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SyncStation

TCP Communication Protocol v2.8

for SyncStation Firmware version 2.18 or higher

This document describes the protocol used during the communication between the PC and the SyncStation, SyncStation+, SyncSationX. For details about communication with a single muovi, muovi+, due+, sessantaquattro or sessantaquattro+, check the related document.

After the SyncStation has completed the initialization phase, it opens a TCP socket accessible from the ethernet connection on port 54320. The connection can be established with direct connection between a PC and the SyncStation using a standard ethernet cable. The IP address of SyncStation is fixed and is 192.168.76.1.

Once connected to the TCP socket, commands and data can be exchanged between the PC and the SyncStation. The commands to start data transfer and configure the wireless devices is a message string including the number of bytes in the message and a CRC8. The message sting can be of two types: StartStop Command, OptSettings Command.

The StartStop Command is structured as:

START BYTE A (with bit 7 = 0)

CONTROL BYTE1: config muovi probe n.1 (opt)

CONTROL BYTE2: config muovi probe n.2 (opt)

CONTROL BYTE3: config muovi probe n.3 (opt)

CONTROL BYTE4: config muovi probe n.4 (opt)

CONTROL BYTE5: config muovi+/sessantaquattro/sessantaquattro+ n.1 (opt)

CONTROL BYTE6: config muovi+/sessantaquattro/sessantaquattro+ n.2 (opt)

CONTROL BYTE7: config due+ probe n.1 (opt)

CONTROL BYTE8: config due+ probe n.2 (opt)

CONTROL BYTE9: config due+ probe n.3 (opt)

CONTROL BYTE10: config due+ probe n.4 (opt)

CONTROL BYTE11: config due+ probe n.5 (opt)

CONTROL BYTE12: config due+ probe n.6 (opt)

CONTROL BYTE13: config due+ probe n.7 (opt)

CONTROL BYTE14: config due+ probe n.8 (opt)

CONTROL BYTE15: config due+ probe n.9 (opt)

CONTROL BYTE16: config due+ probe n.10 (opt)

CRC8

The OptSettings Command is structured as:

START BYTE B (with bit 7 = 1)

OPTION BYTE1: set the waiting time for the SyncStation (opt)

OPTION BYTE2: to be defined (opt)

OPTION BYTE3: to be defined (opt)

OPTION BYTE4: to be defined (opt)

CRC8

The START BYTE A and START BYTE B differs for the most significant bit who is equal to 0 in the START BYTE A and is equal to 1 in the START BYTE B by determining the type of command, respectively StartStop Command and the OptSettings Command. The option command is accepted only if the data transfer is not active.

The description of the two bytes follows:

START BYTE A

0	REC_ON	SIZE4	SIZE3	SIZE2	SIZE1	SIZE0	GO/STOP

bit 6 **REC_ON:** Recording is in progress

1 = the PC is recording the signals received by the SyncStation. When triggered, this bit reset the internal timer for the ramp counter sent on the Accessory Ch2 and start the log of the timestamps on the internal timestamps.log file.

0 = the PC is not recording the received signals from SyncStation. If the Timestapms.log is closed if it was previously opened.

bit 5-1 **SIZE<4:0>:** Size of the command string. The value set with these 5 bits indicates how many CONTROL BYTES follows. The value can range from 1 to 16, it doesn't include the CRC8 byte terminating the command string who must always be in the configuration string

bit 0 **GO/STOP:** Starts/stops the data transfer on the TCP socket

1 = start data transfer of Auxiliary, Accessory and signals channels from muovi probes with EN bit = 1

0 = stop data transfer on the TCP socket

START BYTE B

1	0	SIZE4	SIZE3	SIZE2	SIZE1	SIZE0	0

bit 5-1 **SIZE<4:0>:** Size of the command string. The value set with these 5 bits indicates how many OPTION BYTES follows. The value can range from 0 to 4, it doesn't include the CRC8 byte terminating the command string who must always be in the configuration string. If the SIZE is 0 the command represents a request of firmware version who is provided by the SyncStation as plain text.

The CONTROL BYTEs set the muovi, muovi+, due+, sessantaquattro or sessantaquattro+ detection mode, sampling frequency, and enable/disable the data transfer. The presence of a CONTROL BYTE in the configuration string is used by the SyncStation to compute the amount of data transferred to the PC regardless of the single EN bits in the different CONTROL BYTEs.

The OPTION BYTEs set specific parameters of the SyncStation. The sequence of the CONTROL BYTEs determines the parameter to set.

The CRC8 must be always present. It is obtained as CRC calculation on 8 bits on previous bytes of the command string.

