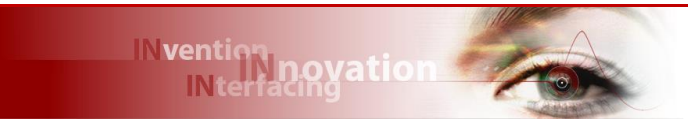
Programmer's Manual

Triple-IN
Experts in Laser Distance Measurements



PSxxx-90+
PACxxx-90-y-zz+
PS Lightweight

Laser Scanner Family
Firmware Version 3.06

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Content

1 Introduction

1.1 About this document

This document applies to all Triple-IN's PS+ and PAC+ Laser Scanners. It provides technical information on the sensor configuration and the communication between a control computer and the sensor firmware. This document is related to the models:

- PSxxx-90+
- PACxxx-90-y-zz+
- PS Lightweight and PS Lightweight Green

It is valid for the following firmware versions:

- PS Firmware Version 3.06.xx
- APU Firmware Version 4.01.xx

If you or your colleagues have any comments on this manual, we would be grateful to hear from you. Please write to:

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1.2 Typographical conventions

The following typographical conventions are used in this document:

“text”	Denotes text that is human readable and can be entered at the keyboard, such as commands, file and program names.
byte[1024]	Denotes an array of values of the defined type.
0x04	Denotes binary values as hexadecimal representation.
italic	Denotes arguments to commands and functions where the argument is to be replaced by a specific value.

1.3 Webserver with Documents and Firmware Updates

The latest version of this document, the “PS Laser Scanner User Manual”, and the latest firmware updates can be obtained from Triple-IN’s homepage `www.triple-in.de`.

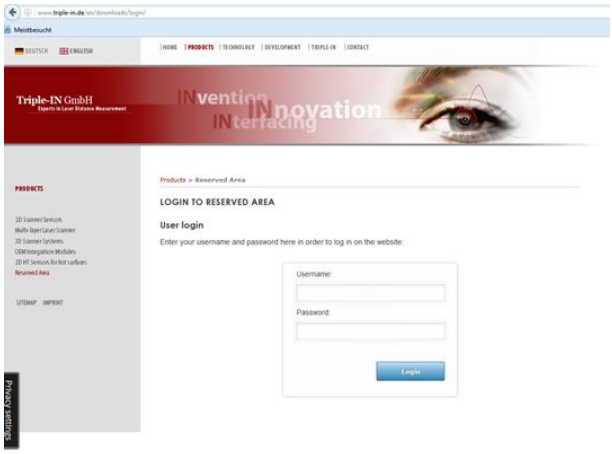

Figure 1 Triple-IN webserver login

Please contact **info@triple-in.de** to get access to the reserved area of the webserver.

1.4 References to the PS Laser Scanners User Manual

This document is a general description about the PS Laser Scanner programming interface. All Triple-IN's Laser Scanners use the same command/response structure.
However, some information is related to individual PS Laser Sensor models. The firmware may use different parameter identifiers, depending on the individual features. The complete list of parameters including a detailed description can be found in chapter *"4 User Parameters"*.

1.5 PSDemoProgram source code project

Triple-IN's web server offers a C/C++ source code project for free download.
PSDemoProgram is a very basic software to communicate and control Triple-IN Laser Sensors over the Ethernet.
PSDemoProgram comes as simple command line application. However, it incorporates the most important PS Laser Scanner commands and an example to design the scan procedure. The program is placed into the public domain and may be used for any purpose.
Note that no warranty or Support is provided by Triple-IN or its distributors on the PSDemoProgram package.

2 Communication interfaces

2.1 Serial RS232 Interfaces

2.1.1 MPU RS232 Settings

PS Sensors provide one serial RS232 interfaces to the Measurement Processing Unit MPU. The standard configuration parameters are:

Parameter	Value
Baud rate	115200 bauds
Data bits	8
Parity	None
Stop bits	1
Handshake	No hardware or software handshake

Figure 2 RS232 settings

2.1.2 RS232 connected with the Measurement Processing Unit MPU

The MPU RS232 interface can be used

- to send **binary commands** to the Measurement Processing Unit MPU and to receive responses
- for the **Terminal mode** as a simple configuration interface. This is an ASCII oriented, human readable menu structure and user interface. The Terminal mode is entered after the user must type 4 times a carriage return characters from a RS232 terminal console to the RS232 of the Measurement Processing Unit. The Terminal mode allows to check and set the user parameters and get a scan line.

```
Triple-IN PS Laser Scanner
[PSFirmWare; 03.06.00.00; (c) Triple-IN GmbH 2019]

SN:         1234
Local IP:   10.0.12.34:1024
Gateway IP: 10.0.10.0:1025

- Running self-test…
- Self-test done.

Type 4 x ENTER to switch to Terminal Mode
```

Figure 3 MPU Terminal Mode

Detailed information how to use the Terminal Mode can be found in the *"PS+ Laser Scanner User's Manual"*.

Caution!

When the Terminal Mode is active, the Ethernet communication channels will not be available anymore.

2.1.3 RS232 to connect a GNSS Receiver

The second serial interface is connected to the APU and is used to connect a GNSS receiver that provide NMEA 0183 Standard sentences with the time in UTC.
The standard communication settings for the second RS232 are:

Parameter	Value
Baud rate	9600 baud
Data bits	8
Parity	None
Stop bits	1
Handshake	No hardware or software handshake

Caution!

The serial GNSS NMEA interface is not supported by all PS+ laser scanner types.

Details of how to connect and configure a GNSS receiver can be found in the *"PS Laser Scanner User's Manual"*.

2.2 Ethernet connection

2.2.1 About Network settings

PS+/PAC+ use the Internet Socket Interface for communications over Ethernet. The sensor socket address is a combination of the IP address (the location of the sensor) and a port (which is mapped to the application program process) into a single identity.
The sensor IP address and the Gateway IP address can be set

- in the RS232 Terminal Mode with the user parameters "Sensor IPv4 address", "Default client IPv4 address", "Gateway IPv4 address", and "IP Subnet Mask".
- by use of the Terminal Mode "3 - Network configuration ..."
- by use of the binary command "SRPM – Set parameter"

Caution!

The sensor needs to be restarted after the network configuration has been changed.
The Ethernet interface is disabled while the Terminal Mode is active.

2.2.1.1 UDP/IP transport protocol

The UDP transport protocol can be used to send commands to the sensor, receive responses and receive the online scan stream.

2.2.1.2 TCP/IP transport protocol

The TCP transport protocol can be used to send commands to the sensor and receive responses. It is possible but not recommended to use TCP/IP to receive online scan stream.

2.2.1.3 Why choose UDP for scan data stream

TCP was designed to be reliable in data transmission. This means that, if a packet of data is not correctly (without errors) received by the destination, the sender will try to transmit it again until it is received correctly.
In a real-time system though it is more important to have always the most recent data available even if it means to have some previous data lost.
The UDP transport protocol has a lot of advantages for this purpose:

- It is stateless, suitable for very large numbers of clients. It is used for example in streaming media applications such as IPTV
- The lack of retransmission delays makes it suitable for real-time applications such as Voice over IP, online games, and many protocols built on top of the Real Time Streaming Protocol
- It works well in unidirectional communication and is suitable for broadcast information such as in many kinds of service discovery and shared information such as broadcast time or Routing Information Protocol

All these attributes (and more) made the UDP protocol the best choice to send the scan data stream to the requesting consumers.

2.2.2 Sensor IPv4 addresses

The sensor has two different IP addresses configured and exposed to the outside:

- Predefined. Is automatically calculated from the serial number and cannot be changed. The network mask is `255.255.0.0` and it is calculated this way:

```
IP = 10.255.(serial_number / 100).(serial_number MOD 100)
```

- Custom. This address can be modified by the user. It is initially set with a default value calculated similarly to the Predefined:

```
IP = 10.0.(serial_number / 100).( serial_number MOD 100)
```

Example:

- The predefine IP address of sensor with serial number “1234” is `10.255.12.34`.
- The default IP address of the same sensor is `10.0.12.34`.

Caution!

The IP address set by the user cannot be the same as the Predefined.
The Port set by the user cannot be one of: 22, 80, 3007, 6969 and 6996.

2.2.3 Default client IPv4 address

The sensor has the possibility to start sending a scan data stream automatically on power on. This function is called "`AutoStart`". With AutoStart enabled, the sensor sends data to a predefined Client immediately. That predefined client is called the "`default client`". The user can define the IP address and port of the default client.

2.2.4 Gateway IPv4 Address

The Gateway in an Ethernet network serves the forwarding hosts to other networks when no other route specification matches the destination IP address of a packet. Often is
the Gateway the router used to connect the local network with the World Wide Web.

2.2.5 Ports and Services

The sensor socket addresses are a combination of an IP address and a port (which is mapped to the application program process). Every available combination identifies a "Service". In the described communication pattern, the sensor provides some functionalities accessible through the Ethernet. The following are the services available by default on a sensor. The IP address of the sensor is built by the serial number as described above.

Service IP/Port	Protocol	Service	Description
`10.255.xx.xx:6969`	TCP/IP	Scan and commands	Command communication line for configuration and online data stream
	UDP/IP	Scan and commands	Command communication line for configuration and online data stream
`10.0.xx.xx:1024`	TCP/IP	Scan and commands	Command communication line for configuration and online data stream
	UDP/IP	Scan and commands	Command communication line for configuration and online data stream
`10.0.xx.xx:6996`	UDP/IP	Announcement	A defined command sent to this channel will respond with the announcement message
`10.0.xx.xx:3007`	TCP/IP	Update	Used to send firmware updates to the sensor
`10.0.xx.xx:22`	TCP/IP	SSH	SSH access to Linux on the APU

`10.0.xx.xx:80`	TCP/IP	Web interface	Access to the sensor web interface

2.2.6 Concurrent connections

Update and Commands TCP/IP listening Services are limited to one connection at a time. This means that if a TCP/IP Service is connected to a client, no other Client can use that service.

2.2.7 Discovering more PS Laser Scanners in a Network

2.2.7.1 PS+/PAC+ sensor feature announcement

PS+ and PAC+ laser scanners have a service able to respond with information about the sensor itself. To receive this information the Client must send a string of **4** specific characters to the sensor using the UDP port **6996**.
All PS+ and PAC+ Laser Scanners with an IP address in this network will reply to us on this request. These characters are:

```
SVCS
```

If we have more sensors connected and they belong to the same network, we can use a broadcast message to reach all of them, without the need to know the exact IP address of each of them.
In case our sensors are under the **`10.0.x.x`** network, we can send a magic Word SVCS to:

```
10.0.255.255:6996
```

2.2.7.2 Sensor Information packet

The structure of the packet sent is defined below in C language by the **`struct PSBroadcastMessage`**.

```
//  Standard services ping port
//
#define PSS_STANDARD_PORT  6996

//  Message types
//
#define PSM_ANNOUNCEMENT  1  // Service announcement for the network

//  Record version
//
#define PSV_VERSION_1  0x00010000

//  Current version used
//
#define PSV_VERSION_CURRENT  PSV_VERSION_1

//  Service types
//
#define PSS_NONE         0   // Invalid value
#define PSS_UPDATE       1   // Update service
#define PSS_PS_PROTOCOL  2   // Triple In sensor protocol (this can be OR-ed with PSS_RT_PROTOCOL)
#define PSS_RT_PROTOCOL  4   // Triple In rotary table protocol (this can be OR-ed with PSS_PS_PROTOCOL)
#define PSS_HTTP         80  // HTTP web pages for administration
#define PSS_SERVICE_PING 9998// The available service ping
#define PSS_SSH          9999// Administration port, normally used for service and debugging

//  Service options mask
//
#define PSSO_UDPIP      0x00000001      // The service is provided through a UDP/IP channel
#define PSSO_TCPIP      0x00000002      // The service is provided through a TCP/IP channel
#define PSSO_TEMPORARY  0x40000000      // The service is temporary, do not rely on it for long term operations


//  Device parameters
//
#define PSDP_SERIAL     0    // Serial number
#define PSDP_STATUS     1    // Sensor status
#define PSDP_MODEL      2    // Sensor model (if any)
#define PSDP_USER_CODE  3    // Specific user code
// Special parameters
#define PSDP_BROADCAST_ENABLED          0x80000001
       // This parameters enables (!= 0) or disables (== 0) the services broadcast

//  Address types
//
#define PSAT_UNKNOWN  0      // Unknown/invalid value
#define PSAT_IPV4     1      // IPv4 address format
#define PSAT_ALL      0x80000000        // Used in services definition only to state that the service is listening on
all available addresses. It must be OD-ed with one of the valid types


struct PSSensorAddress {
  UInt32_t  mType;
  union {
    struct {
      UInt32_t mAddress;     // Packed IPv4 address. The first byte in the address is the higher byte in the packet
      UInt32_t mNetMask;     // Packed IPv4 network mask. The first byte in the network mask is the higher byte in the
packet
    } mIPv4;
  };
};

struct PSSensorService {
  UInt32_t         mService; // The service provided by the entry (see PSS_*)
  PSSensorAddress  mAddress; // The specific address for the service
  UInt32_t         mPort;    // The port used for the service
  UInt32_t         mOptions; // Some options, defined by the PSSO_* mask
};

#define MAX_ADDRESSES        10
#define MAX_SERVICES         30
struct PSBroadcastMessage {
  UInt32_t  mCommand;        // Equal to SVCS
  UInt32_t  mSize; // Size of the total structure
  UInt32_t  mMessage;        // Message type. One of PSM_*. For now only 1 is managed (service announcement)
  UInt32_t  mVersion;        // Version of the structure
  UInt32_t  mDeviceSerial;   // Serial number of the sensor
  UInt32_t  mDeviceStatus;   // Status of the sensor, as defined by per sensor
  UInt32_t  mDeviceModel;    // Sensor model number
  UInt32_t  mDeviceUserCode; // Sensor user code
  UInt32_t  mCountAddresses; // The number of addresses set up on this device
  PSSensorAddress mAddresses[MAX_ADDRESSES];
       // The list of addresses set up on this device
  UInt32_t  mCountServices;  // The number of services provided in the following array
  PSSensorService mServices[MAX_SERVICES];
       // The list of services available on this device
};
```

2.3 Timeouts

The command interface of the firmware has following time outs:

- for measurement requests: 5 seconds
- for measured scans: 30 seconds
- for changing parameters: 60 seconds

The sensor sends an error (ERR\0) response if a timeout has occurred.

