The OpenTherm™ Communications Protocol

A Point-to-Point Communications System
for HVAC Controls

Protocol Specification

The OpenTherm Association is an independent European organisation, constituted under Dutch law, whose object is to promote the introduction and adoption of the OpenTherm technical standard for HVAC system control communication, laid down in this Protocol Specification. The OpenTherm Association controls the application by, and the granting of licences for use of, the OpenTherm trademark and logo.

Change Control History

Version	Date	Description of Changes
1.0		**First official release**
1.1	**1 Feb 1998**	**2.3 OT/+ & OT/- configuration section expanded.** **4.2 Bit-order specified in frame format.** **5.1 Definition of data format expanded and clarified.** **5.3 Message directions changed to indicate read/write instead.** **5.3.1 Special status exchange message mechanism defined.** **6.1 Clarified duty cycle period definition for OT/- signalling.**
1.2A	DRAFT 13 Mar 98	This change control history added. Page numbering corrected. References to Oem/Customer ID Codes changed to Member ID Code 3.2,High-voltage idle-line state is allowed subject to certain restrictions. 3.2.1.1,3.2.2.1 Current, voltage signal level conditions stated. 3.2.1.2,3.2.2.2 Inductance and capacitance test conditions defined. 3.3 New section added on device impedance characteristics. 3.5 New section added on short-circuit feature. 5.1 Definition of data format further clarified. 5.2 Correction to message type references.
1.2B	DRAFT 15 June 98	2.3 State diagram added for OT/+ & OT/- detection. 3.2 Corrected reference to section 3.6 Idle line-high removed - not acceptable to all members. 3.2.1.1 Allowed spec to be different for OT/- and OT/+ 3.2.1.2 Changed "across" to "in series with" (twice) 3.2.2.1 corrected reference to section 3.6 3.3 Changed "capacitance across" to "serial inductance at" 3.6 State machine for short-circuit feature Idle line-high removed - not acceptable to all members. 4.4.1 removed references to 0x00 to allow more general case. 4.4.2 removed references to 0x00 to allow for slave changing data-value. 4.4.3 removed references to 0x00 to allow more general case. 4.5 Added that master & slave should notify comms error. 5.2 changed references to invalid-data-id to Unknown_DataID
1.2C	DRAFT 19 June 98	2.3 Automatic OT plus-lite configuration made mandatory for masters. 3.2 Clarified allowable line signal states. 3.6 Short-circuit detection defined between 5 .. 15 secs. 4.3.1 Inter-message communications period defined as 1.15 sec max. 4.5 Error notification text removed as irrelevant and not always practical. 5.1 Added u16 and s16 data formats for completeness. 5.3 Unused bits/bytes defined as "reserved" (don't care values) instead of 00.
1.2D	DRAFT 25 June 98	5.1 Reserved/unused bits/bytes should be set to zero, but not checked by receiver.
1.2	**RELEASE** **25 June 1998**	**Approved by members of the OpenTherm Association.**
1.3A	DRAFT 5 May 1999	3.4.2.4 Galvanic isolation specified according to EN60730-1 5.2 CH-enable and DHW-enable are now declared mandatory for the master. 5.1 & 5.4 "Member" or "OEM" data id area (128..255) redefined as "Test & Diagnostics" area.
1.3B	DRAFT 17 August 1999	3.2.1.2 Signal dynamic characteristics further clarified in line with test requirements 3.2.2.2 Signal dynamic characteristics further clarified in line with test requirements 3.3 Device Impedance Characteristics removed 4.3.1 Message latency time increased to 100ms New Data ID's added according to NDI 110399-1 : Product Version Number NDI 110399-2 : Capacity Control for Sequencer Applications NDI 110599-3 : Day & Time NDI 110399-4 : Date & Year NDI 110599-5 : Cooling Control NDI 200599-1 ; Solar System Applications NDI 140599-1 : CH Water Filling 5.3.1 Status bits added for cooling control 5.3.2 Configuration bits added for cooling control 5.3.2 Product version number and type added to Configuration Data class

