Application Description

Hot Water Heating

Load Management

7

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Summary:

This document is a part of the HVAC Application Interworking Standard for Hot Water Heating applications. This chapter of Volume 7-11 describes the overall HWH load management mechanisms using locking signals for load shedding and forcing signals for the purpose of forced energy consumption.

Version 01.01.01 is a KNX Approved Standard.

This document is part of the KNX Specifications v2.1.

Document updates

Version	Date	Modifications
0.1	2002.02.22	BKY, document created, TFI approved, KNX Handbook 1.0
1.0	2002.09.12	BKY, editorial corrections, TFI approved, updated for KNX Handbook 1.1
1.1	2003.08.06	BKY, editorial corrections; TFI approved, updated for KNX Handbook 1.1
1.1	2009.06.17	Update in view of publication in the KNX Specifications v2.0.
01.01.01	2013.10.28	Editorial updates for the publication of KNX Specifications 2.1.

References

[01] Chapter 3/7/2 “Datapoint Types”
[02] Chapter 7/11/1 “Heat Production”
[03] Chapter 7/11/2 “Heat Distribution”
[04] Chapter 7/11/4 “Room Heating Control”

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Contents

1 Introduction

1.1 Scope

This document is a part of the Konnex HVAC Application Interworking Standard. It illustrates the load management mechanisms between Heat Production – Heat Distribution - Heat Consumers in case of:

- overload of the Heat Production or Heat Distribution system
- overheat or oversupply in the Heat Production system
- overheat in the Heat Distribution system
- efficient usage of remaining energy after load shutdown
- load priority of selected heat consumers

1.2 Objectives

This Document is mainly illustrative and describes the overall concept of HWH load management whereas in the functional block specifications [02] – [04] only the local usage of forcing and locking signals is described.

The main parts of this documents are informative only because the normative specification is contained in the functional block descriptions. Some parts in this document which complement the functional block specification are however normative and are highlighted.

The implementation of forcing and locking signals is optional and today restricted to LTE mode only. This document is therefore only relevant if these signals and load management functions are implemented.

1.3 Abbreviations

Functional Blocks:

Hot Water Heating (HWH)

Abbreviation	Description
BUC	Burner Controller
BOC	Boiler Controller
HPM	Heat Production Manager
BST	Buffer Storage Tank
HFDM	Heating Flow Demand Manager
FTC	Flow Temperature Controller
HPM	Heat Production Manager
HZC	Heating Zone Controller
HIRC	Heating Individual Room Controller
HRDM	Heating Room Demand Manager
HDTACT	Heat Demand Transformer Actuator Position
HDTRT	Heat Demand Transformer Room Temperature
HDAUX	Auxiliary Heat Demand
DHWC	Domestic Hot Water Controller
DHWS	Domestic Hot Water Scheduler
DHWCPS	Domestic Hot Water Circulation Pump Scheduler
SDHWC	Solar Domestic Hot Water Controller
DHWSM	Domestic Hot Water Setpoint Manager
DHWCPC	Domestic Hot Water Circulation Pump Controller
UDHWSET	DHW User Settings

Ventilation, Air Conditioning and Cold Water (VAC)

Abbreviation	Description
AHUC	Air Handling Unit Controller
CC	Chiller Control
CDAUX	Auxiliary Cooling Demand
CDAUXPER	Auxiliary Cooling Demand Precent
CDTAHU	Cooling Demand Transformer Air Handling Unit
CFDM	Cooling Flow Demand Manager
CPM	Cold Water Production Manager
CRC	Re-Cooling Controller
CZC	Cooling Zone Controller
HDAUXPER	Auxiliary Heating Demand Precent
HDTAHU	Heating Demand Transformer Air Handling Unit
SATC	Supply Air Temperature Controller

Terminal Units (TU) [13]

Abbreviation	Description
ACDTTU	Air Cooler Energy Demand Transformer Terminal Unit
AHDTTU	Air Heater Energy Demand Transformer Terminal Unit
CCDTTU	Chilled Ceiling Energy Demand Transformer Terminal Unit
FCC	Fan Coil Unit Controller
RCC	Radiator and Chilled Ceiling Control
RHDTTU	Radiator Heating Energy Demand Transformer Terminal Unit
SPUC	Split Unit Control
VAVC	Variable Air Volume Control
VDTTU	Ventilation Demand Transformer Terminal Unit
WHPC	Water Heat Pump Control

Sensor, MMI, Actuators - Common Controller Functions [14]

Abbreviation	Description
CFWTS	Condensor Flow Temperature Sensor
CRNWTS	Condensor Retrun Water Temperature Sensor
DPS	Dew Point Status Sensor
FWTS	Flow Water Temperature Sensor
HVA	HVAC Valve
OAD	Outside Air Damper
ORHS	Outside Relative Humidity Sensor
OAQS	Outside Air Quality Sensor
OTS	Outside Air Temperature Sensor
PRD	Presence Detector
RRHS	Room Relative Humidity Sensor
RAQS	Room Air Quality Sensor
RNARHS	Return Air Relative Humidity Sensor
RNAQS	Return Air Quality Sensor
RNATS	Return Air Temperature Sensor
RNWTS	Return Water Temperature Sensor
RSMHD	Room Setpoint Manager HVAC-Mode Driven
RSMTD	Room Setpoint Manager Temperature Driven
RTS	Room Temperature Sensor
SARHS	Supply Air Relative Humidity Sensor
SAQS	Supply Air Quality Sensor
SATS	Supply Air Temperature Sensor
SIS	Sun Intensity Sensor
SMAQ	Setpoint Manager Air Quality
SMRH	Setpoint Manager relative Humidity
UAQSS	Air Quality Setpoint Setting
URHSS	Air Relative Humidity Setpoint Setting
UHRS	User HVAC Room Setting
UHD	User HVAC Display
WCOS	Water Change over Status Sensor
WOS	Window Switch
WSS	Wind Speed Sensor

General

Abbreviation	Description
cs	Company specific
NA	not allowed / not available
LTE	Logical Tag Extended Mode, see [18] Volume 10, LTE Specification
FB	Functional Block
DPT	Datapoint Type
IO	Interface Object
IR	LTE InfoReport Input / Output
IR/P	LTE InfoReport Input with Polling capability (LTE property client)
W	LTE Write Input / Output

2 Distributed load-management functions

This chapter describes some specific HWH load-management functions which concern the whole HWH process chain: from the boiler to the heat-consumers. Here the overall functionality is described whereas in the functional block specification only the local black-box behavior is considered.

