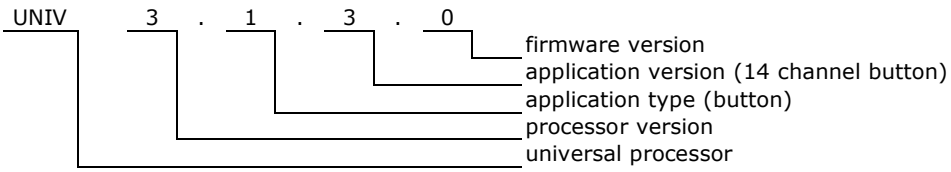
1. Features

- 14 channel button module. Up to 14 buttons with free voltage contacts can be connected to the module
- 7 types of button behaving is recognized: button pressed, released, pressed for 400ms, pressed for 4s, released within 400ms, released between 400ms and 4s, released after 4s
- There is a 20ms reaction time. Button has to be pressed for at least 20ms to activate module. It avoids contacts bouncing.
- 14 LEDs can be connected to indicate status of other devices on the network.
- Included temperature and thermostat feature when Dallas sensor is connected.
- Temperature measurement in range -55°C to +125°C with 0,0625°C resolution
- Setpoint value in range -55°C to +125° C with 0,0625°C resolution
- Hysteresis value adjustable from 0,0625 to 16,000°C with 0,0625°C resolution
- 9 control instructions
- 3 blocking instructions
- Allows defining up to 128 CAN messages which can indirectly control the module
- Self-control feature – pressed button can control the same module
- Allows writing notes in the processor memory
- Uptime counter
- Health check monitor
- Transmit (42 messages) and receive (42 messages) FIFO buffers

2. Compatibility

- Firmware for **UNIV 3.1.3.x** module
- Firmware can be uploaded into processor with bootloader version 3.1 or compatible.

3. Firmware version



4. Communication Frames (messages)

4.1. Button message

Module sends message to the bus, when status of input changes. Module is able to distinguish a few types of button behaving: pressed, released, pressed for 400ms, pressed for 4s, released within 400ms, released between 400ms and 4s , released after 4s. For each situation the unique message is sent to the bus. It is possible to choose for each button separately what massages should be sent.
This firmware controls LEDs connected to switches. LED can be toggled by message received from the bus or locally by pressed button.

Table 1. BUTTON frame (0x301)

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x301	3 2 1 0	Node Nr	Group Nr	0xFF	0xFF	CHANNEL	BUTTON	LED	0xFF	0xFF	0xFF

0x301 – universal module frame, button

- 3 - - not used flag, read as "0"
- 2 - - not used flag, read as "0"
- 1 - - not used flag, read as "0"
- 0 RE - response flag. Flag is equal "1" if node was requested. If flag is equal „0" it means that status of input has just changed.

Node Nr - message sender node number

Group Nr - message sender group number

CHANNEL - input channel 0x01 (button 1) – 0x0E (button 14)

BUTTON - actual input status
0x00 – open
0xFF – closed
0xFE – closed and held for 400ms
0xFD – closed and held for 4s
0xFC – closed and open within 400ms
0xFB – closed and open between 400ms and 4s
0xFA – closed and open after 4s

LED - actual LED status 0x00 – off, 0xFF – on

4.2. Current temperature message

The module sends message when sensor temperature changes by value (0.0625-15.9375°C) defined in configuration. The frame contains temperature setpoint. The setpoint can be adjusted by other modules on the network.

Table 2. CURRENT TEMPERATURE frame (0x304)

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	3 2 1 0	Node Nr	Group Nr	0xFF	0xFF	0x11	TEMPMSB	TEMPLSB	SETPOMSB	SETPOLSB	HYSTER

0x304 – thermometer

- 3 - - not used flag, read as "0"
- 2 - - not used flag, read as "0"
- 1 - - not used flag, read as "0"
- 0 RE - response flag. Flag is equal "1" if node was requested. If flag is equal „0" it means that status of output has just changed.

