COMMUNICATION PROTOCOL FOR
BiMatrix v1.0 RESEARCH PROTOTYPE

Global Electronic Solutions D.O.O.
Cara Dušana 75
21000 Novi Sad, Serbia
Tel: +381 21 302 5993
Fax: +381 21 302 5993
E-mail: office@globalelectronic.rs
Internet: www.globalelectronic.rs

1. Document Data

Title	Communication Protocol for BiMatrix Research Prototype
Subtitle	List of messages
Document type	Communication protocol
Version	1.0

WARNINGS:
BiMatrix is a prototype for research purpose only!
Read the BiMatrix User Manual.pdf carefully!

2. Messages format

BiMatrix will ignore wrong or incomplete messages and will respond with **>ERR<**.

Message without parameters: >XYZ<
Message consists of n ascii characters ("**XYZ**"), begins with ascii character "**>**" and ends with ascii character "**<**"

Message with parameters: >XYZ;xxx<
Message begins with ascii character "**>**" followed by n ascii characters ("**XYZ**") and ascii character "**;**" after which there are m parameters (xxx) and message ends with ascii character "**<**". There are four possible types of parameters:
- **$** ascii character (one byte)
- **b** byte data type (one byte) binary value
- **w** word data type (two bytes) binary value most significant byte is at the beginning
- **l** long data type (four bytes) binary value most significant byte is at the beginning

Communication parameters

Baud rate	Data bits	Parity	Stop bits	Flow control
921600 bps	8	No	1	Hardware RTS/CTS

3. Pulse and n-plet definition
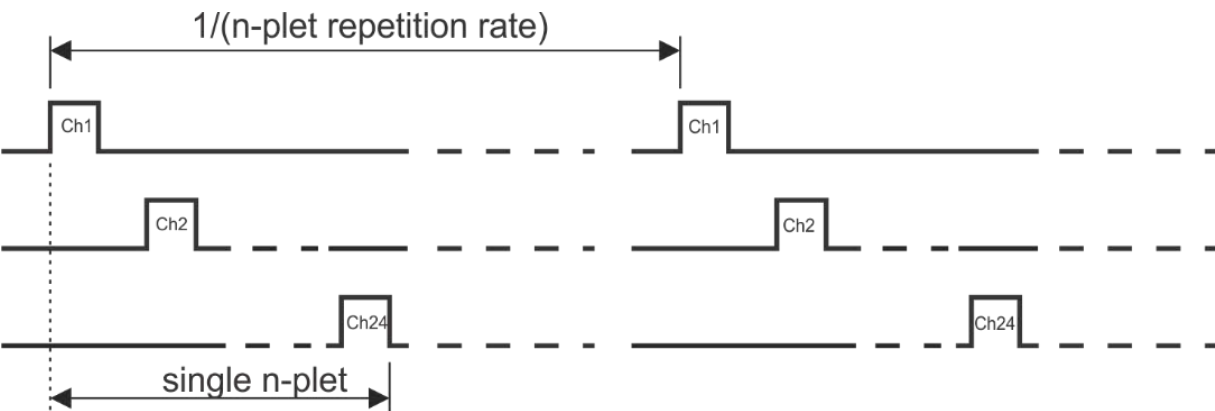
4. Common commands

This set of commands is common for all BiMatrix working modes.

Set current range
Command: **>SR;$<**
Command length: **6 bytes**
Default: **High current rage: >SR;H<**
$ is either an "H" or an "L" ascii character. "H" represents high pulse amplitude range (up to 100mA) and "L" represents low pulse amplitude range (up to 10mA). BiMatrix will respond with **>OK<** or **>ERR<**.

Set voltage of the pulse generator
Command: **>SV;b<**
Command length: **6 bytes**
Default value: **150**
Minimal value: **70**
Maximal value: **150**
Unit: **Volt [V]**
This command sets the voltage of the pulse generator. b is a byte data type and represents the voltage. BiMatrix will respond with **>OK<** or **>ERR<**.

Turn-ON the pulse generator DC/DC converter
Command: **>ON<**
Command length: **4 bytes**
Default: >**OFF<**
This command turns on the DC/DC converter which generates voltage for the pulse generator. This command can only be sent when the DC/DC converter is OFF. BiMatrix will respond with **>OK<** or **>ERR<**.

Turn-OFF the pulse generator DC/DC converter
Command: **>OFF<**
Command length: **5 bytes**
Default: >**OFF<**
This command turns off the DC/DC converter which generates voltage for the pulse generator. This command can only be sent when the DC/DC converter is ON. BiMatrix will respond with **>OK<** or **>ERR<**.