2.1 Load shedding

This chapter gives an overview about the usage and handling of locking signals. Locking signals are used in case of:

– overload protection
– consumer priority handling / load shedding

2.1.1 Structure and usage of the locking signal (normative)

Dependencies of attributes - allowed combinations (cases A – C):
see also HVAC Datapoint Types [01]

	PwrReduction	Type	LockRequest	Description X= don't care
	Normal case			no locking condition, all fields except 'LockRequest' are void: the sender of the signal shall set PwrReduction =0 % and Type = 0 (uncritical). The receiver shall ignore them.
A)	X	X	**0**	
	Protection (critical overload)			unconditional locking command: all heat consumers shall (if locking signals are supported) observe the lock request and reduce their energy consumption according to the PwrReduction value: - 0 %: no reduction; - 100%: max. reduction
B)	0...100%	**1**	**1**	
	Load shedding according to load priority (uncritical overload)			conditional locking command: those heat consumers without load priority shall (if locking signals are supported) observe the lock request and may reduce their energy consumption according to the PwrReduction value: - 0 %: no reduction; - 100%: max. reduction
C)	0...100%	**0**	**1**	

2.1.2 Overload of a single boiler

The Boiler Controller BOC may generate locking signal if the boiler is overloaded. Two types of boiler overload situations are distinguished:

– critical overload because the boiler temperature is below a critical limit (risk of corrosion): this may happen in case of boiler startup or startup of cold heat consumers.
– uncritical overload if the requested boiler temperature can not be provided but the boiler temperature is above a critical limit

In both cases the extent of overload (or vice versa the requested reduction of power consumption) is indicated with a percent value.

Locking signals from BOC are only evaluated in the corresponding Heat Producer Manager HPM

2.1.3 Overload of the Heat Production Segment (boiler sequence)

The Heat Producer Manager HPM collects the locking signals of all connected boilers. These signals can be used in the HPM for boiler sequence control (manufacturer-specific mechanisms). Normally other boilers (if available) will be activated in case of overload of one or more boilers.

If the whole heat production system is overloaded (overload condition in the whole boiler cascade or in a system with only one boiler) the HPM may generate a locking signal which indicates the amount of requested power reduction in the heat consumers. Like in the locking signal of a single BOC the locking signal of the HPM contains information whether the overload is critical or uncritical.

2.1.4 Usage of Locking Signals in the Heat Distribution system

LTE routing mechanism:
Locking signals from the HPM are received by the HFDM in its primary Heat Distribution Segment and they must be transparently routed by the HFDM to its Secondary Heat Distribution Segment without changing data value or datapoint addressing. I.e. only the LTE binding group is changed by the HFDM This routing mechanism is necessary for LTE easy configuration. Because of this LTE routing mechanism, the heat consumers connected to a Heat Distribution Segment do not need to know to which Heat Production Segment or HPM they are connected.

Power reduction in the HFDM:

– If the HFDM receives a critical locking signal (type “protection”) from the HPM the flow temperature in the Secondary Heat Distribution Segment will be normally reduced according to the % reduction factor (manufacturer specific behavior)
– In case of an uncritical locking signal from the HPM the HFDM will usually not react (manufacturer specific behavior) and will provide the demand dependent flow temperature.
– If the HFDM receives a uncritical locking signal from the HFDM in its primary Heat Distribution Segment the flow temperature in the Secondary Heat Distribution Segment may be reduced according to the % reduction factor.

The translation oft the % value (0% means no reduction, 100% means stop energy consumption) to the corresponding reduction of flow temperature is manufacturer specific.

The specific behavior of the HFDM can be enabled/disabled/controlled by company specific parameters.

In all cases a reduction of flow temperature by the HFDM is only possible if an FTC is connected to the HFDM. This is an optional feature of the HFDM.

Any power reduction in the HFDM due to locking signals shall not have an influence on the calculated resulting heat demand signal in the HFDM! Otherwise the system could oscillate.

Local generation of Locking Signals by the HFDM

The HFDM itself may also generate its own locking signal which is sent to the Secondary Heat Distribution Segment. This is an optional feature of the HFDM and the method to calculate the power reduction value is company specific.

The HFDM may generate a locking signal in the following cases:

– Some consumers in the secondary Heat Distribution Segment request absolute load priority. This feature is normally used for DHW load priority. Load priority information is contained in specific attributes in the incoming heat demand signals which are evaluated by the HFDM (see [03]).
  In this case the locking signal from HFDM indicates that consumers without load priority stop energy consumption (100% reduction)

– An overload condition in the Secondary Heat Distribution Segment occurs i.e. the requested flow temperature can not be provided and some consumers request shift load priority in their heat demand signal. In this case the HFDM may also generate a locking signal which leads to load priority between heat consumers. Heat consumers without priority will reduce their energy consumption according to the requested power reduction value.

– A locking signal is received from the HFDM in the primary Heat Distribution Segment. This signal is evaluated in the HFDM and can be combined with the locally calculated locking signal.
  E.g. the received power reduction value from the preceding HFDM and the locally calculated value are compared and the higher power reduction value is sent by the HFDM in the resulting locking signal. The specific behavior in this case can be enabled/disabled/controlled by company specific parameters.

Constraint:
In all three cases the locking signals from HFDM have normally the type 'uncritical'– only the % power reduction value varies. At the moment no useful applications for critical locking signals from HFDM are known. But in principle it is allowed that a HFDM could also generate critical locking signals.

2.1.5 Reaction to Locking Signals in Heating Zone Controllers

Usage of Locking Signals from HPM by the HZC:
In the LTE implementation the HZC is logically connected to a Heat Distribution Segment and the HZC receives routed HPM locking signals from the HFDM in this distribution segment (routing mechanism see 2.1.4.).

