SmartScan UDP message format

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Issue	**Issue Date**	**Change**
B	20th January 2010	Updated
C	27th April 2010	More detail added to slot set up
D	26th August 2011	Details of RFC 1497 terminal byte added to maintenance message. Example maintenance message included.
E	22nd December 2014	Added time of flight compensation messages and updated layout.

1 OVERVIEW

SmartScan communicates with its host via UDP messages over Ethernet. There are diagnostic, maintenance and data messages. Diagnostic messages contain information about the instrument's basic settings, Maintenance messages are used to set up and control the interrogator and data messages contain raw (spectral) or processed (FBG peak) data.

Many of the set up parameters as well as the peak values are expressed as "LASER channel numbers", these are multiplied by 128 to give a resolution that fits into a two byte value e.g. Channel 399 * 128 = 51072, whereas 2^{16} = 65536. Peak values are returned with a fractional portion of a whole channel when divided by 128 by the PC interface.

The wavelength range of the SmartScan is divided up into 400 channels. For a 40 nm SmartScan these are spaced at about 100 pm (12.5 GHz) and for a 35 nm SmartScan at about 88 pm (11 GHz).

Laser Channel	40 nm SmartScan		35 nm SmartScan	
0	191125.0 GHz	1568.567 nm	191680.0 GHz	1564.026
1	191137.5 GHz	1568.465 nm	191691.0 GHz	1563.936
2	191150.0 GHz	1568.362 nm	191702.0 GHz	1563.846
:				
397	196087.5 GHz	1528.871 nm	196087.0 GHz	1528.875
398	196100.0 GHz	1528.773 nm	196098.0 GHz	1528.789
399	196112.5 GHz	1528.676 nm	196109.0 GHZ	1528.703

2 DIAGNOSTIC MESSAGE

2.1 OPERATION

- PC sends diagnostic query to SmartScan port 30001
- SmartScan listens for diagnostic messages on port 30001.
- SmartScan replies using port 30071 to PC port 30001
- SmartScan will use this last IP address received for all replies from now on
- PC should listen on port 30001 for replies from SmartScan

2.2 FORMAT

Message (from PC to SmartScan and SmartScan to PC) consists of one standard UDP datagram. The UDP payload consists of a header as follows, with no following data.

```
struct DIAG
{
        u32     ulTimeStamp;
        u8      ucDamage;               // For future use
        u8      ucState;
        u8      ucvLevel1damage[8];     // For future use
        u8      ucvLevel2damage[8];     // For future use
        u8      ucvSpare[8];            // For future use
};
```

ulTimeStamp	UTC timestamp based on seconds after 01:01:1970. big endian **PC to SmartScan:** PC broadcasts its UTC timestamp so that SmartScan can set its local time **SmartScan to PC:** SmartScan informs PC of what its UTC is set to, PC performs no action
ucState	**PC to SmartScan:** PC instructs SmartScan to go to a state (go to this state) **SmartScan to PC:** Informs PC of SmartScan's current state **Values**: 0 = No Change, 1 = STANDBY, 2 = OPERATIONAL, 3 = MAINTENANCE
ucvLevel1damage[8]	**PC to SmartScan:** not used **SmartScan to PC:** not used
ucvLevel2damage[8]	**PC to SmartScan**: not used **SmartScan to PC:** not used
ucvspare[8]	**PC to SmartScan:** not used **SmartScan to PC:** not used

2.3 DESCRIPTION OF OPERATIONAL STATES

No Change
Used to enquire what the current operation state is without changing it. The PC can send diagnostic messages to the SmartScan during power up to establish when it has switched to operational state.

Standby
This is the default state after power up, in this state the SmartScan transmits no data and will only accept and respond to diagnostic messages.

Operational
This is the normal running state, the SmartScan transmits data messages and can receive, process and respond to diagnostic and maintenance messages. When the SmartScan is ready it will automatically switch to operational state from standby after power up.