3 Data Types and Data Format

3.1 Network Byte Order

The interface uses the Network Byte Order format in Big Endian.

Bit 31			Bit 0
Word at address A			
Half-Word at address A		Half-Word at address A + 1	
Byte at address A	Byte at address A + 1	Byte at address A + 2	Byte at address A + 3

3.2 Basic data types

The basic data types are shown in the next table.

Type definition	Size in bytes (bits)	Remark
Byte	1 (8)	A byte, unsigned, 0..255
Char	1 (8)	A byte, signed, -128..127
Word	4 (32)	Four-byte Word, network byte order (big endian)
Bitfield	4 (32)	Four-byte Word, network byte order (big endian)
String	Variable	A sequence of chars, zero terminated

3.3 Text Strings

In some cases, strings are used by the sensor to send information to the control computer. If not otherwise stated, the strings are always a stream of Chars, zero terminated and `4` bytes aligned, padded with zeroes at the end if needed.

3.4 Sensor specific data formats

3.4.1 Distances

Distance values are generally stored in a `Word` in units of `1/10` mm.
Two special values indicate invalid measurements:

- minimum negative integer indicates that the echo signal was too low.
- maximum integer indicates that the echo signal was noisy or a result of multiple echoes.

Values	Description
`-2147483648 (0x80000000)`	Echo signal was too low
`2147483647 (0x7FFFFFFF)`	Echo signal was noisy

3.4.2 Echo Pulse Width

The pulse width is the time between the rising edge and the falling edge of an echo pulse, measured at the laser receiver. It indicates the strength of the Echo signal.
Pulse widths are handled as 4-byte Word values in picoseconds.
The echo signal and pulse width aren't necessarily proportional to each other, but the latter brings a meaningful information about the strength of the echoed pulse.
The pulse width in conjunction with the distance information provides the echo condition as summarized in the table below:

Pulse width	Distance value	Condition
=0	-2147483648 (0x80000000)	No echo
>0	-2147483648 (0x80000000)	Low Echo
>0	-2147483648 < distance < 2147483647 0x80000000 < distance < 0x7FFFFFFF	Valid distance
>0	2147483647 (0x7FFFFFFF)	Noisy signal

3.4.3 Signal Intensity

The Signal Intensity of an echo signal depends on various parameter, such as the color and the structure of the target surface and some atmospheric conditions.
The signal intensity is provided as one-byte value from 0 to 255. It gives in conjunction with the distance value the measurement conditions described in the table below.

Signal Intensity	Distance value	Condition
=0	-2147483648 (0x80000000)	No echo
>0	-2147483648 (0x80000000)	Low Echo
>0	-2147483648 < distance < 2147483647 0x80000000 < distance < 0x7FFFFFFF	Valid distance
>0	2147483647 (0x7FFFFFFF)	Noisy signal

3.4.4 Angular units

The angle unit depends on a circle with **360000** counts (milli-degree). The scan start angle, the scan angle and the number of a measurement must be used to calculate the scan direction of a single laser pulse:

```
dir = start_angle + (number-1) * scan_angle / number_of_pulses
```

Where

- `dir`: scan direction of a single laser pulse in degree
- `start_angle`: direction of the first laser pulse in the scan in degree
- `number`: number of the single laser pulse in the scan, starting from `1`
- `scan_angle`: scan angle of the scan (field of view) in degree
- `number_of_pulses`: number of laser pulses that formed the scan.

3.4.5 Temperature readings

The sensor handles the temperature readings in `0.1` Celsius. They are normally stored in a Word. Example: a binary reading of "`352`" means "`35.2°` Celsius".

3.5 System Status Bit-field

The scanner performs a self-test and stores the result in a bit-field. The parameter bit field is transmitted with each scan.
During the system start and self-test the firmware sets the "System not ready"-bit (bit `0`). It indicates that all other bits are in an undefined status.
Each self-test result corresponds to a single bit. A set bit signals a system fault or a warning to be taken care of. The system is fail-free if all bits are set to `0`.
One can download the system status bit list from the PS Laser sensor by use of the Terminal mode. The System Status is a `32` bits Word representing a bit mask. The following table describes the meaning of each bit when it is set to `1`.

Bit	Type	Text	Description
0	Warning	System not ready	The system is performing a self-test. During this period are all other bits in this system status undefined
1	Info	Scan buffer is empty.	There are no scans in the buffer and a GSCN command will return no scan data
2	Info	Sensor operating in terminal mode.	Sensor operates in Terminal Mode and will not respond to commands
3	Error	Digital output failure!	A digital output detected a hardware failure
4	Error	Digital input failure!	A digital input detected a hardware failure
5	Error	Check external incremental encoder!	The external incremental encoder interface detected a hardware failure
6	Error	Check mirror motor!	The mirror motor is not running
7	Error	Check angle encoder!	Hardware problem. Please contact service
8	Error	Check field of view!	Clean the front window

Bit	Type	Text	Description
9	Error	Temperature out of operating range!	The temperature is outside of the operating range of the sensor
10	Warning	Check Ethernet	There is no Ethernet connection
11		Reserved	Reserved for future use.
12	Warning	Factory settings not complete!	Hardware configuration problem. Please contact service
13		Reserved	Reserved for future use.
14		Reserved	Reserved for future use.
15		Reserved	Reserved for future use.
16		Reserved	Reserved for future use.
17	Warning	Laser power control is switched off!	The laser power is controlled manually. The user takes responsibility for the eye safety of the sensor.
18	Warning	Check KEM-IC delay unit	Hardware configuration problem. Please contact service
19	Error	Measurement clock error!	Hardware failure. Please contact service
20		Reserved	Reserved for future use.
21		Reserved	Reserved for future use.
22		Reserved	Reserved for future use.
23		Reserved	Reserved for future use.
24	Warning	EDM Mode	Sensor operates in EDM mode.
25	Info	Measurement laser is switched off.	The measurement laser has been switched-off by the user
26		Reserved	Reserved for future use.
27	Error	Measurement laser failure	The measurement laser reported a hardware failure. Please contact service.
28	Warning	Firmware update needs factory reset	Restart the sensor
29	Error	Check APU board version!	Update the APU board firmware to the latest version
30	Warning	System needs to restart	Restart the sensor
31		Reserved for future use	

Figure 4 System Status bits

3.6 Echo number and Master Echo

At measuring through rain, through protection windows, or in dusty surroundings several objects may reflect the laser beam.
PS+ and PAC+ Laser scanners can measure up to **4** echoes. Different data formats are provided to return the data measured.

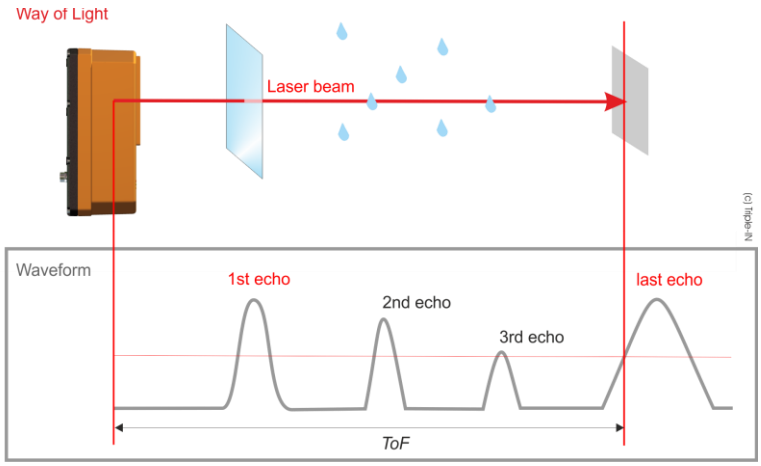

Figure 5 Multi-Echo and Master Echo

In a multi-echo measurement is the **Master Echo** the major distance result. Typical master distances are built by the first echo signal or the last echo signal.
For the formats that provides only one echo, the user parameter "29 Master Echo" must be set. The Master Echo can be one echo 1 to 4. Setting the user parameter "29 Master Echo" to 0 means that the last echo measured becomes the Master Echo.
Some data formats provide the number of echoes measured. Normally the echo number occupies **1** byte only and the value identifies the echoes in order of receiving (echo **1** is the first echo).
More technical information about Multi-Echo measurements and the Master Echo can be found in the *"PS Laser Scanner User's Manual"*.

3.7 Time formats

3.7.1 Sensor Time stamp

The time resolution of the internal real time clock is milliseconds. Time stamps are stored in unsigned **4**-byte integer values. A clock counter overrun occurs after about **1193** hours, which are more than **49** days.
Some PS Laser Sensors support a "Pulse per second" PPS signal. Each rising edge of the PPS signal increases the full seconds of the real time clock while resetting the milliseconds to **0**.

3.7.2 GNSS time

Some PS Laser Sensor types support a RS232 interface to a GNSS receiver. The NMEA 0183 sentences of the GNSS provide an accurate time epoch.
Since the atomic clocks on the satellites are set to their own time system (e.g. GPS time GPST; see the page of United States Naval Observatory) and GNSS time does not contain leap seconds or other corrections that are periodically added to UTC.

To create timestamps of scan data in milliseconds, the sensor processes GNSS time information from the NMEA protocol in two parts:

- The GNSS time is used in Unix time format. This is the number of full seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970.
- The system time is given in milliseconds since midnight.

The GNSS time is 0 until

- one digital input is configured as GNSS input,
- the user parameter "95; GNSS NMEA sentence" is set to "1=prev. PPS" or "2=next PPS",
- a ZDA or a RMC NMEA sentence
- and at least one PPS signal has been received from the GNSS receiver.

The millisecond part is synchronized by the Pulse per second signal of the GNSS receiver. The GNSS time stamp of a scan must be calculated by

```
scan_timestamp = gnss_time [s] + scan_timestamp [ms]
```

With:

- scan_timestamp: the time stamp of a scan in GNSS time
- gnss_time: the date in Unix time format as set by the GNSS.
- scan_timestamp: the time stamp from the internal clock of the PS Laser Scanner, measured in milliseconds.

3.8 Error Codes

Error codes from `-1` to `-1999` correspond to the error codes defined in the "Standard C Library". Error codes below `-2000` are Triple-IN proprietary extensions to this.

Code	Description
-2000	Physical device I/O error
-2001	I/O read error
-2002	I/O write error
-2003	Timeout expired
-2004	User break
-2005	CRC checksum error
-2006	Unknown command
-2007	Parameter is out of range
-2008	Access denied / Permission denied
-2009	Unsupported function
-2010	Invalid handle / Bad address
-2011	Division by zero
-2012	Array index is out of bounds

Code	Description
-2013	Internal buffer overflow
-2014	Fatal system error
-2015	System configuration error
-2016	Error in serialization
-2017	KEM Unit error / Measurement clock failure
-2018	Angle encoder failure / Motor failure
-2019	Temperature out of operating range
-2020	Front screen not clear
-2021	System not ready
-2022	Empty buffer

3.9 CRC32 Checksum

The Cyclical Redundancy Checking (CRC) field is four bytes, containing a 32–bit binary value. The CRC value is calculated by the transmitting control computer, which appends the CRC to the message. The CRC covers the entire message excluding the CRC itself. The laser sensor firmware recalculates a CRC during receipt of the message and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, an error result is reported.
The CRC is started by first preloading a 32–bit register "initial remainder" to all 1's. Then a process begins of applying successive 8–bit bytes of the message to the current contents of the register. Only the eight bits of data in each character are used for generating the CRC. Start and stop bits and the parity bit, do not apply to the CRC32.
The calculation of the CRC32 conforms to the CRC-32-IEEE 802.3 Standard with the following parameters:

```
int32_t CRC32_POLYNOMIAL = 0x04c11db7;
int32_t CRC32_INITIAL_REMAINDER = 0xFFFFFFFF;
int32_t CRC32_FINAL_XOR_VALUE = 0xFFFFFFFF;
int32_t CRC32_TOPBIT = 0x80000000;
```

Note that CRC Checksums sent by the PS Laser Sensors have a big-endian byte order.
Example for tests: „1234567890"gives CRC32=0x261DAEE5

4 User Parameters

4.1 About User Parameters

The configuration of PS Laser Scanners are stored in a table of so-called User Parameters. Every user parameter has

- a unique user parameter number
- a value of type 4-byte Word,
- a default value
- and a valid range.