The usage and reaction to locking signals from HPM is an optional feature of the HZC.

– If the HZC receives a critical locking signal from the HPM the HZC will reduce the flow according to the % reduction factor in any case.
– If the HZC receives a uncritical locking signal from the HPM the HZC will reduce the flow according to the % reduction factor if the HZC has not requested load priority.

Usage of Locking Signals from HFDM by the HZC:
The usage and reaction to locking signals from HFDM is an optional feature of the HZC.
Same behavior as for locking signals from HPM, see above.

The translation oft the % value (0% means no reduction, 100% means stop energy consumption) to the corresponding reduction of flow temperature is manufacturer specific.

Important: Any power reduction or load shedding in the HZC due to locking signals MUST NOT have an influence on the calculation of the flow temperature demand signal.

2.1.6 Reaction to Locking Signals in Individual Room Heating Control systems

LTE routing mechanism:
In the LTE implementation the individual room heating control system of one apartment is linked logically by the HDTRT functional block to a Heat Distribution Segment and the HDTRT receives HPM and HFDM locking signals from the HFDM in this distribution segment.

Since the HDTRT has no built-in pre-controller functionality these signals have no functional effect on the HDTRT itself. But these locking signals are transferred to the individual room controllers HIRC of one apartment. These signals are transparently routed by the HDTRT to the LTE binding group ‘Apartment’ without changing the datapoint values or datapoint addressing. Because of this routing mechanism, the HIRC do not need to know to which Heat Production Segment or Heat Distribution Segment they are connected.

Usage of Locking Signals from HPM and HFDM by the HIRC:
Locking signals can be utilized by the HIRC in order to reduce the energy consumption by closing the valve. But normally this has no big effect because the heat consumption is already reduced before the HIRC system (e.g. in a pre-controller).The usage and reaction to locking signals from HPM and HFDM is therefore an optional feature of the HIRC.

– If the HZC receives a critical locking signal from the HPM or HFDM the HIRC will reduce the flow according to the % reduction factor in any case.
– If the HIRC receives a uncritical locking signal from the HPM or HFDM the HIRC will reduce the flow according to the % reduction factor if the HIRC has not requested load priority.

The translation oft the % value (0% means no reduction, 100% means stop energy consumption) to the corresponding valve position is manufacturer specific.

Important: Any power reduction or load shedding in the HIRC due to locking signals MUST NOT have an influence on the calculation of the heat demand signal.

2.1.7 Reaction to Locking Signals in DHW Controllers

Usage of Locking Signals from HPM by the DHWC:
In the LTE implementation the DHWC is logically connected to a Heat Distribution Segment and the DHWC receives routed HPM locking signals from the HFDM in this distribution segment (routing mechanism see 2.1.4.).

The usage and reaction to locking signals from HPM is an optional feature of the DHWC.

– If the DHWC receives a critical locking signal from the HPM the DHWC will reduce the flow according to the % reduction factor in any case.

– If the DHWC receives a uncritical locking signal from the HPM the DHWC ~~will~~ may reduce the flow according to the % reduction factor if the DHWC has not requested load priority. DHW load will often request absolute or shift load priority (peak-load condition). In some DHW applications it is not useful to reduce/stop DHW load in case of uncritical boiler overload, therefore the DHWC will not react.

Usage of Locking Signals from HFDM by the DHWC:
The usage and reaction to locking signals from HFDM is an optional feature of the DHWC.
Same behavior as for locking signals from HPM, see above.

The translation oft the % value (0% means no reduction, 100% means stop energy consumption) to the actual DHW load behavior is manufacturer specific.

Important: Any power reduction or load shedding in the DHWC due to locking signals MUST NOT have an influence on the calculation of the flow temperature demand signal.

2.1.8 Reaction to Locking Signals in HDAUX

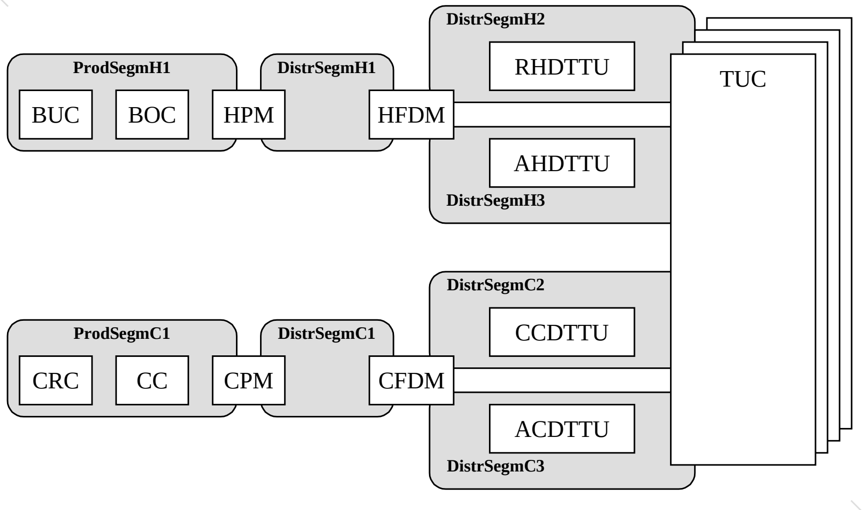
The auxiliary heat demand functional block HDAUX connects an auxiliary “multi-purpose” heat consumer to the heat distribution system. The HDAUX can be used to model very specific / “exotic” heat consumers which do not belong to the category “Room Heating” or “Domestic Hot Water Control” (e.g. heating of a swimming pool etc.).

In the LTE implementation the HDAUX is logically connected to a Heat Distribution Segment and the HDAUX receives locking signals from HPM or HFDM in this distribution segment (same as for HZC or DHWC).

Due to the nature of the HDAUX the reaction to locking signals is manufacturer specific and depending on the specific application of the HDAUX.