Maintenance
In this state the SmartScan will accept, process and respond to maintenance messages but will transmit no data messages

3 MAINTENANCE MESSAGE

3.1 OPERATION

- PC transmits query to SmartScan port 30070
- SmartScan listens for maintenance messages on UDP port 30070.
- SmartScan replies using port 30071 to PC port 30070
- SmartScan will use this last IP address received for all replies from now on
- PC should listen on port 30070

3.2 FORMAT

Message (from PC to SmartScan and SmartScan to PC) consists of one standard UDP datagram. The UDP payload consists of a header as follows, followed by a variable length data array consisting of RFC1497 formatted messages. As defined in the RFC, every message should be terminated with a 0xFF byte and the total length of the message should fall on a 4-byte boundary, to achieve this 0x00 pad bytes must be added prior to the 0xFF terminator byte.

```
struct MAINT
{
        u32     ulCodeStamp;
        u8      ucSpare;
        u8      ucState;
        u8      ucvOptions[1018];
};
```

ulCodeStamp	Fixed cookie number defining message as maintenance **Value:** 0xAA55E00E big endian
ucState	**PC to SmartScan:** PC instructs SmartScan to go to a state **SmartScan to PC:** Informs PC of SmartScan's current state **Values:** 1 = STANDBY, 2 = OPERATIONAL, 3 = MAINTENANCE
ucvOption	Variable length array of RFC formatted commands **PC to SmartScan:** Informs SmartScan to set options to the given values **SmartScan to PC:** Returned options (current settings) **Values:** Defined below

3.3 RFC1497 COMMANDS

These are arranged in the standard RFC format: **[cmd][nr of data bytes][...data bytes...][padding bytes] [terminator byte].** Note that all data values (2 and 4 byte) are in network order, i.e. high significant byte first. Byte defined arrays such as MAC addresses are in normal byte order.

Commands 1 to 127 are SET values. i.e. PC tells SmartScan to set some values and returns it's global values.
Commands 128 to 199 are RETURN values. SmartScan just returns it's global values.

Notes: All numbers are in decimal, except for those in "0xNN" form, which are hex.

3.3.1 SET COMMANDS

Command	Bytes	Description
1	1	Set SmartScan system state. 0 = no change 1 = standby 2 = operational 3 = maintenance
2	1	Set spectrum data source. Valid range: <0..3>

		Sets which optical channel is the source of data in the spectrum data UDP message.
3	2	Sets rate of spectrum data UDP transmission. Valid range: <0..32> **Note**: Higher number gives faster rate.
4	2	Set data transmission rate. Valid range: <0..255> 0 = disable UDP data transmission N = enable UDP data transmission, set rate to 1/N scan time. E.g. if N = 25 and scan time is 400µs, transmission rate is 1 sample per 10ms = 400µs * 25 (e.g. 100Hz rate). **Note**: If LASER step period * LASER step count * N > 65535 the sample interval value in the data header will overflow. In that case, calculate the interval in software and ignore the header value.
5	2	Set Channel Format. b[15] CPU read method 0 = Select Ch 1 = read all 64 b[14] DSP write method 0 = Slot address 1 = Contiguous b[13..9] Not used b[8..4] Number of gratings to interrogate Valid range: <1..16> b[3..0] Number of optical channels to interrogate Valid range: <1..4> **Note1**: In CPU read method 0, any number of gratings <1..16> and optical channels <1..4> can be selected. In CPU read method 1, only gratings <1,2,4,8,16> and channels <1,2,4> can be selected. Method 0 is default. **Note2**: DSP method 0 stores the FBG peaks in the order of their corresponding slot positions, i.e. the slot window must be established beforehand. DSP method 1 stores peaks contiguously. **Note3**: The maintenance message header uses an 8 bit word format to return this code, so the "16 grating" pattern is sent as 0x0n rather than 0x10n. Better to read return CMD [133] which returns the value as a word
6	2	Set all four channel threshold values to same value. Valid range: <0..65535>
8	2	Set first LASER step in scan. Valid range: <0..399> There are only 400 LASER steps defined, therefore the start step plus the steps per scan defined by command 9 should be less than or equal to 400.
9	2	Set acquisition rate. Two available formats, depending on b[15]: if b[15]=0 b[2..0] LASER step count code 0 = 400 1 = 200 2 = 100 3 = 50

b[5..3] LASER step period
0 = 1µs
1 = 2µs
2 = 5µs
3 = 10µs
4 = 20µs
5 = 50µs
b[14..6] Not used
if b[15]=1
b[9..0] Number of steps per LASER scan
Valid range: <1..400>
b[12..10] LASER step period
0 = 1µs
1 = 2µs
2 = 5µs
3 = 10µs
4 = 20µs
5 = 50µs
b[14..13] Not used

18 4 Set interrogator IP address.
Valid after next re-boot.

19 4 Set Subnet Mask.
Valid after next re-boot.

21 4 Set Gateway IP address.
Valid after next re-boot.

