Communication Protocol

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1 MP113 COMMUNICATION PROTOCOL

1.1 GENERAL

The MP113 provides communication with a PC or controller board through the I^2C and UART interfaces.

1.2 INTERFACE SETTING

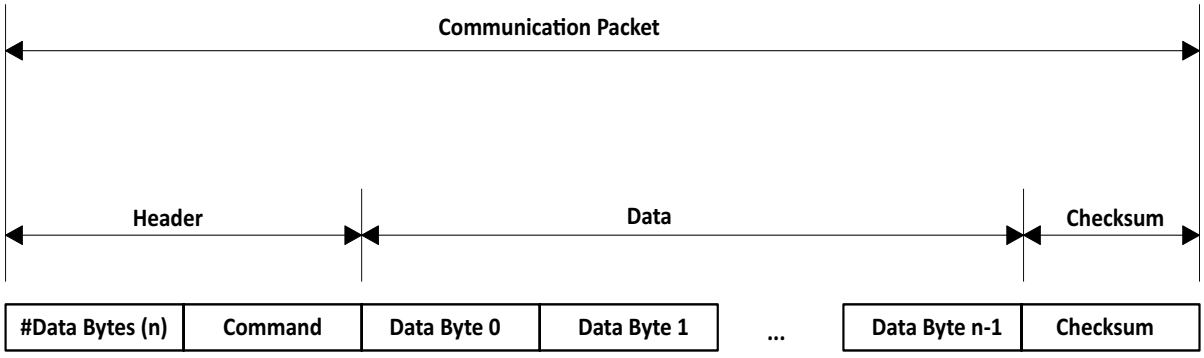
When starting MP113, the communication setting for UART is as follows:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity

The I2C frequency is 100 kHz.

1.3 COMMUNICATION PACKETS (TO MP113)

Data is communicated between an external controller and the MP113 through communication packets. All incoming (received) packets use the following format:



Byte	Description
# Data Bytes (n)	Number of data bytes in the communication packet. This is the total count of “Data Byte 0” to “Data Byte n-1”. It does NOT include any other bytes in the communication packet, like this byte, command, or checksum.
Command	Command for the MP113
Data	Additional information related to the command. The “# Data Bytes (n)” contains the number of data bytes provided here.
Checksum	8-bit checksum, following the LRC checksum rule.

1.4 COMMUNICATION PACKET DATA BYTE SIZE LIMITATION

MP113 has a limited number of data bytes reserved for receiving within a communication packets. The overall size can vary due to software variations or due to overall functionality of MP113. However, the buffer for receiving data bytes for any version of MP113 will be at least 32 bytes.

When implementing the communication with MP113, it is advised to either use communication packets with 32 data bytes or less, or to query the MP113 first for its current receive data buffer size before sending communication packets with more than 32 data bytes.

To query MP113 for the receive data buffer size, you can use the “Read System Information” command.

1.5 CHECKSUM

All received communication packets are checked for a valid checksum. If the checksum does not match the data, MP113 will return a no-acknowledge character (‘N’). MP113 uses a standard LRC checksum, which can be calculated as follows:

Checksum = ((Σ (all bytes in packet, excluding the checksum byte) +1) xor 0xFF:

A C-language like implementation would look as follows:

```
/**
  *  Generate a one byte checksum using the longitudinal redundancy check
  */
unsigned char checksum(unsigned char *buffer, unsigned int numBytes)
{
   unsigned int accu, i;
   unsigned char lrc;
   for (i = 0; i < numBytes; i++)
         accu += buffer[i];

   accu ^= 0xFFFFFFFF;
   lrc = (unsigned char) ((accu +1) & 0xFF);
   return lrc;
}
```

1.6 COMMUNICATION TIMEOUT

MP113 has a built-in timeout while receiving a communication packet. The maximum time between two bytes within a communication packet is currently set as 20ms. If no communication byte is received within that time, MP113 will set the communication packet as corrupt and will respond with a “fail” response (‘N’).