2.1.9 Reaction to Locking Signals in Terminal Unit Controllers

Overview:



In the LTE implementation the terminal unit controllers TUC are linked to the '... demand transformer TU' (RHDTTU, CCDTTU, AHDTTU or ACDTTU). These transformers are in a Heat or a Cold Distribution Segment. These distribution segments link to the HFDM/CFDM.
The terminal unit controllers receive HPM/CPM and HFDM/CFDM locking signals from the HFDM/CFDM in this distribution segments.

The transformers have no built-in pre-controller functionality. Therefore these signals have no functional effect on them.

So the locking signals may directly be used by the terminal unit controllers TUC.

Usage of Locking Signals from HPM and HFDM by the TUC:
Locking signals can be utilized by the TUC in order to reduce the energy consumption by closing the valves. But normally this has no big effect because the energy consumption is already reduced before in a pre-controller. The usage and reaction to locking signals from HPM and HFDM is therefore an optional feature of the TUC.

– If the TUC receives a critical locking signal from the HPM or HFDM the TUC will reduce the flow according to the % reduction factor in any case.

– If the TUC receives a uncritical locking signal from the HPM or HFDM the TUC will reduce the flow according to the % reduction factor if the TUC has not requested load priority.

The translation oft the % value (0% means no reduction, 100% means stop energy consumption) to the corresponding valve position is manufacturer specific.

Important: Any power reduction or load shedding in the TUC due to locking signals MUST NOT have an influence on the calculation of the demand signals.

2.1.10 Reaction to Locking Signals in Ventilation Controllers

Usage of Locking Signals from HPM by the AHUC, SATC, HDAUXPER:
In the LTE implementation the AHUC, SATC and HDAUXPER are logically connected to a Heat Distribution Segment and these functional blocks receive optionally routed HPM locking signals from the HFDM in this distribution segment (routing mechanism see 2.1.4.).

The usage and reaction to locking signals from HPM is an optional feature of the AHUC, SATC and HDAUXPER.

– If the AHUC, SATC, HDAUXPER receive a critical locking signal from the HPM these functional blocks will reduce the flow according to the % reduction factor in any case.
– If the AHUC, SATC, HDAUXPER a uncritical locking signal from the HPM these functional blocks will reduce the flow according to the % reduction factor if there is no load priority demand.

Usage of Locking Signals from HFDM by the AHUC, SATC, HDAUXPER:
The usage and reaction to locking signals from HFDM is an optional feature of these functional blocks.

– If the AHUC, SATC, HDAUXPER receive a locking signal from the HFDM these functional blocks will reduce their power consumption according to a manufacturer specific algorithm.

Important: Any power reduction or load shedding due to locking signals MUST NOT have an influence on the calculation of the flow temperature demand signal.

2.1.11 Locking Signals: data chain

Situation	Reason (examples)	Signal (source)	Destination	Reaction
Critical boiler overload: - low boiler temp. or - low return temp. => boiler protection	- system startup - start „cold“ consumers	BOC: sends LockSignBOC type ‘critical’ X % reduction	HPM -> HFDM-> HFDM -> .... HZC HDTRT ->HIRC DHWC etc	HPM will first activate other boilers. If all boilers are overloaded it may generate a ‘critical’ LockSignHPM LockSignHPM is routed by HFDM Heat consumers including HFDM+FTC reduce flow temperature according to % reduction value in any case (if locking signal is supported)
Uncritical boiler overload: - requested flow temp is not reached and - some heat consumers have heat demand with load priority => load management	- system startup - start „cold“ consumers - start DHW load => ShiftLoadPriority or AbsLoadPriority attribute is set in demand signal (normally set by DHW)	BOC: sends LockSignBOC type ‘uncritical’ X % reduction	HPM-> HFDM-> HFDM -> .... HZC HDTRT ->HIRC (DHWC) etc	HPM will first activate other boilers. If all boilers are overloaded it may generate a ‘uncritical’ LockSignHPM LockSignHPM is routed by HFDM Heat consumers without load priority reduce the flow temperature according to % reduction value (if locking signal is supported)
Uncritical boiler overload - requested flow temp is not reached and - no heat consumers request load priority in their heat demand	- system startup - start „cold“ consumers - general overload - no priority of heat consumers	BOC: sends LockSignBOC type ‘uncritical’ X % reduction	HPM	HPM will first activate other boilers. If all boilers are overloaded it will NOT generate a locking signal
Peak demand within a Heat Distribution Segment: - heat consumers with absolute load priority => load shedding	- e.g. DHW load with absolute priority => AbsLoadPriority attribute is set in demand signal	HFDM: sends LockSignHFDM type ‘uncritical’ 100% reduction	HFDM -> .... HZC HDTRT ->HIRC (DHWC) etc	all heat consumers except those requesting absolute load priority (e.g. DHW) stop their heat consumption (if locking signal is supported)
Overload within a Heat Distribution Segment: - requested flow temp is not reached - some heat consumers request load priority in their heat demand => load management	- system startup - start „cold“ consumers - start DHW load => ShiftLoadPriority attribute is set in (DHW) demand signal	HFDM: sends LockSignHFDM type ‘uncritical’ X % reduction	HFDM -> .... HZC HDTRT ->HIRC (DHWC) etc	Consumers without load priority reduce their heat consumption according to % reduction value

2.2 Forced Load

The following chapter gives an overview about the usage and handling of forcing signals. Forcing signals are used in case of:

- overheat protection
- energy over-supply
- usage of remaining energy after load shutdown

2.2.1 Structure and usage of the forcing signal (normative)

Dependencies of attributes - allowed combinations (cases A – T):

<table>
<tr><th></th><th>RoomHMax</th><th>RoomHComf</th><th>DHWLegio</th><th>DHWNorm</th><th>Overrun</th><th>Oversupply</th><th>Protection</th><th>ForceRequest</th><th>Description

