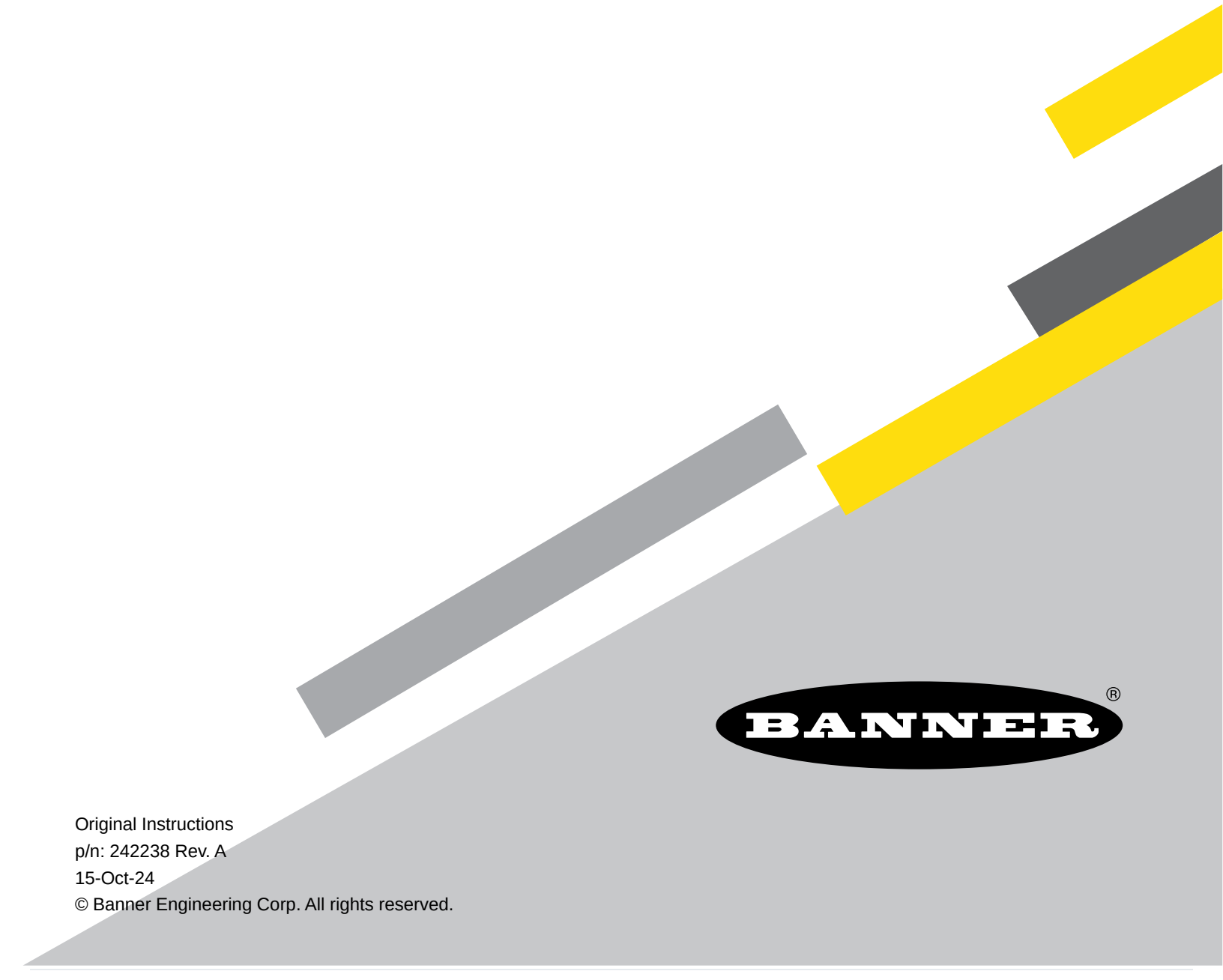
SX5 Safety Laser Scanner Advanced Measurement Communication Manual



Original Instructions
p/n: 242238 Rev. A
15-Oct-24
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Chapter 1 About This Document

Important … Read This Before Proceeding!

It is the responsibility of the machine designer, controls engineer, machine builder, machine operator, and/or maintenance personnel or electrician to apply and maintain this device in full compliance with all applicable regulations and standards.

The device can provide the required safeguarding function only if it is properly installed, properly operated, and properly maintained. This Communication Manual attempts to supplement the Instruction Manual in providing complete installation, operation, and maintenance instructions. *Reading these manuals in their entirety is highly recommended to ensure proper understanding of the operation, installation, and maintenance.* Please direct any questions regarding the application or use of the device to Banner Engineering Corp..

WARNING:

- The user is responsible for following these instructions.
- **Failure to follow any of these responsibilities may potentially create a dangerous condition that could result in serious injury or death.**
- Carefully read, understand, and comply with all instructions for this device.
- Perform a risk assessment that includes the specific machine guarding application. Guidance on a compliant methodology can be found in ISO 12100 or ANSI B11.0.
- Determine what safeguarding devices and methods are appropriate per the results of the risk assessment and implement per all applicable local, state, and national codes and regulations. See ISO 13849-1, ANSI B11.19, and/or other appropriate standards.
- Verify that the entire safeguarding system (including input devices, control systems, and output devices) is properly configured and installed, operational, and working as intended for the application.
- Periodically re-verify, as needed, that the entire safeguarding system is working as intended for the application.

Use of Warnings and Cautions

The precautions and statements used throughout this document are indicated by alert symbols and must be followed for the safe use of the SX Series Safety Laser Scanner. Failure to follow all precautions and alerts may result in unsafe use or operation. The following signal words and alert symbols are defined as follows:

Signal Word and Symbol	Definition
WARNING:	**Warnings** refer to potentially hazardous situations which, if not avoided, could result in serious injury or death.
CAUTION:	**Cautions** refer to potentially hazardous situations which, if not avoided, could result in minor or moderate injury.

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These statements are intended to inform the machine designer and manufacturer, the end user, and maintenance personnel, how to avoid misapplication and effectively apply the SX Series Safety Laser Scanner to meet the various safeguarding application requirements. These individuals are responsible to read and abide by these statements.

UDP-Based Monitoring

This document applies to the following models of SX Safety Laser Scanners:

- SX5-B6
- SX5-M10
- SX5-M70
- SX5-ME70
- SX5-R

Master devices, SX5-Mxxx, can be connected to up to three Remote devices, SX5-R, in a cascade configuration. In this case, the system created by the master and one to three remote scanners are referred to as a cluster.

About this Manual

This Communication Manual is a supplement to the SX5 Instruction Manual and describes the advanced measurement data obtainable from the scanner.

Download the SX5 Instruction Manual, p/n 208913, from www.bannerengineering.com.

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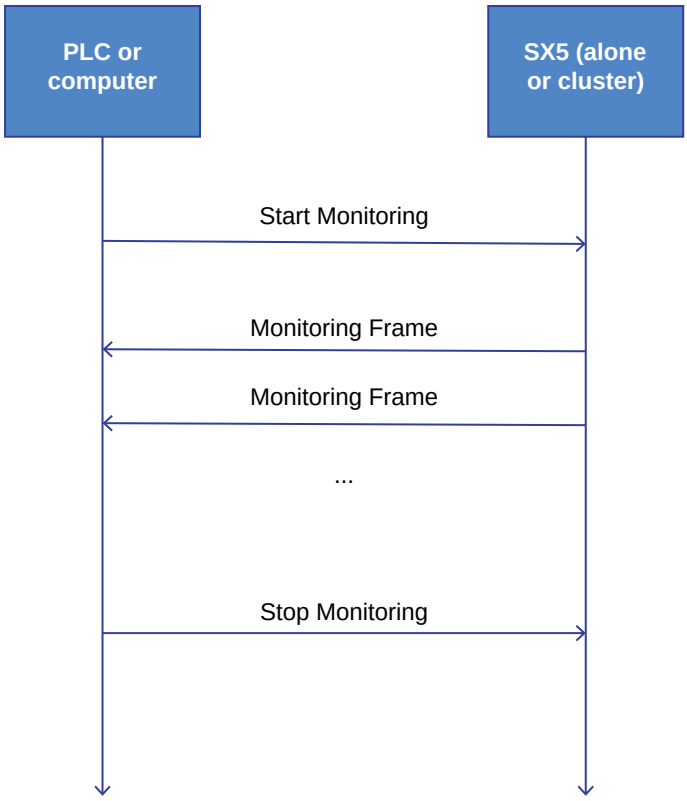
Chapter 2 UDP Based Monitoring for the SX Series Safety Laser Scanner

The SX Series Safety Laser Scanner supports a UDP client-server communication over Ethernet (up to 100 Mbps) that allows a PLC or computer (client) to run the SX Series Safety Laser Scanner monitoring function on the SX Series Safety Laser Scanner (server).



Activating the monitoring function makes it possible to receive measurement distance data and information about the status of the scanner. Information is sent to the PLC or computer by a continuous flow of UDP packets.

If multiple scanners are connected to each other as a cluster, the main unit, Master unit, is responsible for collecting and sending all monitoring frames to the client (PLC or computer).

The data sent from the master device to the client for each complete scan are structured in 6 monitoring frames (see "Monitoring Frame (from Device to Client)" on page 11). If remote devices are connected to the Master device, an additional monitoring frame is sent for each remote device.