		5.3.3 CH Water Fill command added to Remote Command class 5.3.4 Day, Time, Date, Year , Solar storage & collector temp.s added to Information Data class 5.3.8 New class added for new applications 5.3.8.1 Cooling control signal added 5.3.8.2 Boiler sequence control signal added
1.3C	DRAFT 24 October 1999	5.3.1 Correction made to error in definition of "Remote Reset enable" bit.
1.3	**RELEASE 31 Oct. 1999**	**Approved by members of the OpenTherm Association.**
1.4A	DRAFT 30 May 2000	Document renamed "Protocol Specification" in place of "Technical Specification" 4.3.1 Correction made in text concerning wait time of messages (diagram was correct) 5.3.1 Added status bit (bit3 id0-master status) for OTC systems NDI-071299 5.3.2 Added configuration bit (bit3 id3-slave configuration) for DHW storage systems NDI-1303000 5.3.2 Added configuration bit (bit4 id3-slave configuration) for off-low/pump control systems NDI-210400 5.2 !!! New list of mandatory items specified. 5.3.4 Added new data ids for DHW2 and exhaust temperatures NDI-220500-1 5.3.4 Added new data id for Flow temp 2 NDI-220500-2 5.3.1 Added new data id for Tset2 NDI-220500-2 5.3.1 Added new master status bit (bit 4, id0) and slave status bit (bit5, id0) for second loop NDI-220500-2 5.3.3 Added new slave configuration bit (bit5, id3) for second loop NDI-220500-2
2.0A	DRAFT 22 June 2000	1.3 Added comment to help explain important change in version2.0 for mandatory Ids. 4.2 remove MSB-LSB note in the centre of the data-value definition. 5.1 correct description of message classes (six to seven). 5.2 insert table to define all mandatory data-ids and their use. 5.3.2 redefine "low-off&pump control" flag as "Master low-off&pump control function" with states "allowed" and "not-allowed". 5.3.2 redefine "DHWconfig" flag default state as "not specified" instead of "instantaneous" 5.3.2 remove statement referring to configuration data as non-mandatory 5.3.8.2 redefine "Capacity-level setting" as "Maximum relative modulation level setting" 5.4 Add new data ids 31,32,33 and engineering units to overview table and updated some terminology.
2.0B	DRAFT 21 September 2000	5.3.1 Description id 8 corrected 5.4 Overview table completed with id8, message and data type.
2.0	**RELEASE 15 Dec. 2000**	**Approved by members of the OpenTherm Association.**
2.1A	DRAFT 12 Februari 2002	1.3 Note mandatory id's and backward compatibility updated. 2.3 Mandatory OT/- for OpenTherm logo marked masters deleted. 3.2.1.2. Slope of current signal edge deleted. 3.2.2.2. Slope of voltage signal edge deleted. 5.3.2. Opentherm version master and slave added (ID 124, 125). 5.3.2. Explanation ID3 bit 4 corrected. 5.3.4. Operation hours boilers, CH pump and DHW pump/valve added (ID120, 121, 122). 5.3.5. OTC not, flags and ID's removed 5.3.8.3. Remote override room setpoint added 5.4. Operation hours boilers, CH pump and DHW pump/valve added (ID120, 121, 122).. 5.4. Opentherm version master and slave added (ID 124, 125). 6 Remark that OT/- is mandatory for masters deleted.
2.1B	DRAFT 27 March 2002	5.3.4. Room Setpoint CH2 (ID23) added. 5.4. Room Setpoint CH2 (ID23) added.
2.1	**RELEASE 9 April 2002**	**Approved by members of the OpenTherm Association.**
2.2A	11 October	3.2.1.1. Max. open-circuit voltage slave added. 3.2.2.3. Receive threshold voltage range extended. 5.3.1. Diagnostic flag (ID0:LB6) and code (ID115) added. 5.3.4. ID's related to operation hours and number of starts added. 5.3.8.3. Remote override function (ID100) added 5.4. Data-Id overview map updated.
2.2	**RELEASE 7 Februari 2003**	**Approved by members of the OpenTherm Association.**

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1. Introduction

1.1 Background

The trend in boiler technologies towards high-efficiency appliances with gas/air modulation and increased sophistication in control electronics has created a requirement for system communication between boilers and room controllers. At the higher end, home-systems buses provide extensive communications capability and several such systems are available, although no single standard has emerged. Generally, they all require hardware/software solutions whose cost is significant at the lower-end of the market, especially for point-to-point systems. Several proprietary solutions at this low-end have been developed, but offer no cross-compatibility with products from different manufacturers.

There is an increasing demand for a new standard to be established to connect room controllers and boilers in a simple point-to-point fashion with very low entry-level costs. OpenTherm was developed to meet this requirement.

1.2 Key OpenTherm Characteristics

- Compatibility with so-called "dumb" or non-intelligent boiler systems.
- Compatibility with low-cost entry-level room thermostats.
- Compatible with electrical supplies typically normally available within boilers.
- Two-wire, polarity-free connection for concurrent power supply and data transmission.
- Provides a suitable power supply for a room controller so that it can operate without the need for an additional power source such as batteries.
- Implementable in low-cost microcontrollers with small ROM / RAM / CPU-speed requirements.
- Installer friendly feature for boiler testing. Shorting the wires at the boiler provides a simulated maximum heat demand (similar to current on/off systems).
- Allows for the transfer of sensor, fault and configuration data between the devices.
- Provides a mandatory minimum set of data objects, which allows for transmission of a modulating control signal from the room controller to the boiler.

One of the key characteristics of the OpenTherm standard is the two-level approach which allows analogue-type solutions at the low-end.

OT/+ The OpenTherm/plus protocol provides a digital communications system for data-exchange between two microprocessor-based devices.

OT/- The OpenTherm/Lite protocol uses a PWM signal and simple signalling capabilities to allow implementation on analogue-only products.

Both protocols use the same physical layer for data transmission and power-feeding ensuring that the two levels of communications are physically compatible.

1.3 Document Overview

This document specifies a communication system for use with boilers and room controls, which can also be applied to similar devices in the same or related applications. The characteristics and communications features of the both the infrastructure and the attached devices are specified in detail. This document does not provide a prescriptive solution for OpenTherm-compatible controllers, but rather specifies the requirements for such a solution.

This document is divided into the following sections :

1. Introduction	provides an overview of the background and key features of the OpenTherm communications system and defines some terms used in the document.
2. System Overview	gives a top-level architectural view of the target application system and explains OpenTherm in relation to the OSI reference model and outlines the process for ensuring product compliance.
3. Physical Layer	describes the characteristics of the physical medium and the method for bit-level signalling.
4. OT/+ DataLink Layer	describes the composition of OpenTherm/plus frames and allowable conversation formats.
5. OT/+ Application Layer	defines data objects and the mechanisms for transfer of application data between the boiler and room controllers.
6. OT/- Encoding/Application data	describes the special mechanisms for transferring data in the OpenTherm/Lite system.

Note regarding v2.1 of this specification: The new version of this spec defines more mandatory data-ids than the versions 1.x. and 2.0 This important difference means that devices which are compatible with v1.x or 2.0, may not be compatible with v2.1. However backward compatibility at a functional level should not be affected.

