14 positions of the following format:

Year	Month	Day	Hour	Minute	Second	s/100	...
'93'	'11'	'02'	'18'	'58'	'45'	'79'	...

The length of the string is thus pf at least 14. More accurate resolutions are possible by adding pairs of additional characters (s/10000, s/1000000,...).

The 'Recording Type', the 'Scanning Time' and the 'Divider Factor' correspond with the values obtained with the 'DEFINE RECORDER PARAMETERS' command.

The 'Number of Samples' dimension gives the global number of samples including possibly lost samples. The 'Start Delay' and 'Stop Delay' values correspond with the values of the 'DEFINE TRIGGER CONDITION' command.

'Lost Samples' and 'max. Phase Errors' must be considered as additional information for the quality of the recording. A single sample contains the values for all the dimensions defined with the 'DEFINE RECORDER PARAMETER' telegram at the current scanning time. If the 'Scanning Time' or the 'Divider Factor' was unfavourably selected with the 'DEFINE RECORDER PARAMETER' telegram, it is possible that not all samples can be taken on time. They will then be lost or be undefined thus leaving blanks. The number of lost samples in the longest concatenated blank is the 'max. phase error'.

GET RECORDER RESULTS**Code****46**

This command allows to transfer the recording result by packets from the AP-S to the PR-S at the end of the current recording (the last valid recording since the 'INIT' command) or after the successful execution of the 'LOAD RECORDER FILE ' command. The data packets may be requested individually per 'data packet number'.

Each data packet contains the sample defined with the 'data packet number'. The sequence of the values in the data packet corresponds with the list compiled with the 'DEFINE RECORDER PARAMETER' telegram or indicated with the 'LOAD RECORDER FILE' command. The number of values in the data packet is transmitted with the dimension 'Number values m'. If this value is indicated with '0' the scanning on the AP-S did not occur correctly, i.e. this is a lost sample and the values in the list have no significance.

Data to the AP-S:

Entry	Data type
Data Packet Number n	INTEGER4

Data from the AP-S:

Entry	Data type
Data Packet Number n	INTEGER4
Number of values m	WORD
Value 1 in sample n	REAL
Value 2 in sample n	REAL
Value 3 in sample n	REAL
:	:
Value m in sample n	REAL

SAVE RECORDER FILE**Code****47**

This command allows to save the result of a recorder file locally on the AP-S under an attributable file name. The 'File Name' dimension is based on a default directory and a default extension.

Data to the AP-S

Entry	Data type
File Name	STRING

Data from the AP-S

NO DATA

LOAD RECORDER FILE**Code****48**

This command can only be transmitted by the PR-S to the AP-S after initialisation by the 'INIT' telegram. This will result in a local record file stored on the AP-S and specified by the 'File Name' entry being loaded by the AP-S. The 'File Name' dimension is based on a Default Directory and a Default Extension. After this loading process the commands 'GET RECORDER RESULT HEADER' and 'GET RECORDER RESULT' will be executed as if the file process had been prompted on the AP-S by the 'DEFINE RECORDER PARAMETERS', 'DEFINE TRIGGER CONDITION' and 'ACTIVATE RECORDER' commands from the PR-S.

The dimensions and sequence available for a transfer to the PR-S can be drawn from the list of 'Number of Values' length sent by the AP-S to the PR-S.

Data to the AP-S

Entry	Data type
File Name	STRING

Data from the AP-S

Entry	Data type
Number of Values	WORD
Number of 1st value	STRING
Number of 2nd value	STRING
:	:

MISCELLANEOUS**SET GRAPHIC MODE ON AP-S****Code****16**

This command can only be transmitted after the PR-S ↔ AP-S connection has been initialised. It is thus also possible to make AP-S resources available for more important system tasks (communication with the ECU,...) by deactivating a possible local visualisation.

Data to the AP-S

Entry	Data type
Mode	WORD

Mode = 0 ... visualisation is deactivated; Mode = 1... visualisation is activated.