Client Disconnection

Because UDP is a connectionless protocol, disconnecting the client (PLC or computer) from the network (that is, unplugging the Ethernet cable or power off the client) does not result in stopping the monitoring function: If the client's IP has not changed, reconnecting the client to the network allows the monitoring frames to reach the client again. If the client's IP has changed (or the client has been replaced with another one), frames do not reach the client since they are still sent to the previous IP address and port.

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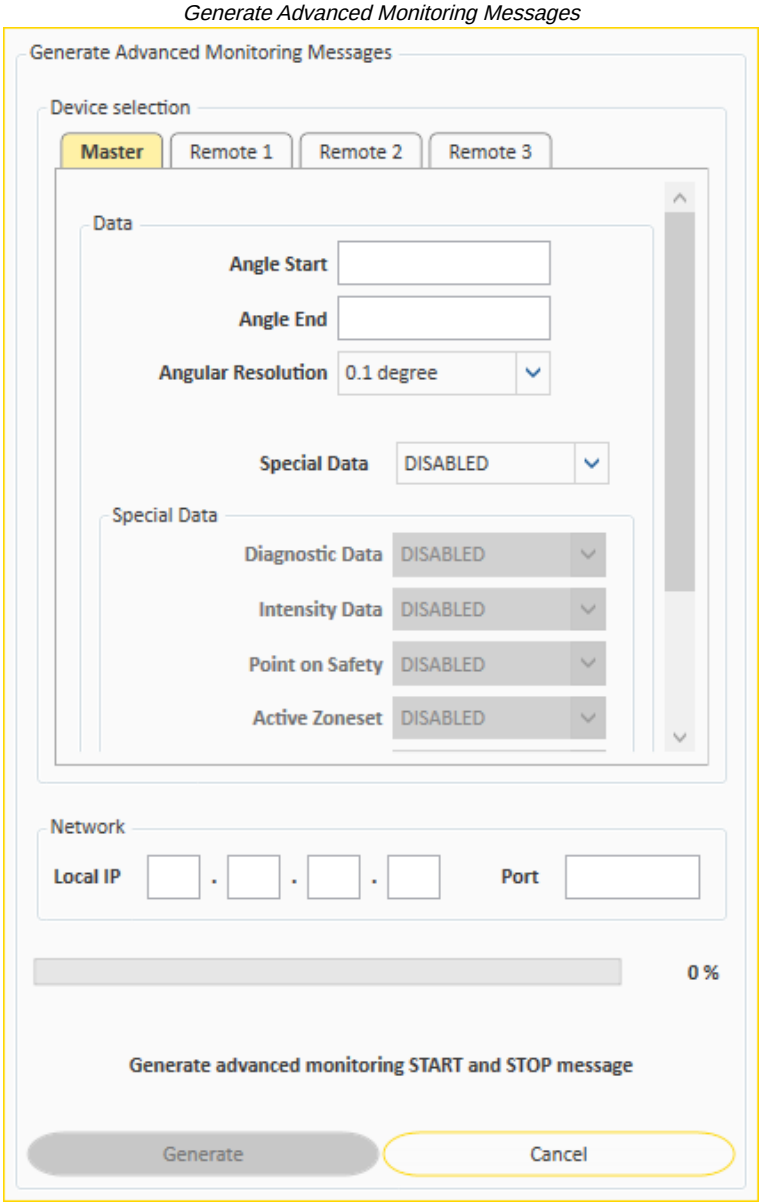
How to Create the Start and Stop Messages

The start and stop messages, referenced in the next section, are created in the SX Series Safety Laser Scanner Configuration Software.

In the Configuration Software version 3.1.3 or higher the option to **Generate Advanced Monitoring Messages** exist. Open the desired configuration that contains the topography of the cluster (Master model and appropriate number of remotes) or create the structure. Under the small **Options** menu is **Advanced Monitoring**.

Generate Advanced Monitoring Messages



From this box the area from which the data is gathered can be limited by entering a start and stop angle. The angular resolution can be selected. The scanner's safety function has a resolution of 0.1 degree, but this results in a lot of data. The resolution can be selected from 0.1 degree up to 5 degrees. For the remote scanners, the resolution can be selected from 0.5 degree up to 5 degrees (only 1 packet per remote).

If any of the special data is desired, enable it in the **Special Data** box. First, enable the **Special Data** box from the **Special Data** menu in the **Data** box.

To receive data from a remote scanner, select the desired remote page in the **Generate Advanced Monitoring Messages** page. Then enable the **Monitoring**.

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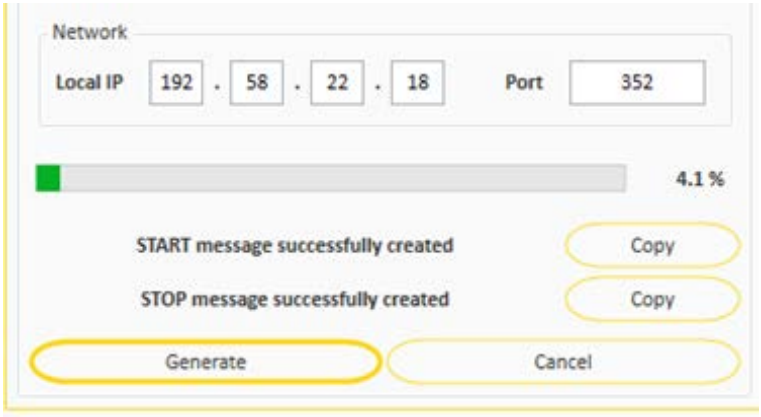
Enter the IP address and port of the client (PLC or computer) in the **Network** box.

After the desired settings have been selected, click **Generate** to create the START and STOP messages. Once generated the START and STOP messages can be copied.



WARNING: Advanced Measurement data may only be used for general monitoring and control activities. Do not use this data for safety-related applications.

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Chapter 3 Command List

The Advanced Measurement protocol includes the following messages:

- Start Request
- Start Reply
- Monitoring Frame(s)
- Stop Request
- Stop Reply

The "Appendix" on page 22 provides some examples of the available messages described in this chapter.

Start Requestion (from Client (PLC or computer) to Device)

The start command must be sent to the SX Series Safety Laser Scanner IP address using UDP port 3000. This command provides the device with information to be sent back to the client.

> **NOTE:** Banner recommends that the Start command be generated using the SX Series Safety Laser Scanner Configuration Software (**Options › Advanced Monitoring**). This ensures that the message is correct and that the information requested meets the communication band.

The UDP payload uses the following format. Unless otherwise indicated, the byte order is little endian.

Offset	Length	Field	Description
0×00	4	CRC	A CRC32 of all the following fields. See "CRC Computation" on page 17
0×04	4	Seq Number	Sequence number of the message
0×08	8	*reserved*	Use all zeros
0×10	4	Op Code	Operation Code (start 0×35)
0×14	4	IP	Client IP address. Byte order: big endian.
0×18	2	Port	Client communication port
0×1A	1	Device Enabled	Enables or disables the monitoring message on one or more devices.[a] **NOTE:** The Master device is always active, therefore its default value is (1000).
0×1B	1	Intensity Enabled	Enables or disables the intensity field on a device.[a]

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Offset	Length	Field	Description
0×1C	1	Point in Safety Enabled	Enables or disables the Point in Safety field, which specifies whether the point of a device lies within the Safety Zone.[a]
0×1D	1	Active Zone-Set Enabled	Enables or disables the field that indicates which Zone Set is active in the device.[a]
0×1E	1	I/O Pin Enabled	Enables or disables the field that shows the configured I/O pins.[a]
0×1F	1	Scan Counter Enabled	Enables or disables the scan counter field.[a]
0×20	1	Speed Encoder Enabled	Enables or disables the field that specifies whether the encoder is active. Because the encoder can only be enabled on the Master device (model SX5-ME70), this 1-byte mask will be (1111) if the encoder is active, or (0000) if the encoder is not active.
0×21	1	Diagnostics Enabled	Enables diagnostics on the selected device.[a]
0×22	2	Master Start Angle	Indicates the start angle of the Master device expressed in tenths of a degree.[b]
0×24	2	Master End Angle	Indicates the end angle of the Master device expressed in tenths of a degree.[c]
0×26	2	Master Resolution	Indicates the angle resolution of the Master device expressed in tenths of a degree. Example: to sample an angle every 0.1°, this value must be 0.1 × 10 = 1
0×28	2	Remote 1 Start Angle	Indicates the start angle of Remote 1 expressed in tenths of a degree.[b] **NOTE:** If the Device Enabled mask of Remote 1 is false (value = 0), this field will have a value = 0.
0×2A	2	Remote 1 End Angle	Indicates the end angle of Remote 1 expressed in tenths of a degree.[b] **NOTE:** If the Device Enabled mask of Remote 1 is false (value = 0), this field will have a value = 0.
0×2C	2	Remote 1 Resolution	Indicates the angle resolution of Remote 1 expressed in tenths of a degree. Example: to sample an angle every 5.0°, this value must be 5.0 × 10 = 50 **NOTE:** If the Device Enabled mask of Remote 1 is false (value = 0), this field will have a value = 0.
0×2E	2	Remote 2 Start Angle	Indicates the start angle of Remote 2 expressed in tenths of a degree.[b] **NOTE:** If the Device Enabled mask of Remote 2 is false (value = 0), this field will have a value = 0.