X= don’t care</th></tr>
<tr><td></td><td colspan="8">Normal case</td><td rowspan="2">no forcing condition, all attributes except ‘ForceRequest’ are void: the sender of the signal shall set these attributes to ‘0’. The receiver shall ignore them.</td></tr>
<tr><td>A)</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td></tr>
<tr><td></td><td colspan="8">Protection (critical overheat)</td><td>unconditional load: heat consumers shall observe the force request;
*) priority mechanism: in case of ‘Protection’ the flag ‘Oversupply’ is meaningless and shall be set to ‘0’ by the sender and shall be ignored by the receiver.</td></tr>
<tr><td>B)</td><td>1</td><td>0</td><td>0</td><td>0</td><td rowspan="9">X</td><td rowspan="9">0 *)</td><td rowspan="9">1</td><td rowspan="9">1</td><td>room heating <u>shall</u> consume as much energy as possible (respecting the maximum flow temperature if necessary).</td></tr>
<tr><td>C)</td><td>0</td><td>1</td><td>0</td><td>0</td><td>room heating <u>shall</u> be activated with ‘Comfort’ setpoint</td></tr>
<tr><td>D)</td><td>0</td><td>0</td><td>1</td><td>0</td><td>DHW load <u>shall</u> be activated with ‘LegioProtect’ setpoint.</td></tr>
<tr><td>E)</td><td>0</td><td>0</td><td>0</td><td>1</td><td>DHW load <u>shall</u> be activated with ‘Normal’ setpoint.</td></tr>
<tr><td>F)</td><td>1</td><td>0</td><td>1</td><td>0</td><td>combination of B) and D)</td></tr>
<tr><td>G)</td><td>1</td><td>0</td><td>0</td><td>1</td><td>combination of B) and E)</td></tr>
<tr><td>H)</td><td>0</td><td>1</td><td>1</td><td>0</td><td>combination of C) and D)</td></tr>
<tr><td>I)</td><td>0</td><td>1</td><td>0</td><td>1</td><td>combination of C) and E)</td></tr>
<tr><td>J)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>critical overheat – type of heat consumers is unspecified: to be used in ForceSignBOC signal only (between BOC and HPM), see 2.2.2</td></tr>
<tr><td></td><td colspan="8">Oversupply (uncritical overheat)</td><td>conditional load: heat consumers can ignore the force request;
priority mechanism: ‘Protection’ has priority over ‘Oversupply’, see above</td></tr>
<tr><td>K)</td><td>1</td><td>0</td><td>0</td><td>0</td><td rowspan="7">X</td><td rowspan="7">1</td><td rowspan="7">0</td><td rowspan="7">1</td><td>room heating may consume as much energy as possible (respecting the maximum flow temperature if necessary). Forced load can be inhibited if room heating is “off” e.g. in energy saving mode</td></tr>
<tr><td>L)</td><td>0</td><td>1</td><td>0</td><td>0</td><td>forced room heating with ‘Comfort’ setpoint. Forced load can be inhibited if room heating is “off” e.g. in energy saving mode</td></tr>
<tr><td>M)</td><td>0</td><td>0</td><td>1</td><td>0</td><td>forced DHW load with ‘LegioProtect’ setpoint. Forced load can be inhibited if the DHW controller is “off” e.g. solar DHW load only</td></tr>
<tr><td>N)</td><td>0</td><td>0</td><td>0</td><td>1</td><td>forced DHW load with ‘Normal’ setpoint. Forced load can be inhibited if the DHW controller is “off” e.g. solar DHW load only</td></tr>
<tr><td>O)</td><td>1</td><td>0</td><td>1</td><td>0</td><td>combination of K) and M)</td></tr>
<tr><td>P)</td><td>1</td><td>0</td><td>0</td><td>1</td><td>combination of K) and N)</td></tr>
<tr><td>Q)</td><td>0</td><td>1</td><td>1</td><td>0</td><td>combination of L) and M)</td></tr>
</table>

	RoomHMax	RoomHComf	DHWLegio	DHWNorm	Overrun	Oversupply	Protection	ForceRequest	Description X= don't care
R)	0	1	0	1					combination of L) and N)
S)	**0**	**0**	**0**	**0**					uncritical overheat – type of heat consumers is unspecified: to be used in ForceSignBOC signal only (between BOC and HPM)), see 2.2.3

	RoomHMax	RoomHComf	DHWLegio	DHWNorm	Overrun	Oversupply	Protection	ForceRequest	Description (continued) X= don't care
	Overrun								'Overrun' can be set e.g. after load shutdown if there is remaining energy in the heat producer. 'Overrun' is independent of 'Protection', 'Oversupply', 'DHWNorm', 'DHWLegio', 'RoomHComf', 'RoomHMax' All heat consumers which were active immediately**) before the overrun condition occurred continue their energy consumption using their last setpoint (which was active before load-shutdown) **) immediately means within 1..2 minutes
T)	X	X	X	X	**1**	**X**	**X**	**1**	

	Priority combinations								the sender shall not use these combinations; reaction of the receiver see below
U)	X	X	**1**	**1**	**0**	**0**	**1**	**1**	'DHWLegio' has priority => the receiver will ignore 'DHWNorm'
V)	**1**	**1**	X	X	**0**	**1**	**0**	**1**	'RoomHMax' has priority => the receiver will ignore 'RoomHComf'

	Illegal combination								unspecified forcing condition: not allowed in the sender and to be ignored by the receiver.
W)	X	X	X	X	**0**	**0**	**0**	**1**	

Support of RoomHMax, RoomHComf, DHWLegio and DHWNorm attributes:

- Heat consumers like HZC, HIRC and DHWC shall support these attributes and shall react accordingly.
- Situation dependent "intelligent" selection of the class of heat consumers and the forced load level is an optional feature of the HPM or HFDM. If this functionality is not supported, the attributes RoomHMax, RoomHComf, DHWLegio and DHWNorm shall be set to a reasonable fixed value by the sender. At least one of the attributes shall be set '1' respecting the allowed combinations.

2.2.2 Overheat of a single boiler

The Boiler Controller BOC may generate a forcing signal (type 'Protection') if the boiler temperature is above a critical limit. This situation may occur if the boiler is (by some reason, e.g. in case of boiler inspection) providing much more energy than requested but there are no or only a few consumers taking hot water from the boiler.