2 OPERATING THE MP113

2.1 FIRST TIME I^2C ADDRESS CONFIGURATION

1. Power on V_{CC}
2. Connect a PC to the UART serial interface
3. Configure the board’s I^2C address
   a.) Use the MP113 GUI “Configuration” menu (see user manual)

b.) Use the “Set Parameter” command, option 8

2.2 FIRST TIME SYSTEM CONFIGURATION

Power on all supplies: V_{CC}, V_B, V_{AUX}, $+V_S$

1. Read status information
   a.) Is supply voltage correct?
   b.) Are temperatures reasonable?

2.) Read system information
   a.) Store the maximum # of waveform samples
   b.) Store receive/transmit buffer size

3.) Read waveform settings
   a.) These are default values

4.) Self-calibrate
   a.) System will auto-adjust waveform settings

5.) Read waveform settings
   a.) Verify they are different from the default values obtained previously

2.3 UPDATING WAVEFORM DATA

To update waveform data, send these commands:

1. Waveform peak voltage
2. Waveform samples
3. Waveform offset voltage
4. Waveform color table
5. Waveform pulse start and A/D sampling markers]

2.4 CONFIGURING THE MP113 FOR THE PRINT-HEAD

Configure the MP113 to the type of print-head you use with the “Set Parameter” command.

1. Set the run mode: grayscale, binary, dingle color, dual color
2. Set the startup run mode: grayscale, binary, single color, dual color

2.5 TURN SYSTEM ON

When you are ready to run the MP113 in the printer, perform the following steps:

1. Ensure steps 2.1 through 2.4 above are complete
2. Make sure emulation mode is OFF
   a.) Set parameter, byte 1
3. Set MP113 to online
   a.) Set parameter, byte 2

2.6 COMMANDS AVAILABLE DURING PRINTING

Only the following commands are available to use while the system is online. All other commands will respond with a “No Acknowledge”.

- Test Communication
- Set Parameter
- Read System Information

2.7 I²C WAIT TIMES

When the MP113 writes data to flash memory, all interrupts in the system are disabled. When communicating with the MP113 via I2C, use the table below to set a minimum wait time for the MP113 to respond. Attempts to the read the I2C bus before these times will return invalid data.

Command	Wait Time (ms)
Self-Calibrate	20
Waveform ColorTable	100
Waveform Pulse Start	100
Waveform Samples	100
Set Parameter	1
Waveform Peak Voltage	1
Waveform Start Delay	1
Waveform Offset Voltage	30

3 MP113 MONITOR STATUS CODES

The value returned by the “Read System Information” command, bytes 7-8, contains power supply, temperature, and calibration error codes.

Error	Bit#	Description
Channel 0 over-temperature	0	Channel 0 temperature has exceeded 85 degrees Celsius
Channel 1 over-temperature	1	Channel 1 temperature has exceeded 85 degrees Celsius
Channel 0 over-temperature warning	2	Channel 0 temperature has exceeded 70 degrees Celsius
Channel 1 over-temperature warning	3	Channel 1 temperature has exceeded 70 degrees Celsius
Power supply over-voltage	4	High voltage power supply has exceeded 165 Volts
Power supply under-voltage	5	High voltage power supply is under 50 Volts
Self-calibration error channel 0	6	Self-calibration on channel 0 failed
Self-calibration error channel 1	7	Self-calibration on channel 1 failed
Reserved	8-15	Reserved

4 MP113 COMMUNICATION COMMANDS

4.1 FIRE PULSE

Byte	Description
0	Number of data bytes in packet (n). Must be 0.
1	Command (‘F’) Note: The fire pulse is only handled if emulation mode is ON.
2	Checksum

Response:

Byte	Description
0	'A' (confirmed) or 'N' (error)

4.2 SELF-CALIBRATION

Byte	Description
0	Number of data bytes in packet (n). Must be 0.
1	Command ('X')
2	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.3 RETRIEVE PRINT-HEAD CALIBRATION DATA

Byte	Description
0	Number of data bytes in packet (n). Must be 0.
1	Command ('B')
2	Checksum

Response:

Byte	Description
0	12 (fixed value)
1	Number of bytes in package (n)
2 ... (n+2)	Calibration data Data is stored in ASCII numbers. See Fujifilm Dimatix Printhead manual for detailed information.
n+3	Checksum

4.4 PIXEL DATA (START OF DOWNLOAD)

Byte	Description
0	Number of data bytes in packet (n). Note: the total number of pixel data count as data bytes. So the number of pixel data in this packet is n-2.
1	Command ('P')

2-3	Total number of pixel data. If this number exceeds the maximum packet size of the UART, it can be sent within multiple packets. Please see the “Pixel Data (Continued)” packet information for the format description of subsequent packets. For MP113, this value must be set to 256.
4-(n+2)	Pixel Data (8-bit values)
n+3	Checksum

Response:

Byte	Description
0	‘A’ (confirmed) or ‘N’ (error)

4.5 PIXEL DATA (CONTINUED)

Byte	Description
0	Number of data bytes in packet (n) If the sum of the number of pixel data in this package and the number of pixel data bytes already received exceeds the total number of pixel data set with at the “Pixel Data (Start of Download)”, an error will occur.
1	Command (‘P’+32)
2-(n+2)	Pixel Data (8-bit values)
n+3	Checksum

Response:

Byte	Description
0	‘A’ or ‘N’

4.6 READ STATUS INFORMATION

Byte	Description
0	Number of data bytes in packet (n). Must be 2.
1	Command (‘R’)
2	1 (fixed value)
3	4 (fixed value)
4	Checksum

Response:

Byte	Description
0	4 (fixed value)
1	10 (fixed value)
2	Current Operation Mode

3	Valid Waveform Available 0 ... No valid waveform stored in the MP113 1 ... MP113 has a valid waveform in the Flash memory
4-5	Length of waveform output in D/A samples (including start delays)
6	I^2C address of module
7-8	Monitor status
9	Supply voltage (in V)
10	Temperature Channel A (in °C)
11	Temperature Channel B (in °C)
12	Checksum

4.7 READ SYSTEM INFORMATION

Byte	Description
0	Number of data bytes in packet (n). Must be 2.
1	Command ('R')
2	1 (fixed value)
3	3 (fixed value)
4	Checksum

Response:

Byte	Description
0	3 (fixed value)
1	17 (fixed value)
2	Number of colors MP113 can handle (1 or 2)
3	Maximum voltage MP113 can handle
4-7	D/A converter operating frequency (in Hz): Byte 5: bit 7-0 of 32-bit value Byte 6: bit 15-8 of 32-bit value Byte 7: bit 23-16 of 32-bit value Byte 8: bit 31-24 of 32-bit value
8-9	Maximum number of waveform samples MP113 can handle Byte 9: lower 8-bit of 16-bit value Byte 10: upper 8-bit of 16-bit value
10	Communication interface receive buffer size. When sending data to the MP113 (like pixel data), the number of data bytes must be less or equal the receive buffer size.
11	Communication interface transmit buffer size.
12-15	PWM clock operating frequency (in Hz): Byte 13: bit 7-0 of 32-bit value Byte 14: bit 15-8 of 32-bit value Byte 16: bit 23-16 of 32-bit value Byte16: bit31-24 of 32-bit value
16	FPGA Startup Mode

17	Checksum

4.8 READ WAVEFORM SETTINGS

Byte	Description
0	Number of data bytes in packet (n). Must be 2.
1	Command ('R')
2	1 (fixed value)
3	6 (fixed value)
4	Checksum

Response (Single Color MP113):

Byte	Description
0	6 (Fixed value)
1	9 (fixed value)
2	Peak voltage of waveform 0 (in Volts)
3-4	Waveform 0 start delay in D/A clock ticks: Byte 4: lower 8-bit of 12-bit value Byte 5: upper 8-bit of 12-bit value
5-6	D/A converter idle value of waveform 0 Byte 6: lower 8-bit of 12-bit idle value Byte 7: upper 8-bit of 12-bit idle value The D/A converter idle voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
7-8	D/A converter idle value of waveform 0 Byte 6: lower 8-bit of 12-bit idle value Byte 7: upper 8-bit of 12-bit idle value The D/A converter idle voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
9-10	D/A converter idle value of waveform 0 Byte 6: lower 8-bit of 12-bit idle value Byte 7: upper 8-bit of 12-bit idle value The D/A converter gain value represents the required increment of the D/A converter that increases the MP113 output by 100V
11	Checksum