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Offset	Length	Field	Description
0×30	2	Remote 2 End Angle	Indicates the end angle of Remote 2 expressed in tenths of a degree.[b] **NOTE:** If the Device Enabled mask of Remote 2 is false (value = 0), this field will have a value = 0.
0×32	2	Remote 2 Resolution	Indicates the angle resolution of Remote 2 expressed in tenths of a degree. Example: to sample an angle every 5.0°, resolution value is 5.0 × 10 = 50 **NOTE:** If the Device Enabled mask of Remote 2 is false (value = 0), this field will have a value = 0.
0×34	2	Remote 3 Start Angle	Indicates the start angle of Remote 3 expressed in tenths of a degree.[b] **NOTE:** Note: If the Device Enabled mask of Remote 3 is false (value = 0), this field will have a value = 0.
0×36	2	Remote 3 End Angle	Indicates the end angle of Remote 3 expressed in tenths of a degree.[b] **NOTE:** If the Device Enabled mask of Remote 3 is false (value = 0), this field will have a value = 0.
0×38	2	Remote 3 Resolution	Indicates the angle resolution of Remote 3 expressed in tenths of a degree. Example: to sample an angle every 5.0°, resolution value is 5.0 × 10 = 50 **NOTE:** If the Device Enabled mask of Remote 3 is false (value = 0), this field will have a value = 0.
TOTAL	58 BYTES		

[a] 1-byte mask. Only the last 4 bits (little endian) are used, each of which represents a device. For example, (1000) only enables the Master device, while (1010) enables both the Master and the second Remote device.

[b] The start angle must have a minimum value of 0 degrees and must not exceed the end angle.

[c] The end angle must have a maximum value of 275 degrees and must not be less than the start angle.

Start Reply (from Device to Client)

The UDP uses the following format. Unless otherwise indicated, the byte order is little endian.

Offset	Length	Field	Description
0×00	4	CRC	A CRC32 of all the following fields. "CRC Computation" on page 17
0×04	4	*reserved*	- (all zeros should be received)

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Offset	Length	Field	Description
0×08	4	OP Code	Operation Code (Start 0×35)
0×0C	4	Res Code	Operation result. If the message is accepted, the returned value is 0×00. If the message is refused, the returned value is 0×EB. If the CRC is not correct, the device will not send any message.
TOTAL	16 BYTES		

Stop Request (from Client to Device)

The Stop Command must be sent to the SX Safety Laser Scanner IP address using UDP port 3000. The UDP uses the following format. Unless otherwise indicated, the byte order is little endian.

Offset	Length	Field	Description
0x00	4	CRC	A CRC32 of all the following fields. See "CRC Computation" on page 17.
0x04	12	*reserved*	Use all zeros
0x10	4	Op Code	Operation Code (Stop 0x36).
TOTAL	20 BYTES		

Stop Reply (from Device to Client)

The UDP uses the following format. Unless otherwise indicated, the byte order is little endian.

Offset	Length	Field	Description
0×00	4	CRC	A CRC32 of all the following fields. See "CRC Computation" on page 17.
0×04	4	*reserved*	- (all zeros should be received)
0×08	4	Op Code	Operation Code (Stop 0×36).
0×0C	4	Res Code	Operation result. If the message is accepted, the returned value is 0×00. If the message is refused, the returned value is 0×F7. If the CRC is not correct, the device will not send any message.
TOTAL	16 BYTES		

Monitoring Frame (from Device to Client)

Monitoring frames are sent by the SX Safety Laser Scanner after a start command. Monitoring frames are sent to the IP address and UDP port specified by the Start Command message.

Each monitoring frame is always composed of:

- 6 messages for the Master device
- 1 message for each Remote device

Each message is composed of the following elements:

- The same information is always stored in the first 19 bytes.
- The remaining bytes are variable in number and depend on the configuration sent with the Start Command. Each configuration sent with the Start Command prompts the system to send data in the monitoring frame. For more information on decoding additional information, refer to "Additional Information" on page 13
- The end of the message is given by either the length or the end message header ID with LEN 0.

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NOTE: Measurement data are always included in the frame; it is not optional.

The UDP uses the following format. Unless otherwise indicated, the byte order is little endian.

Offset	Length	Field	Description
0×00	4	Device Status	Bit mask representing the device status "Device Status" on page 12.
0×04	4	Op Code	Constant 0xCA.
0×08	4	Working Mode	Online = 0×00 Offline = 0×01 Offline test = 0×02
0×0C	4	Transaction Type	Configuration Software monitoring transaction = 0×05.
0×10	1	Scanner ID	Scanner identification: 0 = master/standalone 1 to 3 = remote position
0×11	2	From Theta	From Theta Angle.
0×13	2	Resolution	Angle resolution selected during the configuration phase. The value is expressed in tenths of a degree.
0×15	Variable	Additional Information	Additional information that depends on the start configuration.

Device Status

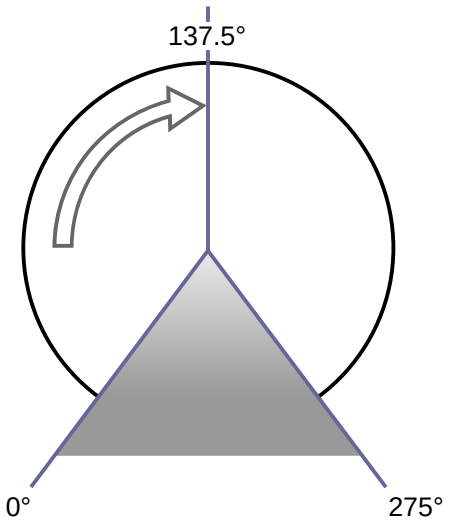
The device status bitmask can be decoded according to the following table:

BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
OSSD1	OSSD2	OSSD3	Warn1	Warn2	Ref_Pts	-	-

From Theta

The following diagram shows the reference system for the **From Theta** field:

From Angle (θ) Determination



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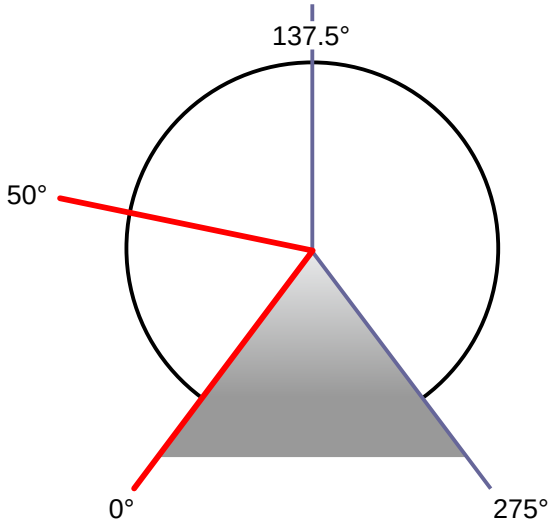
The formula to compute the angular region interested by the measures of a frame is:

Start angle = “FromTheta” /10 {degrees}
End angle = (“FromTheta” + (“Resolution” × “Number of Samples”)) / 10 {degrees}

For example: A frame with “From Theta” equal to 0, “Resolution” equal to 1 and “Number of Samples” equal to 500 covers the angular region from 0 to 50°.

Example Area of Interest



Additional Information

The **Additional Information** field is variable in content and size.

It consists of a vector of the following structures

Header ID	Header length in bytes	Payload
(1 byte)	(2 bytes)	(variable length)

The following tables show how the client can decode all possible structures:

I/O Pin		
ID	**Length**	**Payload**
0×01	62	Area representing the state of the cluster input and output pins (see "I/O Pin State" on page 15).

Scan Counter		
ID	**Length**	**Payload**
0×02	4	Counter indicating the number of rounds that the motor has performed since power-up. It can be used as a timestamp for the data of the same frame.

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Zone Set		
ID	**Length**	**Payload**
0×03	1	Zone set currently active on the cluster. The zone set number is 0-based (that is, "Zone Set 0" refers to the first zone set).

Diagnostics		
ID	**Length**	**Payload**
0×04	40	Area representing diagnostics fault errors (see "Diagnostics" on page 16).

Measures		
ID	**Length**	**Payload**
0×05	Variable	An array of little endian 16-bit unsigned integers representing distances in millimeters. The actual number of samples is given by Length divided by two.

Intensity		
ID	**Length**	**Payload**
0×06	Variable	An array of 16-bit unsigned integers representing the received normalized signal intensities. The actual number of samples is given by Length divided by two.

NOTE: Enabling the intensity doubles the minimum angular resolution.

NOTE: The two most significant bits (15 and 14) represent the channel, while the other (13 to 0) represent the intensity, as illustrated in the table below.

	Byte 1								Byte 2							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Channel		Energy Data													
Diffusive	0	0														
Auxiliary	0	1														
Reflective	1	0														
Intensity data not available	1	1														

Encoder		
ID	**Length**	**Payload**
0×07	4	Two 16-bit unsigned integers representing speeds in cm/s read from the encoders. By order is big endian. This value is expressed in cm/s.