Using the parameter number can the user edit the parameter value, either by use of the terminal mode or with the binary command SPRM.
PS Laser Sensor different models may use different parameter identifiers, depending on the individual features. The complete list of parameters including a detailed description can be found in the following chapters.
There are different types of parameter:

- Constant parameters cannot be changed by the user. Parameters which does not change their value during normal sensor operation are typically defined to by constant. One example of constant parameter is the "50 Sensor serial number". The attempt to change a constant parameter returns an error.
- Read only parameters cannot be changed by the user. Read only parameters value may change during normal operation. One example of constant parameter is the "46 Temperature reading". The attempt to change a constant parameter returns an error.
- Temporary parameters depend on the current system status and will be overwritten if the status has been changed. Temporary parameters will not be stored in the non-volatile memory. Temporary parameters are updated by a self-test during the startup phase. It is recommended to set temporary parameters only after the self-test has been finished.

4.2 List of User parameters

ID	Type	Text
1		User settings
2		User parameter passWord, 0=disabled
3		Scan mode: 1=normal, 2=fast, 3=fine, 4=reserved
4		Auto-start without SCAN/GSCN command, 0=disabled
5		Start mode: 0=Standard, 1=Terminal Mode
6		Startup message on serial interface: 1=enabled
7		Red Laser Marker at startup: 0=off, 1=on, 2=auto
8	Temp.	Red Laser Marker status: 0=off, 1=on
9		Angle units on a full circle
10		Scan angle size [0.001 deg]

ID	Type	Text
11		Scan start direction [0.001 deg]
12	Const.	Scan angle step [0.001 deg]
13	Const.	Scan angle shift [0.001 deg]
14		Sensor IPv4 Address part AA.xx.xx.xx
15		Sensor IPv4 Address part xx.BB.xx.xx
16		Sensor IPv4 Address part xx.xx.CC.xx
17		Sensor IPv4 Address part xx.xx.xx.DD
18		Sensor socket port
19		Default client computer IPv4 part AA.xx.xx.xx
20		Default client computer IPv4 part xx.BB.xx.xx
21		Default client computer IPv4 part xx.xx.CC.xx
22		Default client computer IPv4 part xx.xx.xx.DD
23		Gateway socket port
24		IP Sub-net mask AAA.xxx.xxx.xxx
25		IP Sub-net mask xxx.BBB.xxx.xxx
26		IP Sub-net mask xxx.xxx.CCC.xxx
27		IP Sub-net mask xxx.xxx.xxx.DDD
28	Const.	Number of echoes in GSCN
29		Master echo: 1=first echo, 0=last echo
30	r/o	Number of scans in Scan&Store
31		GSCN format: 4=D, 6=D+E+S, 8=D+PW, 12=1st/last D+E+S, 16=4D
32	Const.	Scan&Store buffer size
33		Reserved for future use
34		Reserved for future use
35		Air condition: heater ON temperature [0.1 Celsius]
36		Air condition: heater OFF temperature [0.1 celsius]
37	Const.	Air condition: heater status, 0=off, 1=on
38		Mirror motor at startup: 0=off, 1=on
39	Temp.	Mirror motor status: 0=off, 1=running
40		External incremental encoder: 0=disabled, 1=enabled
41		External incremental encoder: offset
42	r/o	External incremental encoder: counter
43	Const.	System status bits
45		Front side LEDs, 0=disabled, 1=enabled
46	Const.	Temperature reading [0.1 celsius]
47	Const.	Pulse width at 100% reflectivity [ps]
48	Const.	Pulse width at 3% reflectivity [ps]
49	Const.	Sensor model number
50	Const.	Sensor serial number
51	Const.	Near field suppression range [0.1 mm]
52		Near field suppression zone: 0=min
53		1st Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
54	Temp.	1st Digital output status: 0=open 1=closed
55	Temp.	1st Digital output: pulser setup

ID	Type	Text
56		1st Digital output hold time [ms]
57		1st Digital output delay [ms]
58		1st Digital output logic level: 0=active-high, 1=active-low
59		2nd Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
60	Temp.	2nd Digital output status: 0=open 1=closed
61	Temp.	2nd Digital output: pulser setup
62		2nd Digital output hold time [ms]
63		2nd Digital output delay [ms]
64		2nd Digital output logic level: 0=active-high, 1=active-low
65	Const.	Low echo filter: 0=disabled, 1=enabled
66	Const.	High echo filter: 0=disabled, 1=enabled
67		3rd Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
68	Temp.	3rd Digital output status: 0=open 1=closed
69	Temp.	3rd Digital output: pulser setup
70		3rd Digital output hold time [ms]
71		3rd Digital output delay [ms]
72		3rd Digital output logic level: 0=active-high, 1=active-low
73		4th Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
74	Temp.	4th Digital output status: 0=open 1=closed
75	Temp.	4th Digital output: pulser setup
76		4th Digital output hold time [ms]
77		4th Digital output delay [ms]
78		4th Digital output logic level: 0=active-high, 1=active-low
79		1st Digital input function: 1=enabled, 2=PPS, 3=RTC reset
80	r/o	1st Digital input status
81		2nd Digital input function: 1=enabled, 2=PPS,
82	r/o	2nd Digital input status
83		GSCN command: number of header parameter
84	Const.	Number of digital outputs SW
85	Const.	Number of digital inputs
86		PPS signal period [ms]
87		PPS signal timeout [ms], 0=infinitive
88		Measurement laser at startup: 0=off, 1=on
89	Temp.	Measurement laser status: 0=off, 1=on
90		Get IP Address from DHCP server: 1=enabled
91		Standard Gateway IPv4 part AA.xx.xx.xx
92		Standard Gateway IPv4 part xx.BB.xx.xx
93		Standard Gateway IPv4 part xx.xx.CC.xx
94		Standard Gateway IPv4 part xx.xx.xx.DD
95		GNSS NMEA status: 0=off, 1=prev. PPS, 2=next PPS
96		GNSS Receiver RS232 baudrate
97	Const.	Unix time [s]
98		Special function enable [bit map]
99		User parameter ID used for testing

ID	Type	Text
100	Temp.	Flash memory write protection, 1=locked

Table 6 List of user parameters

4.3 User parameters reference

1 Version of User settings

This parameter contains the version of the list of user parameters.
This value can be used to check the compatibility of the client computer program.

2 User parameters passWord

Setting this parameter to a value different than **0** will protect the Terminal mode. The user will be asked to enter this passWord to enable user parameters table modifications in Terminal mode.

Minimum	Maximum	Default value
0	9999	0

3 Scan mode

This parameter defines the scan mode of the 2D laser. Three are the possible choices:

Value	Meaning
1	Normal mode
2	Fast mode
3	Fine mode

Different sensor models can have different implementation of each scan mode, may not provide all the described scan modes or may provide more. Please refer to your *"PSxxx-90+ Laser Scanner User's manual"* for more information.

4 Auto-start without SCAN/GSCN command

On power on this parameter is checked: if it is equal to **1**, the AutoScan function is enabled after the next sensor start, using the default client address and -port.

Value	Meaning
0	Auto-start is disabled.
1	Auto-start is enabled. After start-up sends the Sensor scans to the default client address automatically.

Caution!

If user parameter 4 is changed during operations, nothing will happen until the sensor is powered off and on again.

5 Start mode

Defines the working mode on startup. Setting this parameter to **1**, the sensor will start (on the next power up) in terminal mode and the communication on the Ethernet port will be disabled. If set to **0**, the sensor will startup in normal mode, enabling the Ethernet port.

Value	Meaning
0	Normal start.
1	After start-up enters Sensor enters the sensor the Terminal Mode. The Ethernet is not available while the Terminal Mode is active.

6 Start-up messages on serial interface

If set to **1**, a startup message will be shown on the MPU serial interface. If set to **0**, nothing will be put on the serial port, until requested by a command.

Value	Meaning
0	No start message on serial interface.
1	After start-up sends the Sensor a startup message including the serial number and firmware version. This is the default.

7 Red Laser Marker at startup

If set to **1**, the Red Laser Marker will be kept on after startup. If set to **0** it will be turned off. The parameter is constant 0 if no Red Laser Marker is installed.

Value	Meaning
0	RLM is off after startup.
1	RLM is switched on after startup. This is the default.

8 Red Laser Marker status

This temporary parameter controls the status of the Red Laser Marker during operations. A value of **1** will turn the RLM on.
The parameter is constant 0 if no Red Laser Marker is installed.

Value	Meaning
0	RLM is off.
1	RLM is switched on.

9 Angle units on a full circle

This constant, read-only parameter contains the number of angle units in a full rotation circle.
The default value is 360000 milli-degree.

10 Scan angle size

The angle aperture for a single scan line. This value can be set to reduce the number of laser pulses that forms the scan, in case only part of the scan area is needed.
The value is expressed in Angle units, see chapter "*3.4.4 Angular units*".
Please refer to your PS sensor Operating manual for more information.

11 Scan start direction

Defines the direction of the first laser pulse in a scan. This value can be incremented to instruct the sensor to start the scan line on a different direction.

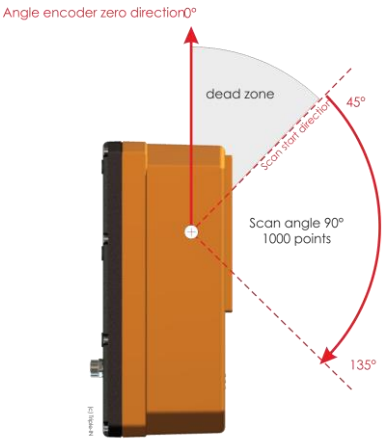

Figure 7 Scan start direction and scan field

As an example, looking at the image on the right, the first available direction is **45°**, which in angle units is **45000**.
Please refer to your *PS sensor Operating manual* for more information.

12 Scan angle step

The user parameter **12 "Scan angle step"** depends on parameter **3 "Scan mode"** and is a constant. It defines the step, in angle units, between the measured points in one scan line.
Please refer to your *PS sensor Operating manual* for more information.

13 Scan angle shift

The constant, read-only user parameter **13 "Scan angle shift"** depends on parameter "**3 Scan mode**" and is set by the firmware. Its value defines the angle step between the starting directions of the scan lines in the four mirrors.
As an example, if the user parameter "**Scan Mode**" is set to "**3=Fine scan mode**" and assuming the user parameter "**11 Scan start direction**" value is set to its default, the following will be the starting directions of the scan lines for every mirror:

Mirror	Starting direction Example
1	45000
2	45045
3	45090
4	45135

Figure 1: Scan angle shift example for the "Fine mode"

14-17 Sensor IPv4 Address

The parameters from **14** to **17** define the Sensor custom IP address.
They are defined by the following table. The default value depends on the serial number. As an example, we'll show the default for the Sensor with SN **1234**.

Parameter	Part	Minimum	Maximum	Default value
14	A (A.x.x.x)	0	255	10
15	B (x.B.x.x)	0	255	0
16	C (x.x.C.x)	0	255	12
17	D (x.x.x.D)	0	255	34

Please refer to chapter "*0 Details of* how to connect and configure a GNSS receiver can be found in the *"PS Laser Scanner User's Manual"*.

Ethernet connection" for more information about the Ethernet addresses.

18 Sensor socket port

This parameter defines the TCP and UDP port used by the sensor to listen and accept connection from the controlling computers.

Minimum	Maximum	Default value
0	65535	1024

19-22 Default client computer IPv4 Address

The parameters from **19** to **22** define the IPv4 address of the default client computer. The client computer IPv4 address and port are used by the AutoStart function in order to automatically start sending a Scan stream on power on.
The IP address is obtained combining the parameters defined by the following table.

Parameter	Part	Minimum	Maximum	Default value
19	A (A.x.x.x)	0	255	10
20	B (x.B.x.x)	0	255	0
21	C (x.x.C.x)	0	255	10
22	D (x.x.x.D)	0	255	0

Please refer to chapter *"0 Details of* how to connect and configure a GNSS receiver can be found in the *"PS Laser Scanner User's Manual"*.

Ethernet connection" for more information about the Ethernet addresses and to chapter "*5.8 SCAN: controlling the data stream"* for information about AutoScan.

23 Client Computer socket port

This user parameter defines the TCP and UDP port used by the sensor in combination with the previous four parameters as the target where to send the UDP Scan stream if AutoStart function is enabled.
Please refer to chapter *"0 Details of* how to connect and configure a GNSS receiver can be found in the *"PS Laser Scanner User's Manual"*.

Ethernet connection" for more information about the Ethernet addresses and to chapter "*5.8 SCAN: controlling the data stream"* for information about AutoScan.

Minimum	Maximum	Default value
0	65535	1025

24-27 IPv4 subnet mask

The user parameters from **24** to **27** define the subnet mask for the network in which the sensor is supposed to work on.
In order the sensor to work correctly, both Sensor and Gateway IP address should be in the same subnet or a specific route must be set in the installation network.
The following table describes the IP definition.

Parameter	Part	Minimum	Maximum	Default value
24	A (A.x.x.x)	0	255	255
25	B (x.B.x.x)	0	255	255
26	C (x.x.C.x)	0	255	0
27	D (x.x.x.D)	0	255	0

28 Number of echoes in GSCN

This constant user parameter depends on the **GSCN** data format. It reflects the number of echoes returned in a **GSCN** datagram. The number of echoes is defined by the chosen Data format, which can be set modifying the user parameter "**31 GSCN data**".

29 Master echo

This user parameter defines the echo used as a preferred distance result:
Some data formats deliver one single distance result while PS Laser scanners can evaluate up to 4 echoes. To decide which one of the 4 echoes is delivered, the user parameter **29 "Master echo"** must be set. The Master Echo can be one echo 1 to 4, or the last echo measured.

