e-xpert *pro* communication interface specification

Rev.02

Contents

1.0 INTRODUCTION

The scope of this document is to define the communication protocol used by the e-xpert pro battery monitor. A basic understanding of a-synchronous communication is required, as well as familiarity with hexadecimal and binary numbers.

2.0 DATA LINK INTERFACE

The e-xpert pro uses a-synchronous communication at 2400bps using 8 data bits, 1 stop bit and even parity. No hardware flow control is used.

2.1 Message transfer

The e-xpert pro communicates via messages. A message consists of at least 5 bytes. Every message starts with the *Header / Destination address* which is followed by the *Source address*. These addresses are used when a hub (currently not available, future product) connects two or more devices together. When connecting the e-xpert pro directly to a host PC (using the optional communication interface kit), the destination and source addresses are ignored. The next byte in the message is the *Device ID* followed by the *Message type*. Whether or not databytes are send after the *Message type* byte depends on the type of message (see section 2.1.4). The last byte in the message is the *End of transfer* byte which closes the message.

The MSB of each byte in the message represents the IDHT (IDentify Header / Trailer) bit. This bit is logic 1 for the *Header / Destination address* byte an the *End of transfer* byte and logic 0 for all the bytes between them. This simplifies the detection of a message start.

2.1.1 Header / Destination address

The IDHT of this byte is logic 1. The 7 bits following the IDHT represent the destination address. A maximum of 127 devices can be addressed, not 128 because the bitcombination FFh (IDHT = logic 1, address 128 = 7 consecutive logic 1's) is defined as the last byte of the transfer (see section 2.1.6). The e-xpert pro will always output destination address 0.

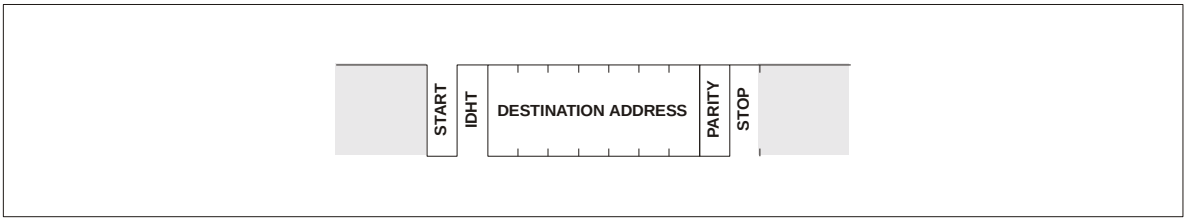


Figure 1 : Header / Destination address

2.1.2 Source address

The IDHT of this byte is logic 0. The 7 bits following the IDHT represent the address of the sender. The e-xpert pro will always output source address 0.

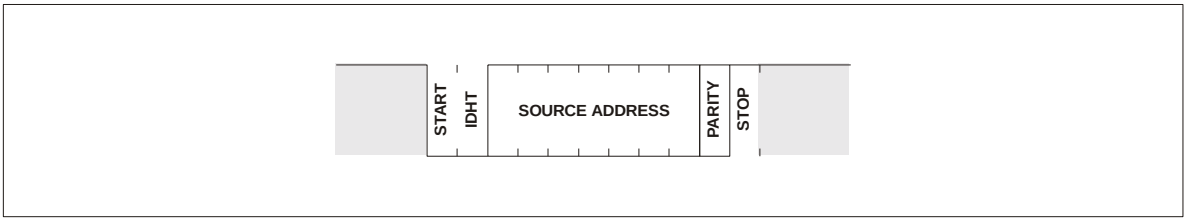


Figure 2 : Source address

2.1.3 Device ID

The IDHT of this byte is logic 0. The 7 bits following the IDHT represent what type of equipment is sending the message. Each type of TBS equipment has it's unique identification number. The Device ID of the e-xpert pro is 22h.

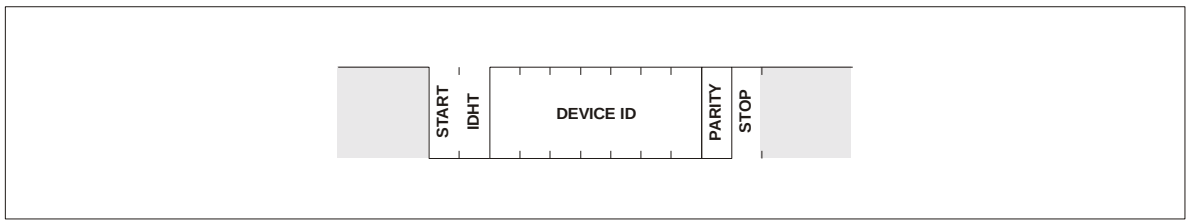


Figure 3 : Device ID

2.1.4 Message type

The IDHT of this byte is logic 0. The 7 bits following the IDHT represent the message type and can be divided into three groups :

1.) *Handshake*.

2.) *Commands.* To put the e-xpert pro in a certain state. For example 'Alarm relais on', 'Alarm relais off', 'Synchronize' etc. or to request data from the e-xpert pro. No data bytes are following a command.

3.) *Data*. Messages that contain data, for example battery voltage, battery current or all the settings of the monitor. The data will be sent in data bytes following the message type.

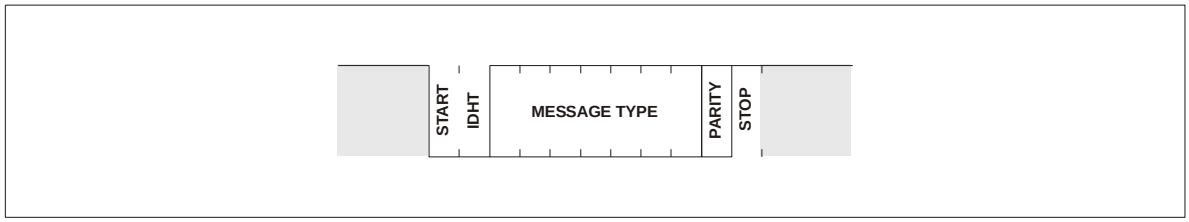


Figure 4 : Message type

See section 2.2 for an overview of all the e-xpert pro message types.

2.1.5 Data field

The data field contains data like battery voltage, battery current etc. The number of data bytes in a message is theoretically not limited. However, because of hardware limitations of the e-xpert pro, the data field can have a maximum length of 27 bytes.

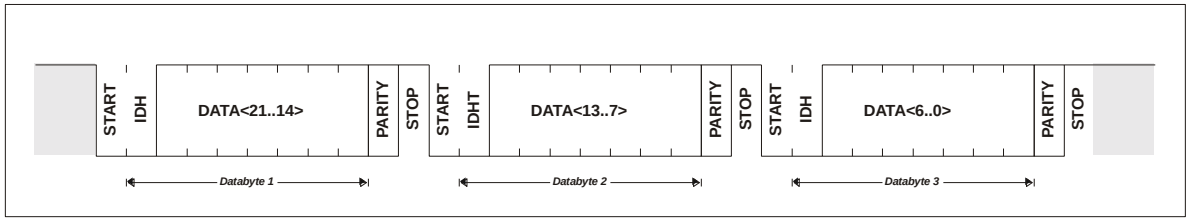


Figure 5 : Data field (example with 3 data bytes)

2.1.6 End of transfer

The IDHT and the 7 following bits of this byte are all logic 1. This *End of transfer* byte is unique because no other field in a message can represent FFh.