Node Nr - message sender node number

Group Nr - message sender group number

0x11 - data type in message (0x11 - temperature frame)

TEMPMSB - most significant byte of measured temperature 0xFC90 – 0x07D0 (-55°C - +125°C), resolution 0.0625°C

TEMPLSB - least significant byte of measured temperature

SETPOMSB - most significant byte of thermostat value 0xFC90 – 0x07D0 (-55°C - +125°C), resolution 0.0625°C

SETPOLSB - least significant byte of thermostat value

HYSTER - switching hysteresis 0x00 – 0xFF (0.0625 – 16.0000°C), resolution 0.0625°C

The temperature data is presented by TEMPMSB and TEMPLSB registers as 12bit sign extended two's complement number. The sign bits 'S' indicate if temperature is positive or negative. For positive numbers S=0 and for negative S=1. Please refer to Dallas sensor datasheet for details.

TEMPMSB

S	S	S	S	S	2^6	2^5	2^4

TEMPLSB

2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}

Table 3. Temperature register format for Current Temperature frame.

4.3. Thermostat message

When measured temperature drops below, or rises above setpoint, the module sends thermostat message. Hysteresis value makes module to not react immediately for temperature changes around switching point. Adequate hysteresis can be set 0.0625 – 16.0000°C with resolution 0.0625°C. This message can toggle other modules on the network.

Table 4. THERMOSTAT frame

Frame type	Flags				Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	3	2	1	0	Node Nr	Group Nr	0xFF	0xFF	0x12	THERM POSITION	0xFF	0xFF	0xFF	THERM STATE

0x304 – thermometer

3	-	- not used flag, read as "0"
2	-	- not used flag, read as "0"
1	-	- not used flag, read as "0"
0	RE	- response flag. Flag is equal "1" if node was requested. If flag is equal „0" it means that status of output has just changed.

Node Nr - message sender node number

Group Nr - message sender group number

0x12 - data type in message (0x12 - thermostat frame)

THERM POSITION - current thermostat status (0x00 - temperature below setpoin, 0xFF - temperature above setpoint, 0x80 – power up value)

THERM STATE - thermostat state (0x00 – turned off, 0xFF – turned on)

4.4. Temperature controller message

The module can operate as a temperature regulator with PWM output. You can specify the PWM period (1-256 minutes) and the duty cycle which depends on temperature error up to 2°C with 0.0625°C resolution (32 positions for heating and 32 for cooling). The controller has a sensitivity setting feature.

Module sends this message when:

1. temperature error has changed and is equal to zero;
2. temperature error has changed and this change is greater or equal to controller sensitivity (value 0,0625°C - 16,0000°C) set in module configuration;
3. begins new period of PWM (value 1 – 255 minutes) set in module configuration;
4. there is a change of PWM state from high to low state. For PWM 100% value, there is no change, so no message is sent;
5. message cyclical transmission time has elapsed, if defined in the configuration (value 1-255 minutes);
6. controller has been turned off or on;
7. module has been asked for status.

Table 5. CONTROLLER frame

Frame type	Flags				Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	3	2	1	0	Node Nr	Group Nr	0xFF	0xFF	0x13	HEAT PWM STATE	HEAT PWM VALUE	COOL PWM STATE	COOL PWM VALUE	CTRL STATE

0x304 – thermometer

3	-	- not used flag, read as "0"
2	-	- not used flag, read as "0"
1	-	- not used flag, read as "0"
0	RE	- response flag. Flag is equal "1" if node was requested. If flag is equal „0" it means that status of output has just changed.

Node Nr - message sender node number

Group Nr - message sender group number

0x13 - data type in message (0x13 - controller frame)

HEAT PWM STATE - heating controller PWM state (0x00 – PWM is off „0", 0xFF – PWM is on „1")

HEAT PWM VALUE - heating controller PWM value 0-255 (0x00 – 0xFF)

COOL PWM STATE - cooling controller PWM state (0x00 – PWM is off „0", 0xFF – PWM is on „1")

COOL PWM VALUE - cooling controller PWM value 0-255 (0x00 – 0xFF)

CTRL STATE - controller state (0x00 – turned off, 0xFF – turned on)

4.5. Temperature sensor error frame

The module sends this message when a temperature sensor reading error has occurred and:
1 elapsed time of cyclic sending, if defined in the configuration (value in the range 1-255 minutes);
2 module was asked for status.