Value	Meaning
0	Last echo. The system processes up to four echo and the last valid echo received is returned. "No Echo" is returned in the case that no valid measurement could be taken.
1	First echo If no echo is detected as first, "No Echo" is returned
2	Second echo If no echo is detected as second, "No Echo" is returned
3	Third echo. If no echo is detected as third, "No Echo" is returned
4	Fourth echo. If no echo is detected as fourth, "No Echo" returned

Even if the sensor can evaluate a maximum of **4** echoes, setting the parameter to "**0=Last echo**" is not the same as setting it to "**4=Fourth echo**".
For example, if we have a laser pulse that returns only one echo, it is at the same time the first and the last, but it is not the fourth. In this case, setting the Master echo to **4**, we'll receive a "no echo" value.

30 Number of scans in Scan&Store

This temporary user parameter reflects the number of scans stored in the Scan&Store buffer, requested by the last SCAN command.
This user parameter is deprecated and kept for compatibility with older firmware versions.

31 GSCN data format

This parameter defines the data format returned in GSCN responses. The list of possible values is described in the table below. Please refer to chapter *"0 GSCN: Getting 2D Scans"* for more information about how to choose the correct GSCN data format.

Value	Abbreviation	GSCN Data Content
4	D	Master echo: Distance only
6	D+E+S	Master echo: Distance, Echo number, Signal intensity
8	D+PW	Master echo: Distance, Pulse width
12	1st/last D+E+S	Master echo: Distance, Echo number, Signal intensity Last echo: Distance, Echo number, Signal intensity
16	4D	Four Distances

32 Scan&Store buffer size

This constant user parameter reflects the maximum size which can be requested on a SCAN command for the Scan&Store buffer.

35 Air condition: Heater ON temperature

This user parameter contains the value, in temperature units of 0.1° Celsius, on which the heater will be switched on. If the temperature goes below this value, the heater will be switched on.
This user parameter has no meaning if no heater is installed.

Minimum	Maximum	Default value
-100	700	150

36 Air condition: Heater OFF temperature

This parameter contains the value, in temperature units of 0.1° Celsius, on which the heater will be switched off. If the temperature goes above this value, the heater will be turned off.
This user parameter has no meaning if no heater is installed.

Minimum	Maximum	Default value
-100	700	200

37 Air condition: Heater status

This constant, read-only parameter reflects the status of the heater. If it contains **1**, the heater is on, if contains **0**, the heater is off.
This user parameter is constant **0** if no heater is installed.

Value	Meaning
0	Heater is off or not installed.
1	Heater is switched on.

38 Mirror motor at startup

The user parameter "38 Mirror motor at startup" defines if the mirror motor must be made run on startup. If it contains **1**, the mirror motor will be started on power on. If **0**, the motor will stay off.

Value	Meaning
0	The mirror motor is stopped after the self-test has finished.
1	The mirror motor is started (default)

39 Mirror motor status

This user parameter gives control on the mirror motor:

- Changing the parameter from **0** to **1** starts the mirror motor.
- Changing it from **1** to **0** stops the mirror motor.

The actual mirror motor status must be read from the parameter "43 System status":

- the System Status Bit 0 "System not ready" is set while the motor accelerates or brakes.
- the System Status Bit 6 "Check mirror motor" is set if the motor is not running.

Value	Meaning
0	The mirror motor is not running
1	The mirror motor is running

Note:

The red LED is on while the motor is stopped.
The mirror motor starts automatically if a SCAN command has been received.
While the motor is starting, the sensor reacts to commands with a delay.

40 External incremental encoder enabled

This user parameter gives control on the external incremental encoder interface. If the value is set to **1**, the external incremental encoder interface is enabled. Set to **0** disables the external incremental encoder interface.
This user parameter is set to constant 0 if the sensor type do not support an external incremental encoder interface.

Value	Meaning
0	The external incremental encoder is disabled or not available. User parameter "42 External incremental status" is always 0.
1	The external incremental encoder is enabled. The user parameter "42 External incremental status" reflects the current encoder count.

41 External incremental encoder: offset

In this parameter can be set a global offset for the incremental encoder counter. The value is added to any reading of the external incremental encoder.

Minimum	Maximum	Default value
-2147483648	2147483647	0

42 External incremental encoder: counter

This temporary parameter reflects the current value of the external encoder counter, including the offset set on the parameter "41 External incremental encoder offset".
The same value is present in the Parameter Section of the GSCN response, if the external encoder interface has been enabled.

Minimum	Maximum	Default value
-2147483648	2147483647	0

43 System Status bits

This read-only user parameter contains the 32 bits Word bitmask reflecting the current System Status.
Detailed information about the System Status can be found in chapter "*3.5 System Status Bit-field*".

Caution!

The System Status bit field contains valid information if the bit "0 System not ready" **is 0. The bit is set during the self-test and while the firmware gathers the current system information.**

45 Front side LEDs enabled

Setting this parameter, we can enable or disable the green, yellow and red front LEDs. A value of **1** will enable the LEDs, a value of **0** will disable them after the sensor has finished it's self-test.

Value	Content
0	LEDs will be switched off after startup and self-test
1	LEDs indicates the sensor status.

46 Temperature reading

This read-only parameter contains the current temperature inside the Sensor, in temperature units of 0.1° Celsius.

47 Pulse width at 100% signal

This constant user parameter reflects the Pulse width value which corresponds to a signal of **100**% strength. This value is the Pulse width threshold for the High Echo Filter. See user parameter **"66 High Echo Filter enabled"** for more information.

48 Pulse width at 3% signal

This constant user parameter reflects the Pulse width value which corresponds to a signal of **3%** strength. This value is the Pulse width threshold for the Low Echo Filter. See user parameter **"65 Low Echo Filter enabled"** for more information.

49 Sensor model number

This constant user parameter reflects the Triple-IN sensor model number.

Model Number	Sensor Types
20220	PS Lightweight
20221 to 20299	PSxxx-90+ PSxxx-90+ Range Module PSHT
20300 to 20399	PACxxx-90+

50 Sensor serial number

This constant, read-only user parameter reflects the sensor's serial number.

51 Near field suppression range

This read-only user parameter contains the minimum distance (in 0.1 mm distance units) which will be measured. This value is calculated adding the hardware-wise minimum distance "zone 0" to the result of the effect created by setting the next parameter "52 Near field suppression zone".

Example:
Zone 3 has been set as near field suppression range. Any echo from a target in the range will be ignored:

```
Near_field_range = zone0 + zone1 + zone2 + zone3
```

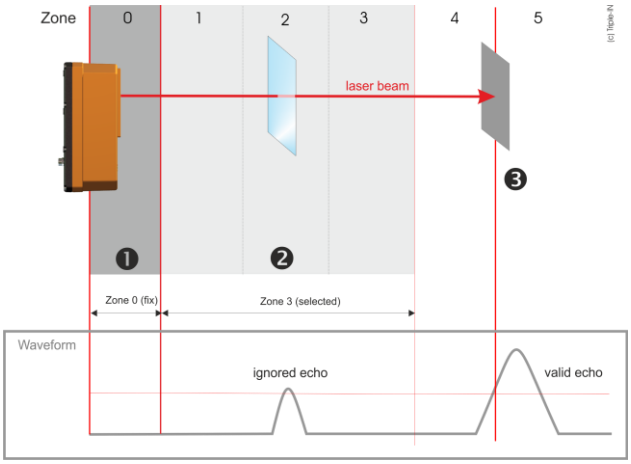

Figure 8 Near-field suppression: example with zone 3

52 Near field suppression zone

The near-field suppression is used to suppress measurements to targets close to the sensor. This prevents the sensor to detect contamination of the optics.
PS Laser Scanners have optional, adjustable near-field suppression. This is divided up in zones, each with a width of about `750` millimeters. Zone `0` defines the closest distance. The closest distance depends on the PS Senor type.
The near field suppression zone can be configured setting this parameter to the desired value.

Minimum	Maximum	Default value
0	100	0

53-58 1st Digital Output configuration

Parameters from **53** to **58** defines the behavior of the first digital output. Those parameters are only enabled if digital outputs are available and parameter "**84 Number of digital outputs**" is greater than **0**.

Parameter	Minimum	Maximum	Default	Description
53	0	3	1	Digital Output function
54	0	1	0	Digital Output status (*Temporary*)
55	0	100000	0	Digital Output pre-set counter (*Temporary*)
56	0	36000	20	Digital Output hold time (ms)
57	0	36000	02	Digital Output delay (ms)
58	0	1	0	Digital Output logic level

Digital Output: function

Every output can perform different functions:

Value	Content
0	Off. The Digital Output is disabled
1	Sync. The Digital Output is set active with the first laser pulse of a scan and is set inactive with the last pulse of a scan.
2	Switch. The Digital Output can be defined using the related parameter "Digital Output status"
3	Pulser. The Digital Output can act as a pulse generator, transmitting the number of pulses set here

Digital Output: status

This read-only user parameter reflects the current logical status of the first digital output.

Value	Content
0	Not active
1	Active

Digital Output: pulser setup

This user parameter defines the number of signals to be output if the digital output was configured as „3=pulser".
This user parameter is used only when the Digital Output function is set to "3 =pulser". It is used to generate a sequence of pulses at the digital output, e.g. to transmit a specific counter information:

1. The sensor firmware copies this value into an internal countdown.
2. If a countdown is already running, the new value is added to the remaining number of pulses.
3. The parameter register is set back to `0` immediately after the pulse generation has started. After this, new counts can be added to current output by writing another counter value.
4. The firmware generates with each count a new pulse.

Digital Output: hold time

This parameter, in conjunction with the "Digital Output delay time", is used only when the "Digital Output function" is set to "3=pulser". It defines the holding time for the active part of the digital signal, measured in milliseconds. The resolution of timing parameters is `10`ms.

Digital Output: delay time

This parameter, in conjunction with the "Digital Output hold time", is used only when the "Digital Output function" is set to "3=pulser". It defines the delay time between the falling and the rising edge of two counter signals, measured in milliseconds. The resolution of timing parameters is `10`ms.

Digital Output: logic level

Defines the logic level of the digital output.

Value	Content
`0`	Normal. When the digital output is closed, logic is high
`1`	Low active. When the digital output is close, logic is low

59-64 2nd Digital Output configuration

Parameters from `59` to `64` defines the behavior of the second digital output. Those parameters are only enabled if the parameter "84 Number of digital outputs" is greater than `1`.
The meanings of the digital output parameters correspond to those of the first digital output.

Parameter	Minimum	Maximum	Default	Description
59	0	3	1	Digital Output function
60	0	1	0	Digital Output status (*Temporary*)
61	0	100000	0	Digital Output pre-set counter (*Temporary*)
62	0	36000	20	Digital Output hold time (ms)
63	0	36000	02	Digital Output delay (ms)
64	0	1	0	Digital Output logic level

For a description on the digital output parameters, see description *"53-58 1st Digital Output configuration"*.

65 Low echo filter enabled

Setting this parameter to **1** enables the low echo filter.
If the laser spot is only partly reflected by object edges, incorrect measurements may arise. A "low echo filter" removes measurements with echo signals less than 3%. To use the full range of sensitivity, the low echo filter can be disabled.
If enabled, the echoes with a Pulse Width lower than the one set on parameter "**48 Pulse width at 3% signal**" are filtered out.

Value	Content
0	Disabled.
1	Low echo filter enabled. Echoes with low signal intensity are filtered out.

66 High echo filter enabled

Setting this parameter to **1** enables the high echo filter.
If the laser spot is reflected by several surfaces, incorrect measurements may arise due to deformations of the echo signal. The "high echo filter" removes measurements which appear with very wide echo signal amplitudes.
The high echo filter can be disabled to allow measurements on reflectors and reflecting foil. The user parameter must be set to 0.
If enabled, the echoes with a Pulse Width higher than the one set on parameter "**47 Pulse width at 100%** signal" are filtered out.

Value	Content
0	Disabled.
1	High echo filter enabled. Echoes with high signal intensity are filtered out.

67-72 3rd Digital Output

Parameters from **67** to **72** defines the behavior of the third digital output. Those parameters are only enabled if parameter "**84 Number of digital outputs**" is greater than **2**.
The meanings of the digital output parameters correspond to those of the first digital output.

Parameter	Minimum	Maximum	Default	Description
67	0	3	1	Digital Output function
68	0	1	0	Digital Output status (*Temporary*)
69	0	100000	0	Digital Output pre-set counter (*Temporary*)
70	0	36000	20	Digital Output hold time (ms)
71	0	36000	02	Digital Output delay (ms)
72	0	1	0	Digital Output logic level

For a description on the digital output parameters, see description *"53-58 1st Digital Output configuration"*.

73-78 4th Digital Output

Parameters from **73** to **78** defines the behavior of the fourth digital output. Those parameters are only enabled if parameter "**84 Number of digital outputs**" is greater than **3**.
The meanings of the digital output parameters correspond to those of the first digital output (parameters 53 to 58).

Parameter	Minimum	Maximum	Default	Description
73	0	3	1	Digital Output function
74	0	1	0	Digital Output status (*Temporary*)
75	0	100000	0	Digital Output pre-set counter (*Temporary*)
76	0	36000	20	Digital Output hold time (ms)
77	0	36000	02	Digital Output delay (ms)
78	0	1	0	Digital Output logic level

For a description on the digital output parameters, see description *"53-58 1st Digital Output configuration"*.

79-80 1st Digital input configuration

The parameters **79** and **80** regulates the function of the first digital input. Those parameters are only enabled if parameter "**85 Number of digital inputs**" is greater than 0.

Parameter	Minimum	Maximum	Default	Description
79	0	1	0	1st Digital Input function
80	0	1	0	1st Digital Input status (*Temporary*)

Digital Input function

Digital inputs can perform different functions.