Data from the AP-S**NO DATA****RESET DEVICE****Code****17**

This command causes the AP-S to activate the reset line of the control device belonging to the indicated 'Emulator LUN'. It can only be used after the 'Emulator LUN' quantity has been defined.

After the execution of the command on the AP-S the latter will be in the same condition as before the execution of this command with respect to the link to the PR-S and control device.

Data to the AP-S

Entry	Data type
Emulator LUN	WORD

Emulator LUN = 0; all the control devices belonging to the selected 'Emulator LUNs' are reset.

Data from the AP-S**NO DATA****SET FORMAT****Code****18**

In addition to the physical representation of the control device dimensions (identification fields, parameters, actual values) a control device (controller) like representation of these data is desired on the PR-S. This representation can be realised by temporarily replacing a random conversion formula 'Controller value x ' → 'Physical value y ' (e.g. $y_p = k_0 \cdot (1 - \exp(-k_1 \cdot x))$) AP-S internally by the special representation $y_p = x$. An internal control device temperature value $T = -234$ is represented in the physical model as $T_p = -17.25$ °C and in the controller model as $T_c = -234.0$

The representation type is made individually switchable for the three logical data types 'identification field', 'parameter' and 'actual value'. All the dimensions required for the representation of an identification field, parameter,.. are affected by this switch over

(e.g. Y(1), Y(2), ... minimum Z(ij),... minimum increment, ... Z[X(2), Y(5)],... given an identification field) and also all the selected data type related commands (e.g. 'SET LOOK-UP TABLE', 'GET LOOK-UP TABLE',... for identification fields, 'GET ON LINE VALUES' for On line values etc.). The data frames allocated to the commands are not affected by this model switch-over (the relevant dimensions are still transmitted in IEEE-REAL format).

A more recent transfer of the command with a modified model switch allows to again change the representation type. The physical model is the default setting. For the log. data type 'Actual value' a switch over of the model is only possible in 'Off line' condition or with an inactive recorder.

Data to the AP-S

Entry	Data type
Log. data type	WORD
Model	WORD

log. data type: 0... all, 1... identification field, 2... parameter, 3...actual values

model: 0... physical model, 1... controller model

Data from the AP-S

NO DATA

If e.g. out of 6 identification fields to be processed the 4th is present in the controller model on the PR-S, the command 'SET FORMAT' allows to switch the representation type for the identification fields to 'controller model'. The command 'GET LOOK-UP TABLE' transfers the 4th identification field to the PR-S and a more recent transmission of the 'CONFIGURE MODEL' command allows to switch back to the physical model to process the other identification fields.

COMMAND SEQUENCES

All commands are executed using the software handshake (i.e. before a command can be executed the previous one must be completed) and be monitored with an individual timeout.

Please note:

All commands were initiated by the PR-S (PR-S= Master, AP-S=Slave)

Basic Sequence

- ⇒ The AP-S periodically checks the reception buffer of the serial line for an incoming PR-S command.
- ⇒ The PR-S sends a command and awaits an answer from the AP-S. If this answer does not reach the PR-S within a command dependent timeout, it is assumed the AP-S is inactive.
- ⇒ The AP-S reads the command, performs all the necessary actions and sends the answer containing the status information back to the PR-S.
- ⇒ The PR-S receives this answer and examines all incoming data.

ExamplesExample 1: User command 'START' on the PR-S:

PR-S sends the 'INIT' user command to the AP-S

Entry	Value
Length	6
Code	2
Check sum	8

The AP-S reads this message from the receive buffer and performs all the necessary actions to prepare the 'Remote Control' operation.

The answer of the AP-S is transmitted to the PR-S.

Entry	Value
Length	8
Code	2
Status (ok)	0
Check sum	10

The PR-S reads this answer and recognises that the AP-S is ready for further commands.

Subsequently, the communication participants and their implemented protocol version identify themselves (version $v2.1=256*2+1$):

Entry	Value
Length	16
Code	31
Protocol version	513
Name PR-S length	5
Name PR-S character	PR-Sx
Check sum	xxxxx

The AP-S name and its protocol version number are transmitted to the PR-S

Entry	Value
Length	20
Code	31
Protocol version	512
Name PR-S length	7
Name PR-S character	AP-Sxyz
Status (ok)	0
Check sum	xxxxx

The PR-S reads this answer and recognises that the AP-S is based on protocol version V2.0. The basic communication capacity is thus ensured.