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Point Safety		
ID	**Length**	**Payload**
0×08	Variable	A bitmask representing all points for which a measure has been requested. If the point is falling in the active safety area, then bit=1, otherwise bit=0.

Frame End Before Standard Length		
ID	**Length**	**Payload**
0×09	0	Field that identifies the end of the frame (no more data available).

NOTE: I/O Pin, Scan Counter, and Diagnostics messages are repeated on every frame, if active.

NOTE: Encapsulated messages are ordered according to their enumeration. For example, if I/O Pin and Measures are active, the message will first indication the I/O Pin data.

I/O Pin State

The input state area is split into two sections: physical inputs and logical inputs.

Because inputs may change at a frequency higher than the message transmission, the physical input section consists of three identical records that store the last three sets of input values. Each record is described in the following table:

Length	Field	Description
4	*reserved*	-
10	Physical Input Signals	Byte array representing the physical input values (see below)

The physical input signals array can be decoded according to the following tables. Bytes from 0 to 5 are unused.

Byte 6

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Zone Set Switching Input 8	Zone Set Switching Input 7	Zone Set Switching Input 6	Zone Set Switching Input 5	Zone Set Switching Input 4	Zone Set Switching Input 3	Zone Set Switching Input 2	Zone Set Switching Input 1

Byte 7

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Override 12	Override 11	Muting 12	Muting 11	Muting Enabled 1	Restart 1	-	Reset

Byte 8

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
EDM 2	Override 22	Override 21	Muting 22	Muting 21	Muting Enable 2	Restart 2	EDM 1

Byte 9

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	EDM 3	Override 32	Override 31	Muting 32	Muting 31	Muting Enable 3	Restart 3

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The logical input section is described by the following table:

Length	Field	Description
4	*reserved*	-
8	Logical Input Signals	Byte array representing the physical input values.

The output section is described by the following table:

Length	Field	Description
4	*reserved*	-
4	Outputs	Bitmask representing output values (see below)

The output bitmask can be decoded according to the following tables.

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
-	-	-	OSSD1_REF PTS	WARN2_SL 3	WARN1_SL V3	OSSD3_SLV 3	OSSD2_SLV 3

Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
OSSD1_S LV3	WARN2_S 2	WARN1_S LV2	OSSD3_S LV2	OSSD2_S LV2	OSSD1_S LV2	WARN2_S LV1	WARN1_S LV1

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
OSSD3_S LV1	OSSD2_S LV1	OSSD1_S LV1	WARN2_ M	WARN1_ M	OSSD3_M	OSSD2_M	OSSD1_M

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
WARN2	WARN1	OSSD3_LOCK	OSSD3	OSSD2_LOCK	OSSD2	OSSD1_LOCK	OSSD1

Diagnostics

The following table shows the structure of the diagnostic payload:

Length	Field	Description
4	*reserved*	-
36	Diagnostic Information	Byte array representing diagnostic information (see below)

In the diagnostic information field, each device (starting from the master) is assigned 9 bytes. Those bytes can be decoded according to the following tables, in which Bit = 1: Error; Bit = 0: No Error.

Byte 0

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OSSD1 Overcurrent / Short circuit	Short circuit at least between two OSSDs	Integrity check problem on any OSSD	Internal error	Internal error	Internal error	Internal error	Internal error

Byte 1

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0

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Window cleaning alarm	Power supply problem	Network problem	Dust circuit failure	Internal error	Internal error	-	OSSD2 Overcurrent / Short circuit

Byte 2

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Measure problem	Internal error	Internal error	Internal error	Incoherence data	Zone: Invalid input transition or integrity	Zone: Invalid input configuration / connection	Window cleaning warning

Byte 3

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Internal communication problem	Internal error	Internal error	Generic error	Display communication problem	Internal error	Internal error	Temperature measurement problem

Byte 4

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Encoder Out of Range	-	-	EDM2 Error	EDM1 Error	Configuration error	Out of range error	Temperature range error

Byte 5

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
-	-	-	-	-	-	-	Encoder: Generic error

Bytes 6 to 8 are not used.

> **NOTE:** After the monitoring function is active, modify the configuration by sending a Stop command first, and then a new Start command with the new configuration.

CRC Computation

The following CRC32 is used to detect accidental changes to raw data while exchanging frames between client and server.

Parameter	Value
	32
Polynomial	0x04C11DB7
Initial Value	0xFFFFFFFF
Final XOR Value	0xFFFFFFFF

Source Code Example

```
public class CRC32
{
        private const UInt32 ORDER = 32;
        private const UInt32 TOP_BIT = 0x80000000;
        private const UInt32 TABLE_SIZE = 256;
```


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```
        private const UInt32 plynomial = 0x04c11db7;
        public const UI32 Initial = 0xffffffff;
        private const UInt32 finalXor = 0xffffffff;
        private static UInt32[] table = new UInt32[TABLE_SIZE];
        private static bool isTableGenerated = false;

        public CRC32()
        {
            generatedTable();
        }

        public UInt32 compute(byte[] data)
        {
            return finalize(computeIncremental(Initial, data));
        }

        public UInt32 computeIncremental(UInt32 crc, byte[] data)
        {
            UInt32 i;
            byte b, pos;

            for (i = 0; i < data.Length; i++)
            {
                b = reflect8(data[i]);

                pos = (byte)((crc ^ (b << 24)) >> 24);
                crc = (UInt32)((crc << 8) ^ ((UInt32)table[pos]));
            }

            return crc ;
    }

    public UInt32 finalize(UInt32 crc)
    {
            UInt32 result;

            result = reflect32(crc) ^ finalXor;
            if (result == 0xffffffff) result ^= 0x1;
            return result;
     }

    private static void generateTable()
    {
        UInt32 bit, div, curr;

        if (isTableGenerated)
            return;

        for (div = 0; div < TABLE_SIZE; div++)
        {

            curr = div << 24;
            for (bit = 0; bit < 8; bit++)
          {
             if ((curr & TOP_BIT) ! = 0)
             {
                curr << 1;
                curr ^= polynomial;
             }
             else
             {
                curr <<= 1;
             }
        }

        table[div] = curr;
    }

    isTableGenerated = true;

}

private static byte reflect8(byte b)
```


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```
{

    byte r, i;

    r – 0;
    for (i = 0; < 8; i++)

    {
        if ((b & (1 << i)) != 0) r |= ((byte)(1 << (7 – i)));
    }

    return r;

}

private static UInt32 reflect32(UInt32 b)
{
    int r, i;

    r = 0;
    for (i = 0); i < 32; i++)
    {
        if ((b & (1 << i)) != 0) r |= ((int)(1 << (31 – i)));
    }

    return (uint)r;

}
```


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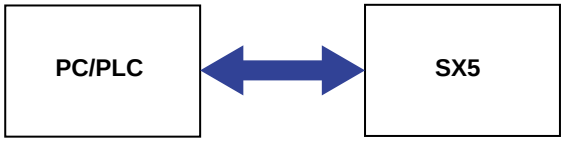
Chapter Contents

Chapter 4 Data Processing Time

The time to process data from UDP command communications is as follows.



The communication time between the SX5 and other devices (that is, PLC or computer) differs depending on your communication environment.

The time elapsed from the acquisition by the SX5 of the first measure contained in a frame and the expedition of the corresponding UDP frame depends on the actual scanner and on the number of connected SX5 devices. Refer to the following table.

Scanner ID Value	No Remote Connected	1 Remote Connected	2 Remote Connected	3 Remote Connected
0 (Master)	2 ms	2 ms	2 ms	2 ms
1 (Remote #1)	NA	30 + 2 ms	30 + 2 ms	30 + 2 ms
2 (Remote #2)	NA	NA	30 + 4 ms	30 + 4 ms
3 (Remote #3)	NA	NA	NA	30 + 6 ms

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Chapter Contents

Chapter 5 Distance Accuracy vs. Target Reflectivity

Considering a distance range from 0 mm to 5500 mm, the following table shows how distance measurement accuracy is affected by the target's reflectivity:

Target Reflectivity	Typical Distance Error
1.80%	± 30 mm
18%	± 24 mm
90%	± 21 mm
100%	± 12 mm

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Chapter 6 Appendix

Protocol Examples

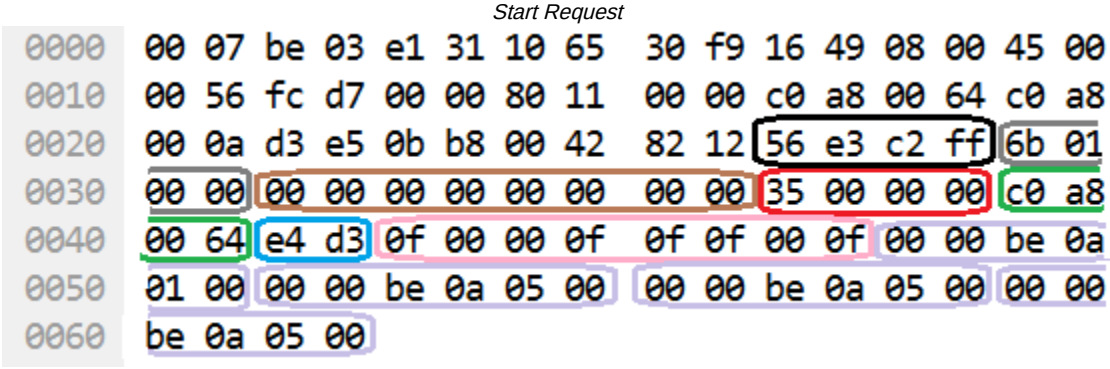
The following examples are based on firmware version 3.1.0 and assume that the cluster is always composed of 1 Master and 3 Remote scanners.