Value	Content
0	Off. The digital input is disabled. This is the default.
1	Digital input is enabled. The current input level is shown in user parameter "**Digital input status**"
2	Digital input is used as pulse per second PPS trigger input. The number of PPS signals received is shown in user parameter "**Digital input status**"

Digital Input status

This read-only parameter contains

the logical status of the digital input if the function has been set to "1=enabled".
the number of PPS signals received if the function has been set to "2=PPS"

Value	Content
0	Digital input is not active
1	Digital input is active
>1	Number of PPS signals received

81-82 2nd Digital input

The parameters **81** and **82** regulates the function of the second digital input. Those parameters are only enabled if parameter "**85 Number of digital inputs"** is greater than **1**.
The meanings of the digital input parameters correspond to those of the first digital input (parameters 79 to 80).

Parameter	Minimum	Maximum	Default	Description
81	0	1	0	2nd Digital Input function
82	0	1	0	2nd Digital Input status (*Temporary*)

83 GSCN command: number of header parameters

This user parameter can be set with the number of parameters that should be included in the GSCN datagram header. The number of GSCN parameter can be reduced to stay compatible with older client computer software.

Minimum	Maximum	Default value
0	13	12

For more detailed information about the GSCN command and the GSCN header parameters see chapter *"0 GSCN: Getting 2D* Scans".

84 Number of digital outputs

This constant, read-only user parameter reflects the number of available digital outputs. Depending on this number appear the user parameters "**53-58 1st Digital output**", "**59-64 2nd Digital output**", "**67-72 3rd Digital output**", and "**73-78 4th Digital output**" as "**reserved**" and may not be changed.

85 Number of digital inputs

This constant, read-only user parameter reflects the number of available digital inputs. Depending on this number appear the user parameters "**79-80 1st Digital input**", "**81-82 2nd Digital input**", as "**reserved**" and may not be changed.

86 PPS signal period

This user parameter defines the time scale of the PPS signal. Typically provide GNSS receivers PPS signals with a period of 1000 ms. However, one may change this default to an individual period.
This user parameter has only an effect if the PPS has been enabled by setting the function of one digital input to "2=PPS".

87 PPS signal timeout

This user parameter defines the PPS signal timeout in milliseconds.
If the PPS has been enabled by setting function of one digital input to "2=PPS", then the system expects a frequent PPS signal. If the PPS is interrupted for some reasons, the System status bit 4 "Digital input failure" is set if this timeout has expired.
The system status is reported with every GSCN command response.
Setting the user parameter "87 PPS signal timeout" to 0 sets the timeout to "eternality".

88 Measurement laser status at startup

Setting this user parameter will decide the value of the parameter "89 Measurement laser status" on the next power up.
The meaning of this parameter is to be a "request to do". The sensor will try to fulfill the request, but a successful set of this parameter will not mean a success for the operation of changing the measurement status.
The status of the measurement laser can be read on the Status Bits Word (see chapter "*3.5 System Status Bit-field*".

Value	Description
0	Measurement laser is switched off after startup.
1	Measurement laser is switched on after startup. This is the default.

89 Measurement laser status

This temporary user parameter gives control on the measurement laser:

- Changing the parameter from 0 to 1 switches the measurement laser on.
- Changing it from 1 to 0 switches the measurement laser off.

The laser status can be found in the user parameter "43 System status" which is also part of each GSCN response:

- the System Status Bit 0 "System not ready" is set while the motor accelerates or brakes, or during the system self-test. During the test, no information about the measurement laser status is available.

- the System Status Bit 25 “Measurement laser is switched off” is set if the laser is not running.

The meaning of this parameter is to be a “request to do”. The sensor will try to fulfill the request, but a successful set of this parameter will not mean a success for the operation of changing the measurement status.

Value	Description
0	Measurement laser shall be switched off
1	Measurement laser shall be switched on

90 Get IP Address from DHCP server

This user parameter allows the PS Laser Scanner to obtain a Sensor IPv4 address from a DHCP server. The IPv4 address defined in the user parameters 14-17 will be replaced as soon as a new IPv4 address has been taken.

Value	Description
0	IPv4 address is defined in the user parameters “14-17 Sensor IPv4 address”
1	Sensor IP address is taken from a DHCP server, if available.

91-94 Standard Gateway IPv4 Address

The user parameters 91 to 94 are used to set the Internet address of the default gateway.
This settings define the packet forwarding rule to use when no specific route can be determined for a given Internet Protocol (IP) destination address.
The Internet Protocol Version 4 (IPv4) designates the address 0.0.0.0 as default gateway address, what is the default setup for PS laser scanners. If another connection to a network provider shall be used, the standard gateway address can be changed.

Parameter	Part	Minimum	Maximum	Default value
91	A (A.x.x.x)	0	255	0
92	B (x.B.x.x)	0	255	0
93	C (x.x.C.x)	0	255	0
94	D (x.x.x.D)	0	255	0

95 GNSS NMEA setup

If the PS+ sensor types supports GNSS, the user parameter “95 GNSS NMEA setup: 0=none, 1=prev. PPS, 2=next PPS“ is used to enable the RS232 serial interface to a GNSS receiver. The parameter defines the relation between the PPS signal and the NMEA sentence with the corresponding time information.

Caution!

The serial GNSS NMEA interface is not supported by all PS+ laser scanner types.
If GNSS NMEA is not supported, then the user parameter 95 is always constant 0.

The NMEA sentences accepted for the time are ZDA, RMC, GGA and GLL and they have a priority as listed here. It means that if more than one arrives, the higher priority one is only used.
For example, if only RMC is sent, only RMC will be used.
If ZDA and GGA are both sent continuously, only ZDA is used (GGA can only be used once when it is first sent before ZDA).
If then ZDA discontinues for any reason, the system will not take GGA as a replacement but wait for the next ZDA. To reset this behavior, disable the NMEA feature (set user parameter "95 GNSS setup" to 0) and enable it again (set user parameter "95 GNSS setup" to 1 or 2).

Value	Description
0	No GNSS receiver is connected at the APU RS232.
1	GNSS receiver is connected at the APU RS232. It provides PPS signals, followed by NMEA sentences with the GNSS time stamp of the PPS signal.
2	GNSS receiver is connected at the APU RS232. It provides a NMEA sentences with the GNSS time stamp of the next PPS signal. The corresponding PPS signal follows the NMEA sentence.

96 GNSS Receiver RS232 baudrate

The NMEA standard 0183/2 is 4800 b/s (bit per second rate) with 8 bits of data, no parity, and one stop bit. However, today use most modern GNSS receivers 9600 b/s, what is the default setup for PS Laser Scanners. The baud rate used can be set by this user parameter. Note that all other RS232 settings follow the NMEA standard:

Parameter	Value
Baud rate	As defined by user parameter "95 GNSS NMEA setup"
Data bits	8
Parity	None
Stop bits	1
Handshake	No hardware or software handshake
RS232 Setting	Value

97 GNSS Time

This read-only user parameter contains the latest GNSS time, if

- the PS+ Laser scanner supports the GNSS NMEA input
- a GNSS receiver is connected at the APU RS232 communication port
- the user parameter “95 GNSS NMEA sentence” is set to “1=prev. PPS” or “2=next PPS”,
- If at least one ZDA or RMC set was received with the GNSS time.

The value is stored in the Unix time format. The Unix time is the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970.

98 Special function enable

This user parameter is reserved for future use.

99 User parameter ID used for testing

This is a parameter at disposal of the user. It is not directly used by the sensor firmware.

Minimum	Maximum	Default value
-2147483648	2147483647	0

100 Flash memory write protection

User parameters are stored the volatile memory. Setting this user parameter to **0** prevents the firmware to write parameters to the flash.
Every system start resets this parameter to **0**.

Value	Description
0	Volatile memory is unlocked
1	Volatile memory is write-protected.

5 Commands and Responses

5.1 About Commands and Responses

The following section describes the command and response programming interface between the PS Laser Scanner and a PC based control program. All commands and response messages have the following structure (character "\0" means ASCII 0):

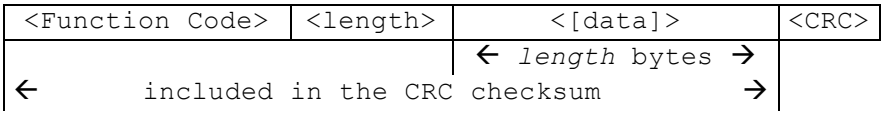

Figure 9 Binary Command and response structure

- Function code: a sequence of ASCII 4 bytes to identify the command.
- Length: the number of the following bytes as 4-byte Word (big endian), without the Function code, the Length and the CRC
- Data: the data segment, this part is optional. Data are transmitted as big endian 4 bytes Words.
- CRC: a 32 bit CRC checksum. The checksum includes the function code, Length, and all Data bytes, but excludes the CRC itself. All integers are added as big endian.

5.2 Command handling flowchart

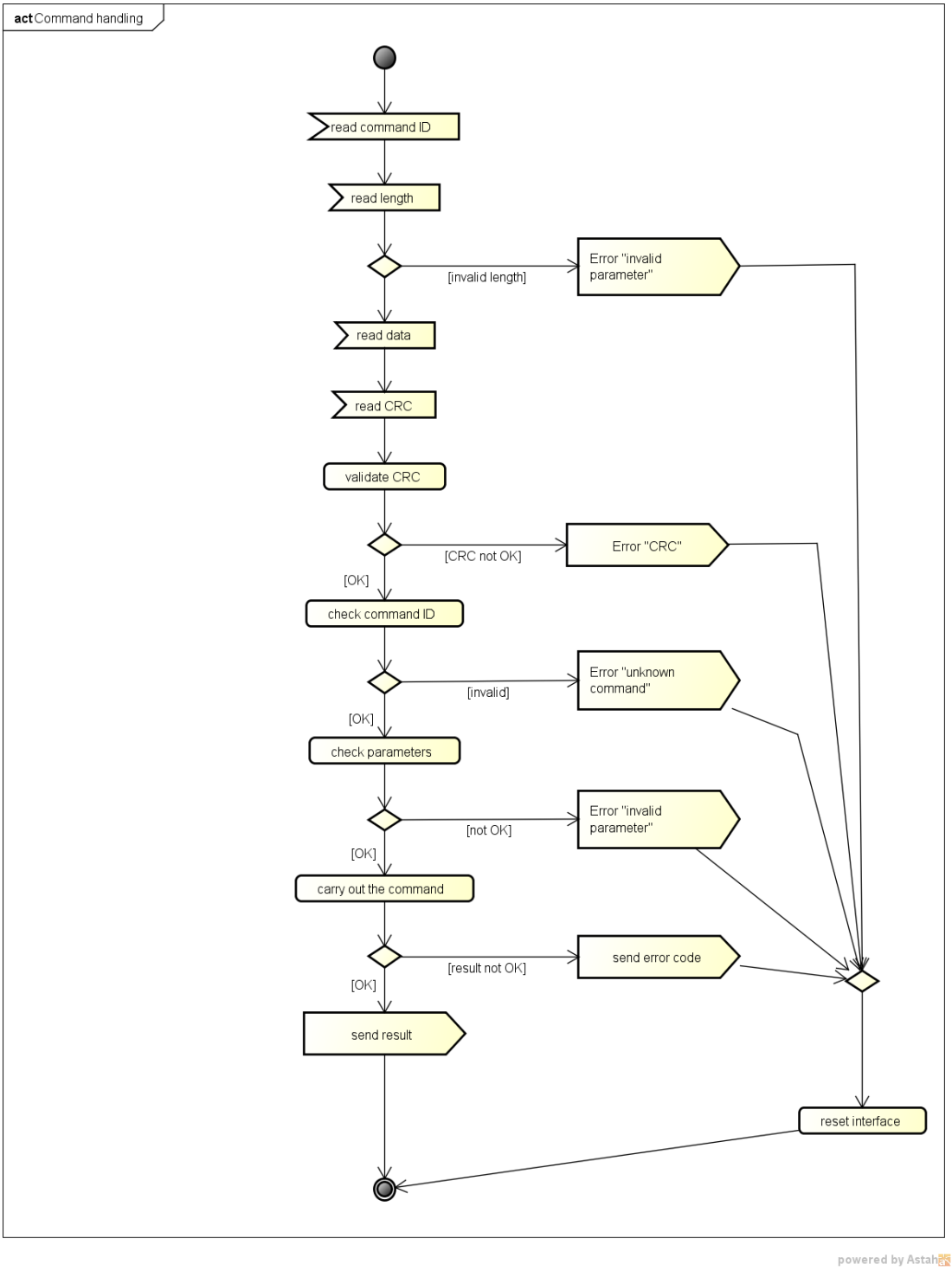

Figure 10 Command handling by the firmware

5.3 List of Commands

The following binary commands are supported:

Command	Response	Description
GVER	Version	Request the Firmware Version
GRTC	Get real time clock count	Request the real time clock counter
SRTC	Set real time clock count	Set the real time clock counter
GPRM	Read parameter	Get the value of a user parameter using the parameter identification code
SPRM	Write parameter	Set a user parameter value
SCAN	Start scan	Starts the scanning mode
GSCN	Get next scan	Request the next measured scan
GPIN	Get parameter info	Request information about a parameter
REST	Perform special operations	Triggers specific operations on the sensor

Table 11 List of commands

In the following paragraphs every Command will be described in detail, with the corresponding expected Response.

5.4 ERR: Error Response

In case some error occurs on the sensor during the processing of a command request, an error response is sent instead of the command Response.
For a complete list of error codes refer to chapter *"3.8 Error Codes"*.