22 2 Set threshold for Ch0 b[15..0]
Valid range <0..65535>

23 2 Set threshold for Ch1 b[15..0]
Valid range <0..65535>

24 2 Set threshold for Ch2 b[15..0]
Valid range <0..65535>

25 2 Set threshold for Ch3 b[15..0]
Valid range <0..65535>

26 2 Write one generic slot table entry

Used to enter slot positions and manual gains

<b15..14> Optical channel
Valid range: <0..3>
<b13..12> Entry type
0 = slot position
1 = gain level
<b11..8> Slot number
Valid range: <0..15>
<b7..0> Data (slot position / 2 or gain level)
Valid range:
Slot position: <0..255>
Gain level: <0..8>

“Optical channel” defines which optical channel to apply the setting to, “entry type” defines the setting type (0 for slots, 1 for gains), "slot number" is the number of the slot either being created or the slot whose manual gain value is being set and "data" is either the end channel of the slot being defined (data = laser channel number / 2) or the gain value to apply to a previously defined slot. Slots should be defined in laser channel order. e.g. to set slot boundaries on optical channel 1 at channel 100, 200, 300 as follows:

		Slot	SLOT3	SLOT2	SLOT1	SLOT0 | Laser channel 399 300 200 100 0 First set [channel 0, slot 0, type 0, data 50], then [channel 0, type 0, slot 1, data 100], then [channel 0, type 0, slot 2, data 150] the next slot should be set to the max channel - 1 (e.g. for a 400 channel scan, set slot 3 to 399 / 2 = 199), all remaining slots (4 to 15) should be set to the maximum (i.e. 255). The laser channels are zero referenced to the start channel as defined by command 8. **Note**: Because data range is 0 to 255, when entering slot position, data is slot position / 2, e.g. for slot position 320 set data to 160
27	4	Write one slot position <b31..24> Not used <b21..20> Optical channel Valid range: <0..3> <b19..16> Slot number Valid range: <0..15> <b15.. 0> Slot position data Valid range: <0..399> **Note**: Unlike command 26, the slot position does not need to be divided by 2.
29	2	Set AGC update rate 0 = disable AGC (use manual gains as set with command 26) N = Enable AGC **Note1**: Set to 2 * LASER step period in µs (see command 9) for stable operation. **Note2**: Lower numbers are faster. **Note3**: When setting up manual gains, disable AGC before defining the slots and gains with commands 26 and 27.
32	4	Set SmartScan clock (UTC)
50	4	Fibre length in metres (supported in firmware version 0x1050 and above). Used in conjunction with command 51 to compensate for time of flight delay in the fibre between the interrogators and the FBG sensors.
51	2	Fibre refractive index times 1000 (supported in firmware version 0x1050 and above). Used in conjunction with command 50 to compensate for time of flight delay in the fibre between the interrogators and the FBG sensors.

3.3.2 Return commands

Command	Bytes	Description
129	1	SmartScan operational state (see command 1)
130	2	Spectrum data source (see command 2)
131	2	Spectra rate (see command 3)
132	2	Data rate (see command 4)
133	2	Channel format (see command 5)
134	2	Threshold level of first optical channel (see command 6)
136	2	First LASER step in scan (see command 8)

137	2	Acquisition rate (see command 9)
139	2	LASER step count (see command 9)
140	2	Software version
146	4	IP address (see command 18)
147	4	Subnet mask (see command 19)
148	6	MAC address
149	4	Network gateway (see command 21)
150	4	Fibre length (see command 50)
151	2	Fibre refractive index times 1000 (see command 51)
160	4	SmartScan clock (UTC) (see command 32)
222	4	Serial number

Note: Other parameters are reported but their values are not relevant to end users

3.4 EXAMPLE MAINTENANCE MESSAGE

AA55 E00E 0000 0402 0000 0302 0000 0101 0200 00FF

AA55 E000	Defines message as type "maintenance"
00	Spare byte
00	System State, 00 = No change
04	CMD = Set rate of continuous data message
02	Two command data bytes to follow
0000	Value for command is 0, = disable transmission
03	CMD = Set rate of scan message (used for spectrum transmission)
02	Two command data bytes to follow
0000	Value for command is 0, = disable transmission
01	CMD = Set system state
01	One command data byte to follow
02	Value for command is 2, = set state to operational
0000	Two 0x00 pad bytes in order that whole message finished on 4-byte boundary
FF	Terminator byte, message length = 20 bytes

This maintenance message would typically be sent at the end of an acquisition session to turn off data transmission and prevent unnecessary traffic on the Ethernet network.