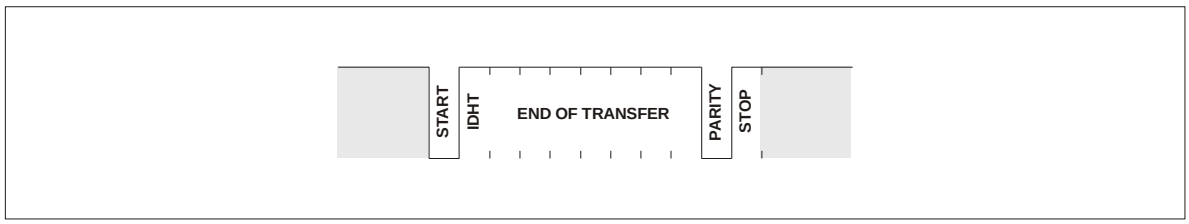


Figure 6 : End of transfer

2.2 Message type overview

This section gives an overview of all the message types the e-xpert pro understands.

2.2.1 Handshake

0x00 *ACK* – Positive acknowledge.

Transmission repetition rate :	on acknowledge
Direction :	output / input
Data type :	handshake

0x01 *NACK* – Negative acknowledge.

Transmission repetition rate :	on negative acknowledge
Direction :	output / input
Data type :	handshake

0x02 *NACK + repeat request* – Negative acknowledge and request to send data again.

Transmission repetition rate :	on communication error
Direction :	output
Data type :	handshake

2.2.2 Commands

0x12 *Alarm switch off* – Switches off the alarm switch.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x13 *Alarm switch on* – Switches on the alarm switch.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x20 *Display test off* – Disables display test.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x21 *Display test on* – Enables display test.

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x22 *Backlight off* – Turns off the backlight (provided that backlight is not on due to a keypress and backlight is not setup to be always on).

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x23 *Backlight on* – Turns on the backlight.

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x26 *Request only off* – Turns off request mode. Now the e-xpert pro sends data every second (this is the default facory status).

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x27 *Request only on* – Turns on request mode. Now the e-xpert pro only sends data on request (requested by a data request command).

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x28 *Store functions* – Store functions in EEPROM.

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x29 *Store history* – Store history in EEPROM.

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x2C *Synchronize* – Synchronizes the e-xpert pro to the battery. See the e-xpert pro user manual for more information on synchronizing. This command does the same as synchronizing the monitor manually by pressing the e-xpert pro's ◄ and ► buttons simultaneously for three seconds.

Transmission repetition rate : -
Direction : input
Data type : command
Response : acknowledge

0x2D *Synchronize + CEF* – Synchronizes the e-xpert pro to the battery and recalculates the CEF. See the e-xpert pro user manual for more information on synchronizing.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x30 *Reset functions* – Reset all functions to their factory default.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x32 *Reset Battery* – Reset all battery history and status data and all internal battery registers. The battery capacity setting (in function setup) will remain unchanged.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x33 *Reset Alarms* – Reset all currently active alarms. For an alarm to trigger again, It's alarm off condition must be met prior to it's alarm on condition.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	acknowledge

0x3C *Up switch pressed* – User has pressed the 'Up' switch (labeled ►).

Transmission repetition rate :	on up switch press
Direction :	output
Data type :	command
Response :	n/a (output only)

0x3D *Menu switch pressed* – User has pressed the 'Menu' switch.

Transmission repetition rate :	on menu switch press
Direction :	output
Data type :	command
Response :	n/a (output only)

0x3E *Down switch pressed* – User has pressed the 'Down' switch (labeled ◄).

Transmission repetition rate :	on down switch press
Direction :	output
Data type :	command
Response :	n/a (output only)

0x40 *Main Voltage request* – Request for main battery voltage data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x60* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	main battery voltage data (message *0x60*)

0x41 *Current request* – Request for current data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x61* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	current data (message *0x61*)

0x42 *Amphours request* – Request for amphours data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x62* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	amphours data (message *0x62*)

0x44 *State-of-Charge request* – Request for state-of-charge data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x64* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	state-of-charge data (message *0x64*)

0x45 *Time Remaining request* – Request for time remaining data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x65* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	time remaining data (message *0x65*)

0x46 *Temperature request* – Request for temperature data. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x66* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	temperature data (message *0x66*)

0x47 *Monitor Status request* – Request for monitor status bits. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x67* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	monitor status data (message *0x67*)

0x4F *All parameters request* – Request for all measured and calculated parameters. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x6F* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	main battery voltage data (message *0x60*) current data (message *0x61*) amphours data (message *0x62*) state-of-charge data (message *0x64*)

time remaining data (message *0x65*)
temperature data (message *0x66*)
monitor status data (message *0x67*)
auxiliary battery voltage data (message *0x68*)

0x50 *Parameter Select request* – Request for selected parameter. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x70* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	parameter select (message *0x70*)

0x51 *Function Dump request* – Request for function dump. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x71* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	function dump (message *0x71*)

0x52 *History Dump request* – Request for history dump. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x72* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	history dump (message *0x72*)

0x5F *Firmware Version request* – Request for firmware version. This message is built in only for e-xpert 501 compatibility and is not recommended. Use message type *0x7F* instead.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	firmware version (message *0x7F*)

0x60 *Main Voltage request* – Request for main battery voltage data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	main battery voltage data (message *0x60*)

0x61 *Current request* – Request for current data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	current data (message *0x61*)

0x62 *Amphours request* – Request for amphours data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	amphours data (message *0x62*)

0x64 *State-of-Charge request* – Request for state-of-charge data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	state-of-charge data (message *0x64*)

0x65 *Time Remaining request* – Request for time remaining data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	time remaining data (message *0x65*)

0x66 *Temperature request* – Request for temperature data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	temperature data (message *0x66*)

0x67 *Monitor Status request* – Request for monitor status bits.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	monitor status data (message *0x67*)

0x68 *Aux. Voltage request* – Request for auxiliary battery voltage data.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	auxiliary battery voltage data (message *0x68*)

0x6F *All parameters request* – Request for all measured and calculated parameters.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	main battery voltage data (message *0x60*) current data (message *0x61*) amphours data (message *0x62*) state-of-charge data (message *0x64*) time remaining data (message *0x65*) temperature data (message *0x66*) monitor status data (message *0x67*) auxiliary battery voltage data (message *0x68*)

0x70 *Parameter Select request* – Request for selected parameter.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	parameter select (message *0x70*)

0x71 *Function Dump request* – Request for function dump.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	function dump (message *0x71*)

0x72 *History Dump request* – Request for history dump.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	history dump (message *0x72*)

0x73 *Status Dump request* – Request for status dump.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	status dump (message *0x73*)

0x74 *External Alarms request* – Request for External Alarms.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	external alarms (message *0x74*)

0x7F *Firmware Version request* – Request for firmware version.

Transmission repetition rate :	-
Direction :	input
Data type :	command
Response :	firmware version (message *0x7F*)

2.2.3 Data

0x60 *Main Battery Voltage* – Main battery voltage.

Transmission repetition rate :	1s / on request
Direction :	output
Data Length :	3 bytes
Resolution :	0.01V / bit gain, 0V offset
Signed :	no
Data range :	0.00V → 655.35V
Data type :	measured

Databyte1<1..0> :	*Main Battery Voltage<15..14>*
Databyte2<6..0> :	*Main Battery Voltage<13..7>*
Databyte3<6..0> :	*Main Battery Voltage<6..0>*

0x61 *Current* – Battery current.