The command 'SWITCHING OFF LINE/ON LINE' with mode = 0 is transmitted to the AP-S. Modifications of identification fields and parameters are henceforth only effective locally on

Entry	Value
Length	26
Code	3
Description file name:Length	8
Description file name:Character	'FORM_TST'
Binary file name:Length	8
Binary file name:Character	'DATA_TST'
Destination	0
Check sum	xxxxx

The AP-S returns the related 'Emulator LUN'.

Entry	Value
Length	10
Code	3
Status	0
Emulator LUN	1

For each defined parameter the 'GET PARAMETER FROM AP-S' command is now processed. They are thus first available on the PR-S.

Entry	Value
Length	16
Code	14
Emulator LUN	1
Parameter name:Length	6
Parameter name:Character	'P IDLE'
Check sum	xxxxx

The corresponding quantities of the requested parameter are transmitted by the AP-S.

Entry	Value
Length	24
Code	14
Status	0
Value	1.23
Minimum value	0.00
Maximum value	2.55
Minimum increment	0.01
Check sum	xxxxx

The following 'SELECT LOOKUP TABLE' command identifies all identification fields to be processed. The 'SELECT LOOKUP TABLE' command is issued for each identification field. The identification field number allocated by the AP-S to the identification field must be unambiguous.

Entry	Value
Length	18
Code	6
EMulator LUN	1
Identification field name:Length	7
Identification field name:Character	'IT BASE'
Check sum	xxxxxx

The PR-S receives the basic data of the identification field as an answer from the AP-S:

Entry	Value
Length	16
Code	6
Status	0
Identification field number	1
y dimension (ny)	3
x dimension (nx)	3
Address (logging info)	1234
Checksum	xxxxx

Subsequently, all selected identification fields are transferred to the PR-S with the 'GET LOOKUP TABLE FROM AP-S' command, where they are stored as a backup copy.

Entry	Value
Length	8
Code	8
Identification number	1
Check sum	17

For each requested identification field the global identification field record is transmitted.

Entry	Value
Length	82
Code	8
Status	0
Identification field length	18
Y(1)	0.00
:	:
Y(3)	5.00
X(1)	0.00
:	:
X(3)	2.00
:	:
Check sum	xxxxx

Example 2: 'ON LINE' user command on the PR-S:

The PR-S transmits the command 'SWITCHING OFF LINE/ON LINE' to the AP-S with mode = 1. Subsequently, the 'GET ON LINE VALUE' command will be periodically executed with the defined scanning rate to transmit the actual values from the AP-S to the PR-S.

Obviously, other commands can be executed between two consecutive packet requests. However, it is possible that for a short while the scanning interval does not correspond with the defined scanning rate.

After this command all the modification interventions on the identification fields and parameters will also be effective in the motor electronic device.

Entry	Value
Length	8
Code	13
Mode	1
Check sum	22

After a positive AP-S answer the PR-S will collect the first data packet from the AP-S with the 'GET ON LINE VALUE' command

Entry	Value
Length	6
Code	19
Check sum	25

In answer the AP-S transmits a packet with actual values in accordance with the definition in the 'PARAMETERS FOR VALUE ACQUISITION' command.

Entry	Value
Length	68
Code	19
Status	0
Number of values	15
SPARK	20.9
ENGINE-SP	2509.0
:	:
Check sum	xxxxx

Example 3: 'OFF LINE' user command on the PR-S:

The PR-S command 'SWITCHING OFF LINE/OFF LINE' is transmitted to the AP-S using mode = 0. Subsequently, all further operations in the identification fields or parameters are only locally effective on the AP-S and no cyclical querying of the current actual values occurs.

Entry	Value
Length	8
Code	13
Mode	0
Check sum	21

Answer transmitted by the AP-S:

Entry	Value
Length	8
Code	13
Status	0
Check sum	21