5.4.1 Error Response from the sensor

```
<ERR\0>
      <Length>
      <error code>
<CRC>
```

Part	Type	Length	Description
Command	Char	4	The Error Response Command. The last byte is binary 0.
Length	Word	4	of following bytes, excluding the CRC
Error code	Word	4	The error code
CRC	Word	4	Checksum

Example

Func.Code	Length	Data	CRC
45 52 52 00	00 00 00 04	FF FF F8 2B	AB E2 32 36

5.5 GVER: Getting the Firmware Version

The command GVER requests the firmware versions of different components in the PS laser scanner. The GVER command contains a parameter which defines the requested hardware component. Common components are the Measurement Processing Unit (MPU) and the Application Processing Unit (APU).
Without parameter returns the sensor the firmware version of the Measurement Processing Unit MPU.
The resulting version code might contain several text lines, each separated by a "line feed" character '\n' (ASCII code 10).

5.5.1 GVER command from a client:

```
<GVER>
     <Length>
     <Component ID>
<CRC>
```

Part	Type	Length	Description
GVER	Char	4	The command
Length	Word	4	Number of following bytes, excluding the CRC
Component ID	Word	4	Hardware component ID
CRC	Word	4	Checksum

Optional parameter Hardware component ID

Value	Description
0	Returns the version string of the MPU firmware
1	Returns the version string of the APU firmware

GVER command example

Func.Code	Length	Data	CRC
47 56 45 52	00 00 00 04	00 00 00 01	09 95 BC 35

5.5.2 GVER response from the sensor

```
<GVER>
     <Length>
     <Component ID>
     <version string>
<CRC>
```

Part	Type	Length	Description
GVER	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding the CRC
Component ID	Word	4	The requested hardware component
Version string	String	Variable	The version string of the component's firmware, terminated by a zero and 4-byte aligned.
CRC	Word	4	Checksum

GVER response example

Func.Code	Length	Data	CRC
47 56 45 52	00 00 00 68	00 00 00 01 42 … 00	A9 73 65 CC

5.5.3 Possible errors with the GVER command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB If the parameter has an invalid value

5.6 GRTC: Reading the Real Time Clock and the UTC time

The remote command GRTC is used to read the real time clock and, optionally, the Unix time.

- The real time clock starts with 0 when the sensor is powered up and has a millisecond resolution.
- The Unix Time is the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970.

Client computers can set the real time clock and the date in Unix time format by use of the command SRTC (see below).

Some PS Laser Sensor types support a RS232 interface to a GNSS receiver, which provide the UTC epoch.
More information about the time formats used can be found in chapter "*3.7 Time*".

5.6.1 GRTC command from a client

```
<GRTC>
     <Length = 0>
<CRC>
```

Part	Type	Length	Description
GRTC	Word	4	Command
Length	Word	4	No following bytes, except of the CRC
CRC	Word	4	Checksum

GRTC command example

Func.Code	Length	CRC
47 52 54 43	00 00 00 00	7A 7C 84 7B

5.6.2 GRTC response from the sensor

```
<GRTC>
     <Length>
     <Milliseconds>
     <Unix time>
<CRC>
```

Part	Type	Length	Description
GRTC	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding the CRC
Milliseconds	Word	4	Real Time Counter in milliseconds
Unix time (optional)	Word	4	Date in Unix time format. This parameter is set if a Unix time is available and not 0.
CRC	Word	4	Checksum

GRTC response example

The first example returns 12:10:15.000 o'clock (Milliseconds), no Unix Epoch set:

Func. Code	Length	Data	CRC
47 52 54 43	00 00 00 04	02 9c 90 58	f7 6d 99 06

The second example returns 12:10:15.000 o'clock (Milliseconds) at Monday, December 3rd 2018 (Unix time):

Func. Code	Length	Data	CRC
47 52 54 43	00 00 00 08	5c 05 1d 27 00 00 00 7b	c7 d4 88 49

5.6.3 Possible errors with the GRTC command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB

5.7 SRTC: Setting the Real Time Clock Counter

The command SRTC allows to set the real time clock and, optionally, the Unix time.
The Unix Time is the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970. Client computers can give this as optional information to define the data.
The Millisecond counts are added to the Unix Epoch time to give an accurate time stamp.
It is recommended to set the Unix Epoch time to 00:00 of the current date and let the milliseconds counter start at midnight. The combination of both information gives an accurate time stamp.
More information about the time formats used can be found in chapter "*3.7 Time*".

Caution!

The SRTC command must not be used if a GNSS receiver is connected at the RS232.

5.7.1 SRTC command from a client

```
<SRTC>
     <Length>
     <Milliseconds>
     <Unix time>
<CRC>
```

Part	Type	Length	Description
SRTC	Char	4	Command
Length	Word	4	Number of following bytes, excluding the CRC
Milliseconds	Word	4	The number of milliseconds since the Unix Epoch time
Unix time (optional)	UWord	4	Date in Unix time format. This parameter is optional.
CRC	Word	4	Checksum

SRTC command examples

The first SRTC example set the real time clock to 12:10:15.000 o'clock (Milliseconds), no Unix Epoch set:

Func.Code	Length	Data	CRC
53 52 54 43	00 00 00 04	02 9c 90 58	f8 73 4f 85

The second SRTC example set the Unix time 12:10:15.000 o'clock at Monday, December 3rd 2018 (Unix time):

Func.Code	Length	Data	CRC
47 52 54 43	00 00 00 08	00 00 00 00 02 9c 90 58	e4 fc a3 58

5.7.2 SRTC response from the sensor

```
<SRTC>
     <Length>
     <Milliseconds>
     <Unix time>
<CRC>
```

Part	Type	Length	Description
SRTC	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding the CRC
Milliseconds	Word	4	The number of milliseconds since the Unix Epoch time
Unix time (optional)	UWord	4	Unix time in seconds since 00:00, Jan 1st 1970. This parameter is optional.
CRC	Word	4	Checksum

SRTC response examples

The first SRTC example responds the system time 12:10:15.000 (Milliseconds), no Unix Epoch set:

Func.Code	Length	Data	CRC
53 52 54 43	00 00 00 04	02 9c 90 58	f8 73 4f 85

The second SRTC example responds the Unix time 12:10:15.000 o'clock at Monday, December 3rd 2018 (Unix time):

Func.Code	Length	Data	CRC
47 52 54 43	00 00 00 08	00 00 00 00 02 9c 90 58	e4 fc a3 58

5.7.3 Possible errors

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB

5.8 SCAN: controlling the data stream

5.8.1 Overview

PS Laser Scanner can response to multiple client computers, using different IP addresses and ports. The command SCAN controls the scan line buffer and the way how the sensor provides measurements to the client computer that sent the SCAN command.
There are three basic storage concepts:

- AutoScan: the sensor automatically starts sending scan data to the address of the client computer that had sent the SCAN command.
- AutoStart: After the start and the self-test, the sensor automatically starts sending scan data to the address of the "Default client computer". Neither a SCAN nor GSCN commands are required.
- Scan&Store: the sensor collects and buffers scan data. Different client computers can request this data with GSCN commands. Client computers can request the scan line with a specific number from the buffer or the most recent one.

5.8.2 AutoScan

To avoid the timing issues that a user can incur using the Command/Response pattern, the PS Laser Scanners can be instructed to send continuous flow of scan data. This function is called AutoScan.
To start the AutoScan function a Client sends the SCAN command with two parameters. The AutoScan function will not be limited to one IP destination at a time, so more client computers can use this function at the same time. Any client must be connected to different Ethernet services. After AutoScan has been enabled, the sensor automatically starts sending GSCN responses to the address of the client computer that had sent the SCAN command.

5.8.3 AutoStart

The AutoStart option enables the automatic and continuous scan data stream. After the start and the self-test, the sensor automatically starts sending GSCN response data to the Ipv4 address of the "Default client computer". Scans are numbered in ascending order, starting with 1.
IPv4 address and port are specified in the “Client computer IPv4 address” related user parameters. The AutoStart function will be activated on power up if the user parameter “4 AutoStart without SCAN/GSCN command” is equal to **1**.

5.8.4 Scan & Store

It is possible to ask the PS sensor to store a few scan lines for us, issuing the SCAN command with a defined parameter value. After the command is sent and accepted, the sensor will start to collect the incoming scan lines until the buffer is full.

The size of the buffer requested with the SCAN command cannot be higher than the value of the parameter "32 Scan buffer size".

5.8.5 Scan Line Buffer

An internal global circular buffer queue of scan lines allows Clients to access them. This queue contains a minimum of **1000** scan lines and is accessible through the GSCN command. If the GSCN command parameter is greater than **0**, the Server will search:

- Inside the server Scan&Store local buffer (if requested, see previous chapter) by index
- Inside the Circular Buffer using the GSCN parameter as Scan Number

With this system is possible for the Client to access earlier scan lines without the need to store them.

5.8.6 SCAN Command description

First parameter: Buffer Size

The first parameter is used to control the Scan&Store function:

- If the parameter is zero, the Scan&Store buffer is cleared and voided. No more scan lines will be accessible by index.
- If the parameter is greater than zero, a new buffer is setup and the next N scan lines will be added to the buffer.

Second optional parameter: AutoScan

The second parameter is used to modify the AutoScan status on the contacted Service.
If the value of the parameter is **0**, the AutoScan function will be disabled. If the value is **1**, the AutoScan function will be enabled and the sensor automatically starts sending GSCN responses to the address of the client computer.

5.8.7 SCAN command from a client

```
<SCAN>
     <Length>
     <Buffer size>
     <AutoScan enable>
<CRC>
```

Part	Type	Length	Description
SCAN	Char	4	Command

Part	Type	Length	Description
Length	Word	4	Number of following bytes, excluding the CRC
Buffer size	Word	4	The size of the buffer for the Scan&Store function
AutoScan	Word	4	Enables or disables the AutoScan function
CRC	Word	4	Checksum

SCAN parameter combinations

Command	Scan&store	AutoScan	Description
"SCAN"	0	0	Stop scan process, clear the Scan&Store buffer, disable the AutoScan function
"SCAN"	n	0	Starts the motor if required, holds up to n scan lines in the buffer for request with command GSCN(x).
"SCAN"	n	1	Starts the motor if required, holds up to n scan lines in the buffer for request with command GSCN(x). Starts the continuous data output of scan lines without request by GSCN.

SCAN command Example

Func.Code	Length	Data	CRC
53 43 41 4E	00 00 00 08	00 00 00 00 00 00 00 01	81 AE 3F D5

5.8.8 SCAN response from the sensor

```
<SCAN>
     <Length>
     <Buffer size>
     <AutoScan enable>
<CRC>
```

Part	Type	Length	Description
SCAN	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding the CRC
Buffer size	Word	4	The size of the buffer for the Scan&Store function
AutoScan	Word	4	The actual state set for the AutoScan function
CRC	Word	4	Checksum

SCAN response examples

```
SCAN,0,1
```

Func.Code	Length	Data	CRC
53 43 41 4E	00 00 00 08	00 00 00 00 00 00 00 01	81 AE 3F D5

This command will enable the AutoScan function and it will clear the Scan&Store buffer.

SCAN,15

Func.Code	Length	Data	CRC
53 43 41 4E	00 00 00 08	00 00 00 00 00 00 00 0F	7D 8D 3E 27

This command will enable the Scan&Store function with a size for 15 scan lines. The AutoScan function status will not be modified.

SCAN,0,0

Func.Code	Length	Data	CRC
53 43 41 4E	00 00 00 08	00 00 00 00 00 00 00 00	F6 A9 0F 43

This command will clear the Scan&Store buffer, will disable the AutoScan function and will stop the measurement process.

5.8.9 Possible errors with the SCAN command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB If the number of parameters passed is invalid
-2009	If the requested feature is not supported by the sensor
-2021	If the system is not ready

5.9 GSCN: Getting 2D Scans

5.9.1 Overview

The command GSCN requests measured scans. If the control computer sets the system into AutoScan mode (see chapter "*5.8 SCAN: controlling the data stream*" for more information) this command is not needed to be sent. Instead, GSCN responses will be sent automatically as soon as a new scan line is available from the measurement system.
A typical scan record contains a time stamp, a scan number, distances, and pulse widths.
The scan number starts with 1 every time the measurement laser is turned on.

Using the GSCN command with scan number **0** will return the latest scan measured (the most typical use case).
The command response is built by two sections:

- The GSCN parameter section contains all information related to the scan. The parameter section contains a time stamp, the scan number and system status information. It also contains information about the size and content of the following data section.
- The GSCN data section is built by a sequence of measurement results, such as the distance and pulse widths.

5.9.2 GSCN Command from a client

```
<GSCN>
     <Length>
     <Scan number>
<CRC>
```

Part	Type	Length	Description
GSCN	Char	4	Command
Length	Word	4	Number of following bytes, excluding the CRC
Scan number	Word	4	The number of the scan to get, **0** to get the latest scan.
CRC	Word	4	Checksum

GSCN command example

Func.Code	Length	Data	CRC
47 53 43 4E	00 00 00 04	00 00 00 00	48 2F E1 C3

5.9.3 GSCN response from the sensor

```
<GSCN>
     <Length>

     Parameter section:
            <Number of GSCN parameters nsp>
            <List of GSCN parameters>[nsp]

     Data section:
            <Number of pulses np>
            <Scan data>[np]
<CRC>
```

Part	Type	Length	Description
GSCN	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding CRC
Number of parameters *nsp*	Word	4	The number of values in the parameters section. This can be 0.
Parameters	Word[nsp]	0 - 13	The scan parameters. This array contains the scan number and the “number of echoes” *ne*.
Number of pulses *np*	Word	4	The number of laser pulses that formed the scan. This can be 0.
Scan data	Word[np][ne]	Variable	Array with “Number of laser pulses” multiplied by “Number of echoes” measurements. The data depends on the user parameter 31 “GSCN command: Scan data content”.
CRC	Word	4	Checksum

GSCN response example

Func.Code	Length	Data	CRC
47 53 43 4E	00 00 1F 70	00 00 00 0A 00 C8 … 00 1E 37	D9 4A A1 6B

5.9.4 Content of the GSCN Parameter Section

The parameter section may contain the data described in the next table. Every GSCN parameter is a Word (32 bits). The order of the GSCN parameter is fixed.