Table 6. SENSOR ERRROR FRAME

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	3 2 1 0	Node Nr	Group Nr	0xFF	0xFF	0xF0	ERROR	0xFF	0xFF	0xFF	0xFF

0x304 – thermometer

3	- - not used flag, read as "0"
2	- - not used flag, read as "0"
1	- - not used flag, read as "0"
0	RE - response flag. Flag is equal "1" if node was requested. If flag is equal „0" it means that status of output has just changed.

Node Nr - message sender node number

Group Nr - message sender group number

0xF0 - data type in message (0xF0 – temperature sensor error frame)

ERROR - error codes
0x01 – sensor not connected
0x02 – connected more than one sensor or connected wrong type of sensor
0x03 – connected wrong type of sensor
0x04 – communication problem on 1-wire network (CRC problem)

4.6. Status request

Status of module can be checked by sending from computer STATUS REQUEST frame (0x109).

Table 7. STATUS REQUEST frame (0x109).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x109	0x0	COMP ID1	COMP ID2	0xXX	0xXX	Node Nr	Group Nr	0xXX	0xXX	0xXX	0xXX

0x1090 – STATUS REQUEST frame

COMP ID1 - computer identifier (must be unique on the network)

COMP ID2 - computer identifier (must be unique on the network)

Node Nr - node number of requested module

Group Nr - group number of requested module

0xXX - inessential data

As response the module will send 17 status frames (Table 8). Meaning of bytes is the same as in Table 1, 2, 4, 5 or 6. Instead of sending current temperature, thermostat and controller frames, the module can send error frame.

Table 8. Response to STATUS REQUEST.

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x301	0x1	Node Nr	Group Nr	0xFF	0xFF	0x01	BUTTON	LED	0xFF	0xFF	0xFF
0x301	0x1	Node Nr	Group Nr	0xFF	0xFF	0x02	BUTTON	LED	0xFF	0xFF	0xFF

...

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x301	0x1	Node Nr	Group Nr	0xFF	0xFF	0x0E	BUTTON	LED	0xFF	0xFF	0xFF
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0x11	TEMPMSB	TEMPLSB	SETPOMSB	SETPOLSB	HYSTER
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0x12	THERM POSITION	0xFF	0xFF	0xFF	THERM STATE
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0x13	HEAT PWM STATE	HEAT PWM VALUE	COOL PWM STATE	COOL PWM VALUE	CTRL STATE

4.7. Uptime request

Table 9. UPTIME REQUEST (0x113).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x113	0x0	COMP ID1	COMP ID2	0xXX	0xXX	Node Nr	Group Nr	0xXX	0xXX	0xXX	0xXX

0x1130 – UPTIME REQUEST frame

COMP ID1 - computer identifier (must be unique on the network)

COMP ID2 - computer identifier (must be unique on the network)

Node Nr - node number of requested module

Group Nr - group number of requested module

0xXX - inessential data

Table 10. Response to UPTIME REQUEST (0x113).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x113	0x1	Node Nr	Group Nr	0xFF	0xFF	0xFF	0xFF	UPTIME3	UPTIME2	UPTIME1	UPTIME0

0x1131 – Response to UPTIME REQUEST frame

Node Nr - message sender node number
Group Nr - message sender group number

UPTIME - (UPTIME3*256^3+UPTIME2*256^2+UPTIME1*256^1+UPTIME3*256^0) in seconds

4.8. Health check request

Table 11. HEALTH CHECK - STATUS REQUEST (0x115).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x115	0x0	COMP ID1	COMP ID2	0x01	0xXX	Node Nr	Group Nr	0xXX	0xXX	0xXX	0xXX

0x1150 – HEALTH CHECK REQUEST frame

COMP ID1 - computer identifier (must be unique on the network)
COMP ID2 - computer identifier (must be unique on the network)

0x01 - status request

Node Nr - node number of requested module

Group Nr - group number of requested module

0xXX - inessential data

As response the module will send two frames (Table 12).