Transmission repetition rate :	1s / on request
Direction :	output
Data Length :	3 bytes
Resolution :	0.01A / bit gain, 0A offset
Signed :	yes
Data range :	-10485.75A → 10485.75A
Data type :	measured

Databyte1<6> :	*Sign (0 = positive current, 1 = negative current)*
Databyte1<5..0> :	*Current<19..14>*
Databyte2<6..0> :	*Current<13..7>*
Databyte3<6..0> :	*Current<6..0>*

0x62 *Amphours* – Amount of amphours removed from the battery.

Transmission repetition rate :	1s
Direction :	output
Data Length :	3 bytes
Resolution :	0.1Ah / bit gain, 0Ah offset
Signed :	yes
Data range :	-9999.9Ah → 0.0Ah
Data type :	calculated

Databyte1<6> :	*Sign (0 = positive amphours, 1 = negative amphours)*
Databyte1<5..0> :	*Amphours<19..14>*
Databyte2<6..0> :	*Amphours<13..7>*
Databyte3<6..0> :	*Amphours<6..0>*

0x64 *State-of-Charge* – State-of-charge of the battery in percent where 0% represents a fully discharged, and 100% a fully charged battery.

Transmission repetition rate :	1s
Direction :	output
Data Length :	3 bytes
Resolution :	0.1% / bit gain, 0% offset
Signed :	no
Data range :	0.0% → 100.0%
Data type :	calculated

Databyte1<1..0> :	*State-of-Charge <15..14>*
Databyte2<6..0> :	*State-of-Charge <13..7>*
Databyte3<6..0> :	*State-of-Charge <6..0>*

0x65 *Time Remaining* – Time remaining until the battery needs to be charged.

Transmission repetition rate :	1s
Direction :	output
Data Length :	3 bytes
Resolution :	1 minute / bit gain, 0 minutes offset
Signed :	yes
Data range :	0 → 14400 minutes (= 240 hours)
Data type :	calculated

Databyte1<6> :	*Sign (1 = negative time remaining)*
Databyte1<5..0> :	*Time Remaining <19..14>*
Databyte2<6..0> :	*Time Remaining <13..7>*
Databyte3<6..0> :	*Time Remaining <6..0>*

Note : A negative time remaining means the time remaining until the battery needs to be charged is infinite because the average current is positive (battery is being charged). On the monitor this is displayed as four dashes : ---- h.

0x66 *Temperature* – Battery temperature.

Transmission repetition rate :	1s
Direction :	output
Data Length :	3 bytes
Resolution :	0.1°C / bit gain, 0°C offset
Signed :	yes
Data range :	-20.0°C → 50.0°C
Data type :	measured

Databyte1<6> :	*Sign (0 = positive temperature, 1 = negative temperature)*

Databyte1<1..0> : *Temperature <15..14>*
Databyte2<6..0> : *Temperature <13..7>*
Databyte3<6..0> : *Temperature <6..0>*

Note : The step size of temperature is 0.5°C, so the outputted value changes with increments of 5.

0x67 *MonitorStatus* – Status of the battery monitor.

Transmission repetition rate :	1s
Direction :	output
Data Length :	3 bytes
Resolution :	-
Signed :	-
Data range :	-
Data type :	status

Databyte1<6> : *reserved*
Databyte1<5> : *reserved*
Databyte1<4> : *Auto-Sync Voltage* – Voltage > Auto-Sync Voltage level
Databyte1<3> : *Auto-Sync Current* – Current < Auto-Sync Current level
Databyte1<2> : *Auto-Sync Charge* – Battery has been discharge far enough to let it Auto-Sync again
Databyte1<1> : *E501 Compatibility Mode* – Battery monitor is outputting data in e-xpert 501 compatibility mode
Databyte1<0> : *Alarm Test* – Alarm switch triggered due to command 'Alarm switch on'

Databyte2<6> : *Backlight Test* – Backlight switched on due to command 'Backlight on'
Databyte2<5> : *Display Test* – Display test switched on due to command 'Display test on'
Databyte2<4> : *No Temperature Sensor* – No temperature sensor detected by battery monitor
Databyte2<3> : *Aux. High Voltage Alarm* – The auxiliary battery's high voltage alarm is triggered
Databyte2<2> : *Aux. Low Voltage Alarm* – The auxiliary battery's low voltage alarm is triggered
Databyte2<1> : *Installer Lock* – Installer-lock is enabled
Databyte2<0> : *Main High Voltage Alarm* – The main battery's high voltage alarm is triggered

Databyte3<6> : *Main Low Voltage Alarm* – The main battery's low voltage alarm is triggered
Databyte3<5> : *Low Battery Alarm* – The discharge floor is reached, main battery needs to be charged
Databyte3<4> : *Battery Flat* – Main battery is fully discharged (0.0%)
Databyte3<3> : *Battery Full* – Main battery is fully charged (100.0%)
Databyte3<2> : *Charge Battery* – Main battery needs to be charged
Databyte3<1> : *Monitor Out-of-Sync* – Monitor is not in sync with battery, charge battery
Databyte3<0> : *Monitor Reset* – Monitor has been reset due to a power-loss

0x68 *Aux. Battery Voltage* – Auxiliary battery voltage.

Transmission repetition rate :	1s / on request
Direction :	output
Data Length :	3 bytes
Resolution :	0.01V / bit gain, 0V offset
Signed :	no

Data range :	0.00V → 655.35V
Data type :	measured

Databyte1<1..0> : *Aux. Battery Voltage<15..14>*
Databyte2<6..0> : *Aux. Battery Voltage<13..7>*
Databyte3<6..0> : *Aux. Battery Voltage<6..0>*

0x70 *Parameter Select* – The parameter displayed on the battery monitor.

Transmission repetition rate :	on request
Direction :	output / input
Data Length :	2 bytes
Resolution :	-
Signed :	no
Data range :	0 - 6
Data type :	status

Databyte1<0> : *Parameter Select<7>*
Databyte2<6..0> : *Parameter Select<6..0>*

0x71 *Function Dump* – Dump of all the settings of the battery monitor.

Transmission repetition rate :	on request / on change
Direction :	output / input
Data Length :	see format specification in section 2.2.4
Resolution :	see format specification in section 2.2.4
Signed :	see format specification in section 2.2.4
Data range :	see format specification in section 2.2.4
Data type :	status

0x72 *History Dump* – Dump of all the history events.

Transmission repetition rate :	on request / on change
Direction :	output
Data Length :	see format specification in section 2.2.5
Resolution :	see format specification in section 2.2.5
Signed :	see format specification in section 2.2.5
Data range :	see format specification in section 2.2.5
Data type :	status

0x73 *Status Dump* – Dump of all the status items.

Transmission repetition rate :	on request / on change
Direction :	output
Data Length :	see format specification in section 2.2.6
Resolution :	see format specification in section 2.2.6
Signed :	see format specification in section 2.2.6
Data range :	see format specification in section 2.2.6
Data type :	status

0x74 *External Alarms* – External alarms to be triggered by the e-xpert pro.

Transmission repetition rate :	on request / on change
Direction :	output
Data Length :	2 bytes
Resolution :	-
Signed :	-
Data range :	-
Data type :	status

Databyte1<0> : *External Alarm 8*

Databyte2<6> : *External Alarm 7*
Databyte2<5> : *External Alarm 6*
Databyte2<4> : *External Alarm 5*
Databyte2<3> : *External Alarm 4*
Databyte2<2> : *External Alarm 3*
Databyte2<1> : *External Alarm 2*
Databyte2<0> : *External Alarm 1*

0x7F *FirmwareVersion* – Firmware version of the batterymonitor.

