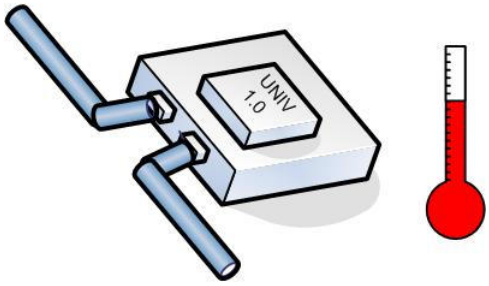
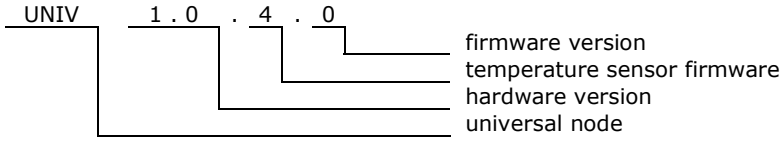
Temperature sensor application
for universal module UNIV 1.0
and processor UNIV 1.0 (CPU)

Features:

- Uses 1-wire digital sensors DS18B20, DS18B20-PAR, or DS1822, DS1822-PAR.
- Measures temperatures from -55°C to +125°C.
- Accuracy ±0.5°C when used with DS18B20, DS18B20-PAR, or ±2.0°C with DS1822 and DS1822-PAR.
- 12bits temperature resolution.
- Operation voltage 10-24V.
- Current consumption 14mA.
- Application includes thermostatic control with resolution 1.0°C
- 1°C hysteresis resolution.
- Remembers last thermostat value in case of power failure.
- Application can be uploaded into devices with bootloader version 2.5 or compatible.



Application version



1. Operation overview

Module sends message to the bus when sensor temperature changes by 0.5°C. It can be used as thermostat. It will send information when temperature is above and below a thermostat switching temperature. Adequate hysteresis can be set with resolution 1°C. Thermostat switching temperature can be adjusted from other modules on the network eg. button module, or infrared receiver. This application allows to connect only one 1-wire device.

2. Technical data

Bus side

Parameter	Symbol	Value	Unit
Power supply voltage	U_s	10-24V	V
Current consumption	I_s	14	mA

Temperature sensor

Parameter	Symbol	Value	Unit
Operating temperature	T	-55 - +125	°C
Operating temperature resolution	T_{RES}	0.0625	°C
Temperature accuracy	T_{ERR}	DS18B20, DS18B20-PAR: ±2 ±0.5 (-10°C - +85°C) DS1822, DS1822-PAR: ±3 ±2 (-10°C - +85°C)	°C
Thermostat switching temperature	T_{THM}	-55 - +125	°C
Thermostat switching temperature resolution	T_{THMRES}	1	°C
Thermostat hysteresis	T_{HIS}	1 – 90	°C
Thermostat hysteresis resolution	T_{HISRES}	1	°C