#	GSCN Parameter	Description
1	Scan number	The scan line number since the measurement laser has been switched on, starting with 1
2	Time Stamp of first laser pulse	Time stamp of the first laser pulse in the scan, given in milliseconds since the Unix epoch time.
3	Scan Start direction	The direction to the first laser pulse of the scan, in degree
4	Scan Angle	The total scan angle, in degree
5	Number of Echoes	Number of echoes returned for each laser pulse
6	Ext. incremental encoder	External incremental encoder reading, if enabled and connected. The unit of this value depends entirely on the external incremental encoder implementation. No Home Index is managed!
7	Temperature	The temperature measured inside the sensor, in temperature units
8	System Status bitfield	The System Status bits field, as described in the appendix “System Status bits”
9	Data Content	The data format used to store the results (see next pages)
10	Scan Line index	The number of the scan line.

#	GSCN Parameter	Description
		PAC multi-line scanner: number of the scan line. PAC laser scanner have two, three, or four scan lines which are numbered from the left to the right. PS Laser scanner provide one scan line only. Here the "Scan line index" identifies the number 1 to 4 of the mirror surface used.
11	Time Stamp of last laser pulse	Time stamp of the last laser pulse in the scan, given in milliseconds since the Unix epoch time in GSCN parameter 12.
12	Unix time	Number of seconds that have elapsed since the Unix epoch. The Unix time is 0 until • one digital input is configured as GNSS input, • the user parameter "95; GNSS NMEA sentence" is set to "1=prev. PPS" or "2=next PPS", • a ZDA or a RMC NMEA sentence • and at least one PPS signal has been received from the GNSS receiver.
13	Optional: Parameters bitmask	A bit-field describing the content of the GSCN parameter section, If the user parameter "84 GSCN command: number of header parameter" is bigger than 12. Reserved for future use.

Caution!

The order of the Scan Parameters is always respected. So, if we set User Parameter "83 GSCN command: number of header parameters" to 5, we'll receive the Scan Parameters from 1 (Scan Number) to 5 (Number of Echoes).

5.9.5 GSCN Data formats

The measurement data of each single laser pulse depend on the user parameter 31 "Scan data content".
The GSCN parameter 8 contains the information about the data format used. The possible values which can be set in this parameter are listed in the following table.

Format	Bytes per pulse	Description
4	4	Master echo, one distance only (4 bytes)
6	6	Master echo with: distance (4 bytes), echo number (1 byte), Signal intensity (1 byte)
8	8	Master echo with:

Format	Bytes per pulse	Description
		distance (4 bytes), Pulse width (4 bytes)
12	12	Master echo and last echo, each with: distance (4 bytes), echo number (**1** byte), Signal intensity (**1** byte)
16	16	Four echoes, each with distance only (4 bytes each)

GSCN Data Format 4

This format will return, for each laser pulse in a scan, the distance measured on the preferred Master Echo.
The Master Echo is defined by the user parameter **"29 Master Echo"**.
The distance format is described in chapter "*3.4 Sensor specific data formats*". The distance unit is 0.1 mm.

Part	Echo	Type	Bytes	Description
Distance	Master	Word	4	The distance of the echo, in distance units of 0.1 mm. INT_MIN means "No echo" or "low echo" INT_MAX means "Noise".

GSCN Data Format 6

This format will return, for each laser pulse, the distance, the echo number and the Signal Intensity measured on the preferred Master Echo.
The Master Echo is defined by the user parameter **"29 Master Echo"**.
The formats of distances and Signal Intensity are described in chapter "*3.4 Sensor specific data formats*". The distance unit is 0.1 mm.

Part	Echo	Type	Bytes	Description
Distance	Master	Word	4	The distance of the echo, in distance units of 0.1 mm. INT_MIN means "No echo" or "low echo" INT_MAX means "Noise".
Echo	Master	Byte	1	Multi-Echo: True index of the Master Echo
Signal	Master	Byte	1	Signal intensity of the Master Echo. 0 means "No Echo" 255 means "Noise"

GSCN Data Format 8

This format will return, for each laser pulse, the distance and the pulse width measured on the preferred Master Echo.

The Master Echo is defined by the user parameter "29 Master Echo".
The format of distances and pulse width and the relation for "no echo" and "low echo" conditions are described in chapter *"3.4 Sensor specific data formats"*.

Part	Echo	Type	Bytes	Description
Distance	Master	Word	4	The distance of the echo, in distance units of 0.1 mm. INT_MIN means "No echo" or "low echo" INT_MAX means "Noise".
Pulse width	Master	Word	4	The pulse width, in picoseconds. 0 means "no echo".

GSCN Data Format 12

This format will return, for each laser pulse, the distance, the echo number and the Signal Intensity measured on the preferred Master Echo and on the last valid echo.
The Master Echo is defined by the user parameter "29 Master Echo".
The GSCN data format returns the same values for both, Master Echo and last echo, if

- only the first single echo is present,
- the Master Echo has been set to "0=Last echo",

The formats of distances and Signal Intensity are described in chapter "*3.4 Sensor specific data formats*". The distance unit is 0.1 mm.

Part	Echo	Type	Bytes	Description
Distance	Master	Word	4	The distance of the echo, in units of 0.1 mm. INT_MIN means "No echo" or "low echo" INT_MAX means "Noise".
Echo	Master	Byte	1	Multi-Echo: True index of the Master Echo (1 – 4)
Signal	Master	Byte	1	Signal intensity of the Master Echo. 0 means "No Echo" 255 means "Noise"
Distance	Last	Word	4	The distance of the last valid echo, in units of 0.1 mm. INT_MIN means "No echo"
Echo	Last	Byte	1	Multi-Echo: True index of the last Echo (1 – 4)
Signal	Last	Byte	1	Signal intensity of the last echo. 0 means "No Echo"

GSCN Data Format 16

This format will return, for each laser pulse, the distance of every measured echo.

Part	Echo	Type	Bytes	Description
Distance	1st	Word	4	Distance of the 1st echo, in units of 0.1 mm.

Part	Echo	Type	Bytes	Description
				INT_MIN means “No echo” or “low echo” INT_MAX means “Noise”.
Distance	2nd	Word	4	Distance of the 2nd echo, in units of 0.1 mm. INT_MIN means “No echo” or “low echo” INT_MAX means “Noise”.
Distance	3rd	Word	4	Distance of the 3rd echo, in units of 0.1 mm. INT_MIN means “No echo” or “low echo” INT_MAX means “Noise”.
Distance	4th	Word	4	Distance of the 4th echo, in units of 0.1 mm. INT_MIN means “No echo” or “low echo” INT_MAX means “Noise”.

5.9.6 Possible errors with the GSCN command

If a scan is requested that isn't available in the scan buffer yet, the command blocks the response until the scan was measured. The firmware returns with an error if this takes longer than the timeout.
If an invalid scan number was requested (bigger than defined with SCAN), will the firmware return with an "index out of bounds" response.
In case the vertical scanner motor was switched off, then return GSCN commands
An empty scan if the scan number was **0**;
A timeout error if the number of scans was greater **0**.
If an invalid scan number was requested (e.g. number bigger than defined with SCAN), the firmware will return with an “index out of bounds” response.

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first **8** characters (Command and length) are not completed within **5** seconds
-2007	If the number of bytes to be received is bigger than **8** kB
-2012	If the requested scan is not zero and not in one of the buffers
-2021	If the system is not ready

5.9.7 GSCN command flowchart

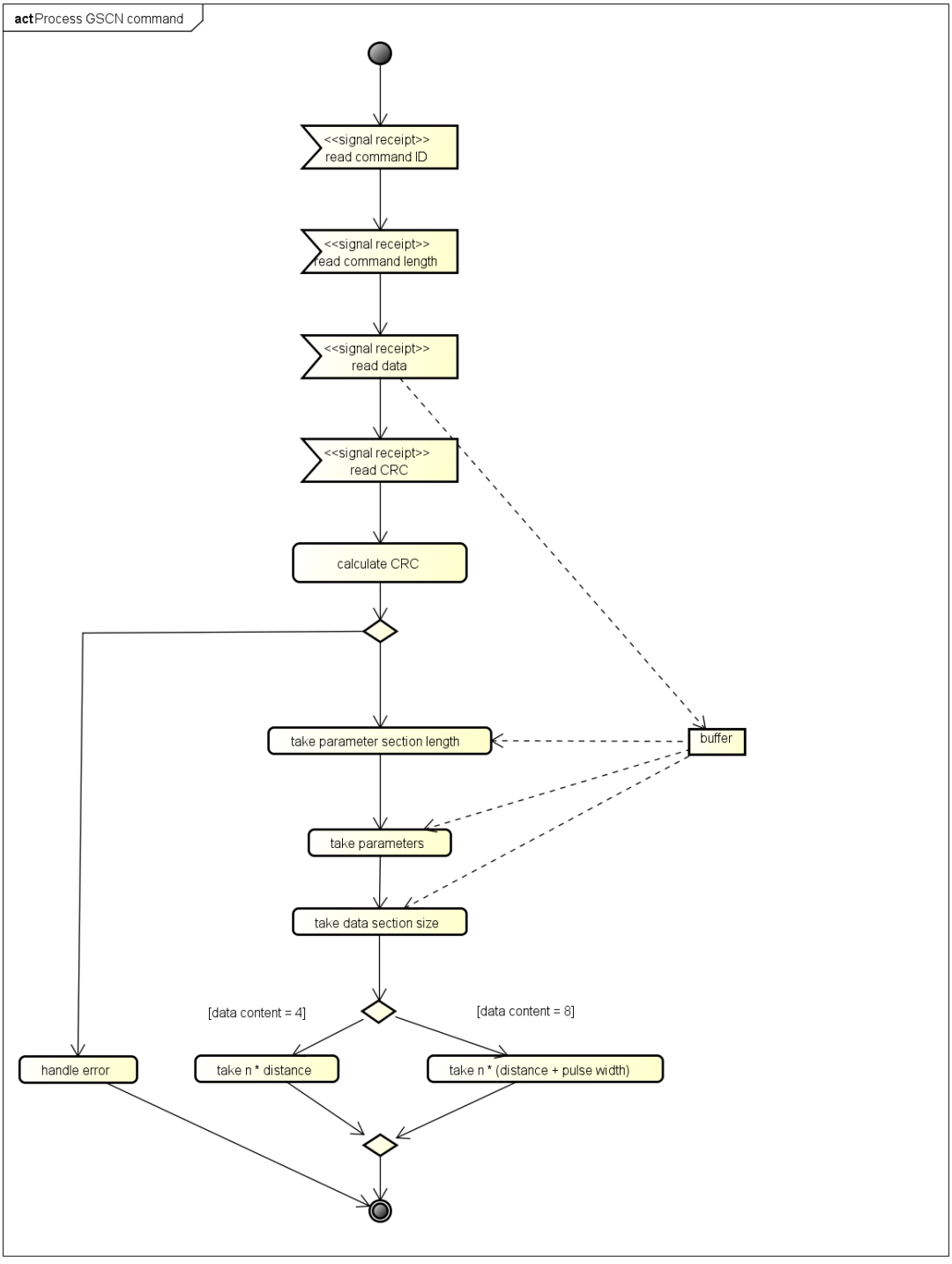

Figure 12 GSCN handling by a control computer

The next scan cannot be requested by GSCN if multiple GSCN commands are pending. The control computer must wait for the response before sending the next command. Communication may also fail if commands are sent while the scanner is in terminal mode.

5.10 GPIN: Getting Parameter Information

The remote command GPIN is used to get information about user parameter. The command returns human-readable information about the parameter's name and the minimum and the maximum values allowed to be set.
GPIN can also be used to get a readable error message for an error code. Send GPIN with the negative error code ID to get the corresponding error message.
If the requested parameter is the one after the last parameter ID, the system will return a valid response with 0s as all parameter values and an empty string as description.
For parameter ID bigger than this, an error will be returned.

5.10.1 GPIN command from a client

```
<GPIN>
     <Length = 4>
     <Parameter ID>
<CRC>
```

Part	Type	Length	Description
GPIN	Char	4	The Command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The parameter identifier
CRC	Word	4	Checksum

GPIN command example

Func.Code	Length	Data	CRC
47 50 49 4E	00 00 00 04	00 00 00 03	5F E6 46 B1

5.10.2 GPIN response from the sensor

```
<GPIN>
     <Length>
     <Parameter ID>

     Parameter value and limits:
            <Number of GPIN parameter>
            <Value>
            <Minimum value>
            <Maximum value>

     Parameter description:
            <Text length>
            <Text description>
<CRC>
```

Part	Type	Length	Description
GPIN	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The requested parameter identifier
Number of GPIN parameter	Word	4	The number of parameter information Words following to describe the parameter
Value	Word	4	The current parameter value
Minimum	Word	4	The minimum value which can be set on the parameter
Maximum	Word	4	The maximum value which can be set on the parameter
Text length	Word	4	The length of the following description string, including the terminating 0
Description	String	Variable	The zero-terminated text string giving a human-readable parameter description. The same description is visible in the Terminal mode. The data is aligned to a 4 bytes Word. Unused bytes are filled with zero
CRC	Word	4	Checksum

GPIN response example

Func.Code	Length	Data	CRC
47 50 49 4E	00 00 00 48	00 00 00 03 … 65 64 00	53 F1 F8 9D

5.10.3 Possible errors with the GPIN command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB If the parameter ID is not known or hidden

5.11 GPRM: Reading a User Parameter

The remote command GPRM is used to read user parameters from the sensor. A parameter identification code specifies the desired parameter.
PS Laser Sensor models use different parameter identifiers, depending on the individual features. The complete list of parameters including a detailed description can be found in the chapter *"4 User Parameters"*.
One can download the parameter list from the PS Laser sensor by use of the Terminal mode.