Transmission repetition rate :	on request
Direction :	output / input
Data Length :	2 bytes
Resolution :	0.01 / bit gain, 0 offset
Signed :	no
Data range :	1.00 → 163.84
Data type :	status

Databyte1<6..0> : *FirmwareVersion<13..7>*
Databyte2<6..0> : *FirmwareVersion<6..0>*

2.2.4 Function Dump format specification

A function dump consists of 6 or 7 (depending on firmware version) separate messages each with message type 0x71. Each message contains a different function group indicated by the first data byte of the message. The function groups are:

1 : System properties
2 : Low battery alarm settings
3 : Low voltage alarm settings
4 : High voltage alarm settings
5 : Main battery properties
6 : Battery monitor properties
7 : Additional system properties (only available on firmware version 1.08 and up)

The data bytes following the function group indicator contain the functions (e-xpert pro settings) of that group. This data needs some additional processing to actually represent the e-xpert pro settings. Some functions need an offset while others must be multiplied by a constant or variable factor.

2.2.4.1 System properties

Message 1 where *Databyte1<6..0>* equals 1.

F1.0 *Auto-Sync Voltage* – Auto-Sync Voltage (V).

Direction :	output / input
Data Length :	1 byte
Resolution :	0.1V / bit gain, 8.0V offset
Signed :	no
Data range :	8.0 → 33.0V
Data type :	status

Databyte2<6..0> : *Auto-Sync Voltage <13..7>*
Databyte3<6..0> : *Auto-Sync Voltage <6..0>*

*Auto-Sync Voltage = ((((Databyte2 * 0x80) + Databyte3) * 0.1) + 8.0) * F6.5*

F1.1 *Auto-Sync Current* – Auto-Sync Current (% of battery capacity).

Direction :	output / input
Data Length :	1 byte
Resolution :	0.1% / bit gain, 0.5% offset
Signed :	no
Data range :	0.5 → 10.0%
Data type :	status

Databyte4<6..0> : *Auto-Sync Current <6..0>*

*Auto-Sync Current = (Databyte4 * 0.1) + 0.5*

F1.2 *Auto-Sync Time* – Auto-Sync time (seconds).

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 1, 1 item offset
Signed :	no
Data range :	1 → 12
Data type :	status

Databyte5<6..0> : *Auto-Sync Time <6..0>*

Auto-Sync Time = table_read(Databyte5 + 1)

F1.3 *Discharge Floor* – Discharge floor (%).

Direction :	output / input
Data Length :	1 byte
Resolution :	1% / bit gain, 0% offset
Signed :	no
Data range :	0 → 99%
Data type :	status

Databyte6<6..0> : *Discharge Floor <6..0>*

Discharge Floor = Databyte6

F1.4 *Battery Temperature* – Battery temperature (°C).

Direction :	output / input
Data Length :	1 byte
Resolution :	1°C / bit gain, -20°C offset
Signed :	no
Data range :	-20 → 50°C / AU
Data type :	status

Databyte7<6..0> : *Battery Temperature <6..0>*

if Databyte7 = 51
then Battery Temperature = 'AU'
else Battery Temperature = Databyte7 - 20

F1.5 *Time Remaining Averaging Period* – Time remaining averaging period.

Direction :	output / input
Data Length :	1 byte
Resolution :	-

Signed : no
Data range : 0 → 2
Data type : status

Databyte8<6..0> : *Time Remaining averaging period <6..0>*

Time Remaining averaging period = Databyte8

2.2.4.2 Low battery alarm settings

Message 2 where *Databyte1<6..0>* equals 2.

F2.0 *Low battery alarm on SOC* – Low battery alarm on (%).

Direction : output / input
Data Length : 1 byte
Resolution : 1% / bit gain, 0% offset
Signed : no
Data range : 0 → 99%
Data type : status

Databyte2<6..0> : *Low battery alarm on SOC <6..0>*

Low battery alarm on SOC = Databyte2

F2.1 *Low battery alarm on Volt* – Low battery alarm on (V).

Direction : output / input
Data Length : 1 byte
Resolution : 0.1V / bit gain, 8.0V offset
Signed : no
Data range : 8.0 → 33.0V
Data type : status

Databyte3<6..0> : *Low battery alarm on Volt <13..7>*
Databyte4<6..0> : *Low battery alarm on Volt <6..0>*

*Low battery alarm on Volt = ((((Databyte3 * 0x80) + Databyte4) * 0.1) + 8.0) * F6.5*

F2.2 *Low battery alarm off SOC* – Low battery alarm off (%).

Direction : output / input
Data Length : 1 byte
Resolution : 1% / bit gain, 1% offset
Signed : no
Data range : 1 → 100% / FULL
Data type : status

Databyte5<6..0> : *Low battery alarm off SOC <6..0>*

if Databyte5 = 100
then Low battery alarm off SOC = 'FULL'
else Low battery alarm off SOC = Databyte5 + 1

F2.3 *Low battery alarm on delay* – Low battery alarm on delay (seconds).

Direction : output / input
Data Length : 1 byte
Resolution : see table 1
Signed : no

Data range : 0 → 11
Data type : status

Databyte6<6..0> : *Low battery alarm on delay <6..0>*

Low battery alarm on delay = table_read(Databyte6)

F2.4 *Minimum alarm on time* – Minimum 'alarm on' time (hh:mm).

Direction : output / input
Data Length : 1 byte
Resolution : see table 2
Signed : no
Data range : 0 → 19
Data type : status

Databyte7<6..0> : *Minimum alarm on time <6..0>*

Minimum alarm on time = table_read(Databyte7)

F2.5 *Maximum alarm on time* – Maximum 'alarm on' time (hh:mm).

Direction : output / input
Data Length : 1 byte
Resolution : see table 2, 1 item offset
Signed : no
Data range : 1 → 20
Data type : status

Databyte8<6..0> : *Maximum alarm on time <6..0>*

Maximum alarm on time = table_read(Databyte8 + 1)

F2.6 *Enable low battery alarm* – Enable low battery alarm / use contact.

Direction : output / input
Data Length : 1 byte
Resolution : see table 3
Signed : no
Data range : 0 → 9
Data type : status

Databyte9<6..0> : *Enable low battery alarm <6..0>*

Enable low battery alarm = table_read(Databyte9)

2.2.4.3 Low voltage alarm settings

Message 3 where *Databyte1<6..0>* equals 3.

F3.0 *Main low voltage alarm on* – Main battery low voltage alarm on (V).

Direction : output / input
Data Length : 1 byte
Resolution : 0.1V / bit gain, 8.0V offset
Signed : no
Data range : 8.0 → 33.0V
Data type : status

Databyte2<6..0> : *Main low voltage alarm on <13..7>*
Databyte3<6..0> : *Main low voltage alarm on <6..0>*

*Main low voltage alarm on = ((((Databyte2 * 0x80) + Databyte3) * 0.1) + 8.0) * F6.5*

F3.1 *Main low voltage alarm on delay* – Main battery low voltage alarm on delay (seconds).

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 1
Signed :	no
Data range :	0 → 11
Data type :	status

Databyte4<6..0> : *Main low voltage alarm on delay <6..0>*

Main low voltage alarm on delay = table_read(Databyte4)

F3.2 *Enable main low voltage alarm* – Enable main battery low voltage alarm / use contact.