The signal is evaluated in the Heat Producer Manager HPM only. See chapter 2.2.4

2.2.3 Oversupply condition in a single boiler

The Boiler Controller BOC may generate a forcing signal (type 'Oversupply') if the boiler temperature is higher than requested by the HPM but below a critical limit. This situation may occur e.g. in wood fired boilers or solar supported heat production systems.

The signal is evaluated in the Heat Producer Manager HPM only. See chapter 2.2.5

2.2.4 Overheat of the Heat Production Segment (boiler sequence)

The Heat Producer Manager HPM collects the forcing signals of all connected boilers. The reaction to these signals is manufacturer-specific.

- Forcing signals from BOC can be used in the HPM for boiler sequence control. Active boilers can be shut down in case of critical overheat of one or more boilers.
- If the critical overheat condition persists in one or more boilers, the HPM may generate a forcing signal (type ‘Protection’) in order to trigger forced heat consumption. Critical forcing signals shall be considered by the heat consumers (unconditional load).
- HPM with higher functionality may indicate whether DHW load and/or Room Heating should be activated. Details see chapter 2.2.1

2.2.5 Oversupply condition a Heat Production Segment (boiler sequence)

The Heat Producer Manager HPM collects the forcing signals of all connected boilers. The reaction to these signals is manufacturer-specific.

- Forcing signals from BOC can be used in the HPM for boiler sequence control. The number of active boilers / boiler stages will normally be reduced in case of uncritical oversupply condition.
- If the oversupply condition persists in the boiler sequence, the HPM may generate a forcing signal (type ‘Oversupply’) in order to trigger forced heat consumption. Uncritical forcing signals can be considered by the heat consumers (conditional load).
- HPM with higher functionality may indicate whether DHW load and/or Room Heating should be activated. Details see chapter 2.2.1

2.2.6 Usage of spare energy after load shutdown

After load shutdown (no more heat demand by the heat consumers) the HPM will disable the boilers in the heat production segment but some boilers may still have spare energy for a certain time. Individual BOC can indicate the presence of spare energy by a forcing signal (type ‘Overrun’). It is normally desirable to use this remaining energy in the heat consumers.

If there is a significant amount of remaining energy in the heat production system after load shutdown, the HPM may generate a forcing signal (type ‘Overrun’). Heat consumers which were active immediately before load shutdown continue their energy consumption using their last setpoint (which was active before load-shutdown). Details see chapter 2.2.1

2.2.7 Usage of Forcing Signals in the Heat Distribution system

LTE routing mechanism:
Forcing signals from the HPM are received by the HFDM in its primary Heat Distribution Segment and they must be transparently routed by the HFDM to its secondary Heat Distribution Segment without changing data value or datapoint addressing. I.e. only the LTE binding group is changed by the HFDM This routing mechanism is necessary for LTE easy configuration. Because of this LTE routing mechanism, the heat consumers connected to a Heat Distribution Segment do not need to know to which Heat Production Segment or HPM they are connected.

Reaction to Forcing Signals by the HFDM:

– If the HFDM receives a forcing signal with the type ‘Protection’ or ‘Oversupply’ <u>from the HPM</u>, the HFDM will increase the flow temperature in the Secondary Heat Distribution Segment until a max. flow temperature (parameter of the HFDM) is reached. I.e. the pre-controller FTC will open the valve accordingly. The attributes DHWNorm’, ‘DHWLegio’, ‘RoomHComf’, ‘RoomHMax’ are normally ignored because they are not relevant for the heat distribution system.
  This is an optional feature of the HFDM.

– If the HFDM receives a forcing signal with the type ‘Overrun’ from the HPM, the HFDM will restore the last flow temperature setpoint (which was valid before load shutdown) in the secondary Heat Distribution Segment. This is an optional feature of the HFDM.
– If the HFDM receives a forcing signal from the HFDM in its primary Heat Distribution Segment, the behavior of the HFDM is the same as for forcing signals from HPM, see above.

The specific reaction of the HFDM to forcing signals can be enabled/disabled/controlled by company specific parameters.

In all cases an increase of flow temperature by the HFDM is only possible if an FTC is connected to the HFDM. This is an optional feature of the HFDM.

Any increase of flow temperature by the HFDM due to forcing signals shall not have an influence on the calculated resulting heat demand signal in the HFDM! Otherwise the system could oscillate.

Local generation of Forcing Signals by the HFDM

Overheat conditions may also occur in a HFDM in specific situations (e.g. in a heat-exchanger). Therefore the HFDM can in principle also generate its own forcing signal which is independent from the forcing signal from HPM.

The locally generated forcing signal is sent to the secondary Heat Distribution Segment. This is an optional feature of the HFDM and the method to generate the signal is company specific.

The HFDM may generate a forcing signal in the following cases (same mechanism as in the HPM):
– critical overheat in heat exchanger => type ‘Protection’
– oversupply: uncritical overheat in heat exchanger. The heat-exchanger temperature is much higher than requested by heat demand => type ‘Oversupply’
– overrun: indicates that remaining energy is available in the heat-exchanger after load shutdown => type ‘Overrun’
– An external forcing signal received from the HFDM in the primary Heat Distribution Segment is evaluated in the HFDM. Its value can be combined with the locally calculated forcing signal.

HFDM with higher functionality may indicate whether DHW load and/or Room Heating should be activated. Details see chapter 2.2.1

Generation of forcing signals by the HFDM can be enabled/disabled/controlled by company specific parameters.

2.2.8 Reaction to Forcing Signals in Heating Zone Controllers

The reaction of the Heating Zone Controller HZC to forcing signals from HPM and HFDM is identical.

Forcing signals of the type ‘Protection’ or ‘Oversupply’ are only accepted by the HZC if either the attribute RoomHMax or RoomHComf is set (activate room heating).