CONTROL BYTEX:

DEV3	DEV2	DEV1	DEV0	EMG/EEG	MODE1	MODE0	EN

bit 7-4 **DEV<3:0>:** Probe number

0101 = The command set the configuration of muovi+/sessantaquattro(+) 2

0100 = The command set the configuration of muovi+/sessantaquattro(+) 1

0011 = The command set the configuration of muovi probe 4

0010 = The command set the configuration of muovi probe 3

0001 = The command set the configuration of muovi probe 2

0000 = The command set the configuration of muovi probe 1

bit 4 **EMG/EEG:** Working mode

1 = EMG Mode Fsamp 2000 Hz, high pass filter at 10 Hz(1), 16 bit resolution

0 = EEG Mode Fsamp 500 Hz, DC coupled, 24 bit resolution

bit 3-1 **MODE<1:0>:** Detection mode

11 = Test mode. Sends ramps on all bioelectrical + IMU/AUX/accessory channels

10 = Impedance check on all bioelectrical + IMU/AUX/accessory channels

01 = This option only affects EMG mode and firmware version 3.2.0 or higher. If EEG is set, or previous version of firmware is used, this mode is the same as 00. Monopolar mode with preamp gain is 4. 32 monopolar bioelectrical signals + 6 accessory signals. Resolution is 572.2 nV and range +/-18.75 mV(2).

00 = Monopolar mode with preamp gain 8. 32 monopolar bioelectrical signals + 6 accessory signals. Resolution is 286.1 nV and range +/-9.375 mV(2).

bit 0 **EN:** Enable data transfer for the corresponding device

1 = Enable data transfer to the station

0 = Disable data transfer to the station

(1) High pass filter implemented by firmware subtracting the exponential moving average, obtained by:

$$Average\_ChX[t] = (1-\alpha)\ Average\_ChX[t-1] + \alpha\ ChX[t]$$

Where α is equal to 1/25 for MODE = 0, 1 or 2. It is equal to 1/2 in case of Impedance check.

For the standard modes, this result in a high pass filter with a cut-off frequency of 10.5 Hz, when sampling the signals at 2000 Hz. More in general the cut-off frequency is Fsamp/190.

(2) Preamp gain of 4 has a double input range and a slightly larger noise w.r.t. preamp gain of 8. It can be used when DC component of EMG signals is higher and generates saturation before the high pass filter resulting in flat signals. The input range before the high pass filter is +/-600mV when the preamp is set to 4 and +/-300mV when the preamp is set to 8.

OPTION BYTE1:

LAT7	LAT6	LAT5	LAT4	LAT3	LAT2	LAT1	LAT0

bit 7-0 **LAT<7:0>:** Latency

The value can range from 1 to 200. It set the latency in terms of accumulate blocks into the internal buffer of the SyncStation waiting for the corresponding sample from one or more wireless devices. Refer to the next pages for additional details.

Data sent to the PC is sent out in packets that depend on the configuration of the probes. The output packets contain samples from all active channels for a duration equal to the lower sending interval of the active wireless devices. This packet of outgoing data is defined as an output packet for the PC.

For each connected and configured device, and for the auxiliary inputs, the SyncStation allocates a certain amount of memory as input buffer, such that 32 WiFi packets per probe can fit. The received data is temporarily written to the respective input buffers waiting to be processed and copied to the output buffer. When the entire output packet for the PC is available within the output buffer, it is sent to the PC. If data from some devices is not received within a maximum time limit, the output packet for the PC is still sent by inserting values of 0 into the samples of the missing device. Figure 1 graphically describes the handling of input and output packets.

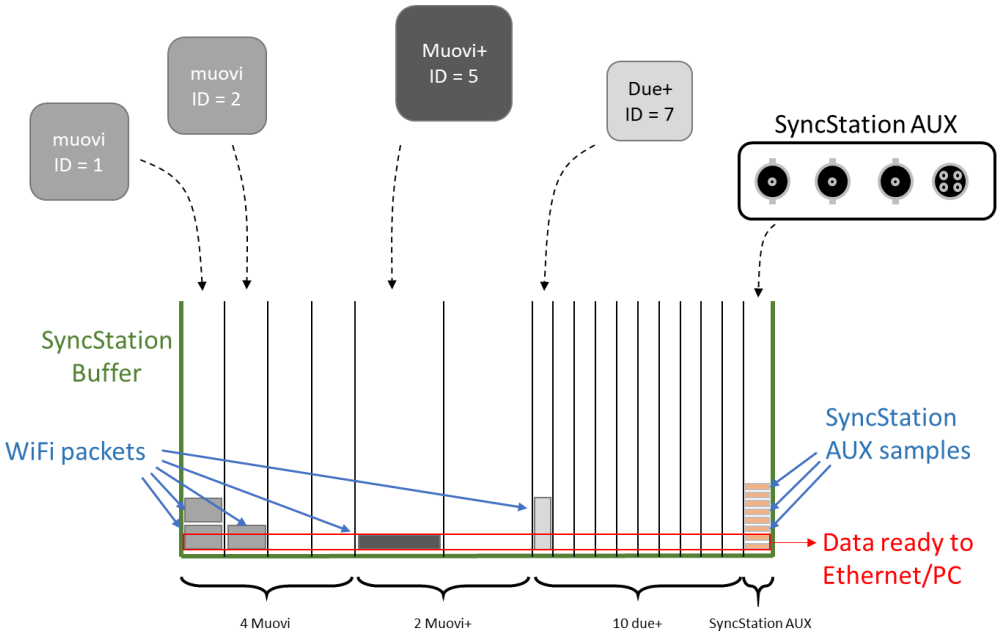

FIG. 1: *Simplified graphical representation of data handling by the SyncStation: packets received via WiFi from the various active probes is accumulated in FIFO buffers as well as samples acquired from the auxiliary channels. When a minimum number of samples from all active devices are available, an output packet for the PC containing samples from all devices is sent via Ethernet to the PC. An*