Set the number of n-plets to be generated
Command: **>SN;l<**
Command length: **9 bytes**
Default value: **0**
Minimal value: **0 (infinity)**
Maximal value: **16777215**
l is a long data type value which represents the number of n-plet periods which will be generated. If this parameter is set during pulse generation, the new value will be updated before the next trigger. If the value of l is 0 the n-plets will be generated indefinitely. BiMatrix will respond with **>OK<**.

Set time between pulses in n-plet
Command: **>ST;b<**
Command length: **6 bytes**
Default value: **1**
Minimal value: **1**
Maximal value: **255**
Unit: **millisecond [ms]**
This command will set the time interval between pulses in the n-plet. b is a byte data type value which represents the time interval in ms, so if b = 1 the time between two pulses in the n-plet will be 1ms. The minimum value of this parameter is 1, and the maximum is 255. BiMatrix will check whether this value is acceptable, taking other parameters into account, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not.

Set delay after trigger
Command: **>SD;l<**
Command length: **9 bytes**
Default value: **0**
Minimal value: **0**
Maximal value: **16777215**
Unit: **millisecond [ms]**
This command will set the delay after a trigger. l is a long data type value which represents the delay after the trigger in ms. If this parameter is set during delay or pulse generation, the new value will be updated before the next trigger. BiMatrix will respond with **>OK<**.

Pulses generation Trigger
Command: **>T<**
Command length: **3 bytes**
Default state: **No trigger**
This command will trigger the pulse generation. If the pulse generation is not active this command will start the pulse generation. If the pulse generation is active this command will stop the pulse generation. BiMatrix will respond with **>OK<**.

Read remaining battery capacity
Command: **>SOC<**
Command length: **5 bytes**
This command is a request related to battery status. BiMatrix will respond with **>SOC;b<** where b is a byte data type value which represents the decimal value of the batteries remaining capacity in percents (0 - 100%).

5. Long communication protocol

Set n-plet repetition rate
Command: **>SF;w<**
Command length: **7 bytes**
Default value: **50**
Minimal value: **1**
Maximal value: **400**
Unit: **n-plets per second [pps]**
This command will set the n-plet repetition rate. w is a word data type value which represents the n-plet repetition rate. BiMatrix will check if the desired n-plet repetition rate can be generated based on other pulse generation parameters. If the n-plet repetition rate is set during pulse generation, the new value will be updated when the current n-plet period expires. BiMatrix will respond with **>OK<**, or **>ERR<**.

Set pulse width for every pulse in n-plet
Command: **>PW;wwwwwwwwwwwwwwwwwwwwwwwwww<**
Command length: **53 bytes**
Default value: **250**
Minimal value: **50**
Maximal value: **1000**
Unit: **microsecond [µs]**
This command will set the pulse width for every pulse in the n-plet. w is a word data type value. If the value is out of range, it will be ignored, and the previous value will be preserved. BiMatrix will check whether this value is acceptable, taking other parameters into account, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not.

Set amplitude of the pulses in n-plet
Command: **>SC;wwwwwwwwwwwwwwwwwwwwwwwwww<**
Command length: **53 bytes**
Minimal value: **0**
Default value: **100**
Maximal value: **1000**
Unit in case of High current range: **w/10 milliamps [mA]**
Unit in case of Low current range: **w/100 milliamps [mA]**
This command will set the current amplitude of every pulse in the n-plet. w is a word data type value.

In high current mode (**>SR;H<** is set), the amplitude ranges from 0 to 100.0mA. In this mode, w represents the value of current amplitude multiplied by 10. For example: the value 505 means that the current will be set to 50.5mA.
In low current mode (**>SR;L<** is set), the amplitude ranges from 0 to 10.00mA. In this mode, w represents the value of current amplitude multiplied by 100. For example, the value 505 means that the current will be set to 5.05mA.
If amplitude of the pulse is above maximal value, BiMatrix will limit it to the maximal value. BiMatrix will respond with **>OK<**.

5.1. Unipolar pulse generation mode

In this mode, the user can choose the common anode and up to 24 cathodes or the common cathode and up to 24 anodes.

Switch to Unipolar pulse generation mode
Command: **>MUX;OFF<**
Command length: **9 bytes**
Default mode: **Unipolar pulse generation mode: >MUX;OFF<**
This command will activate unipolar pulse generation mode. BiMatrix will respond with **>OK<**.

Common electrode definition
Command: **>ASYNC;$<**
Command length: **9 bytes**
Default electrode definition: **COMMON CATHODE: >ASYNC;C<**
$ is either an "A" or a "C" ascii character. It represents the common electrode for the unipolar pulse generation mode: "A" = common anode or "C" = common cathode. This command must be sent to activate unipolar pulse generation mode in long communication protocol. BiMatrix will respond with **>OK<** or **>ERR<**.