- If the HZC receives a critical forcing signal (type ‘Protection’) it will react in any case (unconditional load).
  => RoomHMax attribute is set: the HZC will increase the flow until a max. flow temperature (parameter) is reached
  => RoomHComf attribute is set: room heating shall be temporarily activated with ‘Comfort’ room temperature setpoint (HVACMode = Comfort)
- If the HZC receives a uncritical forcing signal (type ‘Oversupply’) it may react or may ignore the signal (conditional load). Forcing signal could e.g. be ignored if the HZC is in an energy saving mode. If the signal is accepted, the reaction is the same as for type ‘Protection’, see above

If the HZC receives a forcing signal with the type ‘Overrun’ immediately after load shutdown it will temporarily keep the last flow temperature setpoint (used before shutdown) for control loop (pump overrun). So remaining energy in the heat producer / heat exchanger is efficiently used after load shutdown.

Forcing signals must NOT have an influence on the calculation of the flow temperature demand signal of the HZC (otherwise system may „oscillate“)

The implementation of forcing signals is an optional feature of the HZC

2.2.9 Reaction to Forcing Signals in Individual Room Heating Control systems

LTE routing mechanism:
In the LTE implementation the individual room heating control system of one apartment is linked logically by the HDTRT functional block to a Heat Distribution Segment and the HDTRT receives HPM and HFDM forcing signals from the HFDM in this distribution segment.

Since the HDTRT has no built-in pre-controller functionality these signals have no functional effect on the HDTRT itself. But these forcing signals are transferred to the individual room controllers HIRC of one apartment. These signals are transparently routed by the HDTRT to the LTE binding group ‘Apartment’ without changing the datapoint values or datapoint addressing. Because of this routing mechanism, the HIRC do not need to know to which Heat Production Segment or Heat Distribution Segment they are connected.

Usage of Forcing Signals from HPM and HFDM by the HIRC:
The reaction of the HIRC to forcing signals from HPM and HFDM is identical.

Forcing signals of the type ‘Protection’ or ‘Oversupply’ are only accepted by the HIRC if either the attribute RoomHMax or RoomHComf is set (activate room heating).

- If the HIRC receives a critical forcing signal (type ‘Protection’) it will <u>react in any case</u> (unconditional load).
  => RoomHMax attribute is set: the HIRC will open the valve (100% flow).
  => RoomHComf attribute is set: room heating shall be temporarily activated with ‘Comfort’ room temperature setpoint (HVACMode = Comfort)
- If the HIRC receives a uncritical forcing signal (type ‘Oversupply’) it <u>may react or may ignore</u> the signal (conditional load). Forcing signal could e.g. be ignored if the HIRC is in an energy saving mode. If the signal is accepted, the reaction is the same as for type ‘Protection’, see above

If the HIRC receives a forcing signal with the type ‘Overrun’ immediately after load shutdown it will temporarily keep the last flow temperature setpoint (used before shutdown) for control loop (pump overrun). So remaining energy in the heat producer is efficiently used after load shutdown.

Forcing signals must NOT have an influence on the calculation of the heat demand signal of the HIRC or HDTRT (otherwise system may „oscillate“)

The implementation of forcing signals is an optional feature of the HIRC

2.2.10 Reaction to Forcing Signals in DHW Controllers

The reaction of the DHW Controller DHWC to forcing signals from HPM and HFDM is identical.

Forcing signals of the type ‘Protection’ or ‘Oversupply’ are only accepted by the DHWC if either the attribute DHWLegio or DHWNorm is set (activate DHW load).

- If the DHWC receives a critical forcing signal (type ‘Protection’) it will <u>react in any case</u> (unconditional load).
  => DHWLegio attribute is set: DHW load shall be activated with ‘LegioProtect’ setpoint
  => DHWNorm attribute is set: DHW load shall be activated with ‘Normal’ setpoint
- If the DHWC receives a uncritical forcing signal (type ‘Oversupply’) it <u>may react or may ignore</u> the signal (conditional load). Forcing signal could e.g. be ignored if solar DHW load is currently active. If the signal is accepted, the reaction is the same as for type ‘Protection’, see above

If the DHWC receives a forcing signal with the type ‘Overrun’ immediately after load shutdown it will temporarily keep the last flow temperature setpoint (used before shutdown) for control loop (pump overrun). So remaining energy in the heat producer / heat exchanger is efficiently used after load shutdown.

Forcing signals must NOT have an influence on the calculation of the flow temperature demand signal of the DHWC (otherwise system may „oscillate“)

The implementation of forcing signals is an optional feature of the DHWC

2.2.11 Reaction to Forcing Signals in HDAUX

The auxiliary heat demand functional block HDAUX connects an auxiliary “multi-purpose” heat consumer to the heat distribution system. The HDAUX can be used to model very specific / “exotic” heat consumers which do not belong to the category “Room Heating” or “Domestic Hot Water Control” (e.g. heating of a swimming pool etc.).

In the LTE implementation the HDAUX is logically connected to a Heat Distribution Segment and the HDAUX receives forcing signals from HPM or HFDM in this distribution segment (same as for HZC or DHWC).

Due to the nature of the HDAUX the reaction to forcing signals is manufacturer specific and depending on the specific application of the HDAUX.

Depending on the installation or application HDAUX may:

- react like a room heating system
- react like a DHW system
- react in any case (if RoomHMax or RoomHComf or DHWLegio or DHWNorm attribute is set)
- react only on forcing signals with type ‘Overrun’
- ignore all types of forcing signals
- etc.

2.2.12 Reaction to Forcing Signals in Terminal Unit Controllers

Overview:
See also picture in chapter 2.1.9

In the LTE implementation the terminal unit controllers TUC are linked to the '... demand transformer TU' (RHDTTU, CCDTTU, AHDTTU or ACDTTU). These transformers are in a Heat or a Cold Distribution Segment. These distribution segments link to the HFDM/CFDM.
The terminal unit controllers receive HPM/CPM and HFDM/CFDM forcing signals from the HFDM/CFDM in this distribution segments.

The transformers have no built-in pre-controller functionality. Therefore these signals have no functional effect on them.

So the forcing signals may directly be used by the terminal unit controllers TUC.

Usage of Forcing Signals from HPM and HFDM by the TUC:

The implementation of forcing signals is an optional feature of the TUC.

The reaction of the TUC to forcing signals from HPM and HFDM is identical.