Monitoring Started Via the Configuration Software

Start Request

The following figure shows a start command request performed by the Configuration Software.

Start Request



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	CRC of the command	Little endian	
Gray	Sequence number	Little endian	
Brown	*reserved*	Empty/all zeros	
Red	Operation code	Little endian	In this example, the operation code of 0 × 35 identifies the start command
Green	IP address of the receiver client	Big endian	In this example, the IP address is 192.168.0.100
Blue	Port number	Big endian	In this example, the port number is 58579
Pink	Enabled bit		In this example, zone set, I/O, scan counter, and diagnostics are enabled on four devices. Measures are enabled by default.

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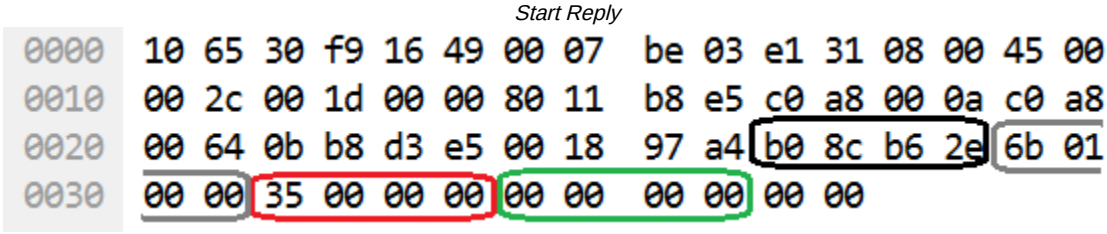
Color	Description	Format	Additional Information
Purple	Each slot represents the start angle, stop angle, and resolution for each scanner. Each value is 2-bytes long and expressed in tenths of a degree.	Little endian: • Master (first slot): start angle is 0, stop angle is 2750 (0×0ABE), resolution is 1 • Remotes (second, third, and fourth slots): start angle is 0, stop angle is 2750, resolution is 5.	

Start Reply

The following figure shows a start command response.

Start Reply



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	CRC of the command	Little endian	
Gray	Sequence number	Little endian	
Red	Operation code	Little endian	
Green	Operation result		In this case, all zeros, meaning no error

Monitoring frame created by the Master Scanner

The Master scanner divides its 275° into six zones: five zones of 50° each and the last zone of 25°. Each zone corresponds to a different frame (the Master scanner needs a total of six frames to transfer a complete set of measures).

The following figure shows the Master frame for the first zone (0° – 50°).

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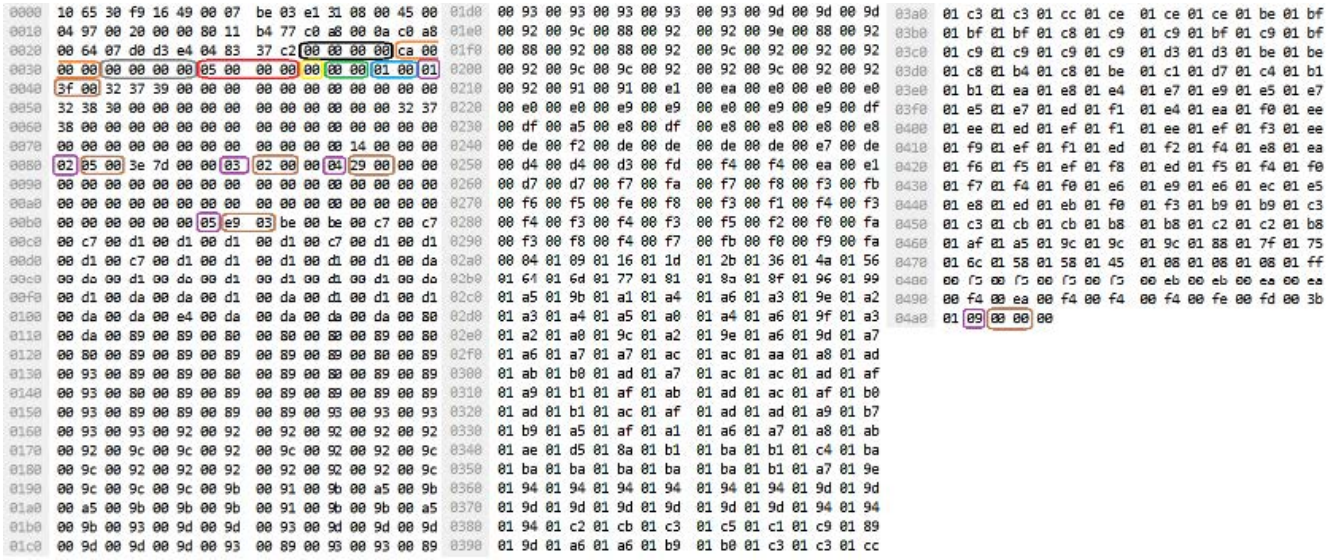
Master Frame 1



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	Device status	Little endian	
Orange	Operation code	Little endian	In this example, the operation code of 0xCA identifies a monitoring frame command
Gray	Working mode		
Red	Transaction type	Little endian	In this example, the transaction type is 5
Yellow	Scanner ID		Master is equal to zero
Green	From theta	Little endian	Start angle of this frame
Blue	Resolution	Little endian	
Purple	Header ID		See "Header and Payload on page 25 for the list of IDs and data requested.
Brown	Payload length (+1) in bytes of the corresponding ID	Little endian	In this example, this field is 0x3F = 63. This means that 63 must be added to the current position to move to the start of the next header ID.

The frame format does not change between zones, but the values can. In particular, ‘From Theta’ values change according to the start angle value of the relevant frame.

- Hex 0×0000 (decimal 0) for the first frame
- Hex 0×01F4 (decimal 500) for the second frame
- Hex 0×03E8 (decimal 1000) for the third frame
- Hex 0×05DC (decimal 1500) for the fourth frame
- Hex 0×07D0 (decimal 2000) for the fifth frame
- Hex 0×09C4 (decimal 2500) for the sixth frame

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Header and Payload

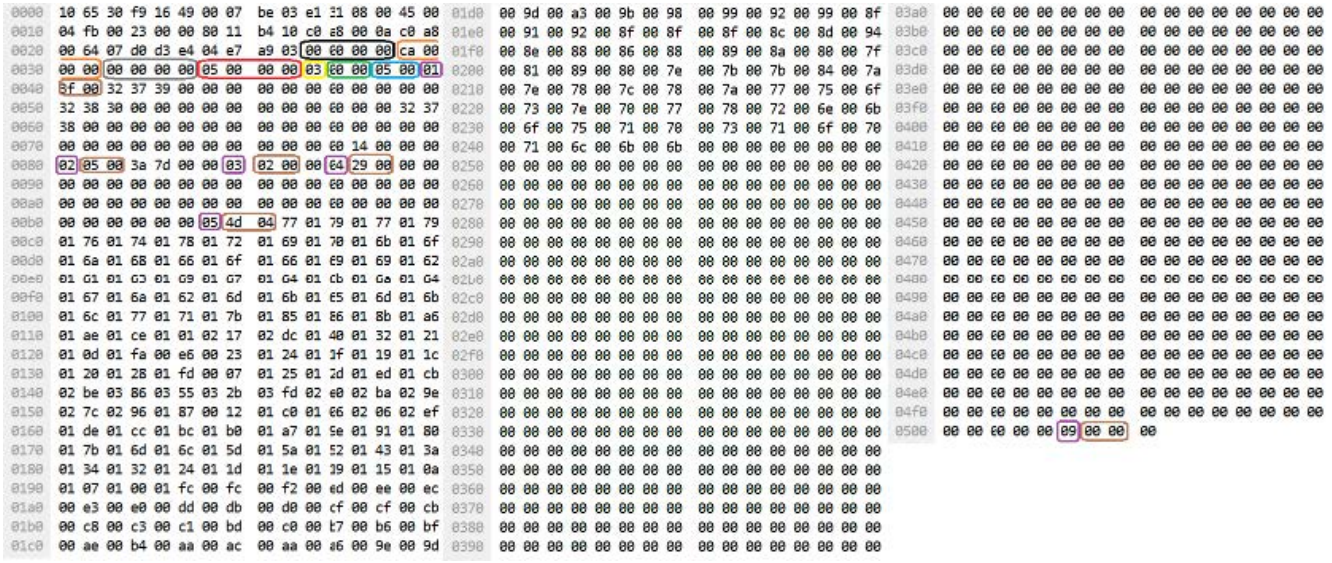
Header Value	Description	Payload Length
0×01	I/O data	0x003F
0×02	Scan counter	0x0005
0×03	Zone set	0x0002
0×04	Diagnostics	0x0029
0×05	Measures	0x039E
0×09	End of frame	0x0000

Monitoring frame from Remote Scanner

Differing from the Master, a Remote scanner does not divide its 275° into six zones, but it can send all 275° of values through a single frame. The maximum resolution it can support is 0.5 degrees, which is why a single frame for each scan is enough to send all the data.

