

## DSI-STREAMER DATA OUTPUT SOCKET

The DSI-Streamer application can optionally open an output socket that streams the sensors' data. When this feature is active, DSI-Streamer opens port 8844 as a server and listens for connections. When a client connects to the socket, DSI-Streamer:

- sends a greeting packet,

When the TCP/IP **Start** streaming button is pressed, DSI-Streamer:

- sends montage packet(s),
- sends a data rate packet,
- sends a start data packet.
- Begins streaming data if the sensors are running.

As events occur, the appropriate event packet is sent. The greeting, montage, data rate, start data, and stop data packets are all event type packets. The byte structure of the packets is described in the following sections.

### 1. PACKET STRUCTURE

All packets have the same header structure. The purpose of the header is to have a delimiter to define the beginning of the packet and to define the packet type, length of the packet and the packet number. The header consists of 12 bytes. The packet data follows the header.

All numeric data is in **big-endian format**, both for unsigned integers and floating point numbers.

The “Byte Offset” indicates the byte number in the packet where the given packet element starts. Notice that the Packet Start element begins at byte offset = 0 and is 5 bytes long. That means that the Packet Start element is the first 5 bytes of the packet. Also notice that the byte offset plus the element length is the byte offset of the next element.

	Field	Byte Offset	Element Length	Data Type	Description
Header	Packet Start	0	5 bytes	ASCII	All packets start with “@ABCD “
	Packet Type	5	1 byte	Unsigned Integer	1 EEG Sensor Data 2-4 Reserved 5 Event
	Packet Length	6	2 bytes	Unsigned Integer	Number of bytes in the packet after the header.
	Packet Number	8	4 bytes	Unsigned Integer	The packet number starts at 0. The server increments for every packet it sends.
	Data	12	Packet Length number of bytes	Depends on Packet Type	Packet payload

## 2. EVENT PACKETS

Event packets, like all other packets start with the 12 byte header that is described in the proceeding section. An event packet will be identified by having a value of 5 in the packet type byte (fifth byte) of the packet header. The first 8 bytes of an event packet data section describe the event type and the sending node. If there is a message included with the event, it will be included as an ASCII string following the 8 byte event description.

Field	Byte Offset	Element Length	Data Type	Description
Header	0	12 bytes	Mixed	Described in previous section
Event Code	12	4 bytes	Unsigned Integer	See table below
Sending Node	16	4 bytes	Unsigned Integer	0 Not applicable 1 Headset node
Length of Message	20	4 bytes	Unsigned Integer	The number of bytes in the string. This element will only be present if there is a message attached.
Message	24	Variable	ASCII	The message is optional, not all events have messages.

### 2.1 Event Codes

The following table describes the meaning of the event codes. The “Status” column indicates the implementation status, NI indicates that the event code is not implemented.

Code	Event	Description	Message
1	Greeting/Version	Server's version and id info.	DSI-Streamer Version: x.y
2	Data start	Data acquisition started on a node	No message
3	Data stop	Data acquisition stopped on a node	No message
4	Reserved		
5	Reserved		
6	Reserved		
7	Reserved		
8	Reserved		
9	Sensor Map	Send a node's sensor list.	Comma delimited list of sensors connected to the node. Disconnected sensors are named '-'. NI
10	Data Rate	Send user's mains frequency (50 or 60 Hz) and sensor sampling frequency (300, 600, or 900 Hz)	Message contains mains frequency and sampling frequency

### 3. EEG SENSOR DATA PACKET

The data section of the EEG sensor packets starts with a timestamp and an ADC status indicator followed by EEG data, typically 25 channels, with Trigger data (TRG) being sent as Ch25.