Set n-plet pulses and output channels for each pulse
Command: **>SA;xxxxxxxxxxxxxxxxxxxxxxxx<**
Command length: **77 bytes**
Default value: **all 0**
This command will set the output channels for every pulse in the n-plet active. x consists of three bytes with the first byte being the higher-order byte. MSB correlates to the 24th output channel, and LSB correlates to the 1st output channel. The maximum number of pulses in the n-plet which can be defined is 24, but biMatrix will check whether the defined

number of pulses is acceptable, taking into account other parameters, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not.

Example of command:

>SA;0x800000 0x400000 0x000000<

According to the example above, BiMatrix will generate a duplet of pulses. The first pulse will be routed through the 24th output channel, and second pulse will be routed through the 23rd output channel.

Example of the unipolar pulse generation mode:

Set three channels active (CH1, CH3, CH5) with amplitudes of 10mA, 20mA and 50mA respectively. Repetition rate of the pulses will be set to 50pps. A common anode will be selected. The pulse generator voltage will be set to 120V. The pulse width will be 250us for every pulse in n-plet.	
Command	Comment
>ON<	Turn ON DC/DC conv.
>SV;0x78<	Output voltage = 120V
>MUX;OFF<	Unipolar pulse generation mode
>SF;0x0032<	n-plet repetition rate is 50pps
>ASYNC;A<	Common anode selection
>SR;H<	High current range
>SA;0x000001 0x000004 0x000010 0x000000 ... 0x000000<	Channels 1, 3 and 5 are set.
>SC;0x0064 0x00C8 0x01F4 0x0000 0x0000 ... 0x0000<	Amplitudes of the pules are 10mA, 20mA and 50mA respectively.
>PW;0x00FA 0x00FA 0x00FA 0x00FA 0x00FA ... 0x00FA<	Pulse width of all pulses is 250µA
>T<	Trigger pulse generator

5.2. Bipolar pulse generation mode

This mode can be used in application where the user wants to dynamically change the pulse distribution. Any output channel (electrode matrix field) can be set as an anode or a cathode.

Switch to Bipolar pulse generation mode
Command: >MUX;ON<
Command length: **8 bytes**
Default mode: **Unipolar pulse generation mode: >MUX;OFF<**
This command will activate bipolar pulse generation mode. BiMatrix will respond with **>OK<**.

Set n-plet pulses and output channels cathode/anode pairs for each pulse
Command: >CA;xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy xy <
Command length: **149 bytes**
Default value: **all 0**
This command will set output channel pairs (cathode/anode) for every pulse in the n-plet. x and y consist of three bytes each. x represents output channels which will be connected to the cathode electrode fields, and y represents output channels which will be connected to the anode electrode fields for each pulse in the n-plet. The maximum number of pulses in the n-plet which can be defined is 24, but BiMatrix will check whether the defined number of pulses is acceptable, taking other parameters into account, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not.

Example of the bipolar pulse generation mode.

N-plet, in this case triplet, consists of three pulses. First pulse will pass thorough channels 22 and 23, second pulse will pass throung channels 1 and 2 and third pulse will pass through channels 15 and 16. Channels 22, 1 and 15 will be cathodes and channels 23, 2 and 16 will be anodes. Amplitudes of the pulses will be set to 10mA, 20mA and 50mA, respectively. Repetition rate of the pulses will be set to 50pps. Pulse generator voltage will be set to 120V. Pulse width will be 250us for every pulse in triplet.	
Command	Comment
>ON<	Turn ON DC/DC conv.
>SV;0x78<	Output voltage = 120V
>MUX;ON<	Bipolar pulse generation mode
>SF;0x0032<	n-plet repetition rate is 50pps
>SR;H<	High current range

>CA;0x200000 0x400000 0x000001 0x000002 0x004000 0x008000 0x000000 0x000000 ... 0x000000 0x000000 <	Channels 22, 1 and 15 will be cathodes and channels 23, 2 and 16 will be anodes.
>SC;0x0064 0x00C8 0x01F4 0x0000 0x0000 ... 0x0000<	Amplitudes of the pulses are 10mA, 20mA and 50mA respectively.
>PW;0x00FA 0x00FA 0x00FA 0x00FA 0x00FA ... 0x00FA<	Pulse width of all pulses is 250µA
>T<	Trigger pulse generator

6. Short communication protocol

This protocol can be used to set unipolar pulse generation mode with minimum message length. This protocol is used in a specific operating mode of the BiMatrix where each pulse in the n-plet can be distributed to a single output channel only.