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 3
Signed :	no
Data range :	0 → 9
Data type :	status

Databyte5<6..0> : *Enable main low voltage alarm <6..0>*

Enable main low voltage alarm = table_read(Databyte5)

F3.3 *Aux. low voltage alarm on* – Auxiliary battery low voltage alarm on (V).

Direction :	output / input
Data Length :	1 byte
Resolution :	0.1V / bit gain, 8.0V offset
Signed :	no
Data range :	8.0 → 33.0V
Data type :	status

Databyte6<6..0> : *Aux. low voltage alarm on <13..7>*
Databyte7<6..0> : *Aux. low voltage alarm on <6..0>*

*Aux. low voltage alarm on = ((((Databyte2 * 0x80) + Databyte3) * 0.1) + 8.0) * F6.5*

F3.4 *Aux. low voltage alarm on delay* – Auxiliary battery low voltage alarm on delay (seconds).

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 1
Signed :	no
Data range :	0 → 11
Data type :	status

Databyte8<6..0> : *Aux. low voltage alarm on delay <6..0>*

Aux. low voltage alarm on delay = table_read(Databyte8)

F3.5 *Enable aux. low voltage alarm* – Enable auxiliary battery low voltage alarm / use contact.

Direction : output / input
Data Length : 1 byte
Resolution : see table 3
Signed : no
Data range : 0 → 9
Data type : status

Databyte9<6..0> : Enable aux. low voltage alarm <6..0>

Enable aux. low voltage alarm = table_read(Databyte9)

2.2.4.4 High voltage alarm settings

Message 4 where *Databyte1<6..0>* equals 4.

F4.0 Main high voltage alarm on – Main battery high voltage alarm on (V).

Direction : output / input
Data Length : 1 byte
Resolution : 0.1V / bit gain, 10.0V offset
Signed : no
Data range : 10.0 → 35.0V
Data type : status

Databyte2<6..0> : Main high voltage alarm on <13..7>
Databyte3<6..0> : Main high voltage alarm on <6..0>

*Main high voltage alarm on = ((((Databyte2 * 0x80) + Databyte3) * 0.1) + 10.0) * F6.5*

F4.1 Main high voltage alarm on delay – Main battery high voltage alarm on delay (seconds).

Direction : output / input
Data Length : 1 byte
Resolution : see table 1
Signed : no
Data range : 0 → 11
Data type : status

Databyte4<6..0> : Main high voltage alarm on delay <6..0>

Main high voltage alarm on delay = table_read(Databyte4)

F4.2 Enable main high voltage alarm – Enable main battery high voltage alarm / use contact.

Direction : output / input
Data Length : 1 byte
Resolution : see table 3
Signed : no
Data range : 0 → 9
Data type : status

Databyte5<6..0> : Enable main high voltage alarm <6..0>

Enable main high voltage alarm = table_read(Databyte5)

F4.3 Aux. high voltage alarm on – Auxiliary battery high voltage alarm on (V).

Direction : output / input
Data Length : 1 byte

Resolution :	0.1V / bit gain, 8.0V offset
Signed :	no
Data range :	10.0 → 35.0V
Data type :	status

Databyte6<6..0> : *Aux. high voltage alarm on <13..7>*
Databyte7<6..0> : *Aux. high voltage alarm on <6..0>*

*Aux. high voltage alarm on = ((((Databyte2 * 0x80) + Databyte3) * 0.1) + 10.0) * F6.5*

F4.4 *Aux. high voltage alarm on delay* – Auxiliary battery high voltage alarm on delay (seconds).

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 1
Signed :	no
Data range :	0 → 11
Data type :	status

Databyte8<6..0> : *Aux. high voltage alarm on delay <6..0>*

Aux. high voltage alarm on delay = table_read(Databyte8)

F4.5 *Enable aux. high voltage alarm* – Enable auxiliary battery high voltage alarm / use contact.

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 3
Signed :	no
Data range :	0 → 9
Data type :	status

Databyte9<6..0> : *Enable aux. high voltage alarm <6..0>*

Enable aux. high voltage alarm = table_read(Databyte9)

2.2.4.5 Main battery properties

Message 5 where *Databyte1<6..0>* equals 5.

Fx.x *Reserved – Don't use*

Databyte2<6..0> : *Reserved*

F5.0 *Battery capacity* – Battery capacity (Ah).

Direction :	output / input
Data Length :	2 bytes
Resolution :	variable, 20Ah offset
Signed :	no
Data range :	20 → 9990Ah
Data type :	status

Databyte3<6..0> : *Battery capacity <13..7>*
Databyte4<6..0> : *Battery capacity <6..0>*

*Temporary Value = ((Databyte3 * 0x80) + Databyte4)*
if Temporary Value < 980
then Battery capacity = Temporary Value + 20

else if Temporary Value < 1780
*then Battery capacity = ((Temporary Value – 980) * 5) + 1000*
*else Battery capacity = ((Temporary Value – 1780) * 10) + 5000*

F5.1 *Nominal discharge rate* – Nominal discharge rate (hours).

Direction :	output / input
Data Length :	1 byte
Resolution :	1h / bit gain, 1h offset
Signed :	no
Data range :	1 → 20h
Data type :	status

Databyte5<6..0> : *Nominal discharge rate <6..0>*

Nominal discharge rate = Databyte5 + 1

F5.2 *Nominal temperature* – Nominal temperature (°C).

Direction :	output / input
Data Length :	1 byte
Resolution :	1°C / bit gain, 0°C offset
Signed :	no
Data range :	0 → 40h
Data type :	status

Databyte6<6..0> : *Nominal temperature <6..0>*

Nominal temperature = Databyte6

F5.3 *Temperature Coefficient*– Battery temperature coefficient (%cap/°C).

Direction :	output / input
Data Length :	1 byte
Resolution :	0.01%cap/°C / bit gain, 0.00%cap/°C offset
Signed :	no
Data range :	OFF / 0.01 → 1.00%cap/°C
Data type :	status

Databyte7<6..0> : *Temperature Coefficient <6..0>*

if Databyte7 = 0
then Temperature Coefficient = 'OFF'
*else Temperature Coefficient = Databyte7 * 0.01*

F5.4 *Peukert Exponent* – Peukert exponent.

Direction :	output / input
Data Length :	1 byte
Resolution :	0.01 / bit gain, 1.00 offset
Signed :	no
Data range :	1.00 → 1.50
Data type :	status

Databyte8<6..0> : *Peukert Exponent <6..0>*

*Peukert Exponent = (Databyte8 * 0.01) + 1.00*

F5.5 *Self discharge rate* – Self discharge rate (%/month).

Direction :	output / input
Data Length :	1 byte
Resolution :	0.1%/month / bit gain, 0.0%/month offset
Signed :	no
Data range :	OFF / 0.1%/month → 25.0%/month
Data type :	status

Databyte9<6..0> : *Self discharge rate <6..0>*

if Databyte9 = 0
then Self discharge rate = 'OFF'
*else Self discharge rate = Databyte9 * 0.1*

F5.6 *Charge Efficiency* – Charge efficiency factor / CEF (%).

Direction :	output / input
Data Length :	1 byte
Resolution :	1% / bit gain, 50% offset
Signed :	no
Data range :	50 → 100% / AU
Data type :	status

Databyte10<6..0> : *Charge Efficiency <6..0>*

If Databyte10 = 51
then Charge Efficiency = 'AU'
else Charge Efficiency = Databyte10 + 50

2.2.4.6 Battery monitor properties

Message 6 where *Databyte1<6..0>* equals 6.

F6.0 *Display Parameter* – Display parameter.