The following figure shows the frame of a Remote Scanner:

Remote 3 Frame



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	Device status	Little endian	
Orange	Operation code	Little endian	In this example, the operation code of 0xCA identifies a monitoring frame command
Gray	Working mode		
Red	Transaction type	Little endian	

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Continued from page 25

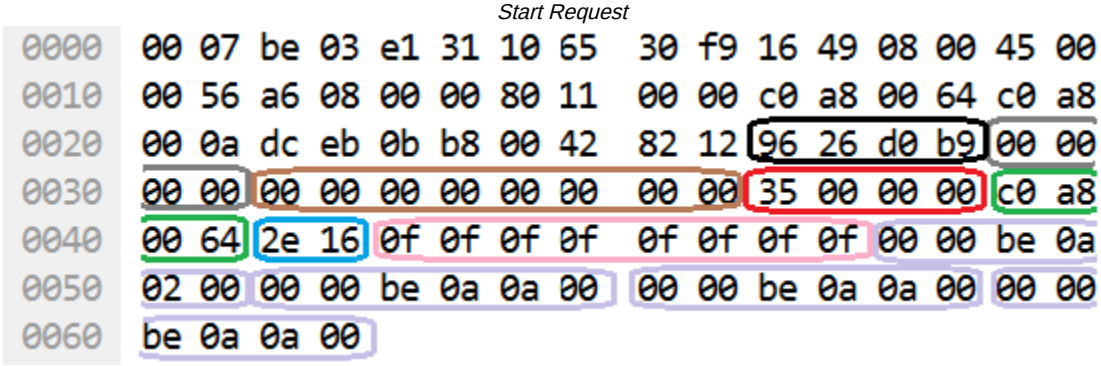
Color	Description	Format	Additional Information
Yellow	Scanner ID		Master is equal to zero • First Remote equal to one • Second Remote equal to two • Third remote equal to three
Green	From theta	Little endian	Start angle of this frame
Blue	Resolution	Little endian	
Purple	Header ID		The data transferred is the same as the Master scanner, see "Header and Payload on page 25 for the list of IDs and data requested
Brown	Payload length of the corresponding ID	Little endian	

Full Angle Monitoring

Start Request

The following figure shows a customer start command request.

Start Request



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	CRC of the command	Little endian	
Gray	Sequence number	Little endian	
Brown	*reserved*	Empty/all zeros	
Red	Operation code	Little endian	
Green	IP address of the receiver client	Big endian	
Blue	Port number	Big endian	
Pink	Enabled bit		In this case all data types are enabled on four devices

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Continued from page 26

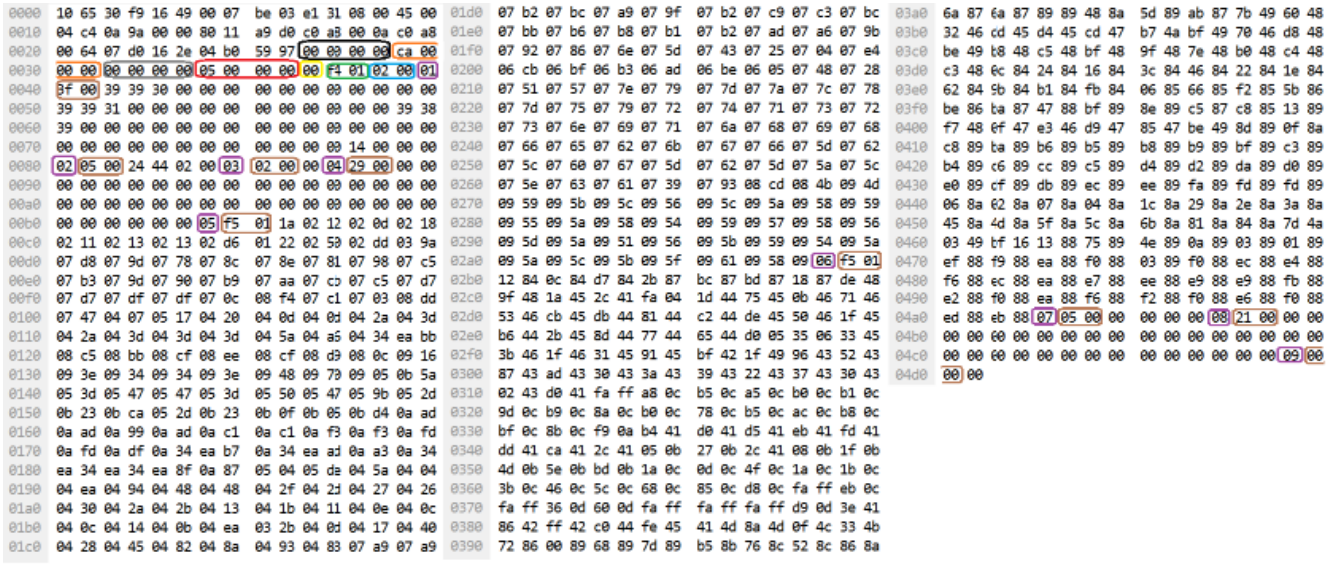
Color	Description	Format	Additional Information
Purple	Each slot represents the start angle, stop angle, and resolution for each scanner.	Each value is 2-bytes long and expressed in tenth of a degree: • Master (first slot): start angle is 0, stop angle is 2750 (0x0ABE), resolution is 2 • Remotes (second, third, and fourth slots): start angle is 0, stop angle is 2750, resolution is 10	

The start command response is the same as the one described in "Start Reply" on page 23.

Monitoring Frame Created by the Master Scanner

The following figure shows the Master frame for the second zone (50° to 100°).

Master Frame 2



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	Device status	Little endian	
Orange	Operation code	Little endian	
Gray	Working mode		
Red	Transaction type	Little endian	
Yellow	Scanner ID		Master is equal to zero
Green	From theta	Little endian	Start angle of this frame, 0x01F4 equals 500
Blue	Resolution (0×02)	Little endian	
Purple	Header ID		See "Header and Payload on page 28 for the list of IDs and data requested

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Continued from page 27

Color	Description	Format	Additional Information
Brown	Payload length of the corresponding ID	Little endian	

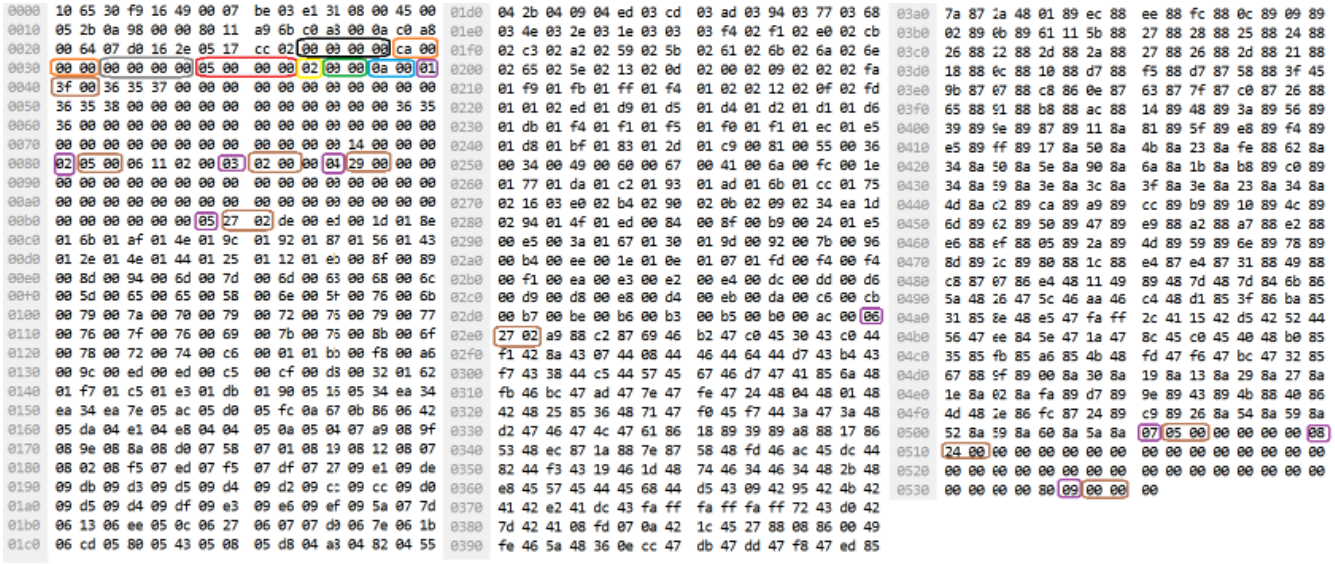
Header and Payload

Header Value	Description	Payload Length
0×01	I/O data	0x003F
0×02	Scan counter	0x0005
0×03	Zone set	0x0002
0×04	Diagnostics	0x0029
0×05	Measures	0x01F5
0×06	Intensity	0x01F5
0×07	Encoder	0x0005
0×08	Point in safety	0x0021
0×09	End of frame	0x0000

Monitoring frame from Remote Scanner

The following figure shows the Remote frame.