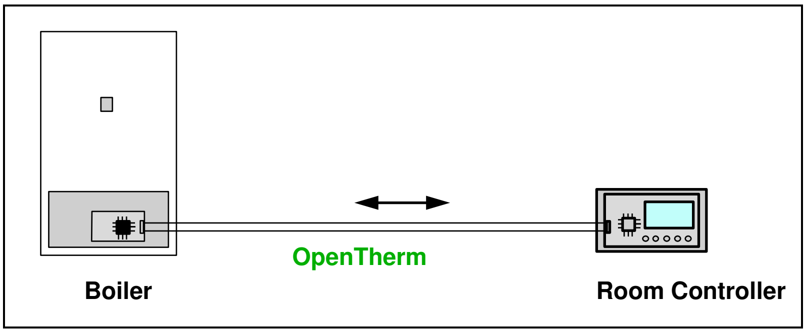
1.4 Nomenclature & Abbreviations

OT/+	OpenTherm/plus
OT/-	OpenTherm/Lite
OSI/RM	The OSI 7-layer protocol reference model.
PWM	Pulse-width modulation
Room Unit	The device which calculates the "demand" in the system, which is communicated to the Boiler Unit. The use of the term *room* is not intended to be literally restrictive but is used for convenience.
Boiler Unit	The device which receives the "demand" from the room unit and typically is responsible for providing energy to satisfy that demand. The use of the term *boiler* is not intended to be literally restrictive but is used for convenience.
AL	Application Layer
DLL	Data-Link Layer
PL	Physical Layer
TSP	Transparent Slave Parameter
RBP	Remote Boiler Parameter
CH	Central Heating
DHW	Domestic Hot Water
OEM	Original Equipment Manufacturer
OTC	Outside Temperature Compensation
FHB	Fault History Buffer

2. System Overview

2.1 System Architecture and Application Overview

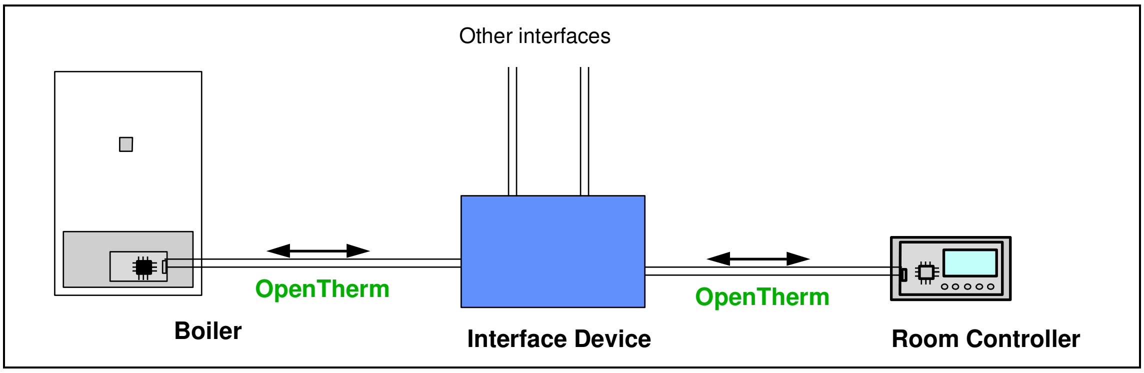
OpenTherm is a point-to-point communication system and connects boilers with room controllers, therefore it is not possible to connect several boilers or room controllers in the manner of bus-based systems. OpenTherm assumes that the room controller is calculating a heating demand signal in the form of a water temperature Control Setpoint based on room temperature error (or other control form, e.g. OTC) which it needs to transmit to the boiler so that the it can control the output of the boiler. The boiler in turn can transmit fault and system information to the room controller for display or diagnostics. A large number of data items are defined in the OT/+ Application Layer Protocol, covering these and many other pieces of system data.



2.2 Provision for Future Architectures/Expansion

The OpenTherm communication system is designed to allow for future expansion at the application layer by provision of reserved data-ids and at the data-link layer by the use of reserved (spare) bits within the frame.

In order to address applications which would normally require a bus-based communications system, it is conceived that intermediate gateways / interface devices would manage multiple OpenTherm communications lines. In the example below, the interface device acts as a "virtual boiler" to the room controller and acts as a "virtual room unit" to the boiler. In this way, other devices can be addressed while maintaining the basic point-to-point approach.

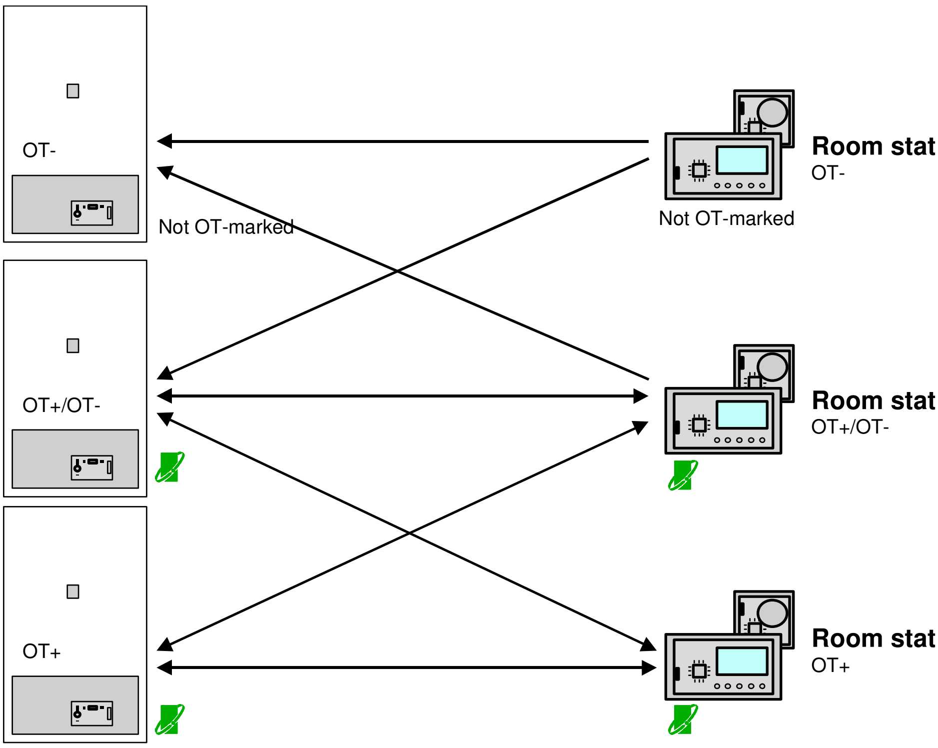


All future revisions of the OpenTherm Protocol Specification must be approved by the Members of The OpenTherm Association.