This is a special (sort of hidden) function. On the e-xpert pro itself, reading out F6.0 will give you the battery monitor's firmware version. Since the firmware version can be retrieved thru its own message via TBS-Link, the necessity of retrieving it via the function dump becomes obsolete. Therefore F6.0 is used to enable / disable the readout of each individual parameter in normal operation of the e-xpert pro. When a parameter readout is enabled, its corresponding bit in *Databyte2* is set otherwise it is cleared. Note that this function only affects the readout on the e-xpert pro itself, a disabled parameter can always be retrieved via TBS-Link.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	-
Data type :	status

Databyte2<0> : *Enable / disable main battery Voltage readout*
Databyte2<1> : *Enable / disable auxiliary battery Voltage readout*
Databyte2<2> : *Enable / disable Current readout*
Databyte2<3> : *Enable / disable Amphours readout*
Databyte2<4> : *Enable / disable State-of-Charge readout*
Databyte2<5> : *Enable / disable Time Remaining readout*
Databyte2<6> : *Enable / disable Temperature readout*

Display Parameter = Databyte2

F6.1 *Shunt amp. rating* – Shunt ampere rating (A).

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 4
Signed :	no
Data range :	10 → 9000A
Data type :	status

Databyte3<6..0> : *Shunt amp. rating <6..0>*

Shunt amp. Rating = table_read(Databyte3)

F6.2 *Shunt mV rating* – Shunt mV rating (mV).

Direction :	output / input
Data Length :	1 byte
Resolution :	10mV / bit gain, 50mV offset
Signed :	no
Data range :	50 / 60mV
Data type :	status

Databyte4<6..0> : *Shunt mV rating <6..0>*

*Shunt mV Rating = (Databyte4 * 10) + 50*

F6.3 *Backlight Mode* – Display backlight mode.

Direction :	output / input
Data Length :	1 byte
Resolution :	see table 1
Signed :	no
Data range :	OFF / 5 → 300 / ON / AU
Data type :	status

Databyte5<6..0> : *Backlight mode <6..0>*

```
if Databyte5 = 0
  then Backlight mode = 'OFF'
  else if Databyte5 = 13
    then Backlight mode = 'ON'
    else if Databyte5 = 14
      then Backlight mode = 'AU'
      else Backlight mode = table_read(Databyte5)
```

F6.4 *Alarm Contact Polarity* – Alarm contact polarity.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	NO / NC
Data type :	status

Databyte6<6..0> : *Alarm Contact Polarity <6..0>*

```
if Databyte6 = 0
  then Alarm Contact Polarity = 'NO'
  else Alarm Contact Polarity = 'NC'
```


F6.5 *Voltage Prescaler* – Voltage prescaler.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	1 / 5 / 10
Data type :	status

Databyte7<6..0> : *Voltage Prescaler <6..0>*

if DataByte7 = 0
then Voltage Prescaler = 1
else if DataByte7 = 1
then Voltage Prescaler = 5
else Voltage Prescaler = 10

F6.6 *Temperature Unit Selection* – Temperature unit selection.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	°C / °F
Data type :	status

Databyte8<6..0> : *Temperature Unit Selection <6..0>*

if Databyte8 = 0
then Temperature Unit Selection = '°C'
else Temperature Unit Selection = '°F'

F6.7 *Auxiliary input mode* – Auxiliary input mode.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	0 → 1
Data type :	status

Databyte9<6..0> : *Auxiliary input mode <6..0>*

Auxiliary input mode = Databyte9

F6.8 *Communication mode* – Communication mode.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	0 → 3
Data type :	status

Databyte10<6..0> : *Communication mode <6..0>*

Communication mode = Databyte10

F6.9 *Setup Lock* – Setup lock.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	OFF / ON
Data type :	status

Databyte11<6..0> : *Setup Lock <6..0>*

if Databyte11 = 0
then Setup Lock = 'OFF'
else Setup Lock = 'ON'

2.2.4.7 Additional system properties

Message 7 where *Databyte1<6..0>* equals 7.

F1.6 *Auto-sync Sensitivity*

This function is added to firmware version 1.08 to adjust the auto-sync algorithm when it fails to auto-sync with the default setting. Only change this setting when F1.0, F1.1 and F1.2 are set correctly and automatic synchronization still fails. If automatic synchronization takes too long or does never occur, lower this value. When the battery monitor synchronizes too early, increase this value.

Direction :	output / input
Data Length :	1 byte
Resolution :	-
Signed :	no
Data range :	0 → 10
Data type :	status

Databyte2<6..0> : *Auto-sync sensitivity*

Auto-sync sensitivity = Databyte2

Fx.x *Reserved – Don't use*

Databyte3<6..0> : *Reserved*
Databyte4<6..0> : *Reserved*
Databyte5<6..0> : *Reserved*

2.2.5 History Dump format specification

A history dump consists of 2 separate messages each with message type 0x72. Each message contains a different history group indicated by the first data byte of the message. The history groups are:

1 : Battery history
2 : Alarm history

The data bytes following the history group indicator contain the history items of that group. This data may need some additional processing to actually represent the e-xpert pro history value.

2.2.5.1 Battery history

Message 1 out of 2 where *Databyte1<6..0>* equals 1.

H1.0 *Average Discharge (Ah)*– Average discharge in Amphours (Ah).

Direction :	output
Data Length :	3 bytes
Resolution :	0.1Ah / bit gain, 0.0Ah offset
Signed :	no (always negative)
Data range :	-9999.9Ah → 0Ah
Data type :	calculated

Databyte2<1..0> : *Average Discharge (Ah) <15..14>*
Databyte3<6..0> : *Average Discharge (Ah) <13..7>*
Databyte4<6..0> : *Average Discharge (Ah) <6..0>*

H1.1 *Average Discharge (%)* – Average discharge in percent state-of-charge (%).

Direction :	output
Data Length :	2 bytes
Resolution :	0.1% / bit gain, 0.0% offset
Signed :	no (always negative)
Data range :	-100.0% → 0.0%
Data type :	calculated

Databyte5<6..0> : *Average Discharge (%) <13..7>*
Databyte6<6..0> : *Average Discharge (%) <6..0>*

H1.2 *Deepest Discharge (Ah)*– Deepest discharge in Amphours (Ah).

Direction :	output
Data Length :	3 bytes
Resolution :	0.1Ah / bit gain, 0.0Ah offset
Signed :	no (always negative)
Data range :	-9999.9Ah → 0Ah
Data type :	calculated

Databyte7<1..0> : *Deepest Discharge (Ah) <15..14>*
Databyte8<6..0> : *Deepest Discharge (Ah) <13..7>*
Databyte9<6..0> : *Deepest Discharge (Ah) <6..0>*

H1.3 *Deepest Discharge (%)* – Deepest discharge in percent state-of-charge (%).

Direction :	output
Data Length :	2 bytes
Resolution :	0.1% / bit gain, 0.0% offset
Signed :	no (always negative)
Data range :	-100.0% → 0.0%
Data type :	calculated

Databyte10<6..0> : *Deepest Discharge (%) <13..7>*
Databyte11<6..0> : *Deepest Discharge (%) <6..0>*

H1.4 *Total Amphours removed* – Total amount of Amphours removed from the battery.

Direction :	output
Data Length :	4 bytes
Resolution :	0.1Ah / bit gain, 0.0Ah offset
Signed :	no
Data range :	0Ah → 9999999.9Ah
Data type :	calculated

Databyte12<6..0> : *Total Amphours removed <27..21>*
Databyte13<6..0> : *Total Amphours removed <20..14>*

Databyte14<6..0> : *Total Amphours removed <13..7>*
Databyte15<6..0> : *Total Amphours removed <6..0>*

H1.5 *Total Amphours charged* – Total amount of Amphours charged.