Remote 3 Frame



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	Device status	Little endian	
Orange	Operation code	Little endian	
Gray	Working mode		
Red	Transaction type	Little endian	

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Color	Description	Format	Additional Information
Yellow	Scanner ID		In this case the second Remote has a value equal to 0x02
Green	From theta	Little endian	Start angle is equal to 0x00
Blue	Resolution (0x0A)	Little endian	
Purple	Header ID		The data transferred is the same as the Master scanner, see "Header and Payload on page 28 for the list of IDs and data requested
Brown	Payload length of the corresponding ID	Little endian	

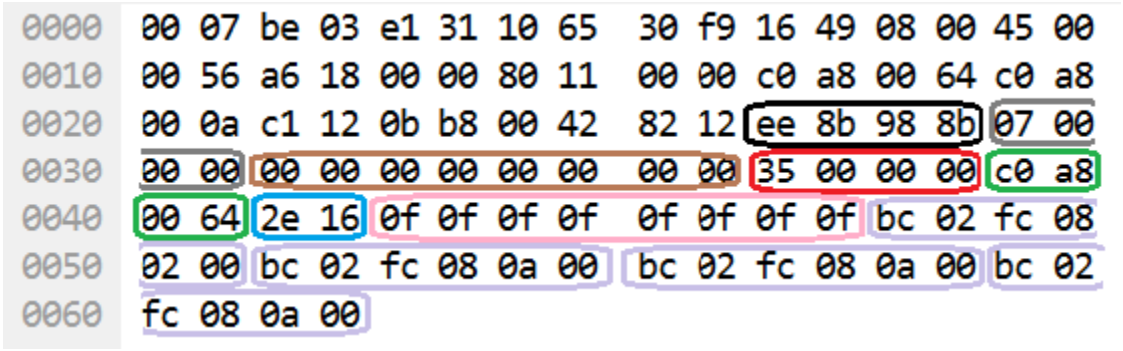
Partial Angle Monitoring

It is possible to request not only full angle data, but also partial angle data. In this example, the monitoring data request of the range 70° to 230° is analyzed.

Start Request Customer Command

The following figure shows a customer start command request.

Start Request



The colors used in the figure mean the following:

Color	Description	Format	Additional Information
Black	CRC of the command	Little endian	
Gray	Sequence number	Little endian	
Brown	*reserved*	Empty/all zeros	
Red	Operation code	Little endian	
Green	IP address of the receiver client	Big endian	
Blue	Port number	Big endian	
Pink	Enabled bit		In this case all data types are enabled on four devices

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Color	Description	Format	Additional Information
Purple	Each slot represents the start angle, stop angle, and resolution for each scanner.	Each value is 2-bytes long and expressed in tenth of a degree: • Master (first slot): start angle is 700, stop angle is 2300, resolution is 2 • Remotes (second, third, and fourth slots): start angle is 700, stop angle is 2300, resolution is 10.	

Monitoring Frame created by the Master Scanner

In this case, the Master frame is received as in "Master Frame Content on page 30: the first and last frames are outside the angel range requested and all header IDs are present except for the payload of measure related data (measure, intensity and point in safety), for which the header ID length is equal to one.

The second and fifth frames contain measure related data of only a part of the sector.

The third and fourth frames contain measure data of the entire sector.

Master Frame Content

Frame Number	I/O Pin	Scan Counter	Zone Set	Diagnostics	Measure	Intensity	Encoder	Point in Safety
1	x	x	x	x			x	
2	x	x	x	x	x	x	x	x
3	x	x	x	x	x	x	x	x
4	x	x	x	x	x	x	x	x
5	x	x	x	x	x	x	x	x
6	x	x	x	x			x	

The following two figures show the Master frame for the first (0° – 50°) and sixth (250° – 275°) frames. The behavior described above is observed (only header ID highlighted in purple).

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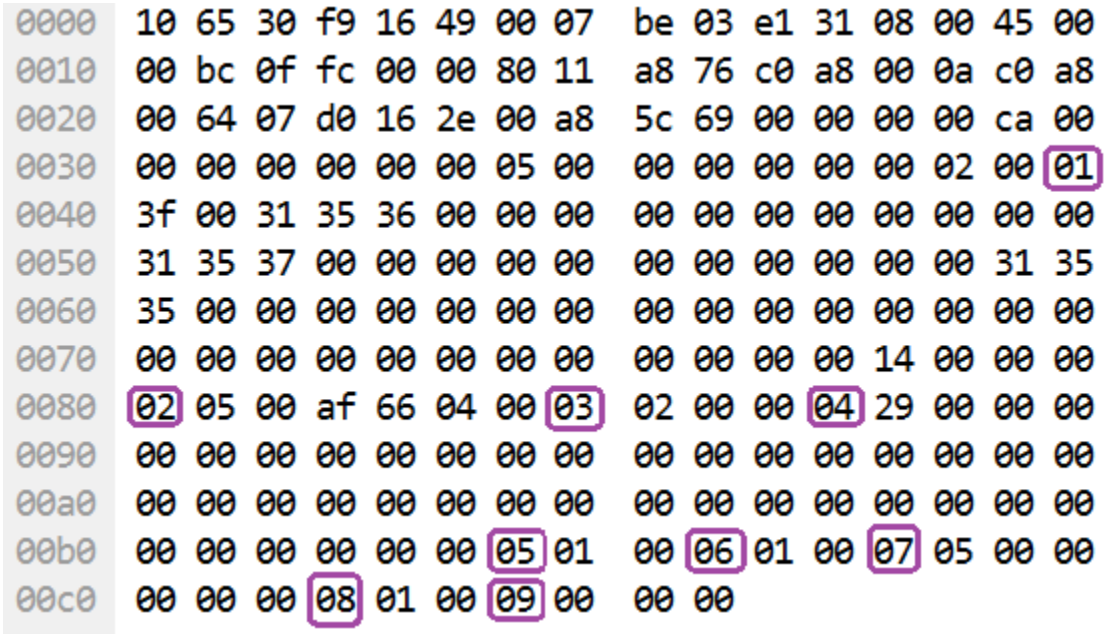
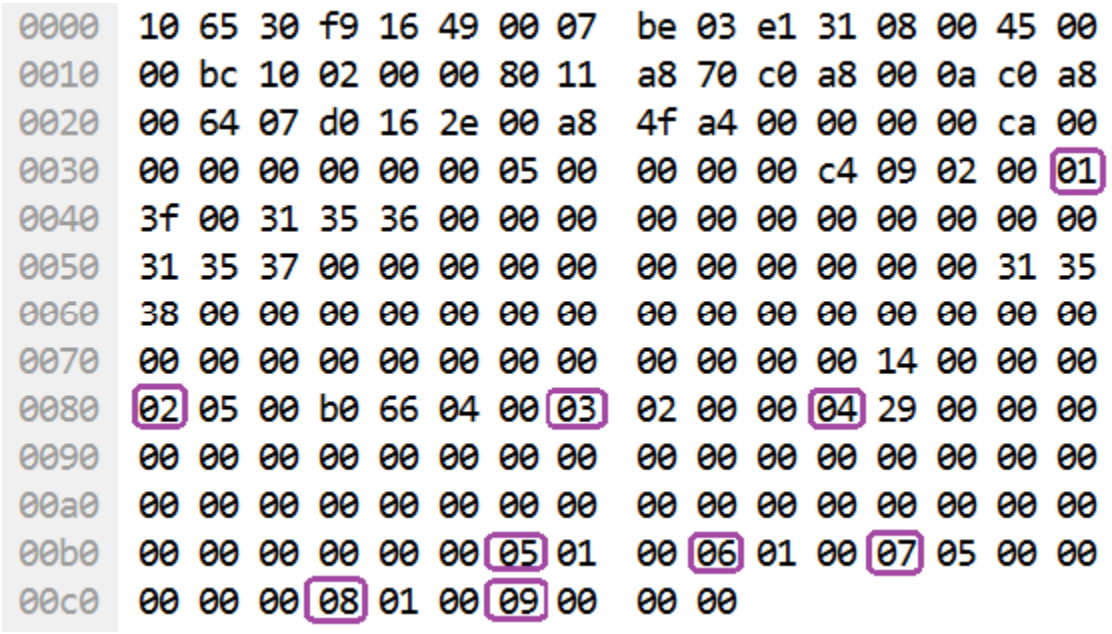
Master Frame 1



Master Frame 6



The following figure shows the second frame (50°–100°), where the data requested corresponds to a part of the sector. The start angle is not 500, but 700.