4 PEAK DATA

4.1 OPERATION

- SmartScan sends using UDP port 30071 to PC port 30002
- PC should listen on port 30002 for messages
- PC does not need to transmit messages. SmartScan does not respond to PC messages

4.2 FORMAT

UDP payload consists of a header of 36 bytes (see below) followed by N bytes (N/2 16 bit words) of data. A payload will contain an integer number of complete scans.

Example: Take an 8 grating, 4 channel system. Each sample block will contain 8 x 4 = 32 data words. Because of Ethernet size limitations, only up to 22 such sample blocks can be included in each UDP payload.

```
struct  DATA
{
        u16     usFrameSize;            // Total number of bytes
        u8      ucHdrSizex4;            // Number of bytes in header/4 (9)
        u8      ucFrameFormat;          // eg 0x84, 8gratings, 4channels
        u32     ulFrameCount;           // Incremented number
        u32     ulTimeStampH;           // UTC seconds H (scan time)
        u32     ulTimeStampL;           // UTC second  L (scan time)
        u32     ulTimeCodeH;            // UTC seconds   (tx time)
        u16     usTimeInterval;         // sample interval in µS, ie 400
        u16     usSpare;                //
        u16     usMinChannel;           // First LASER step, eg 0
        u16     usMaxChannel;           // Last LASER step, eg 399
        u32     ulStartFreq;            // LASER start frequency
        u32     ulStepFreq;             // LASER step frequency
};
```

usFramesize	Total number of bytes. **Value:** (data words * 2) + 36
ucHdrSizex4	Number of bytes in header / 4 **Value:** 9
ucFrameFormat	MSB = number of gratings, LSB = number of channels. If MSB = 0 it is 16 gratings **Value:** 0x84 = 8gr/4ch, 0x04 = 16gr/4ch
ulFrameCount	Incremented frame count **Value:** 1,2,3....
usTimeInterval	Sample interval in µs, time for one scan **Value:** 400 for 400µs.
usSpare	Not used
ulStartFreq	Lowest LASER frequency (i.e. emission frequency at LASER channel 0) Start frequency (THz) = (ulStartFreq >> 16) + ((ulStartFreq & 0xFFFF) / 1000)
ulStepFreq	LASER step frequency (i.e. difference in emission frequency between LASER channels) Step frequency (GHz) = (ulStepFreq >> 16) + ((ulStepFreq & 0xFFFF) / 1000)
Data	Header is followed by 2 bytes of data per grating, per scan,representing the “channel number * 128”, see section 1 Overview for more details. Note the offset from LASER channel 0 is set by maintenance command 8, if not 0, then it must be added as an offset to the data values.

In our 8gr/4ch example the data order would be:
Ch1Gr1, Ch1Gr2…Ch1Gr7, Ch1Gr8, Ch2Gr1, Ch2Gr2…Ch2Gr8, Ch3Gr1…Ch3Gr8, Ch4Gr1…Ch4Gr8
The data order is then repeated for the 2nd to 22nd samples.

The UTC time-stamp applies to the first sample in the message, the PC can generate timestamps for the remaining samples by adding multiples of the time interval.

5 SPECTRUM DATA

5.1 OPERATION

- SmartScan sends using UDP port 30071 to PC port 30072
- PC should listen on port 30072 for messages
- PC does not need to transmit messages. SmartScan does not respond to PC messages

5.2 FORMAT

UDP payload consists of a header of 36 bytes (see below) followed by LASER step count words of scan data. Scan data is unsigned 16 bit words in network (big endian) format.

```
struct SPECTRUM
{
	u16	usFrameSize;		// Total number of bytes - 2
	u8	ucHdrSizex4;		// Number of bytes in header/4 (9)
	u8	ucFrameFormat;		// Scan source optical channel
	u32	ulFrameCount;		// Incremented on every message
	u32	ulTimeStampH;		// UTC seconds H (scan time)
	u32	ulTimeStampL;		// UTC seconds L (scan time)
	u32	ulTimeCodeH;		// UTC seconds   (transmit time)
	u16	usTimeInterval;		// scan time interval µs
	u16	usNrSteps;		// Steps per scan
	u16	usMinChannel;		// First LASER step
	u16	usMaxChannel;		// Last LASER step
	u32	ulUnused1;		// 0
	u32	ulUnused2;		// 0
};
```