Table 12. Response to HEALTH CHECK - STATUS REQUEST (0x115).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x115	0x1	Node Nr	Group Nr	0x01	RXCNT	TXCNT	RXCNTMX	TXCNTMX	CANINTCNT	RXERRCNT	TXERRCNT

0x1151 – Response to HEALTH CHECK REQUEST frame

Node Nr - message sender node number
Group Nr - message sender group number

0x01 - frame 1 (current values)

RXCNT - current level of receive FIFO buffer

TXCNT - current level of transmit FIFO buffer

RXCNTMX - maximum level of receive FIFO buffer since power up

TXCNTMX - maximum level of transmit FIFO buffer since power up

CANINTCNT - number of CAN interface restarts since power up

RXERRCNT - current receive errors register

TXERRCNT - current transmit errors register

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x115	0x1	Node Nr	Group Nr	0x02	0xFF	0xFF	RXCNTMXE	TXCNTMXE	CANINTCNTE	RXERRCNTE	TXERRCNTE

0x1151 – Response to HEALTH CHECK REQUEST frame

Node Nr - message sender node number
Group Nr - message sender group number

0x02 - frame 2 (maximum values saved in eeprom memory)

RXCNTMXE - maximum ever level of receive FIFO buffer

TXCNTMXE - maximum ever level of transmit FIFO buffer

CANINTCNTE - maximum ever number of CAN interface restarts

RXERRCNTE - maximum ever receive errors

TXERRCNTE - maximum ever transmit errors

To clear maximum values saved in eeprom memory the frame shown in Table 13 must be sent. There is no response to this message.

Table 13. HEALTH CHECK - CLEAR REQUEST (0x115).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x115	0x0	COMP ID1	COMP ID2	0x02	0xXX	Node Nr	Group Nr	0xXX	0xXX	0xXX	0xXX

0x1150 – HEALTH CHECK REQUEST frame

COMP ID1 - computer identifier (must be unique on the network)
COMP ID2 - computer identifier (must be unique on the network)

0x02 - clear request

Node Nr - node number of requested module

Group Nr - group number of requested module

0xXX - inessential data

5. Module control

The module can be controlled directly from PC, or indirectly by other modules. In both situation all instructions in the table below can be used. Blocking instructions can't be used in direct control.

5.1. Control instruction

The Table 14 shows instructions, which can be executed by the module.

Instruction	Instruction Codding								Note	Control	
	INSTR1	INSTR2	INSTR3	INSTR4	INSTR5	INSTR6	INSTR7	INSTR8		Direct	Indirect
TURN OFF LED	**0x00**	**LED1**	**LED2**	0xXX	0xXX	0xXX	0xXX	0xXX	It will turn off chosen LEDs, and the rest will stay unchanged.	√	√
TURN ON LED	**0x01**	**LED1**	**LED2**	0xXX	0xXX	0xXX	0xXX	0xXX	It will turn on chosen LEDs, and the rest will stay unchanged.		
TOGGLE LED	**0x02**	**LED1**	**LED2**	0xXX	0xXX	0xXX	0xXX	0xXX	It will toggle chosen LEDs, and the rest will stay unchanged.		

0xXX – inessential data

LED1	Note
0x01	- (00000001) - only LED1
0x02	- (00000010) - only LED2
0x03	- (00000011) - LED1 & LED2
0x04	- (00000100) - only LED3
...	
0xFF	- '11111111' - LED1, 2, 3, 4, 5, 6, 7, 8

bit <7> - LED8, bit <6> - LED7, bit <5> - LED6, bit <4> - LED5, bit <3> - LED4, bit <2> - LED3, bit <1> - LED2, bit <0> - LED1

LED2	Note
0x01	- (00000001) - only LED9
0x02	- (00000010) - only LED10
0x03	- (00000011) – LED9 & LED10
0x04	- (00000100) - only LED11
...	
0x3F	- (00111111) – LED9, 10, 11, 12, 13, 14

bit <5> - LED14, bit <4> - LED13, bit <3> - LED12, bit <2> - LED11, bit <1> - LED10, bit <0> - LED9