3. Hardware

3.1. Schematic

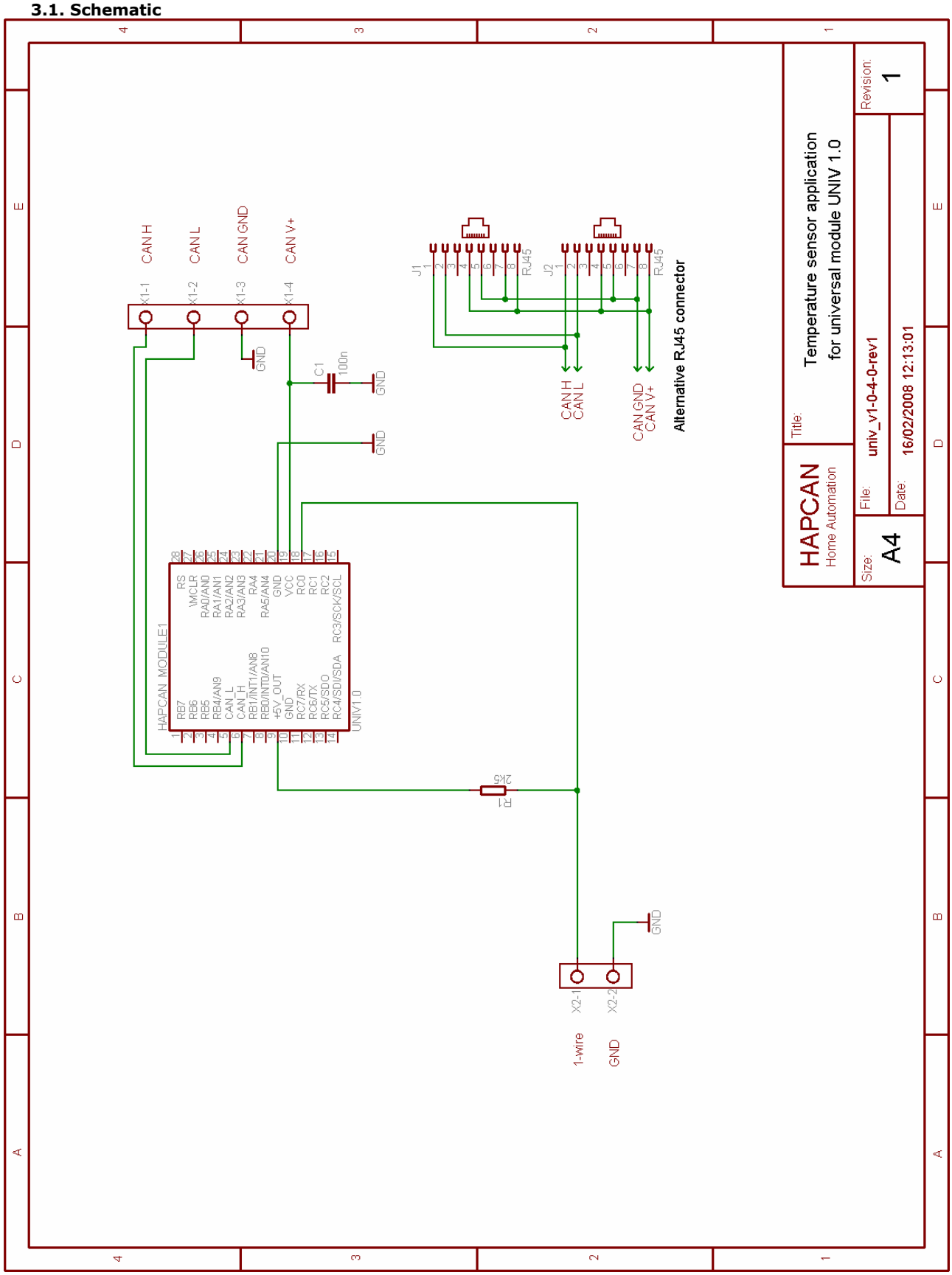


Figure 1. Schematic of temperature sensor for universal module UNIV 1.0

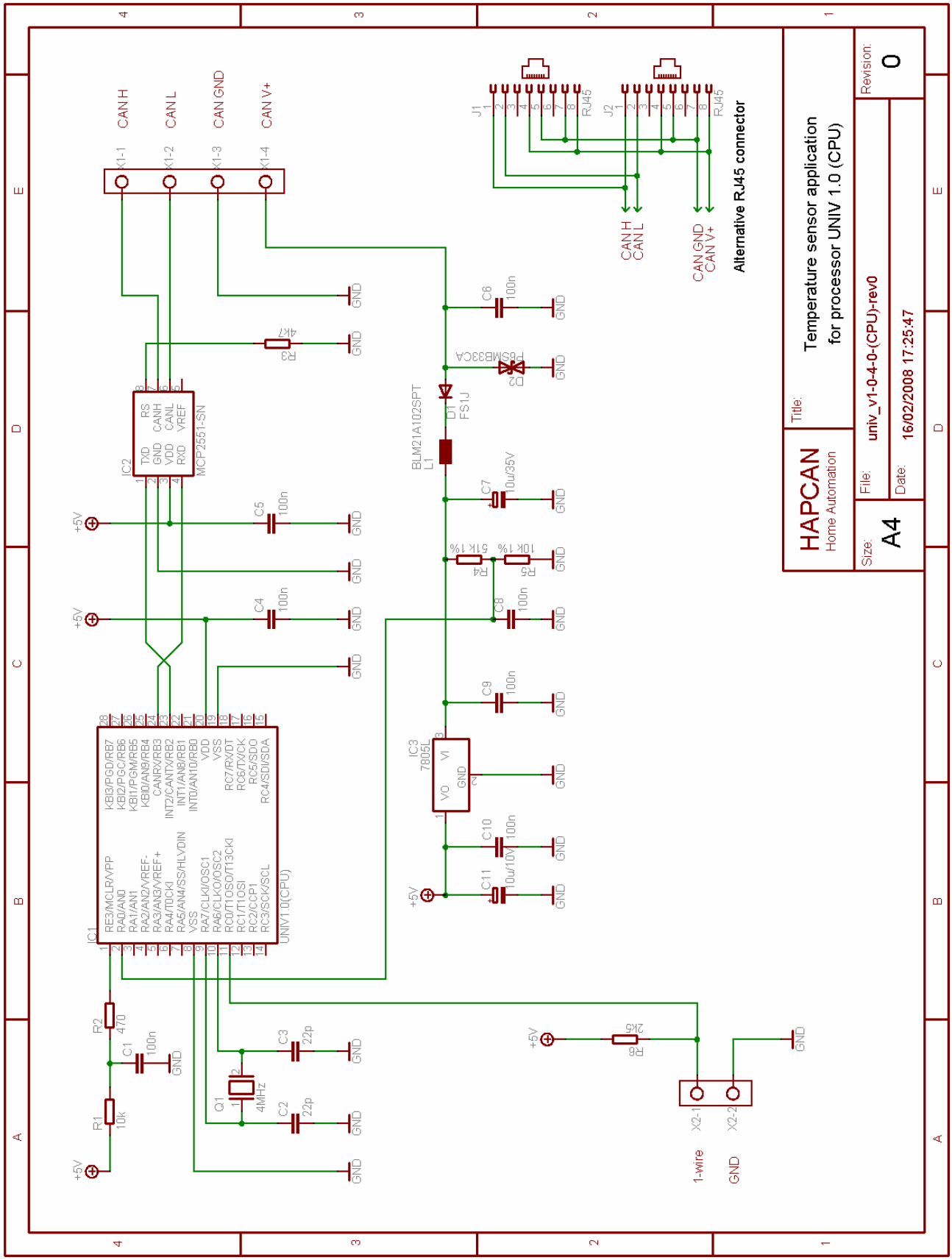
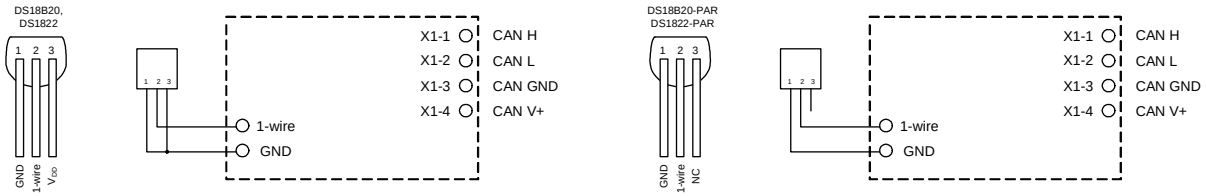


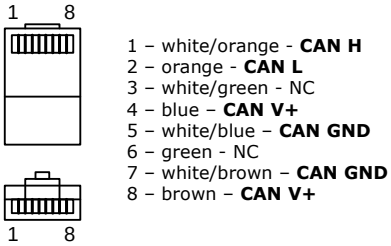
Figure 2. Schematic of temperature sensor for processor UNIV 1.0 (CPU).

3.2. Connections



Note that if module is first or last on the bus, resistor 120ohm must be connected between pins CAN H and CAN L.

Figure 3. Connection schematic for different sensor types.



1 – white/orange - **CAN H**
2 – orange - **CAN L**
3 – white/green - NC
4 – blue – **CAN V+**
5 – white/blue – **CAN GND**
6 – green - NC
7 – white/brown – **CAN GND**
8 – brown – **CAN V+**

Figure 4. Bus connection with RJ45 option.