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Master Frame 2

```
0000  10 65 30 f9 16 49 00 07  be 03 e1 31 08 00 45 00
0010  03 27 0f fd 00 00 80 11  a6 0a c0 a8 00 0a c0 a8
0020  00 64 07 d0 16 2e 03 13  06 b4 00 00 00 00 ca 00
0030  00 00 00 00 00 00 05 00  00 00 00 bc 02 02 00 01
0040  3f 00 31 35 36 00 00 00  00 00 00 00 00 00 00 00
0050  31 35 37 00 00 00 00 00  00 00 00 00 00 00 31 35
0060  35 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0070  00 00 00 00 00 00 00 00  00 00 00 00 14 00 00 00
0080  02 05 00 af 66 04 00 03  02 00 00 04 29 00 00 00
0090  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00a0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00b0  00 00 00 00 00 00 05 2d  01 34 ea 34 ea 7b 0a c1
00c0  0a 17 05 d4 04 63 04 ea  04 0d 04 94 04 48 04 35
00d0  04 2e 04 2a 04 23 04 23  04 31 04 2b 04 27 04 10
00e0  04 22 04 11 04 0e 04 06  04 0c 04 0c 04 f8 03 e1
00f0  03 22 04 04 04 17 04 35  04 1e 04 28 04 78 04 8f
0100  04 93 04 fc 06 b2 07 9f  07 b2 07 b2 07 a9 07 a9
0110  07 a9 07 9f 07 c3 07 bf  07 bc 07 b9 07 bd 07 ba
0120  07 b4 07 aa 07 a3 07 99  07 91 07 80 07 76 07 62
0130  07 4b 07 1f 07 04 07 e5  06 d0 06 c2 06 bc 06 b4
0140  06 ab 06 df 06 3e 07 28  07 51 07 6b 07 7f 07 7c
0150  07 7e 07 79 07 7b 07 7a  07 74 07 77 07 71 07 75
0160  07 6f 07 6e 07 65 07 6e  07 6f 07 6e 07 6f 07 6a
0170  07 6b 07 63 07 68 07 67  07 66 07 61 07 67 07 62
0180  07 5e 07 65 07 5f 07 5a  07 60 07 5f 07 60 07 5d
0190  07 61 07 58 07 62 07 5c  07 5d 07 58 07 5d 07 13
01a0  07 76 08 ae 08 2a 09 48  09 57 09 57 09 59 09 59
01b0  09 57 09 57 09 5a 09 5b  09 55 09 58 09 53 09 58
01c0  09 59 09 5b 09 55 09 51  09 5a 09 50 09 59 09 59
01d0  09 59 09 56 09 59 09 55  09 51 09 5d 09 5f 09 62
01e0  09 5c 09 5d 09 06 2d 01  fa ff fa ff d7 0d 87 0d
01f0  55 42 05 43 9c 44 42 4d  14 46 7b 4d 45 4c 70 4b
0200  37 86 df 88 9b 89 7a 89  68 8b 81 8c 6b 8c ca 8a
0210  71 87 1c 87 57 89 5b 8a  87 89 d3 87 9b 49 83 48
0220  5c 46 dc 45 dc 45 20 47  c6 4a 26 4a 7b 46 d3 48
0230  a0 49 2c 49 c5 48 d0 48  9e 48 90 48 b8 48 d1 48
0240  ce 48 cd 48 11 84 27 84  09 84 29 84 2a 84 16 84
0250  44 84 8e 84 8e 84 d9 84  03 85 62 85 dd 85 48 86
0260  88 86 c3 87 3a 88 b9 89  8e 89 15 88 19 85 27 89
0270  63 49 52 47 e9 46 e3 47  63 47 3a 49 5d 89 09 8a
0280  b6 89 b1 89 b8 89 ad 89  b4 89 bf 89 b0 89 b4 89
0290  b7 89 cb 89 cf 89 c4 89  ce 89 d0 89 ce 89 cd 89
02a0  d3 89 e7 89 e4 89 e0 89  ec 89 fa 89 f1 89 f5 89
02b0  fc 89 ff 89 08 8a 04 8a  1d 8a 21 8a 25 8a 3f 8a
02c0  48 8a 54 8a 4d 8a 59 8a  65 8a 82 8a 8e 8a 4d 4b
02d0  0a 49 6e 16 af 14 54 89  5f 89 17 89 fc 88 f9 88
02e0  f9 88 e9 88 ea 88 ee 88  ef 88 f1 88 ec 88 eb 88
02f0  f2 88 e7 88 e2 88 f9 88  ef 88 ed 88 f0 88 ec 88
0300  ee 88 ed 88 dd 88 f1 88  fe 88 e6 88 e8 88 e7 88
0310  e4 88 eb 88 07 05 00 00  00 00 00 08 14 00 00 00
0320  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0330  00 09 00 00 00
```


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Monitoring frame from the Remote Scanner

The following figure shows the Remote 1 frame. The start angle is not zero but 700.

Remote 1 Frame

```
0000  10 65 30 f9 16 49 00 07  be 03 e1 31 08 00 45 00
0010  03 50 10 04 00 00 80 11  a5 da c0 a8 00 0a c0 a8
0020  00 64 07 d0 16 2e 03 3c  93 0f 00 00 00 00 ca 00
0030  00 00 00 00 00 00 05 00  00 00 01 bc 02 0a 00 01
0040  3f 00 31 35 39 00 00 00  00 00 00 00 00 00 00 00
0050  31 35 37 00 00 00 00 00  00 00 00 00 00 00 31 35
0060  38 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0070  00 00 00 00 00 00 00 00  00 00 00 00 14 00 00 00
0080  02 05 00 93 66 04 00 03  02 00 00 04 29 00 00 00
0090  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00a0  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
00b0  00 00 00 00 00 00 05 41  01 34 ea 34 ea 34 ea cf
00c0  00 4b 01 59 00 61 00 14  01 bf 01 34 ea 34 ea 61
00d0  08 92 08 f9 01 8d 01 09  01 2a 01 34 07 08 07 23
00e0  08 d6 07 d3 07 c5 07 c6  07 b8 07 b6 07 b1 07 f7
00f0  07 9a 09 a9 09 ac 09 aa  09 a4 09 b2 09 a6 09 a5
0100  09 ab 09 ae 09 b2 09 b9  09 bd 09 c8 09 cc 09 d1
0110  09 dc 09 da 09 9c 06 62  06 1d 06 e9 05 0a 06 14
0120  06 f2 06 b1 06 70 06 22  06 e9 05 aa 05 6f 05 42
0130  05 20 05 f4 04 d1 04 b0  04 8c 04 6b 04 50 04 45
0140  04 19 04 ff 03 ef 03 cd  03 b6 03 a6 03 9b 03 7f
0150  03 6e 03 65 03 51 03 3e  03 33 03 25 03 26 03 1a
0160  03 0a 03 08 03 b5 02 a9  02 ad 02 b7 02 c9 02 ca
0170  02 c1 02 bc 02 86 02 7f  02 7a 02 6f 02 70 02 6c
0180  02 67 02 68 02 60 02 80  02 78 02 79 02 6f 02 75
0190  02 64 02 4b 02 4a 02 4a  02 45 02 4a 02 51 02 67
01a0  02 69 02 68 02 6e 02 6d  02 70 02 71 02 70 02 74
01b0  02 71 02 76 02 7c 02 fc  01 ef 01 f3 01 87 02 0f
01c0  02 c2 01 2e 01 cb 00 9a  00 cc 00 c2 00 c3 00 fe
01d0  00 d7 00 7f 01 36 ea 36  ea e1 01 ba 01 a6 01 b0
01e0  01 09 02 34 ea 34 ea 34  ea 34 ea 34 ea ed 01 30
01f0  01 e2 00 d8 00 dc 00 86  00 06 41 01 fa ff fa ff
0200  fa ff 21 44 96 42 5a 44  a0 44 83 43 50 41 fa ff
0210  fa ff 19 04 c8 03 2c 41  ee 41 63 43 0e 43 9c 88
0220  9b 47 dd 47 b6 88 e9 88  04 89 26 89 4a 89 5f 89
0230  8a 89 5a 48 81 88 9e 88  95 88 92 88 8f 88 97 88
0240  88 88 94 88 96 88 89 88  8e 88 89 88 78 88 7d 88
0250  66 88 63 88 68 88 5d 88  7c 88 1a 86 61 86 5a 88
0260  40 46 61 88 a8 87 f7 86  12 87 69 87 9f 87 d2 87
0270  fe 87 3b 88 72 88 94 88  a6 88 b7 88 06 89 57 89
0280  6d 89 ea 85 2f 89 4f 89  93 89 98 89 57 89 ec 89
0290  47 89 4b 89 c3 89 e0 89  9c 89 02 8a 0a 8a 1e 8a
02a0  5b 8a 4b 8a 0b 8a d6 89  51 89 4f 8a ef 89 29 8a
02b0  7d 8a 82 8a 42 8a f5 89  e6 89 45 8a 54 8a 55 8a
02c0  56 8a 47 8a 2c 8a 48 8a  49 8a 8f 89 e8 89 b6 89
02d0  e6 89 e4 89 8b 89 8c 89  ba 89 c5 89 d5 89 d4 89
02e0  87 89 68 89 f0 89 02 8a  f6 89 f1 89 f5 89 ea 89
02f0  ea 89 c7 89 77 89 a6 88  0e 87 74 48 7c 47 7e 48
0300  c9 85 7b 48 0a 46 f6 45  1e 46 69 46 fa 44 ac 44
0310  e6 44 f0 43 e6 43 b6 41  65 03 40 02 2c 41 2c 41
0320  49 41 2f 41 2c 41 fa ff  fa ff fa ff fa ff fa ff
0330  2c 41 ef 42 81 44 06 46  e2 47 5e 48 07 05 00 00
0340  00 00 00 08 15 00 00 00  00 00 00 04 70 ee 07 00
0350  00 00 00 00 00 00 00 00  00 00 09 00 00 00
```


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Chapter Contents

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