5.11.1 GPRM command from a client

```
<GPRM>
     <Length = 4>
     <Parameter ID>
<CRC>
```

Part	Type	Length	Description
GPRM	Char	4	Command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The user parameter identifier
CRC	Word	4	Checksum

GPRM command example

Func.Code	Length	Data	CRC
47 50 52 4D	00 00 00 04	00 00 00 03	B9 25 00 6B

5.11.2 GPRM response from the sensor

```
<GPRM>
     <Length = 8>
     <Parameter ID>
     <Value>
<CRC>
```

Part	Type	Length	Description
GPRM	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The requested parameter identifier
Value	Word	4	The actual value stored in the requested parameter
CRC	Word	4	Checksum

GPRM response example

Func.Code	Length	Data	CRC
47 50 52 4D	00 00 00 08	00 00 00 03 00 00 00 01	06 1E B7 53

5.11.3 Possible errors with the GPRM command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds
-2007	If the number of bytes to be received is bigger than 8 kB If the parameter ID is not known or hidden If the parameter value is out of range

5.12 SPRM: Setting a User Parameter

The remote command SPRM is used to write a single parameter to a register in the PS Laser Scanner. The parameter identification code specifies the parameter to be written. The parameter value is checked, and non-temporary parameters are stored in the non-volatile memory of the sensor.
The normal response is a copy of the request, returned after the parameter content has been written. The command SPRM has a prolonged timeout of 60 seconds.
The flash device is specified with a limited lifetime of 100000 program/erase cycles.

5.12.1 SPRM command from a client

```
<SPRM>
     <Length = 8>
     <Parameter ID>
     <new Value>
<CRC>
```

Part	Type	Length	Description
SPRM	Word	4	Command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The user parameter identifier
New value	Word	4	The new user parameter value to be set
CRC	Word	4	Checksum

SPRM command example

Func.Code	Length	Data	CRC
53 50 52 4D	00 00 00 08	00 00 00 08 00 00 00 01	43 D8 F4 5B

5.12.2 SPRM response from the sensor

```
<GPRM>
     <Length = 8>
     <Parameter ID>
     <actual value>
<CRC>
```

Part	Type	Length	Description
SPRM	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding CRC
Parameter ID	Word	4	The user parameter identifier
Actual value	Word	4	The actual value stored in the user parameter
CRC	Word	4	Checksum

SPRM response example

Func.Code	Length	Data	CRC
53 50 52 4D	00 00 00 08	00 00 00 08 00 00 00 01	43 D8 F4 5B

5.12.3 Possible errors with the SPRM command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing If the flash cannot be written
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds If the flash write procedure do not return within 60 seconds
-2007	If the number of bytes to be received is bigger than 8 kB If the parameter ID is not known or hidden If the parameter value is out of range

5.13 REST: Special operations on Ethernet

The remote command REST is used to instruct the sensor to perform some special operations. This command uses a value as a bitmask in which every bit is assigned with a special meaning.

Caution!

The REST command is only available for Ethernet, not for RS232.

5.13.1 REST command from an Ethernet client

```
<REST>
     <Length>
     <Operation bitmask>
     <Magic number>
<CRC>
```

Part	Type	Length	Description
REST	Char	4	Command
Length	Word	8	Number of following bytes, excluding CRC
Operation	Word	4	Operation bit mask; see table below
Magic number	Word	4	The magic number 0x446f4974 is used to confirm the operation
CRC	Word	4	Checksum

Operation bit mask

Bit n°	Operation
1	If this bit is set, the APU is restarted
23	If this bit is set, the password of user “dev” is reset to the factory value.
Others	All the other bits are reserved for future use and must be set to 0.

If not otherwise stated, the operation bits can be combined safely.

REST command example

Func.Code	Length	Data	CRC
52 45 53 54	00 00 00 08	00 00 00 02 44 6F 49 74	28 51 23 63

5.13.2 REST response from the sensor

```
<REST>
     <Length>
     <Operation bitmask>
     <Magic number>
<CRC>
```

Part	Type	Length	Description
REST	Char	4	Response to the command
Length	Word	4	Number of following bytes, excluding CRC
Operation	Word	4	The operations bit mask
Magic number	Word	4	The magic number 0x446F4974 used to confirm the operation
CRC	Word	4	Checksum

REST response example

Func.Code	Length	Data	CRC
52 45 53 54	00 00 00 08	00 00 00 02 44 6F 49 74	28 51 23 63

5.13.3 Possible errors with the REST command

Error	Case
-2001	If the streaming device has reported a hardware failure on reading
-2002	If the streaming device has reported a hardware failure on writing If the flash cannot be written
-2003	If the first 8 characters (Command and length) are not completed within 5 seconds

Error	Case
	If the flash write procedure do not return within 60 seconds
-2006	CRC checksum error
-2007	If the number of bytes to be received is bigger than 8 kB If the parameter ID is not known or hidden If the parameter value is out of range

6 Appendix

6.1 System Status Bit-field reference table

Bit	Type	Text	Description
0	Warning	System not ready	The system is performing a self-test. During this period are all other bits in this system status undefined
1	Info	Scan buffer is empty.	There are no scans in the buffer and a GSCN command will return no scan data
2	Info	Sensor operating in terminal mode.	Sensor operates in Terminal Mode and will not respond to commands
3	Error	Digital output failure!	A digital output detected a hardware failure
4	Error	Digital input failure!	A digital input detected a hardware failure
5	Error	Check external incremental encoder!	The external incremental encoder interface detected a hardware failure
6	Error	Check mirror motor!	The mirror motor is not running
7	Error	Check angle encoder!	Hardware problem. Please contact service
8	Error	Check field of view!	Clean the front window
9	Error	Temperature out of operating range!	The temperature is outside of the operating range of the sensor
10	Warning	Check Ethernet	There is no Ethernet connection
11		Reserved	Reserved for future use.
12	Warning	Factory settings not complete!	Hardware configuration problem. Please contact service
13		Reserved	Reserved for future use.
14		Reserved	Reserved for future use.
15		Reserved	Reserved for future use.
16		Reserved	Reserved for future use.
17	Warning	Laser power control is switched off!	The laser power is controlled manually. The user takes responsibility for the eye safety of the sensor.
18	Warning	Check KEM-IC delay unit	Hardware configuration problem. Please contact service
19	Error	Measurement clock error!	Hardware failure. Please contact service
20		Reserved	Reserved for future use.
21		Reserved	Reserved for future use.
22		Reserved	Reserved for future use.
23		Reserved	Reserved for future use.
24	Warning	EDM Mode	Sensor operates in EDM mode.
25	Info	Measurement laser is switched off.	The measurement laser has been switched-off by the user
26		Reserved	Reserved for future use.
27	Error	Measurement laser failure	The measurement laser reported a hardware failure. Please contact service.
28	Warning	Firmware update needs factory reset	Restart the sensor
29	Error	Check APU board version!	Update the APU board firmware to the latest version
30	Warning	System needs to restart	Restart the sensor
31		Reserved for future use	

6.2 Error code reference table

Code	Description
-2000	Physical device I/O error
-2001	I/O read error
-2002	I/O write error
-2003	Timeout expired
-2004	User break
-2005	CRC checksum error
-2006	Unknown command
-2007	Parameter is out of range
-2008	Access denied / Permission denied
-2009	Unsupported function
-2010	Invalid handle / Bad address
-2011	Division by zero
-2012	Array index is out of bounds
-2013	Internal buffer overflow
-2014	Fatal system error
-2015	System configuration error
-2016	Error in serialization
-2017	KEM Unit error / Measurement clock failure
-2018	Angle encoder failure / Motor failure
-2019	Temperature out of operating range
-2020	Front screen not clear
-2021	System not ready
-2022	Empty buffer

6.3 User Parameter reference table

ID	Type	Text
1		User settings
2		User parameter passWord, 0=disabled
3		Scan mode: 1=normal, 2=fast, 3=fine, 4=reserved
4		Auto-start without SCAN/GSCN command, 0=disabled
5		Start mode: 0=Standard, 1=Terminal Mode
6		Startup message on serial interface: 1=enabled
7		Red Laser Marker at startup: 0=off, 1=on, 2=auto
8	Temp.	Red Laser Marker status: 0=off, 1=on
9		Angle units on a full circle
10		Scan angle size [0.001 deg]
11		Scan start direction [0.001 deg]
12	Const.	Scan angle step [0.001 deg]
13	Const.	Scan angle shift [0.001 deg]
14		Sensor IPv4 Address part AA.xx.xx.xx
15		Sensor IPv4 Address part xx.BB.xx.xx
16		Sensor IPv4 Address part xx.xx.CC.xx
17		Sensor IPv4 Address part xx.xx.xx.DD
18		Sensor socket port
19		Default client computer IPv4 part AA.xx.xx.xx
20		Default client computer IPv4 part xx.BB.xx.xx
21		Default client computer IPv4 part xx.xx.CC.xx
22		Default client computer IPv4 part xx.xx.xx.DD
23		Gateway socket port
24		IP Sub-net mask AAA.xxx.xxx.xxx
25		IP Sub-net mask xxx.BBB.xxx.xxx
26		IP Sub-net mask xxx.xxx.CCC.xxx
27		IP Sub-net mask xxx.xxx.xxx.DDD
28	Const.	Number of echoes in GSCN
29		Master echo: 1=first echo, 0=last echo
30	r/o	Number of scans in Scan&Store
31		GSCN format: 4=D, 6=D+E+S, 8=D+PW, 12=1st/last D+E+S, 16=4D
32	Const.	Scan&Store buffer size
33		Reserved for future use
34		Reserved for future use
35		Air condition: heater ON temperature [0.1 Celsius]
36		Air condition: heater OFF temperature [0.1 celsius]
37	Const.	Air condition: heater status, 0=off, 1=on
38		Mirror motor at startup: 0=off, 1=on
39	Temp.	Mirror motor status: 0=off, 1=running
40		External incremental encoder: 0=disabled, 1=enabled
41		External incremental encoder: offset
42	r/o	External incremental encoder: counter
43	Const.	System status bits
45		Front side LEDs, 0=disabled, 1=enabled
46	Const.	Temperature reading [0.1 celsius]
47	Const.	Pulse width at 100% reflectivity [ps]
48	Const.	Pulse width at 3% reflectivity [ps]
49	Const.	Sensor model number
50	Const.	Sensor serial number
51	Const.	Near field suppression range [0.1 mm]
52		Near field suppression zone: 0=min
53		1st Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
54	Temp.	1st Digital output status: 0=open 1=closed

ID	Type	Text
55	Temp.	1st Digital output: pulser setup
56		1st Digital output hold time [ms]
57		1st Digital output delay [ms]
58		1st Digital output logic level: 0=active-high, 1=active-low
59		2nd Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
60	Temp.	2nd Digital output status: 0=open 1=closed
61	Temp.	2nd Digital output: pulser setup
62		2nd Digital output hold time [ms]
63		2nd Digital output delay [ms]
64		2nd Digital output logic level: 0=active-high, 1=active-low
65	Const.	Low echo filter: 0=disabled, 1=enabled
66	Const.	High echo filter: 0=disabled, 1=enabled
67		3rd Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
68	Temp.	3rd Digital output status: 0=open 1=closed
69	Temp.	3rd Digital output: pulser setup
70		3rd Digital output hold time [ms]
71		3rd Digital output delay [ms]
72		3rd Digital output logic level: 0=active-high, 1=active-low
73		4th Digital output function: 0=off, 1=sync, 2=switch, 3=pulser
74	Temp.	4th Digital output status: 0=open 1=closed
75	Temp.	4th Digital output: pulser setup
76		4th Digital output hold time [ms]
77		4th Digital output delay [ms]
78		4th Digital output logic level: 0=active-high, 1=active-low
79		1st Digital input function: 1=enabled, 2=PPS, 3=RTC reset
80	r/o	1st Digital input status
81		2nd Digital input function: 1=enabled, 2=PPS,
82	r/o	2nd Digital input status
83		GSCN command: number of header parameter
84	Const.	Number of digital outputs SW
85	Const.	Number of digital inputs
86		PPS signal period [ms]
87		PPS signal timeout [ms], 0=infinitive
88		Measurement laser at startup: 0=off, 1=on
89	Temp.	Measurement laser status: 0=off, 1=on
90		Get IP Address from DHCP server: 1=enabled
91		Standard Gateway IPv4 part AA.xx.xx.xx
92		Standard Gateway IPv4 part xx.BB.xx.xx
93		Standard Gateway IPv4 part xx.xx.CC.xx
94		Standard Gateway IPv4 part xx.xx.xx.DD
95		GNSS NMEA status: 0=off, 1=prev. PPS, 2=next PPS
96		GNSS Receiver RS232 baudrate
97	Const.	Unix time [s]
98		Special function enable [bit map]
99		User parameter ID used for testing
100	Temp.	Flash memory write protection, 1=locked

6.4 List of figures