Response (Dual Color MP113):

Byte	Description
0	6 (fixed value)
1	18 (fixed value)
2	Peak voltage of waveform 0 (in Volts)
3-4	Waveform 0 start delay in D/A clock ticks: Byte 4: lower 8-bit of 16-bit value Byte 5: upper 8-bit of 16-bit value

5-6	D/A converter idle value of waveform 0 Byte 6: lower 8-bit of 12-bit idle value Byte 7: upper 8-bit of 12-bit idle value T he D/A converter idle voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
7-8	D/A converter zero value of waveform 0 Byte 6: lower 8-bit of 12-bit zero value Byte 7: upper 8-bit of 12-bit zero value The D/A converter zero voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
9-10	MP113 gain value of waveform 0 Byte 6: lower 8-bit of 16-bit gain value Byte 7: upper 8-bit of 16-bit gain value The D/A converter gain value represents the required increment of the D/A converter that increases the MP113 output by 100V
11	Peak voltage of waveform 1 (in Volts)
12-13	Waveform 1 start delay in D/A clock ticks: Byte 4: lower 8-bit of 16-bit value Byte 5: upper 8-bit of 16-bit value
14-15	D/A converter idle value of waveform 1 Byte 6: lower 8-bit of 12-bit idle value Byte 7: upper 8-bit of 12-bit idle value The D/A converter idle voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
16-17	D/A converter zero value of waveform 1 Byte 6: lower 8-bit of 12-bit zero value Byte 7: upper 8-bit of 12-bit zero value The D/A converter zero voltage can be calculated as Offset (in Volts) = 214.5V * offset value/4095
18-19	MP113 gain value of waveform 1 Byte 6: lower 8-bit of 16-bit gain value Byte 7: upper 8-bit of 16-bit gain value The D/A converter gain value represents the required increment of the D/A converter that increases the MP113 output by 100V
20	Checksum

4.9 SET PARAMETER

Byte	Description
0	Number of data bytes in packet (n). Must be 2.
1	Command (‘S’)

2	Parameter to be set: 0 … none 1 … emulation mode 2 … operation mode 3 … MP113 current run mode 4 … Reset MP113 FPGA (complete) 5 … Reset MP113 FPGA (waveform input/output only) 6 … MP113 run mode after startup 7 … Download the pixel data from the microcontroller to the FPGA 8 … Set the I2C address
3	Value for parameter: (1) Emulation mode: 0=0ff, 1-255=on (2) Operation mode: 0=offline, 1-255=online ((3) Run mode - Bit 0… don't care (ignored) - Bit 1 … 0=grayscale, 1=binary - Bit 2 … 0=single color, 1=dual color - Bit 3 … 0=normal, 1=demo/emulation mode (4) Reset MP113 FPGA (full): 0=no reset, 1-255=execute reset (5) Reset MP113 FPGA (waveform): 0=no reset, 1-255=execute reset (6) MP113 startup mode - Bit 0… 0=offline, 1=online - Bit 1 … 0=grayscale, 1=binary - Bit 2 … 0=single color, 1=dual color - Bit 3 … 0=normal, 1=demo/emulation mode (7) Download pixel data: no parameter required (8) Set I2C address: new I2C address (1-127)
4	Checksum

Response:

Byte	Description
0	'A' (confirmed) or 'N' (error)

4.10 TEST COMMUNICATION

Byte	Description
0	Number of data bytes in packet (n). Must be 0.
1	Command ('T')
2	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.11 WAVEFORM COLOR TABLE