4. Firmware

Firmware can be uploaded by using HAPCAN Programmer, which can be downloaded from site http://siwilo.com/hapcan/software.

4.1. Current temperature message

The module sends message when sensor temperature changes by 0.5°C. Construction of this message is shown in Table1. This message can toggle other modules on the network.

Table 1. CURRENT TEMPERATURE frame

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	0x0	Node Nr	Group Nr	0xFF	0xFF	0x01	TEMPMSB	TEMPLSB	THERMOS VALUE	HYSTER	0xFF

0x304 – universal module frame, temperature sensor application

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 - node number on the network

Group Nr - group number of the node on the network

0x01 - data type in message (0x01 - temperature frame)

TEMPMSB - most significant byte of measured temperature

TEMPLSB - least significant byte of measured temperature

THERMOS VALUE - set value of thermostat switching temperature 0xC9 – 0x7D (-55°C - +125°C)

HYSTER - switching hysteresis (1- 90°C)

The temperature data is presented by MSB and LSB registers as 9bit 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.

MS Byte

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

LS Byte

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

Figure 5. Temperature register format for Current Temperature frame.

4.2. Thermostat message

When measured temperature drops below, or rises above thermostat switching temperature, the module sends thermostat message. Hysteresis value makes module to not react immediately for temperature changes around switching point. This message can toggle other modules on the network.

Table 2. THERMOSTAT frame

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	0x0	Node Nr	Group Nr	0xFF	0xFF	0x02	THERMOS STATUS	0xFF	INSTR1	INSTR2	TIMER

0x304 – universal module frame, temperature sensor application

Node Nr - node number on the network

Group Nr - group number of the node on the network

0x02 - data type in message (0x02 - thermostat frame)

THERMOS STATUS - current thermostat status (0x00 - temperature below thermostat switching value, 0xFF - temperature above thermostat switching temperature)

INSTR1 - instruction that is waiting for execution, or 0xFF if none instruction (instructions are described in Module Control section)

INSTR2 - second byte of instruction that is waiting for execution, or 0xFF

TIMER - delay value of waiting instruction, or 0x00 if none waiting

4.3. Status request

Status of module can be checked by sending from computer STATUS REQUEST frame (0x109) (see Table 3).

Table 3. 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

0x109 – 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

In response the module will send an error frame if there is a problem with 1-wire bus, or two frames – temperature frame & thermostat frame (see table 4). Meaning of bytes is the same as in table 1 and 2.

Table 4. Response for STATUS REQUEST.

Error frame

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0xFF	ERROR CODE	0xFF	0xFF	0xFF	0xFF

ERROR CODE = 0x01 – there is no 1-wire sensor on the bus
ERROR CODE = 0x02 – there are more than one sensor or wrong device (without 64bit identifier)
ERROR CODE = 0x03 – wrong device on the bus
ERROR CODE = 0x04 – CRC problem (1-wire transmission problem)

or

Current temperature status

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0x01	TEMPMSB	TEMPLSB	THERMOS VALUE	HYSTER	0xFF

Thermostat status

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x304	0x1	Node Nr	Group Nr	0xFF	0xFF	0x02	THERMOS STATUS	0xFF	INSTR1	INSTR2	TIMER

Temperature registers in current temperature status frame give 12bit resolution (see Figure 6).

MS Byte

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

LS Byte

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

Figure 6. Temperature register format for current temperature status frame.

4.4. Module control

Module can be controlled directly from PC, or indirectly by other modules. In both situation all 3 instruction can be used. The thermostat value can be adjusted by other modules on the network. For instance can be increment or decrement by button module or remote controller through infrared receiver. New thermostat value will be stored in eeprom memory, in case of power failure, approximately 4s after adjusting.

4.4.1. Control instruction

The module understands 3 instructions shown below in the table 5.

Table 5. Instructions coding

Instruction	Instruction code		Description
	INSTR1	INSTR2	
Set thermostat to	0x00	0xC9 – 0x7D	Sets thermostat to value equal INSTR2
Dec thermostat by	0x01	0x00 – 0xFF	Decrease thermostat value by INSTR2
Inc thermostat by	0x02	0x00 – 0xFF	Increase thermostat value by INSTR2

4.4.2. Timer

All instructions can be executed with delay 1s-20h set by TIMER register. Drawing below shows time dependence of TIMER register.