Forcing signals of the type ‘Protection’ or ‘Oversupply’ are only accepted by the TUC if either the attribute ‘RoomHMax’ or ‘RoomHComf’ is set (activate room heating).

- If the TUC receives a critical forcing signal (type ‘Protection’) it will react in any case (unconditional load).
  => RoomHMax attribute is set: the TUC will open the valve (100% flow).
  => RoomHComf attribute is set: room heating shall be temporarily activated with ‘Comfort’ room temperature setpoint (HVACMode = Comfort)
- If the TUC receives a uncritical forcing signal (type ‘Oversupply’) it may react or may ignore the signal (conditional load). Forcing signal could e.g. be ignored if the TUC is in an energy saving mode. If the signal is accepted, the reaction is the same as for type ‘Protection’, see above

If the TUC receives a forcing signal with the type ‘Overrun’ immediately after load shutdown it will temporarily keep the last flow temperature setpoint (used before shutdown) for control loop (pump overrun). So remaining energy in the heat producer is efficiently used after load shutdown.

Forcing signals MUST NOT have an influence on the calculation of the heat demand signal of the TUC (otherwise system may „oscillate“)

2.2.13 Reaction to Forcing Signals in Ventilation Controllers

Usage of Forcing Signals from HPM or HFDM by the AHUC, SATC, HDAUXPER:
In the LTE implementation the AHUC, SATC and HDAUXPER are logically connected to a Heat Distribution Segment and these functional blocks receive routed HPM forcing signals or HFDM forcing signals from the HFDM in this distribution segment (routing mechanism see 2.2.7.).

The usage and reaction to forcing signals is an optional feature of the AHUC, SATC and HDAUXPER. The handling of forcing signals from HPM and HFDM is identical.

If a force request with the type ‘Protection’, ‘Oversupply’ or ‘Overrun’ is demanded by the HPM or HFDM the AHUC, SATC and HDAUXPER may be force to consume energy according to a company specific algorithm.
Forcing signals of the type ‘Protection’ or ‘Oversupply’ are usually only accepted by ventilation controllers if either the attribute RoomHMax or RoomHComf is set (activate room heating).

Note: To be able to consume energy, the ventilation has to be started. In some cases this may reduce user comfort and requires additional electrical energy. Therefore it is usually recommended to use spare energy for DHW load or hot water heating.

Any forced power consumption MUST NOT have an influence on the calculation of the heat demand signals of the ventilation system.

2.2.14 Forcing Signals: data chain

Situation	Reason (examples)	Signal (source)	Destination	Reaction
Critical boiler overheat: energy production is too high and a critical temperature limit is reached => avoid activation of safety temperature limiter	– solar energy – wood fired boiler – boiler inspection	BOC sends ForceSignBOC type 'Protection'	HPM -> HFDM-> HFDM -> .... HZC HDTRT ->HIRC DHWC etc	HPM will first deactivate other boilers if possible. If the overheat condition persists the HPM will generate a ForceSignHPM with type 'Protection' and the attributes for the selected class of consumers and load levels set (RoomHMax, RoomHComf, DHWLegio, DHWNorm). ForceSignHPM is routed by HFDM All addressed heat consumers shall increase flow temperature according to load level attributes (unconditional load) Pre-controller HFDM+FTC open valve until max. flow temp (parameter) is reached
Energy oversupply: energy production is too high but the boiler temperature is uncritical	– solar energy – wood fired boiler	BOC sends ForceSignBOC type 'Oversupply'	HPM -> HFDM-> HFDM -> .... HZC HDTRT ->HIRC DHWC etc	HPM will first deactivate other boilers if possible. If the oversupply condition persists the HPM will generate a ForceSignHPM with type 'Oversupply' and the attributes for the selected class of consumers and load levels set (RoomHMax, RoomHComf, DHWLegio, DHWNorm). ForceSignHPM is routed by HFDM Addressed heat consumers may increase flow temperature according to load level attributes (conditional load) Pre-controller HFDM+FTC open valve until max. flow temp (parameter) is reached
Overrun: Boiler has remaining energy after load shutdown	- no advanced scheduling information available - unexpected load shedding => use remaining energy in boiler	BOC sends ForceSignBOC type 'Overrun'	HPM -> HFDM-> HFDM -> .... HZC HDTRT ->HIRC DHWC etc	HPM generates ForceSignHPM ForceSignHPM is routed by HFDM all heat consumers that were consuming energy just before keep the last setpoint for control loop (pump overrun) => pre-controller HFDM+FTC keeps last setpoint

Situation	Reason (examples)	Signal (source)	Destination	Reaction
Critical overheat of heat exchanger: a critical temperature limit is reached	- unexpected load shedding	HFDM sends ForceSignHFDM type ‘Protection’ and the attributes for the selected class of consumers and load levels set (RoomHMax, RoomHComf, DHWLegio, DHWNorm).	HFDM -> .... HZC HDTRT ->HIRC DHWC etc	All addressed heat consumers shall increase flow temperature according to load level attributes (unconditional load) Pre-controller HFDM+FTC open valve until max. flow temp (parameter) is reached
Energy oversupply in the heat exchanger: flow temperature in the secondary heat distribution segment is too high but uncritical	- unexpected load shedding - system failure	HFDM sends ForceSignHFDM type ‘Oversupply’ and the attributes for the selected class of consumers and load levels set (RoomHMax, RoomHComf, DHWLegio, DHWNorm)	HFDM -> .... HZC HDTRT ->HIRC DHWC etc	Addressed heat consumers may increase flow temperature according to load level attributes (conditional load) Pre-controller HFDM+FTC open valve until max. flow temp (parameter) is reached
Overrun: Heat exchanger has remaining energy after load shutdown	- no advanced scheduling information available - unexpected load shedding => use remaining energy in the heat exchanger	HFDM sends ForceSignHFDM type ‘Overrun’	HFDM -> .... HZC HDTRT ->HIRC DHWC etc	All heat consumers that were consuming energy just before keep the last setpoint for control loop (pump overrun) => pre-controller HFDM+FTC keeps last setpoint