Revisions		
Rev	**Description**	**Date**
1.0	Updated; Communication Protocol shared by both ES and ET Systems	Jul-05-15

ES/ET Electronic Unit

Version 2.0.1.14

Communication Protocol

	Date	**Commwell Research & Development Ltd.**
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1.0 Scope

This document defines the protocol used to transfer data and send commands between the PhysioGlove ES and PhysioGlove ET systems and the Electronic Unit. It defines data formats and procedures used for information exchange. As stated, this document applies to both the ES-ECG system and the PhysioGlove ET System.

2.0 Applicable documents

- 001-101-001 Remote Presence and Care System – Communication Protocol

3.0 Glossary, Abbreviation, and Acronyms

- ADC – Analog to Digital Converter
- ECG – Electrocardiogram
- USB – Universal Serial Bus
- LSB – Least Significant Byte
- MSB – Most Significant Byte
- RPCS – Remote Presence and Care System

4.0 General Overview

The enclosed protocol is proprietary to COMMWELL (adapted from the RPCS Communication Protocol) and is designed specifically to meet its system requirements and limitations. The structure of the system is outlined in Figure 1, where the communication interface is a USB 1.1 or higher. The USB link speed is limited to 112 kbps, which is one of the main limitations.

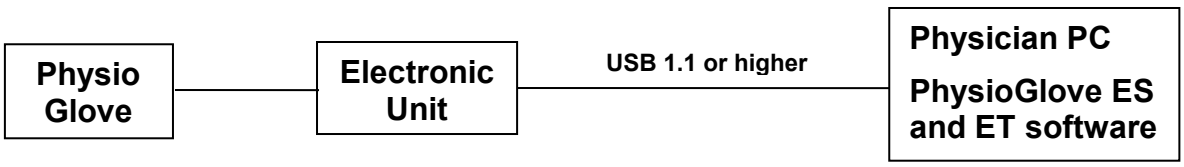

Figure 1 - System structure

Current design includes 2 layers: a link layer, and a transport layer. The link layer defines data encoding and transfer, while the transport layer defines data format and the logical flow of an exchange.

5.0 The Link layer

Using currently available hardware, the data link layer is assumed to have a reliable connection at 112 kb/s. Data transfer is performed using a standard asynchronous 8n1 format at 112000 baud.

6.0 The Transport layer

At a transport layer, data exchange is performed by datagrams, arranged as packets. Each packet contains a header with fields for data destination, data source, transfer type, sequential number, data length and header checksum. The data itself follows the header and may contain up to 32 bytes, followed by a data checksum byte.

Destination and source fields are 8 bits each and packed into 1 byte, allowing a maximum of 256 sources and 256 destinations.

Transfer type is one byte and is used to distinguish between commands, confirmations, data, and status reports.

Sequential number is a simple packet counter, two bytes wide, rolling over to zero after 65535. It facilitates the detection of completely missed packets.

Data length is a one byte wide, signed byte count, with allowed values from 0 to 255. The byte count includes the data bytes and the data checksum, but does not include the header bytes.

Header checksum is a 2's complement of an 8-bit sum of all header bytes, not including the checksum byte. The sum of all header bytes and the header checksum byte should produce a "0" result.

Data checksum is a 2's complement of an 8-bit sum of data bytes, not including checksum and header. The sum of all data bytes and the data checksum byte should produce a "0" result.

Figure 2 shows a packet format, where each row represents a byte in the packet, the top byte being transmitted first.

Destination
Source
Transfer type
Seq Number LSB
Seq Number MSB
Data length
Header checksum
First byte of data
... (More data, up to 56 byte)
Data checksum

Figure 2 - Packet format

7.0 Address allocation

Each device involved in a data exchange, command, or status report, or referred to as a source or destination of data, has to have its own unique number. This number will be used as the source or destination address during the data exchange. Addresses "0" and "255 (0xFF)" are reserved and should remain unassigned for better protocol reliability.

Address allocation should be performed according to the following scheme:

Table 1 represents current assigned addresses:

Table 1 - Address Allocation

Device	*Hex*	*Decimal*
PhysioGlove ES PC	80	128
PhysioGlove Electronic unit One Lead	15	21
PhysioGlove Electronic unit 363Hz	16	22
PhysioGlove Electronic unit 500Hz	17	23

8.0 Transfer types

Transfer type byte codes should adhere to the following rules:

1. All data transfer types are encoded with the type MSB set to "0", i.e. with numbers 0 to 127.
2. Commands are encoded with numbers 128 to 191 (0x80 to 0xBF)
3. Status reports are encoded with numbers 192 to 255 (0xC0 to 0xFF)

The commands and status reports mentioned here belong to the Transport layer and, therefore, may carry only data relating to traffic control, blocking factors, link failures etc. Command/control interface to the HUBS should be implemented on this level, since HUBS are communications devices.

Currently, the following commands are defined:

Code	**Function (**in Hex decimal)
84	Request a status report
85	Request a device data flow
86	Suspend data flow from device
89	Self-Test Request
96	Update Device Name
97	ID request
98	Request status/version string
99	Request battery status

Status reports:

Code	**Status/Reports** (in Hex decimal)
C0	Device Acknowledge Ok
C1	Device Acknowledge Error
C8	Device Stop Acknowledge
D0	FAULT LEAD DETECTION

D4 Status/Version Acknowledge

D5 Glove Type Acknowledge

D6 Self-Test Acknowledge

D7 IdRequest Acknowledge

BB Disable High-Pass

BE Enable High-Pass

CC Enable High-Pass Acknowledge

CD Disable High-Pass Acknowledge

9.0 Data link layer

Here device data, control, and command information between the PhysioGlove ES software and the Electronic unit is being transferred. It is the responsibility of the device itself (device controller) to recognize/distinguish among data and control information.