Common electrode definition
Command: **>SYNC;$<**
Command length: **8 bytes**
Default: **Long communication protocol mode**
$ is either an "A" or a "C" ascii character. It represents the common electrode for unipolar pulse generation mode: "A" = common anode or "C" = common cathode. This command must be set to activate short communication protocol. BiMatrix will respond with **>OK<** or **>ERR<**.

Set output channel activity
Command: **>MP;xb<**
Command length: **9 bytes**
Minimum x value: **0**
Maximum x value: **255**
Minimum b value: **1**
Maximum b value: **255**
Unit for b value: **n-plets per second [pps]**
This command will set the output channels which will be active, and also a number of pulses in the n-plet which is equal to the number of active output channels. Each pulse in the n-plet will be distributed successively through a single output channel, starting from channel 1 towards channel 24. The parameter x consists of three bytes and each byte represents the corresponding output channel's activity: MSB represents the 24th output channel activity and LSB represents the first output channel's activity (0 means the channel is not active, 1 means the channel is active). The parameter b is a byte data type

value which represents the n-plet repetition rate. The maximum number of pulses in the n-plet which can be defined is 24, but BiMatrix will check whether the defined number of pulses is acceptable, taking into account other parameters, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not.

Set pulse width for every pulse in n-plet
Command: **>PW;wwwwwwwwwwwwwwwwwwwwwwww<**
Command length: **53 bytes**
Default value: **250**
Minimal value: **50**
Maximal value: **1000**
Unit: **microsecond [µs]**

This command will set the pulse width for each of the 24 output channels regardless of the channel's activity which was set by the >MP;xb< command. w is word data type, with the first byte being the higher-order byte. The first w value represents the pulse width for output channel 1, the second w value for output channel 2 etc. If the value is out of range, it will be ignored, and the previous value will be preserved. BiMatrix will check whether this value is acceptable, taking into account the other parameters, and respond with **>OK<** if it is OK, or with **>ERR<** if it is not. The illustration is shown below:

CH01	CH02	CH03	CH04	…	CH23	CH24
> P W ; 0x01F4	0x01F4	0x01F4	0x01F4	…	0x01F4	0x01F4 <

Set amplitude of the pulses in n-plet
Command: **>SC;wwwwwwwwwwwwwwwwwwwwwwww<**
Command length: **53 bytes**
Minimal value: **0**
Default value: **100**
Maximal value: **1000**
Unit in case of High current range: **w/10 milliamps [mA]**
Unit in case of Low current range: **w/100 milliamps [mA]**

This command will set the pulse amplitude for each of the 24 output channels regardless of the channel's activity which was set by the >MP;xb< command. w is a word data type, with the first byte being the higher-order byte. The first w value represents the pulse amplitude for output channel 1, the second w value for output channel 2 etc.

In high current mode (**>SR;H<** is set), the amplitude ranges from 0 to 100.0mA. In this mode, w represents the value of the current amplitude multiplied by 10. For example: the value 505 means that the current will be set to 50.5mA.

In low current mode (**>SR;L<** is set), the amplitude ranges from 0 to 10.00mA. In this mode, w represents the value of the current amplitude multiplied by 100. For example, the value 505 means that the current will be set to 5.05mA.

If the amplitude of the pulse is above the maximal value, BiMatrix will limit it to the maximal value. BiMatrix will respond with **>OK<**. The illustration is shown below:

	CH01	CH02	CH03	CH04	…	CH23	CH24	
> S C ;	0x01F4	0x01F4	0x01F4	0x01F4	…	0x01F4	0x01F4 <	

Example of the short communication protocol:

Set three channels (CH1, CH3, CH5) with amplitudes of 10mA, 20mA and 50mA respectively. The n-plet repetition rate will be set to 50pps. A common anode will be selected. The pulse generator voltage will be set to 120V. The pulse width will be 250us for every pulse in n-plet.	
Command	Comment
>ON<	Turn ON DC/DC conv.
>SV;0x78<	Output voltage = 120V
>MUX;OFF<	Unipolar pulse generation mode
>SYNC;A<	Short command set with common anode.
>SR;H<	High current range
>MP;0x000015 0x32<	Active channels 1, 3 and 5 with n-plet repetition rate of 50pps.
>SC;0x0064 0x0000 0x00C8 0x0000 0x01F4 0x0000 ... 0x0000<	Amplitudes of the pulse for channels 1, 3 and 5 are 10mA, 20mA and 50mA respectively.
>PW;0x00FA 0x00FA 0x00FA 0x00FA 0x00FA ... 0x00FA<	Pulse width of all pulses is 250µA
>T<	Trigger pulse generator