Field	Byte Offset	Element Length	Data Type	Description
Header	0	12 bytes	Mixed	Described in previous section
Timestamp	12	4 bytes	Float	Timestamp of the data point
Data Counter	16	1 byte	Unsigned Integer	Data packet counter from the node <i>(currently produces 0's only)</i>
ADC Status	17	6 bytes	Unsigned Integer	2-bits per channel: 00 = off, 01 = OK, 10 = rail low, 11 = rail high <i>(currently produces sample data)</i>
Ch1 Data	23	4 bytes	Float	EEG sensor data in uV
Ch2 Data	27	4 bytes	Float	EEG sensor data in uV
...	...	4 bytes	Float	EEG sensor data in uV
ChN Data	$4*(Nch-1) + 23$	4 bytes	Float	EEG sensor data in uV
ChN+1	$4*Nch + 23$	4 bytes	Float	Trigger Value (0 or 1)

## 4. ACCELEROMETER PACKET

Packets that contain accelerometer data are interleaved with EEG data packets. It has a header described in section 1 with the packet type equal to **130**. The data length is the same as for EEG (111 bytes). The packet structure is listed in the following section:

Field	Length (bytes)	Data Type	Description
Header	12 bytes	Mixed	Described in section 1
ADC sequence	1 byte	Byte	0..255 sequential numbers assigned by a digitizer. Can be used to verify data continuity.
Array of Data	48 bytes	Array [1..3] of accelerometer data	Three accelerometer readings each of which contains time and three values in “g” units.
reserved	62 bytes	Array of bytes	The elements of the array are set to zero. Their purpose is make the length of the accelerometer packet same as the length of the EEG packet.

The Array of Data has three elements each of them consists of

Field	Length (bytes)	Type	Description
Time	4	Floated	Time of measurements (seconds)
X-component of acceleration	4	Floated	
Y-component of acceleration	4	Floated	
Z-component of acceleration	4	Floated	

All these fields are floated 4-byte numbers sent in the big-endian format.

## 5. START/STOP COMMANDS

The purpose of Start and Stop commands is to monitor through socket recording of data to hard drive. Do not confuse with Start/Stop of the TCP/IP session.

The Start/Stop Commands option was implemented in dsi-streamer v.1.08.44 released on 08/16/2018.

The packets have a header described in the section 1 with the packet type equal to **5**. The header is followed by an **event** field that defines the command and **node** that defines sender but not used now. Both event and node fields are unsigned 4 bytes integers.

When Client received a packet, Server of dsi-streamer returns the index of the event and confirmation message.

The packets received by Client of DSI-Streamer are:

*Set Up File for Data Recording:*

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 5. The length depends on the Length of the File Name.
Event Code	4	Unsigned integer	Event code = 15
Node code	4	Unsigned integer	Node Code = 1
Record format	1	Byte	Currently not used. A file in binary dsi format will be created. Conversion to csv and edf formats depends on settings of dsi-streamer
Length of the File Name	2	Unsigned integer	the length of the file name for data recording
File Name	Not defined	Array of Char	File name for data recording is an array of characters. The length is defined by the Length of the File Name parameter. The 1 <sup>st</sup> byte is the 1 <sup>st</sup> character of the string.

*Start Data Recording*

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 5. The length is not used.
Event Code	4	Unsigned integer	Event code = 16
Node code	4	Unsigned integer	Node Code = 1

Record on trigger	1	Byte	If non-zero, it sets the trigger value at raising edge of which data recording starts. If the field is zero, data recording starts immediately
Limit of data recording	4	Unsigned integer	If non-zero, it sets the duration of data recording in seconds after which data recording stops. If zero, there is no time limitation for data recording.

## *Stop Data Recording*

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 5. The length is not used.
Event Code	4	Unsigned integer	Event code = 3
Node code	4	Unsigned integer	Node Code = 1

The structure of the confirmation packet is

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type is 6. The length is 111.
Event Code	4	Unsigned integer	Event code is the same as for the confirmed command.
Node code	4	Unsigned integer	Node Code = 1
Subtype	1	Byte	Not used but can be used for extension of the packet type.
Message	102	Array of Char	Confirmation message depends on the event code. Elements of array that are not used are set to zero.

A message consists of the following fields:

- “Data Recording Stopped” for event =3; “File setup received” for event =15; “Data Recording Started” for event = 16
- “@ t= <time of the message: 10 characters> sec”
- Extra information that is File Name for event = 15 or “@trig = <trigger value> Trec: <Time of recording in integer format> sec”. If recording is not synchronized with trigger or there is no time limitation for recording, the corresponding fields are skipped.