9.1 ECG

9.1.1 From PhysioGlove ES software to ECG Electronic unit

Table 2 - Start ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Start ECG	0x85
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x00
7	Header Check Sum		

Table 3 - Stop ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Stop ECG	0x86
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x00

Byte	Generic Definition	Specific Definition	Value
7	Header Check Sum		

Table 4 - Version Request ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Version Request	0x98
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x00
7	Header Check Sum		

Table 5 - Self-test Request ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Self-Test Request	0x89
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x00
7	Header Check Sum		

Table 6 - Self-test Request ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Self-Test Request	0x89
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x00
7	Header Check Sum		

Table 7 - Set Device ID

Byte	Generic Definition	Specific Definition	Value

Byte	Generic Definition	Specific Definition	Value
1	Destination	ECG Electronic unit	0x16 or 0x17
2	Source	PhysioGlove ES	0x80
3	Transfer Type	Set Device ID	0xa0
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		Length of ID
7	Header Check Sum		
8	Data 1	ASCII	
9	Data 2	ASCII	
…		ASCII	
N	Data N	End of String	0x00
N+1	Data Check Sum		

9.1.2 From ECG Electronic unit to PhysioGlove ES PC

Table 8 - Data Transmission from ECG

Byte	Generic Definition	Specific Definition	Value
1	Destination	PhysioGlove ES	0x80
2	Source	ECG Electronic unit	0x16 or 0x17
3	Transfer Type	Cable device ID	0xD5
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x02
7	Data 1	Glove ID	1 – Glove 2 – Std Electrode
8	Data 2	Reserved	0
9	Header Check Sum		

The above packet is sent only once, when the Start ECG command is received. The following packet is sent every time until the Stop ECG command is received:

Byte	Generic Definition	Specific Definition	Value
1	Destination	PhysioGlove ES	0x80

Byte	Generic Definition	Specific Definition	Value
2	Source	ECG Electronic unit	0x16 or 0x17
3	Transfer Type	Data	0x00
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		0x50
7	Header Check Sum		
8	Data 1	LSB Channel 1	
8	Data 2	MSB Channel 1	
9	Data 3	LSB Channel 2	
10	Data 4	MSB Channel 2	
⇣	⇣	⇣	⇣
20	Data 15	LSB Channel 8	
21	Data 16	MSB Channel 8	
22	Data17	LSB Channel 1	
⇣	⇣	⇣	⇣
86	Data 79	LSB Channel 8	
87	Data 80	MSB Channel 8	
88	Data Check Sum	MSB Channel 2	

where:

Channel 1 is Lead I

Channel 2 is Lead III

Channel 3 is Lead V1

Channel 4 is Lead V2

Channel 5 is Lead V3

Channel 6 is Lead V4

Channel 7 is Lead V5

Channel 8 is Lead V6

- Pacemaker

  If all lead data is -129 (decimal) this packet is recognized as a Pacemaker packet

Table 9 - ECG Version Transmission

Byte	Generic Definition	Specific Definition	Value
1	Destination	PhysioGlove ES	0x80
2	Source	ECG Electronic unit	0x16 or 0x17
3	Transfer Type	Ack Version	0xD4
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		Length of string
7	Header Check Sum		
8	Data 1	First Char	
9	Data 2	Second char	
⇣	⇣	⇣	⇣
XX	Data n	Last char	
XX	Header Check Sum		

Self-test results (For 363Hz)

Byte	Generic Definition	Specific Definition	Value
1	Destination	PhysioGlove ES	0x80
2	Source	ECG Electronic unit	0x16 or 0x17
3	Transfer Type	Ack Self-Test	0xD6
4	Sequence Number lsb		
5	Sequence Number msb		
6	Data Length		96(dec)
7	Header Check Sum		
8	Data 1	A1	
9	Data 2	A2	
⇣	⇣	⇣	⇣
XX	Data n	C’8	
XX	Header Check Sum		

ASIC I

Pulse 4.25 mV

	Test Lead II	Test Lead III	Lead V
LA,RA,RL = 130mv+pulse, LL=V=0	a1,a2	b1,b2	
LA,RA,RL = -130mv+pulse, LL=V=0	a3,a4	b3,b4	
LA,RA,RL = 0mv, LL=V=130mv +pulse	a5,a6		
LA,RA,RL = 0mv, LL=V=-130mv + pulse	a7,a8		c7,c8

ASIC II

Pulse 4.25 mV

	Test Lead II	Test Lead III	Lead V
LA,RA,RL = 130mv+pulse, LL=V=0	a'1,a'2	b'1,b'2	
LA,RA,RL = -130mv+pulse, LL=V=0	a'3,a'4	b'3,b'4	
LA,RA,RL = 0mv, LL=V=130mv +pulse	a'5,a'6		
LA,RA,RL = 0mv, LL=V=-130mv + pulse	a'7,a'8		c'7,c'8

Self-Test result for Electronic Unit 500Hz

This data is received in regular ECG DATA format for requesting Electronic Unit 500Hz Self-Test, but values received from electronic unit are in Self-test format (Table 6):

- Lead I , III , V3-6 value 20480 +/- 5%
- Lead V1, V2 value 11264 +/- 5%