2.3 Product Compliance and Marking

All products marked with the OpenTherm logo must comply with the requirements of this document. The OpenTherm logo, trademark and the protocol can only be used with the permission of The OpenTherm Association. The OpenTherm Association is responsible for compliance testing procedures and licensing.

- A ***boiler or room controller*** can be marked with the OpenTherm logo if it conforms to the specification contained herein for OT/+.
- A ***boiler or room controller*** can not be marked with the OpenTherm logo if it only conforms to the specification contained herein for OT/-.

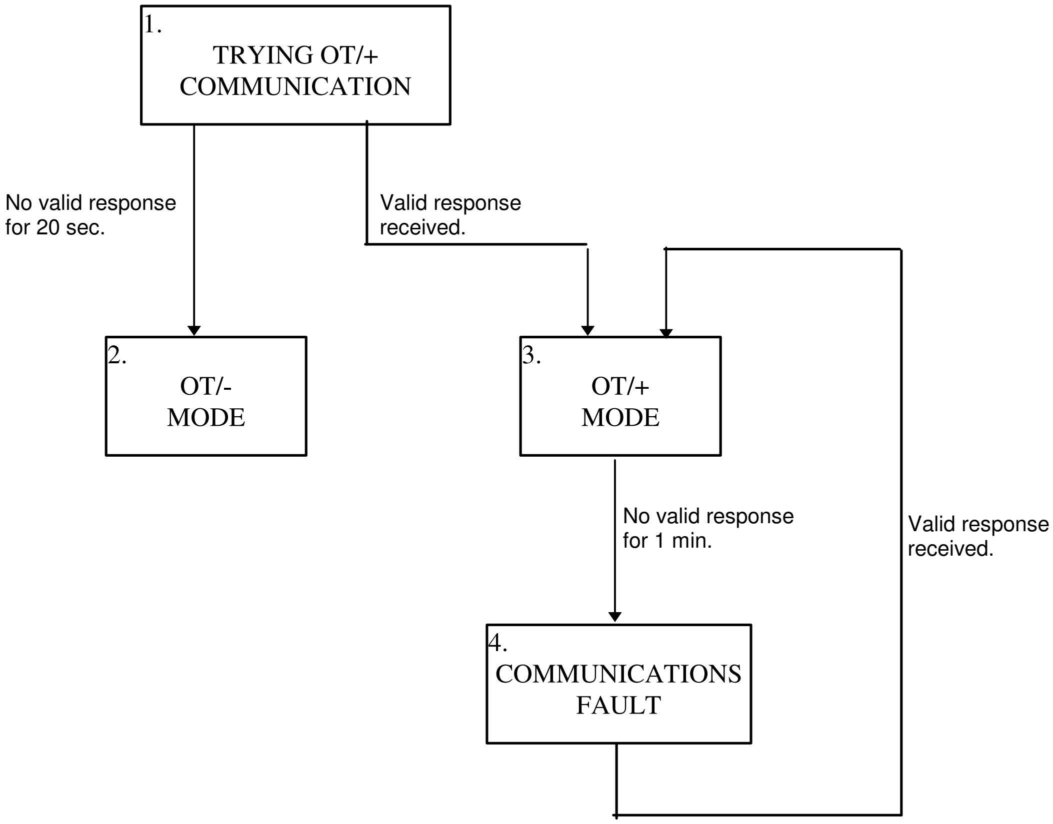


When a room unit which can operate both in OT/+ and OT/- modes is connected to a boiler controller, some configuration needs to take place to determine which protocol to use. This configuration should be achieved automatically as follows :

On power-up or after the physical connection is made, the room unit tries to communicate using OT/+ messages. If the boiler controller does not respond to one of these messages after 20 seconds, then the room unit switches to using OT/- signalling.

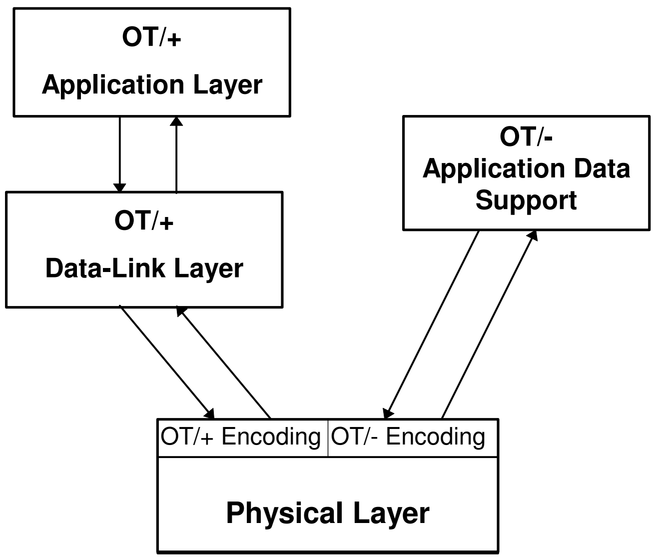
An OT/+ boiler controller must start communications within this 20 second period or future OT/+ communications will not be possible unless the room unit is reset or re-connected.

The state diagram below illustrates the OT/+ to OT/- detection in the master.