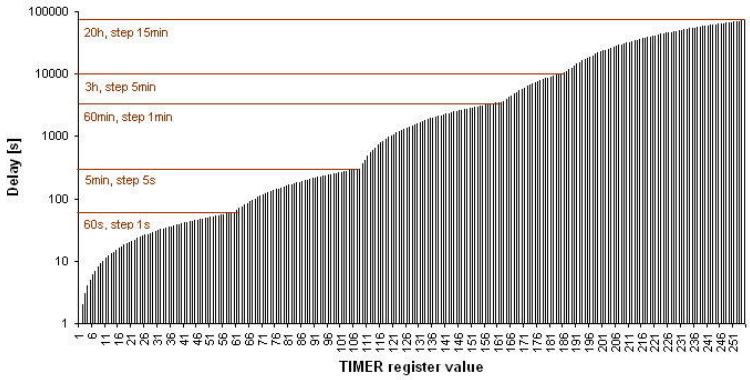


Figure 5. Delay/timer register relationship.

4.4.3. Direct control

By sending DIRECT CONTROL message it is possible to control module. The message contains instruction, which will be executed by module. The module can be also controlled from HAPCAN Programmer. As a response the module will send actual status frames.

Table 6. DIRECT CONTROL frame (0x10A).

Frame type	Flags	Module	Group	D0	D1	D2	D3	D4	D5	D6	D7
0x10A	0x0	COMP ID1	COMP ID2	0xXX	0xXX	Node Nr	Group Nr	0xXX	INSTR1	INSTR2	TIMER

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 - instruction to be executed (byte1)

INSTR2 - instruction to be executed (byte2)

TIMER - instruction delay

4.4.4. Indirect control

Indirect control means that module will react to messages sent by other modules on the network. It depends on configuration (linking devices) programmed into the module.

4.5. Configuration

With this version of application parameters below can be configured:

- Module identifier (module number and group number);
- Module description (16 chars);
- Thermostat value on power up;
- Thermostat hysteresis;
- Linking device with other modules (indirect control of module)

Configuration process can be done by using HAPCAN Programmer.

4.5.1. 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). Belonging to particular group might be used in future applications.

4.5.2. Module description

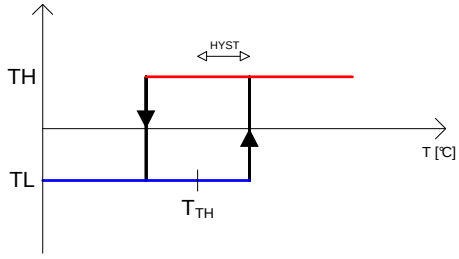
Every module can have 16 char description, which makes easier for user (programmer) to distinguish nodes. Examples of node descriptions: living-temp, bed2-temp1 etc.

4.5.3. Power up thermostat value

The thermostat value on power up can be set 0xC9 – 0x7D (-55°C - +125°C). It can also be chosen last adjusted value before power disconnection.

4.5.4. Thermostat hysteresis

Hysteresis prevents module from switching constantly around thermostat value. Thermostat will be switched to 0xFF (high state) if temperature rises above thermostat switching value + hysteresis value. It will be switched to 0x00 (low state) if temperature drops below thermostat switching point – hysteresis (see Figure 6).



T_{TH} – Thermostat switching point
TH – Thermostat in high state
TL – Thermostat in low state
HYST – hysteresis value

Figure 6. Switching point and hysteresis.

4.5.5. Linking devices

The module has 24 memory cells (boxes), which can contain information about messages sent by other nodes. The module can react to these messages. There is info in each box about message and instruction that will be executed when message is received.

5. Document version

File	Note	Date
univ_v1-0-4-0a.pdf	Original version	August 2007
univ_v1-0-4-0b.pdf	T_{ERR} correction	October 2007
univ_v1-0-4-0c.pdf	UNIV 1.0 (CPU) update	February 2008