Direction :	output
Data Length :	4 bytes
Resolution :	0.1Ah / bit gain, 0.0Ah offset
Signed :	no
Data range :	0Ah → 9999999.9Ah
Data type :	calculated

Databyte16<6..0> : *Total Amphours removed <27..21>*
Databyte17<6..0> : *Total Amphours removed <20..14>*
Databyte18<6..0> : *Total Amphours removed <13..7>*
Databyte19<6..0> : *Total Amphours removed <6..0>*

H1.6 *Cycles* – Number of cycles (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte20<6..0> : *Cycles <13..7>*
Databyte21<6..0> : *Cycles <6..0>*

H1.7 *Synchronizations* – Number of synchronizations (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte22<6..0> : *Synchronizations <13..7>*
Databyte23<6..0> : *Synchronizations <6..0>*

H1.8 *Full Discharges* – Number of full discharges (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte24<6..0> : *Full Discharges <13..7>*
Databyte25<6..0> : *Full Discharges <6..0>*

2.2.5.1 Alarm history

Message 2 out of 2 where *Databyte1<6..0>* equals 2.

H2.0 *Low battery alarms* – Number of low battery alarm triggers (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte2<6..0> : *Low battery alarms <13..7>*
Databyte3<6..0> : *Low battery alarms <6..0>*

H2.1 *Main low voltage alarms* – Number of main battery low voltage alarm triggers (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte4<6..0> : *Main low voltage alarms <13..7>*
Databyte5<6..0> : *Main low voltage alarms <6..0>*

H2.2 *Aux. low voltage alarms* – Number of auxiliary battery low voltage alarm triggers (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte6<6..0> : *Aux. low voltage alarms <13..7>*
Databyte7<6..0> : *Aux. low voltage alarms <6..0>*

H2.4 *Main high voltage alarms* – Number of main battery high voltage alarm triggers (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte8<6..0> : *Main high voltage alarms <13..7>*
Databyte9<6..0> : *Main high voltage alarms <6..0>*

H2.5 *Aux. high voltage alarms* – Number of auxiliary battery high voltage alarm triggers (#).

Direction :	output
Data Length :	2 bytes
Resolution :	1 / bit gain, 0 offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte10<6..0> : *Aux. high voltage alarms <13..7>*
Databyte11<6..0> : *Aux. high voltage alarms <6..0>*

2.2.6 Status Dump format specification

A status dump consists of 1 message with message type 0x73. This message has a group indicator in the first data byte of the message. The value of this group indicator is 1.

The data bytes following the status group indicator contain the status items of that group. This data may need some additional processing to actually represent the e-xpert pro status value.

St.1 *Days running* – Days running.

Direction :	output
Data Length :	3 bytes
Resolution :	0.25days / bit gain, 0.0% offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte2<1..0> : *Charge Efficiency <15..14>*
Databyte3<6..0> : *Charge Efficiency <13..7>*
Databyte4<6..0> : *Charge Efficiency <6..0>*

*Days running = ((Databyte2 * 0x4000) + (Databyte3 * 0x80) + Databyte4) / 4)*

St.2 *Days since synchronized* – Days since synchronized.

Direction :	output
Data Length :	3 bytes
Resolution :	0.25days / bit gain, 0.0% offset
Signed :	no
Data range :	0 → 9999
Data type :	calculated

Databyte5<1..0> : *Charge Efficiency <15..14>*
Databyte6<6..0> : *Charge Efficiency <13..7>*
Databyte7<6..0> : *Charge Efficiency <6..0>*

*Days since synchronized = ((Databyte5 * 0x4000) + (Databyte6 * 0x80) + Databyte7) / 4)*

St.3 *Charge Efficiency* – Automatically calculated Charge Efficiency Factor (%).

Direction :	output
Data Length :	3 bytes
Resolution :	1 / 32768 % / bit gain, 0.0% offset
Signed :	no
Data range :	0.0 → 100.0%
Data type :	calculated

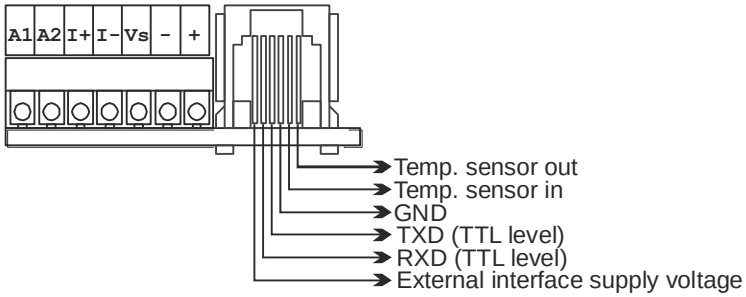
Databyte8<1..0> : *Charge Efficiency <15..14>*
Databyte9<6..0> : *Charge Efficiency <13..7>*
Databyte10<6..0> : *Charge Efficiency <6..0>*

*Charge Eff. = (((Databyte8 * 0x4000) + (Databyte9 * 0x80) + Databyte10) * 100.0) / 32768*

3.0 PHYSICAL INTERFACE

Pin 2 and 3 of the expansion port are TTL-level receive and transmit ports of the battery monitor. Use the optionally available isolated RS-232 interface to transform these TTL-levels to RS-232 levels. The input to output isolation barrier of this interface is >1000V.

The pin out of the rear side RJ12 expansion port is :



4.0 PRACTICAL EXAMPLES

The e-xpert pro can operate in one of two communication modes.

Automatic mode : the battery monitor outputs all measured and calculated parameters automatically once second and transmits data when pressing a key and when leaving setup-mode. This is the standard mode for every e-xpert pro leaving the factory.

Request only mode : the battery monitor only sends data when receiving a request for it (through a sys-ex data request, see chapter 2.2.4). Transmitting data when pressing a key and when leaving setup-mode is also disabled this mode.

Regardless of the selected communication mode, the monitor will send the firmware version on power up. This is necessary for compatibility with TBS Electronics' own Dashboard software.

Note : The request only mode is only available on firmware versions 1.01 and up. Therefore only chapter 4.1 is of interest for users communicating with an e-xpert pro containing firmware version 1.00.

Note : It is possible that, when in request only mode and the supply voltage of the monitor (and the communication interface) is decreasing slowly to a level outside the RS-232 margins, the monitor sends a NACK+Repeat Request due to a communication error.

4.1 Automatic mode

In this chapter we'll discuss the communication sequence of an e-xpert pro in broadcast mode (default).