SET SETPOINT TO	**0x03**	**THMSB**	**THLSB**	0xXX	0xXX	0xXX	0xXX	0xXX	It sets setpoint to value indicated in THER1 & THER2 registers	√	√
DECREASE SETPOINT BY	**0x04**	**STEP**	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	It decreases setpoint by value STEP*0,0625°C		
INCREASE SETPOINT BY	**0x05**	**STEP**	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	It increases setpoint by value STEP*0,0625°C		

0xXX – inessential data

THMSB	**THLSB**	Note
0xFC90 - 0x07D0		Setpoint value 0xFC90 – 0x07D0 (-55°C - +125°C), resolution 0,0625°C, where THMSB – most significant byte, THLSB – least significant byte

STEP	Note
0x01	- setpoint value will be changed (decreased or increased) by 1*0,0625°C=0,0625°C value
0x02	- setpoint value will be changed (decreased or increased) by 2*0,0625°C=0,1250°C value
...	
0xFF	- setpoint value will be changed (decreased or increased) by 255*0,0625°C=15,9375 °C value
0x00	- setpoint value will be changed (decreased or increased) by 256*0,0625°C=16,0000 °C value

TURN OFF THERMOSTAT/CONTROLLER	**0x06**	**MODULE**	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	Turns off chosen modules	√	√
TURN ON THERMOSTAT/CONTROLLER	**0x07**	**MODULE**	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	Turns on chosen modules		
TOGGLE THERMOSTAT/CONTROLLER	**0x08**	**MODULE**	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	Toggles chosen modules		

0xXX – inessential data

MODULE	Note
0x01	- (00000001) - only THERMOSTAT
0x02	- (00000010) - only CONTROLLER
0x03	- (00000011) – THERMOSTAT & CONTROLLER

bit <1> - CONTROLLER, bit <0> - THERMOSTAT

ENABLE BOX	**0xDD**	**BoxX**	**BoxY**	0xXX	0xXX	0xXX	0xXX	0xXX	It enables chosen boxes – these boxes will be compared with next received message from the bus.		√
DISABLE BOX	**0xDE**	**BoxX**	**BoxY**	0xXX	0xXX	0xXX	0xXX	0xXX	It disables chosen boxes – these boxes will be passed when next message arrives from the bus.		√
TOGGLE BOX	**0xDF**	**BoxX**	**BoxY**	0xXX	0xXX	0xXX	0xXX	0xXX	It toggles boxes – enables when they are disabled and vice versa		√

0xXX – inessential data

BoxX	Note
0x00	- from Box 1
0x01	- from Box 2
...	
0x7F	- from Box 128

BoxY	Note
0x00	+ 0 -(and not anyone else)
0x01	+ 1 -(and 1 following)
...	
0x7F	+127 -(and 127 following)

5.3. Direct control

It is possible to control module by sending DIRECT CONTROL message. The message contains instruction, which will be executed by the module. The module can be also controlled from HAPCAN Programmer.

Table 15. DIRECT CONTROL frame (0x10A).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x10A	0x0	COMP ID1	COMP ID2	INSTR1	INSTR2	Node Nr	Group Nr	INSTR3	INSTR4	INSTR5	INSTR6

0x10A – DIRECT CONTROL frame

COMP ID1 - computer identifier (must be unique on the network)

COMP ID2 - computer identifier (must be unique on the network)

Node Nr - node number of requested module

Group Nr - group number of requested module

INSTR1-6 - instruction to be executed (byte1)

5.4. Indirect control

Indirect control means that module will react to messages sent by other modules on the network. It depends on configuration programmed into the module boxes (memory cells).
This firmware has feature to set simple conditions of executing instruction. To do so, you can use blocking instruction (0xDD – 0xDF) shown in Table 14.

6. Configuration

Below are parameters that can be configured with this firmware. Configuration process can be done using HAPCAN Programmer.

6.1. Module identifier

Every module on the network must have unique identifier. The identifier is made of two bytes, module number (1 byte) and group number (1 byte). Identifier of the Ethernet Interface can be changed in HAPCAN Programmer in software settings.