2.4 Protocol Reference Model

In order to describe the OpenTherm system, it is split up into an layered architecture based on the OSI Reference Model. The OSI/RM is an abstract description of inter-process data communication. It provides a standard architecture model that constitutes the framework for the development of standard protocols. The OSI/RM defines the functions of each of 7 defined layers and the services each layer provides to the layers above and below it. OpenTherm is only described in terms of the functions of the layers. Inter-layer communication is considered an implementation issue. The diagram below shows the OpenTherm Reference Model.



The **Application Layer** is responsible for transfer of application data between the application software in the boiler and room controllers. It defines data-classes, data-id numbers and format of data-values for transmission. It also specifies the minimum AL support for all OpenTherm-compatible devices.

The **Data-Link Layer** is responsible for building the complete frame incorporating the AL data-id and value and calculating the error-check code. It defines message types and conversation formats and performs error-checking on a received frame. It regulates the flow of information on the line.

The **Physical Layer** defines the electrical and mechanical characteristics of the medium and the mechanism for transmission of a bit, including bit-level encoding. It also performs bit-level error checking on an incoming frame(OT/+)

3. Physical Layer

3.1 Medium Definition- Characteristics of the Transmission Line

Number of Wires	:	2
Wiring type	:	untwisted pair *
Maximum line length	:	50 metres
Maximum cable resistance	:	2 * 5 Ohms
Polarity of connections	:	Polarity-free, i.e. interchangeable.

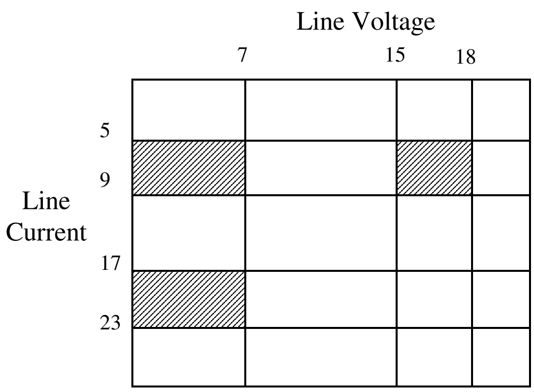
* In electrically noisy environments it may be necessary to use twisted pair or screened cable.

3.2 Signal Transmission Definition

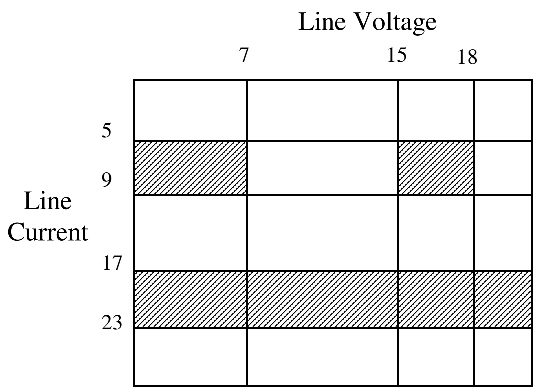
The system operates by sending current signals from the boiler unit to the room unit and voltage signals in the reverse direction.

The physical idle state of the line is a low-power consumption state i.e. low current and low voltage. Note that all specifications should be fulfilled within the complete temperature range in which the device is in use.

Summary of allowable line signal conditions :



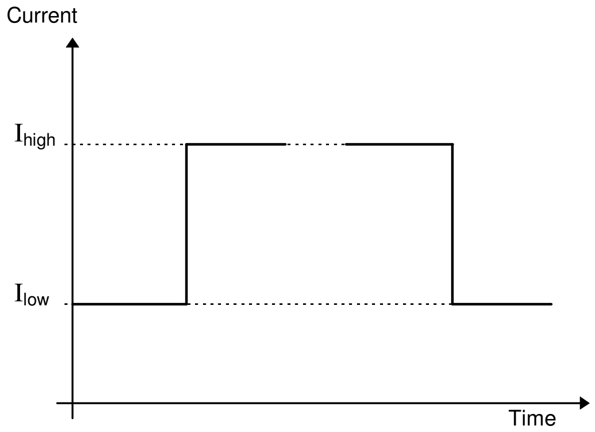
OpenTherm Plus System



OpenTherm Lite System

3.2.1 Transmitted Signal - Boiler Unit to Room Unit

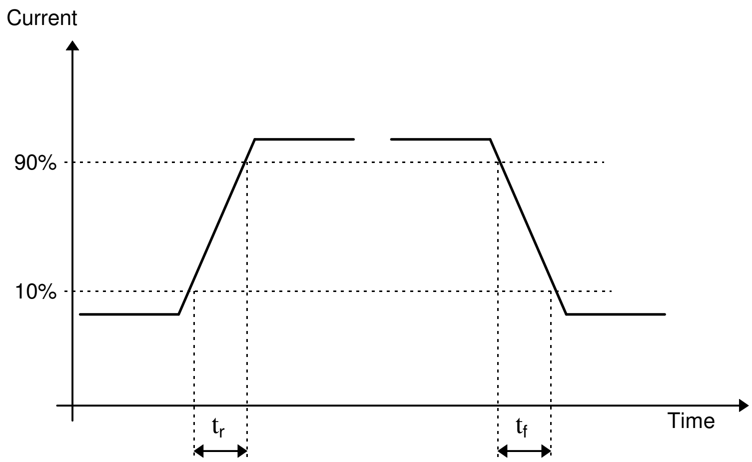
3.2.1.1 Static Characteristics - Amplitude



Current signal High level	I_{high}	:	17 .. 23 mA	
Current signal Low level	I_{low}	:	5 .. 9 mA	(idle state)
Maximum open-circuit voltage		:	42 Vdc	

Current signal specifications to be maintained when voltage = V_{low} for OT/+ devices.
Current signal specifications to be maintained when voltage = V_{low} or V_{high} for OT/- devices. This ensures that an OT/- slave can signal a lock-out signal independent of the master signalling.)

