

MightyWatt R3 Communication Protocol Description

Board revision: 3.1

Minimum firmware version: 3.1.4

Arduino IDE tested: 1.8.1 (Arduino.cc)

Guide revision: E (2017-10-27)

Introduction

This document describes how MightyWatt R3 communicates with computer control application. Periodic data transfers use unsigned raw data; no negative numbers are transferred. Functions that should be called once during the initialization return data as ASCII text.

To check the integrity of data, CRC-16 CCITT (polynomial 0x1021) is appended as the last two bytes (LSB first) of each data transfer from computer to MightyWatt and each **Measurement and status** report from MightyWatt to computer. CRC is not used for the initialization string transfers (**IDN**, **QDC** and possible **Error messages** list).

Abbreviations

The following abbreviations are used through the text:

| Abbreviation or term | Meaning |
|----------------------|--|
| MSB | Most significant bit/byte |
| LSB | Least significant bit/byte |
| Firmware | Arduino sketch |
| Host | Controlling computer |
| Load | MightyWatt R3 |
| CRC | Cyclic redundancy check, specifically the CRC-16 CCITT |

Watchdog

The load has a watchdog, which will set the load to zero current after a certain period (`COMMUNICATION_WATCHDOG_TIMEOUT` in `CommunicationWatchdog.h`). To reset the watchdog, it is necessary to send commands through the serial line. The purpose is to automatically stop the load when the communication is lost or become 100% corrupted.

Data transfer description

Each data transfer is initiated by the host; load only responds to requests.

First byte is a header which determines what the load is supposed to do. Header is a bit field.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------|-----|--------|--------|----------|----|----|----|----------|
| Function | R/W | DL MSB | DL LSB | C4 (MSB) | C3 | C2 | C1 | C0 (LSB) |

R/W: READ or WRITE bit. 1 = Write to load (set something), 0 = Read from load (get data).

DL: Data stage length. 0 = 0 bytes (no data stage), 1 = 1 byte, 2 = 2 bytes, 3 = 4 bytes.

C4–C0: Command ID.

Each header can be followed by up to 4 data bytes. The number of data bytes is defined by DL. Data stage is sent LSB first. After the optional data bytes, the CRC is appended. Thus, one transfer from computer to the load is composed of header, optional data stage and CRC.

READ command

The READ command will instruct the load to send data to the host. What data is returned depends on the value of Command ID. Four Command IDs are supported:

1: Measurement and status report:

| Byte | Data |
|------|--|
| 0 | Measured current LSB, μA |
| 1 | Measured current, μA |
| 2 | Measured current, μA |
| 3 | Measured current MSB, μA |
| 4 | Measured voltage LSB, μV |
| 5 | Measured voltage, μV |
| 6 | Measured voltage, μV |
| 7 | Measured voltage MSB, μV |
| 8 | Measured temperature, $^{\circ}\text{C}$ |
| 9 | Status flags (see below) |
| 10 | User pins (see below) |
| 11 | Error flags (see below) LSB |
| 12 | Error flags |
| 13 | Error flags |
| 14 | Error flags MSB |

Status flags is a bit field:

| Bit | Meaning |
|-----|--|
| 0 | 0 = constant current mode, 1 = constant voltage mode |
| 1 | 0 = high voltage range, 1 = low voltage range |
| 2 | 0 = high current range, 1 = low current range |
| 3 | 0 = LED off, 1 = LED on |
| 4 | 0 = fan off, 1 = fan on |
| 5 | 0 = 2-wire mode, 1 = 4-wire mode |
| 6–7 | reserved |

User pins is a bit field; each set bit means that the corresponding logical pin is set (high). Five pins can be controlled in this board revision and the mapping of logical pins (0–4) to the physical pins starting from logical pin 0 is: 2, 6, 7, 10 and 13.

Error flags is a bit field; each set bit means that the corresponding error is active. The error description can be obtained by command “4”, *Error messages*.

2: IDN. This is Identify. Load returns “MightyWatt R3” as ASCII text, including CR+LF. It is suitable for the identification of the connected device. No CRC is transmitted in this response.

3: QDC. This is Query Device Capabilities. This returns 10 lines of ASCII text described below. No CRC is transmitted in this response.

| Line | Data |
|------|--|
| 0 | Calibration date (from Configuration.h) |
| 1 | Firmware version (from MightyWatt.h) |
| 2 | Board revision (from Configuration.h) |
| 3 | Maximum current supported by DAC (from calibration values in Configuration.h), μA |
| 4 | Maximum current supported by ADC (from calibration values in Configuration.h), μA |
| 5 | Maximum voltage supported by DAC (from calibration values in Configuration.h), μV |
| 6 | Maximum voltage supported by ADC (from calibration values in Configuration.h), μV |
| 7 | Maximum power (from Configuration.h), μW |
| 8 | Input resistance of voltmeter (from Configuration.h), $\text{m}\Omega$ |
| 9 | Temperature threshold for overheat (from Limiter.h), $^{\circ}\text{C}$ |

4: Error messages. This returns text description of possible errors reported by the load. Command returns up to 32 lines. No CRC is transmitted in this response. The actual errors are then reported in a bit field in **Measurement and status** report.