After powering up the battery monitor it immediately starts sending (broadcasting). You don't need to send any command to enable the transmission of data. It will first send the *firmware version* once and then starts sending the *voltage*, *current*, *amphours*, *state-of-charge*, *time-to-go*, *temperature* and *monitor status* once a second. So after power-up you will get the data as follows :

// power up

// few hundred milliseconds delay

`0x80 0x00 0x22 0x7F 0xf1 0xf2 0xFF` (*fx* = firmware version)

// one second delay

```
0x80 0x00 0x22 0x60 0xu1 0xu2 0xu3 0xFF   (ux = voltage)
0x80 0x00 0x22 0x61 0xi1 0xi2 0xi3 0xFF   (ix = current)
0x80 0x00 0x22 0x62 0xa1 0xa2 0xa3 0xFF   (ax = amphours)
0x80 0x00 0x22 0x64 0x%1 0x%2 0x%3 0xFF   (%x = state-of-charge)
0x80 0x00 0x22 0x65 0xh1 0xh2 0xh3 0xFF   (hx = time-to-go)
0x80 0x00 0x22 0x66 0xt1 0xt2 0xt3 0xFF   (tx = temperature)
0x80 0x00 0x22 0x67 0xm1 0xm2 0xm3 0xFF   (mx = monitor status)
```

// one second delay

```
0x80 0x00 0x22 0x60 0xu1 0xu2 0xu3 0xFF   (ux = voltage)
0x80 0x00 0x22 0x61 0xi1 0xi2 0xi3 0xFF   (ix = current)
0x80 0x00 0x22 0x62 0xa1 0xa2 0xa3 0xFF   (ax = amphours)
0x80 0x00 0x22 0x64 etc.....
```

Now let's look at the voltage output a bit closer :

The battery monitor doesn't output the data in ASCII values, it's a bit more complex. The outputted string looks like this :

`0x80 0x00 0x22 0x60 0x`*u1* `0x`*u2* `0x`*u3* `0xFF` (*ux* = voltage)

The bytes *u1*, *u2* and *u3* represent the voltage data as follows : because the MSB of all the bytes between the header (0x80) and the e.o.t. trailer (0xFF) always represent a logical 0, we have 7 bits per byte left to represent the data. So with the three data-bytes *u1*, *u2* and *u3* we can transmit a 21-bit number. These three bytes hold the voltage data as follows :

u1<6..0> = voltage<20..14>
u2<6..0> = voltage<13..7>
u3<6..0> = voltage<6..0>

As you can see bit 6 of *u1* (the 1st data byte in the string) holds the MSB of the 21-bit number and bit 0 of *u3* (the 3rd and last data byte in the string) holds the LSB of the 21-bit number. Let's assume the battery monitor outputs :

```
0x80 0x00 0x22 0x60 0x00 0x09 0x11 0xFF
```

This would represent a voltage of :

```
(0x00 << 14) + (0x09 << 7) + 0x11

=

0x000000 + 0x000480 + 0x000011

=

0x000491 = 1169d
```

11.69Volts.

Note : the << operator is a C / C++ 'bitwise shift left' operator. The operation :

```
X << Y
```

shifts the value of *X* to the left by *Y* bits. An example :

```
0x0009       = 0000 0000 0000 1001b

0x0009 << 7 = 0000 0100 1000 0000b = 0x0480
```

The Turbo Pascal / Delphi equivalent of the << operator is the `shl` operator. The same result can be achieved by multiplying :

```
X << 7  = X * 0x80

X << 14 = X * 0x4000

X << 21 = X * 0x200000
```

The same rule applies for every outputted parameter. With current and amphours we have to deal with a sign. the format of the current (see also chapter 2.2.5) data looks like this :

i1<6> = sign (0 = positive current, 1 = negative current)
i1<5..0> = current<19..14>
i2<6..0> = current<13..7>
i3<6..0> = current<6..0>

Current<15..0> is not in 2's complement it's just a positive number ranging from 0..1048575 representing a current of 0.00Amps to 10485.75Amps. So when the battery monitor outputs :

```
0x80 0x00 0x22 0x61 0x40 0x47 0x1E 0xFF
```

it represents a current of :

```
(0x40 << 14) + (0x47 << 7) + 0x1E = 0x10239E
```

where bits<19..0> of the result hold 0x239E = 9118 which represents a current of 91.18Amps, bit<20> of the result = 1 making the current a negative current (flowing out of the battery). So :

```
0x80 0x00 0x22 0x61 0x40 0x47 0x1E 0xFF = -91.18Amps
```

The same trick works for the amphours output only this parameter has a 1 decimal resolution. A decimal Value of -793 represents -79.3Amphours.

The format of the state-of-charge output is basically the same as that of the voltage output only that the state-of-charge output is hardware limited to 0x3E8 = 1000d which represents 100.0%.

Time remaining is presented in minutes. It is signed where the sign bit represents a negative time remaining. A negative time remaining means the time remaining until the battery needs to be charged is infinite because the average current is positive (battery is being charged). On the monitor this is displayed as four dashes : ---- h.

If for example the battery monitor outputs :

```
0x80 0x00 0x22 0x65 0x00 0x05 0x2C 0xFF
```

then shifting `0x05` left 7 positions and adding `0x2C` would make `0x2AC` which decimally represents 684 minutes or 11 hours and 24 minutes to go. The range is 0..14400 minutes which equals 0..240 hours.

The temperature output is always in °C regardless of the temperature unit selection in function F6.6 and has a 0.1°C resolution. However, the step size of temperature is 0.5°C, so the outputted value changes with increments of 5. An example temperature output :

```
0x80 0x00 0x22 0x66 0x00 0x02 0x09 0xFF
```

Now shifting `0x02` left 7 bits and adding `0x09` to it would make `0x109` which represents 265 or 26.5°C.

The temperature is also signed so the output:

```
0x80 0x00 0x22 0x66 0x40 0x00 0x28 0xFF
```

would make -4.0°C.

4.2 Request mode

When the monitor is put in "Request mode" you can retrieve the data with the "All parameters request" command (message type 0x6F). It is strongly advised NOT to retrieve the data by sending a request for each individual parameter sequentially. The outputted data in request only mode has the same format as in automatic mode.

APPENDIX

Table 1: Short timer in seconds

Index	Time (seconds)
0	0
1	5
2	10
3	15
4	30
5	45
6	60
7	90
8	120
9	150
10	180
11	240
12	300

Table 2: Long timer in hh:mm

Index	Time (hh:mm)
0	0:00
1	0:05
2	0:10
3	0:15
4	0:30
5	0:45
6	1:00
7	1:30
8	2:00
9	2:30
10	3:00
11	4:00
12	5:00
13	6:00
14	7:00
15	8:00
16	9:00
17	10:00
18	11:00
19	12:00
20	--:-- *[1]

*[1] *Infinite.*

Table 3: Enable alarm / use contact

Index	Value
0	OFF *[1]
1	Internal Contact
2	External Contact 1 *[2]
3	External Contact 2 *[2]
4	External Contact 3 *[2]
5	External Contact 4 *[2]
6	External Contact 5 *[2]
7	External Contact 6 *[2]
8	External Contact 7 *[2]
9	External Contact 8 *[2]

*[1] *Alarm disabled.*

*[2] *Use only in combination with the optional alarm output expander.*

Table 4: Shunt Amp. ratings

Index	Amp. rating
0	10
1	11
2	12
3	13
4	14
5	15
6	16
7	17
8	18
9	19
10	20
11	21
12	22
13	23
14	24
15	25
16	30
17	35
18	40
19	45
20	50
21	55
22	60
23	65
24	70
25	75
26	80
27	85
28	90
29	95
30	100
31	110
32	120
33	130
34	140
35	150
36	160
37	170
38	180
39	190
40	200
41	210
42	220
43	230
44	240
45	250
46	300
47	350
48	400
49	450
50	500
51	550
52	600
53	650
54	700
55	750

56	800
57	850
58	900
59	950
60	1000
61	1100
62	1200
63	1300
64	1400
65	1500
66	1600
67	1700
68	1800
69	1900
70	2000
71	2100
72	2200
73	2300
74	2400
75	2500
76	3000
77	3500
78	4000
79	4500
80	5000
81	5500
82	6000
83	6500
84	7000
85	7500
86	8000
87	8500
88	9000