internal timer determines a maximum time limit within which the send condition can occur. In case it does not occur in time due to non-received packets from one or more probes (probes unavailable, delayed, not connected etc...), the missing data is replaced with zeros.

The output buffer can hold up to 210 output packet s of all channels and all connected devices. The maximum limit for sending data to the PC, even in the absence of data from all probes, by default is 200 output packets accumulated in the buffer. These packets are scanned by the sampling of the AUX signals inside the SyncStation.

It should be noted that not necessarily a "hole" between the data shown in real time during the signal acquisition represents a real loss of data. The data may simply be temporarily unavailable but still saved in the internal buffers of the probes and sent later.

Each connected device generates two accessory channels containing information related to the RF synchronization signal sent by the SyncStation, the use of the internal memory buffer of the move probe, and a sample counter. In particular, channel 37 for muovi, channel 69 for muovi+/sessantaquattro and channel 7 for due+ has one bit dedicated to indicating the status of the synchronization signal, 7 bit indicating the trigger code and 8 bits dedicated to indicate the use of the internal buffer:

Accessory channel n. 1											
bit 23	…	bit 16	bit 15	bit 14	bit 13	…	bit 18	bit 7	bit 6	…	Bit 0
0	…	0	TRIG	TR_CODE6	TR_CODE5	…	TR_CODE0	0	BUF6	…	BUF0

bit 23-16 Not used, fixed at 0. These bits are not present when the resolution is 16 bit.

bit 15 TRIG: indicates the level of the trigger signal sampled at the same time as the bioelectric signals.

bit 14-8 TR_CODE <6..0>: Trigger code. It is used to mark each trigger pulse with a code ranging from 1 to 127 to help the offline alignment between the different devices and the SyncStation. Time for processing the TR_CODE may vary, and the code can appear in a subsequence sample with respect to the sample where the trig pulse is detected.

bit 7 Not used, fixed at 0.

bit 6-0 BUF<6:0>: indicator of utilization of the internal FIFO buffer of Muovi. This value is the percentage of memory bytes occupied by samples previously acquired and not yet sent via WiFi. The maximum size of the FIFO buffer is 190152 bytes.

The second accessory channel for the wireless device is a sample counter. This is incremented with each new sample acquired and can be used to check if one or more samples have been lost. The difference between

two successive values in fact indicates how many samples have passed since the previous sampling and if some data has been lost it is possible to identify how many samples have been lost. Once the counter has arrived at the largest possible value with the corresponding resolution, it starts over with the counting.

The two accessory channels of the SyncStation contain information relating to the RF synchronization signal generated by the SyncStation (present on the "SYNC" BNC), the use of the memory buffer inside the move probe and a sample counter. In particular, the first accessory channel has a dedicated bit to indicate the status of the Synchronization signal and 15 dedicated bits to indicate the use of the internal buffer:

Accessory channel SyncStation n. 1								
bit 15	bit 14	bit 13	…	bit 8	bit 7	bit 6	…	bit 0
TRIG	TR_CODE6	TR_CODE5	…	TR_CODE0	BUF7	BUF6	…	BUF0

bit 15 TRIG: represents the level of the trigger signal sampled at the same time as the bioelectrical signals.

bit 14-8 TR_CODE <6..0>: Trigger code. It is used to mark each trigger pulse with a code ranging from 1 to 127 to help the offline alignment between the different devices and the SyncStation. Time for processing the TR_CODE may vary, and the code can appear in a subsequence sample with respect to the sample where the trig pulse is detected.

bit 7-0 BUF <7:0>: indicator of use of the FIFO buffer inside the SyncStation. This value indicates how many output packet s is waiting to be sent to the PC are present in the SyncStation. Failure to send is caused by missing or not yet received data from some wireless probe. The maximum number of backward output packets is 200, after which the pending data are sent anyway. This value can be reduced by changing the configuration of the SyncStation.

The second accessory channel for the SyncStation is a sample counter. This is incremented with each new sample acquired from the accessory inputs and can be used to check if one or more samples have been lost. The difference between two successive values in fact indicates how many samples have elapsed since the previous sampling and if some data have been lost, it is possible to identify how many samples have been lost. Once the counter reaches 65535, it restarts from 0 with the count.