3.2.1.2 Dynamic Characteristics



Requirement for Room Unit / Master

Current signal rise time	t_r	:	50µs max,	(typical 20µs)
Current signal fall time	t_f	:	50µs max,	(typical 20µs)

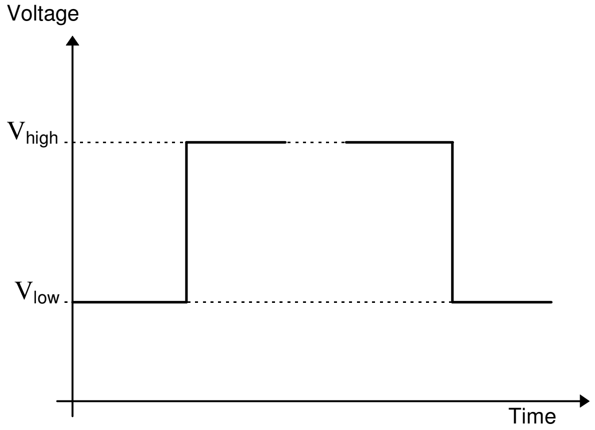
3.2.1.3 Receiver Thresholds

In order to set satisfactory signal-to-noise ratios, the receiver (room unit) should recognise a level change as significant at a threshold point within the following limits :

Current receive threshold	I_{rcv}	:	11.5 .. 14.5 mA,nominal 13 mA

3.2.2 Transmitted Signal - Room Unit to Boiler Unit

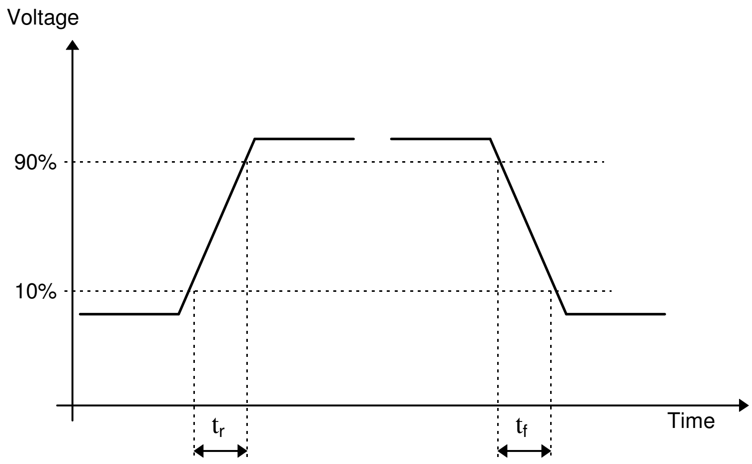
3.2.2.1 Static Characteristics - Amplitude



Voltage signal High level	V_{high}	:	15 .. 18 V.	
Voltage signal Low level	V_{low}	:	7 V. max.	(idle state)

Voltage signal specifications to be maintained when current = $I_{low.}$

3.2.2.2 Dynamic Characteristics



Requirement for Boiler Unit / Slave

Voltage signal rise time	t_r	:	50µs max,	(typical 20µs)
Voltage signal fall time	t_f	:	50µs max,	(typical 20µs)

3.2.2.3 Receiver Thresholds

In order to set satisfactory signal-to-noise ratios, the receiver (boiler unit) should recognise a level change as significant at a threshold point within the following limits :

Voltage receive threshold	V_{rcv}	:	9.5 .. 12.5 V.	nominal 11 V.

3.3 Power Feeding

It is the intention that OpenTherm provides suitable power from the boiler unit to the room unit such that no additional power connection or use of batteries is required for the room unit.

3.3.1 Options

The options for supplying power to an OpenTherm room unit are :

i) line (OpenTherm-supplied) power
ii) local supply (mains, batteries or other independent power source)

Any OpenTherm room unit is permitted to use line-power (provided that its requirements are met by the available current and voltage), or are free to exercise option (ii) above.

3.3.2 Power-Feed Characteristics

3.3.2.1 Room Unit Current

Guaranteed current available from the line is the minimum allowable idle signalling current (5 mA). This includes the current necessary to operate the regulator which develops the supply voltage in the room unit.

Room unit current consumption : 5 mA max.

3.3.2.2 Room Unit Voltage

The minimum voltage available to supply the room unit circuitry is a function of the implementation of the room unit communications interface. It is directly related to the Idle Line voltage and to the voltage drops associated with the polarity management circuitry and the voltage signalling circuit in idle state.
As a guide, a nominal voltage of 3.3V is achievable with a low cost implementation of the interface.

3.3.2.3 Connection polarity

The room unit shall provide the functionality to operate regardless of polarity of the line signal.

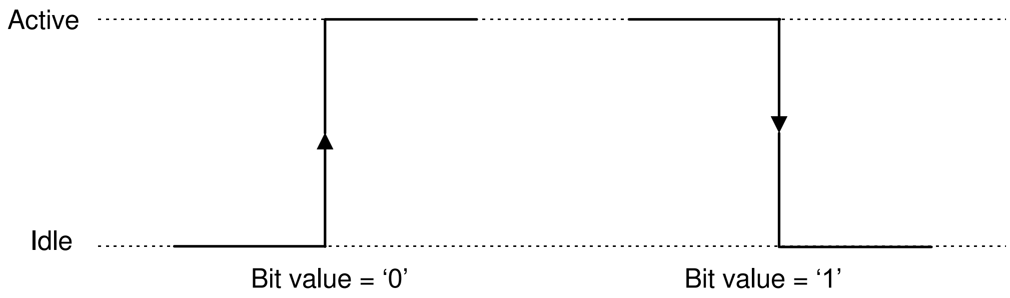
3.3.2.4 Galvanic isolation

The boiler interface shall provide safety isolation from the mains power line (ref. EN60730-1).