6.2. Module description

Every module can have 16 char description, which makes easier for user (programmer) to distinguish nodes.

6.3. Button settings
For each button it is possible to configure what type of button behaving is recognized by module. Module can recognize when:
- button is pressed,
- button is released,
- pressed and held for 400ms,
- pressed and held for 4s,
- pressed and released within 400ms (quick click),
- pressed and released between 400ms and 4s,
- pressed and released after 4s.

For each behaving a separate message will be sent on the bus.
WARNING: It is very important to choose only messages which will be used on the network to keep traffic on the bus as low as possible.

6.4. Thermostat/Controller state on power up
There are 3 possible settings: thermostat / regulator on, off, and the state before power failure, which must be unchanged for 6 seconds before turning off the power, to be remembered.

6.5. Setpoint value on power up
The thermostat value on power up can be set between 0xFC90 – 0x07D0 (-55°C - +125°C). It can also be chosen last adjusted value before power disconnection (0x0800).

6.6. Temperature offset
It is possible to calibrate the thermometer by setting temperature offset, which will be added to measured temperature. Temperature with added offset will be displayed as current temperature and will be used to check against the thermostat. The temperature offset value can be chosen from range 0xFC90 – 0x07D0 (-55°C - +125°C) with 0.0625°C resolution. If no calibration is needed the offset should be set to 0x0000.

6.7. Temperature sensitivity
This parameter defines the minimum change of sensor temperature when the module sends the temperature message.

6.8. Periodical messages
This parameter defines the period between cyclical temperature, thermostat and controller frames. The parameter is defined individually for temperature, thermostat and controller. The period can be set between 0x01-0xFF (1min - 255min). The 0x00 value disables the cyclic sending messages.

6.9. Thermostat hysteresis
Hysteresis prevents module from switching constantly around setpoint value. Thermostat will be switched to 0xFF (high state) if temperature rises above (setpoint + hysteresis). It will be switched to 0x00 (low state) if temperature drops below (setpoint – hysteresis) (see Figure 1). The hysteresis value can be chosen from 0x00 to 0xFF (0.0625°C tp 16.0000°C) with 0.0625°C resolution.

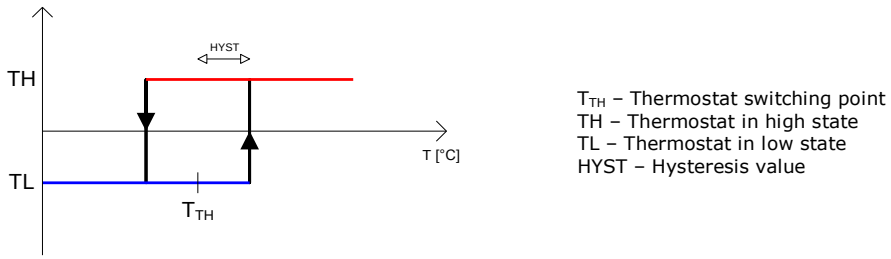


Figure 1. Switching point and hysteresis.

6.10. Controller sensitivity
Specifies the minimum temperature error change for controller to react. The value can be set between 0.0625°C - 16.0000°C.

6.11. The controller PWM period
The period of the PWM signal can be set in the range from 1 - 255 minutes. This setting is common to control heating and cooling.

6.12. Temperature error to PWM duty cycle mapping table
Table allows temperature error to PWM signal duty cycle mapping. The table contains 32 fields or temperature error from 0.0625 to 2.0000°C (resolution 0.0625°C). The duty cycle values: 0x00-0xFF (0% -100%). The module has two tables: one for heating and another for cooling control. The duty cycle for temperature error greater than 2.0000°C is the same as for the value of 2.0000°C.

6.13. Text notes.
Up to 1024 characters can be written into processor's memory.

6.14. Linking devices
The module has 128 memory cells (boxes). Each box can contain information about message sent by other node, and instruction which will be executed when that message is received.

7. License

8. Document version

File	Note	Date
univ_3-1-3-0a.pdf	Original version	June 2014