## 6. FNIR PACKET

TCP/IP transfer of fNIR data is available only for DSI-Streamer that supports the fNIR/EEG Headset.

In addition to packets sent in the beginning of TCP/IP session for EEG packets, there are fNIR Montage, fNIR Header, EEG Header, and fNIR Mains packets. fNIR data stream is interleaved with EEG data.

All fNIR packets have header described in section 1 with packet type **105**.

- Structurer is the same as for the EEG Montage packet with fNIR pods listed instead of EEG sensors. The event code is 9 and the node is 1
- EEG header transfers information same as header of EEG csv file however this option is not implemented in the conventional non-fNIR branch of DSI-Streamer. Structure of the EEG Header packet:

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 5 and length = 75
Event Code	4	Unsigned integer	Event code = 12
Node code	4	Unsigned integer	Node Code = 1
HS_name_L	1	Byte	Length of headset name (=16)
HS_name	16	Array [0..15] of Char	Name of headset (“DSI-FNIR”) with zero filled beyond that.
Data_Units_L	1	Byte	Length of data units array (=4)
Data_Units	4	Array [0..3] of Char	“uV “
Filt_Descript_L	1	Byte	Length of filter description (=16)
Filt_Descript	16	Array [0..15] of Char	“Non-Filtered” followed by zeros.
Filt_Delay_L	1	Byte	Length of the Filter Delay Field
Filt_Delay	8	Floated 8 byte	Delay of EEG filter in data points (=16)
Ref_L	1	Byte	Length of the reference location field
Ref	16	Array [0..15] of Char	Reference location, e.g., “Pz”
ADC_st_mask_L	1	Byte	Not used
ADC_st_mask	1	Byte	Not used

- fNIR Header packet has same structure with the following differences in the highlighted fields
  - **Header:** packet type is **105** and packet length is **90**.
  - **Data Units:** “uM “
  - Instead of **ADC\_st\_mask\_L** and **ADC\_st\_mask** there are
    - **EmitterArr\_L** – 1Byte – the length of the array of active emitters (=16)
    - **EmitterArr** - array [1..2, 1..8] of bytes – indices of emitter1 and emitter2 in pods ([1111111144444444] by default).
- fNIR Mains packet has the same structure as EEG Mains packet but different packet type and sample rate:

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 5 for EEG and 105 for fNIR. The length is 28.
Event Code	4	Unsigned integer	Event code = 10
Node code	4	Unsigned integer	Node Code = 1
String Length	4	Unsigned integer	Length of message (=16)
Gr	6	Array [0..15] of Char	Mains ('50' or '60') and sampling rate ('300' for EEG and fNIR sample rate for fNIR)

The order of sending te starting packets are:

1. Greeting
2. EEG Montage
3. fNIR Montage
4. EEG Header
5. fNIR Header
6. Mains
7. fNIR Mains
8. Start.



## 6.1 fNIR Data Packet

fNIR Data Packets are interleaved with EEG Data Packets. They have the following structure:

Field	Length (bytes)	Type	Description
Header	12	Mixed	See section 1 with packet type = 101. The length is 111.
Time	4	Floated	Time of the packet in seconds
SeqNum	1	Byte	Sequence number (0..255) of ADC
Pod Number	1	Byte	The number of fNIR pod (1..8)
data	102	Array[1..2,1..3] of OxiDeOxi record.	Oxi/DeOxi output for two emitters at three wavelengths (760, 810, and 850nm).
reserved	3	Array [0..2] of Byte	Reserved. Used to make the same data length as for EEG packet.

The OxiDeOxi record has the following structure:

Field	Length (bytes)	Type	Description
Oxi	8	Floated	Concentration of oxygenized blood (uM)
DeOxi	8	Floated	Concentration of deoxygenized blood (uM)
QoD	1	Byte	Quality of Data: 1: data is good, 0: no data <0: data is not valid.