3.4 OpenTherm/plus Bit-Level Signalling

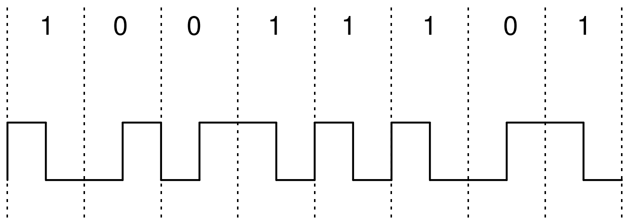
3.4.1 Bit Encoding Method

Bit encoding method	:	Manchester / Bi-phase-L
Bit value '1'	:	active-to-idle transition
Bit value '0'	:	idle-to-active transition



Manchester encoding is a self-clocking code giving the advantage of bit-synchronisation since there is always at least one transition in the middle of the bit-interval. It also has a fixed average d.c. component over the frame of half the idle and active levels which allows greater predictability of power supply requirements, and additionally the absence of an expected transition can be used to detect errors.

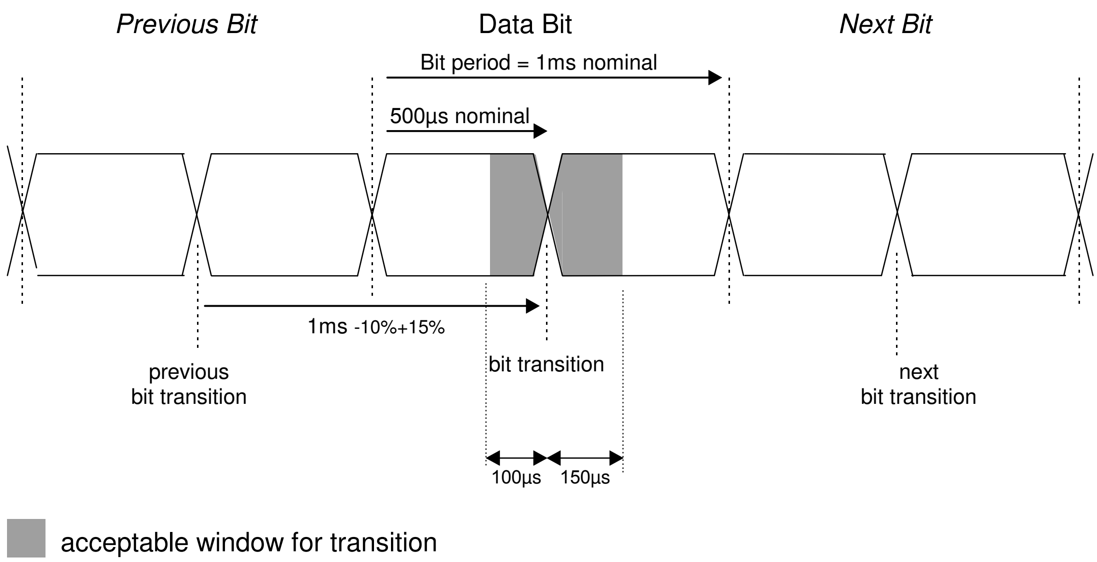
Example



3.4.2 Bit Rate and Timing

Bit rate	:	1000 bits/sec nominal
Period between mid-bit transitions	:	900µs .. 1150µs (nominal 1ms)

Timing should be reset on each transition so that any timing errors do not accumulate



acceptable window for transition

3.4.3 Bit-level Error Checking

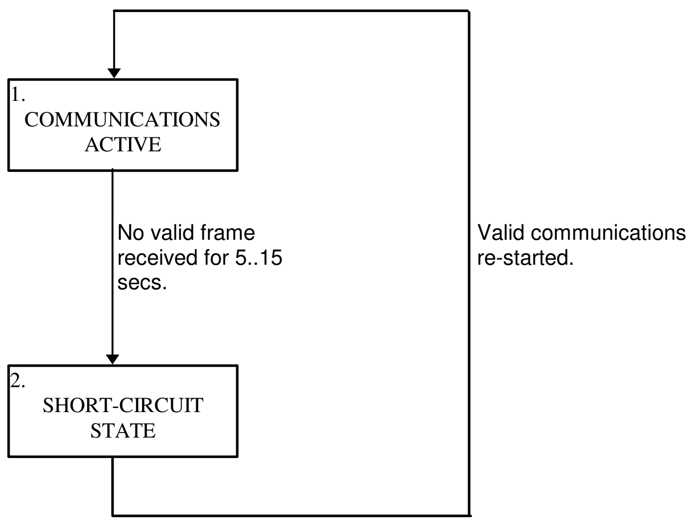
The primary error-checking method in OpenTherm is provided through the Manchester encoding. Manchester validity should be checked by the receiver and the data frame rejected if an error is detected.

3.5 Special Installation Short-Circuit Feature

The boiler unit must support an important installation feature which allows the terminals at the boiler to be short-circuited to simulate a heat demand such as can be done with existing on/off boilers. The boiler unit should interpret the short-circuit as a heat demand within15 secs of the short-circuit being applied. This must be supported by both OT/+ and OT/- boilers.

It is allowable that this can implemented by a software-detection method. The software short-circuit condition is defined as a low-voltage state (V_{low}) with no valid communications frame for at least 5 seconds.

The state diagram below illustrates this.