Byte	Description
0	Number of data bytes in packet (n). Note: the channel number counts as data byte. So the number of color table bytes is (n-1). The number of color table bytes must be 1-4, so the number of data bytes in packet must be 2-5.
1	Command ('C')
2	Channel number (1 or 2)
3-(n+2)	Color table information. The color table information is provided as follows: Byte 4, bit 3-0: Color table for pulse 0 Byte 4, bit 7-4: Color table for pulse 1 Byte 5, bit 3-0: Color table for pulse 2 Byte 5, bit 7-4: Color table for pulse 3 ...
n+3	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.12 WAVEFORM OFFSET VOLTAGE

Byte		Description
0		Number of data bytes in packet (n). Must be 3 (mode 2) or 7.
1		Command ('O')
2		Channel number (1 or 2)
3-4		Byte 4: lower 8-bit of D/A converter idle value Byte 5: upper 8-bit of D/A converter idle value The D/A converter idle value must be a 12-bit value from 0-4095. The value can be calculated as follows: Value = idle voltage (in Volt) * 4095/214.5
Byte 0 = 3	Byte 0 = 7	
	5-6	Byte 6: lower 8-bit of D/A converter zero value Byte 7: upper 8-bit of D/A converter zero value The D/A converter zero value must be a 12-bit value from 0-4095. The value can be calculated as follows: Value = zero voltage (in Volt) * 4095/214.5
	7-8	Byte 8 lower 8-bit of MP113 gain value Byte 9: upper 8-bit of MP113 gain value The gain value is the 12-bit D/A converter increment that causes the MP113 output to increase by 100V.
5	9	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.13 WAVEFORM PEAK VOLTAGE

Byte	Description
0	Number of data bytes in packet (n). Must be 2.
1	Command ('V')
2	Channel number (1 or 2)
3	Peak Voltage of waveform to corresponds to the waveform sample value of 255.
4	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.14 WAVEFORM PULSE START AND A/D SAMPLING POINT MARKERS

Byte	Description
0	Number of data bytes in packet (n). Note: the channel number counts as data byte. So the number of number of waveform pulse start markers is (n-1)/4. As each marker needs 4 bytes of data, (n-1) must be a multiple of 4. The number of markers [(n-1)/4] must be a value between 1 and 7.
1	Command ('M')
2	Channel number (1 or 2)
3-(n+2)	Pulse Start Markers: Byte 4: lower 8-bit of pulse start marker 0. Must be zero Byte 5: upper 8-bit of pulse start marker 0. Must be zero Byte 6: lower 8-bit of A/D sample marker 0 Byte 7: upper 8-bit of A/D sample marker 0 Byte 8: lower 8-bit of pulse start marker 1 Byte 9: upper 8-bit of pulse start marker 1 Byte 10: lower 8-bit of A/D sample marker 1 Byte 11: upper 8-bit of A/D sample marker 1 Byte 12: lower 8-bit of pulse start marker 2 ...
n+3	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.15 WAVEFORM SAMPLES (START OF DOWNLOAD)

Byte	Description
0	Number of data bytes in packet (n). Note: the channel number and the total number of waveform samples count as data bytes. So the number of waveform samples in this packet is n-3.
1	Command ('W')
2	Channel number (1 or 2)
3-4	Total number of waveform samples. If this number exceeds the maximum packet size of the UART, it can be sent within multiple packets. Please see the "Waveform Samples (Continued)" packet information for the format description of subsequent packets.
5-(n+2)	Waveform Samples (8-bit values each)
n+3	Checksum

Response:

Byte	Description
0	'A' or 'N'

4.16 WAVEFORM SAMPLES (CONTINUED)

Byte	Description
0	Number of data bytes in packet (n) If the sum of the number of waveform samples in this package and the number of waveform samples already received exceeds the total number of waveform samples set with at the "Waveform Samples (Start of Download)", an error will occur.
1	Command ('W'+32)
2-(n+2)	Waveform Samples (8-bit values each)
n+3	Checksum

4.17 WAVEFORM START DELAY

Byte	Description
0	Number of data bytes in packet. Must be 3
1	Command ('D')
2	Channel number (1 or 2)
3-4	Start delay in D/A converter clock cycles

5	Checksum

Response:

Byte	Description
0	‘A’ (confirmed) or ‘N’ (error)