WRITE command

Commands are followed by a 1, 2 or 4-byte data stage and end with a CRC.

1: Constant current mode. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|--------------------------------|
| 0 | Set current LSB, μA |
| 1 | Set current, μA |
| 2 | Set current, μA |
| 3 | Set current MSB, μA |

2: Constant voltage mode. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|--------------------------------|
| 0 | Set voltage LSB, μV |
| 1 | Set voltage, μV |
| 2 | Set voltage, μV |
| 3 | Set voltage MSB, μV |

3: Constant power mode using constant current internally. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|------------------------------|
| 0 | Set power LSB, μW |
| 1 | Set power, μW |
| 2 | Set power, μW |
| 3 | Set power MSB, μW |

4: Constant power mode using constant voltage internally. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|------------------------------|
| 0 | Set power LSB, μW |
| 1 | Set power, μW |
| 2 | Set power, μW |
| 3 | Set power MSB, μW |

5: Constant resistance mode using constant current internally. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|------------------------|
| 0 | Set resistance LSB, mΩ |
| 1 | Set resistance, mΩ |
| 2 | Set resistance, mΩ |
| 3 | Set resistance MSB, mΩ |

6: Constant resistance mode using constant voltage internally. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|------------------------|
| 0 | Set resistance LSB, mΩ |
| 1 | Set resistance, mΩ |
| 2 | Set resistance, mΩ |
| 3 | Set resistance MSB, mΩ |

7: Software-controlled constant voltage mode. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|---------------------|
| 0 | Set voltage LSB, μV |
| 1 | Set voltage, μV |
| 2 | Set voltage, μV |
| 3 | Set voltage MSB, μV |

8: Maximum power point tracker. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|-------------------------|
| 0 | Initial voltage LSB, μV |
| 1 | Initial voltage, μV |
| 2 | Initial voltage, μV |
| 3 | Initial voltage MSB, μV |

If the initial voltage is zero, the load will attempt to set it automatically – to 90 % of the open-circuit voltage.

9: Simple ammeter. This command does not have a data stage.
Ammeter can be disabled by sending a “constant mode” command.

10: Series resistance. This command is followed by a 4-byte data stage:

| Byte | Data |
|------|-------------------------------|
| 0 | Set series resistance LSB, mΩ |
| 1 | Set series resistance, mΩ |
| 2 | Set series resistance, mΩ |
| 3 | Set series resistance MSB, mΩ |

11: 2-wire or 4-wire voltage sensing. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|--|
| 0 | 0 = set 2-wire mode (default), 1 = set 4-wire mode |

12: Measurement speed. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|---|
| 0 | 0 = internal ADC autoranging & filter* disabled (not used by the Windows control application), 1 = internal ADC autoranging enabled, filter* disabled, 2 = internal ADC autoranging & filter* enabled (default) |

*) Filter is an internal (in the firmware) 42-period (~200 ms) triangular weighted moving average filter.

13: Fan rules. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|--|
| 0 | 0 = always on (default), 1 = automatic – cool, 2 = automatic – quiet |

14: LED rules. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|--|
| 0 | Flag word, defines when LED is on; rules can be combined |

15: LED brightness. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|---|
| 0 | Sets duty cycle of the PWM that controls LED brightness; 255 = 100% |

16: Current range autoranging. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|--|
| 0 | 0 = fixed high current range when in constant current mode, 1 = autoranging active |

17: Voltage range autoranging. This command is followed by a 1-byte data stage:

| Byte | Data |
|------|--|
| 0 | 0 = fixed high voltage range when in constant voltage mode, 1 = autoranging active |

18: Action on user pins. This command is followed by a 1-byte data stage that is a bit field:

| Byte | Data | |
|------|------------|---|
| 0 | Bit 0 to 4 | The action is performed on logical pins whose corresponding bit is 1. Five pins can be controlled in this board revision and the mapping of logical pins (0–4) to the physical pins starting from logical pin 0 is: 2, 6, 7, 10 and 13. |
| | Bit 5 to 6 | Reserved |
| | Bit 7 | This bit determines the action – if 0, then the selected logical pins will be reset; if 1, the selected logical pins will be set. |

Examples

1) Set constant voltage, 6.5 V:

command byte: 0b11100010 (bit 7: 1 = WRITE; bit 6 and 5:

0b11 (3) = number of following data bytes is 4; bit 4–0: 0b10 (2) = constant voltage mode)

data byte 0: 0b10100000 (160 \Rightarrow 160 μ V)

data byte 1: 0b00101110 (46 \Rightarrow 46·256 = 11 776 μ V)

data byte 2: 0b01100011 (99 \Rightarrow 99·256² = 6 488 064 μ V)

data byte 3: 0b00000000 (0)

CRC LSB: 0b01000111 (71)

CRC MSB: 0b01010110 (86)

2) Read device capabilities:

command byte: 0b00000011 (bit 7: 0 = READ, bit 6 and 5: 0 = no data stage;

bit 4–0: 0b11 (3) = QDC)

CRC LSB: 0b01100011 (99)

CRC MSB: 0b00110000 (48)