4. OpenTherm/plus DataLink Layer Protocol

4.1 Overview

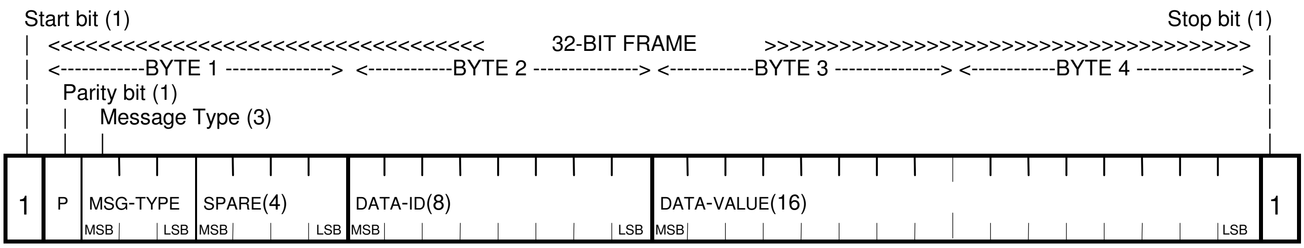
The data-link layer is responsible for the following functions :

- builds the complete frame from the information passed to it from the application layer.
- performs error-checking on an incoming frame.
- defines message types and allowable conversation exchanges.

4.2 Frame Format

Data is transmitted in 32 bit frames, with an added start bit ('1') at the beginning and stop bit ('1') at the end.

The frame format is identical for both directions, being laid out as follows:



Elements of the frame structure are described in the following sections.

4.2.1 Parity Bit - P

The parity bit should be set or cleared such the total number of '1' bits in the entire 32 bits of the message is even.

4.2.2 Message Type - MSG-TYPE

The message type determines the contents and meaning of the frame. Seven of the eight possible values for the message type are defined.

Master-to-Slave Messages	
Value	**Message type**
000	READ-DATA
001	WRITE-DATA
010	INVALID-DATA
011	*-reserved-*

Slave-to-Master Messages	
Value	**Message type**
100	READ-ACK
101	WRITE-ACK
110	DATA-INVALID
111	UNKNOWN-DATAID

4.2.3 Spare Data - SPARE

These bits are unused in this release of the protocol. They should always be '0'.

4.2.4 Data Item Identifier - DATA-ID

The DATA-ID is an 8 bit value which uniquely identifies the data item or items being transmitted. A full list of data ID's and corresponding data items are listed in the OT/+ Application Layer section.

4.2.5 Data Item Value - DATA-VALUE

This contains the 16 bit value of the data item corresponding to the frame's data identifier. In some messages, the data-value is composed of two separate items, each of 8-bits in length. These will be denoted as DATA-BYTE1 and DATA-BYTE2.

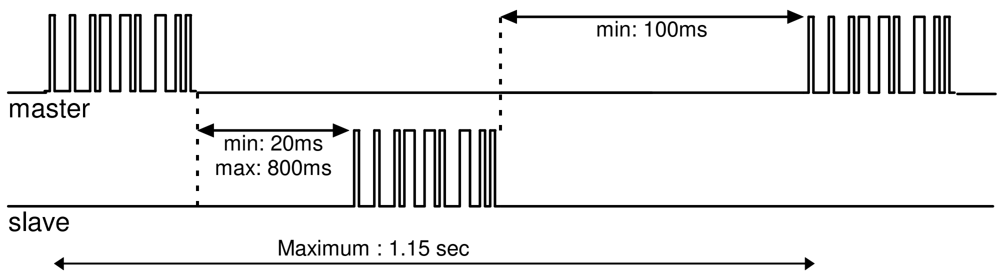
4.3 Conversation Format

4.3.1 Overview

OpenTherm data transfer consists of a series of 'conversations' between the devices controlled by a strict master/slave relationship. OpenTherm requires that the control device, e.g. a room unit, is always the master and the control plant, e.g. a boiler, is always the slave.

In all cases the master initiates a conversation by sending a single frame. The slave is expected to respond with a single frame reply within a defined period of 20ms to 800ms from the end of the master transmission. The master unit must wait 100ms from the end of a previous conversation before initiating a new conversation. The master must communicate at least every 1 sec (+15% tolerance).

This timing is shown below



A conversation is limited to a single exchange of frames. Three types of conversation are possible, listed in the next section.

4.3.2 Message Notation

In the rest of this section and in the OT/+ Application Layer Protocol section, a function-style notation is used to describe the various messages in order to aide explanation.

<msg-type> (id=<data-id>, <data-value>)

represents a message with msg-type=<msg-type>, data-id =<data-id> and data-value = <data-value>.

<msg-type> (id=<data-id>, <data-byte1>, <data-byte2>)

represents a message with msg-type=<msg-type>, data-id =<data-id> and data-value = <data-byte1>&<data-byte2>.

e.g. READ-DATA (id=1, ControlSetpoint-value)
READ-DATA (id=11, TSP-index, 00)

4.3.3 Default Data-Values

For some messages, no "real" data is being sent. e.g. in a normal Read-Data request. The data-value will be set to a default value of zero. i.e. two bytes of 0x00 and 0x00.

4.4 Conversation Details

4.4.1 Read-Data Request

READ-DATA (DATA-ID, DATA-VALUE)

The master is requesting a data value, specified by the data identifier, from the slave. The message type sent by the master is 'Read-Data', as shown above. Typically no data-value is sent and a value of 0x0000 will be used, but in some circumstances the master may, although it is requesting a value from the slave, also send a value to the slave with this message e.g. for data-verification. This is defined by the OT/+ Application Layer protocol.

The slave should make one of the three possible responses listed below:

- READ-ACK (DATA-ID, DATA-VALUE,)

If the data ID is recognised by the slave and the data requested is available and valid. The value of the data item is returned.

- DATA-INVALID (DATA-ID, DATA-VALUE)

If the data ID is recognised by the slave but the data requested is not available or invalid. DATA-VALUE can be 0x0000 in this case.

- UNKNOWN-DATAID (DATA-ID, DATA-VALUE)

If the slave does not recognise the data identifier. DATA-VALUE can be 0x0000 in this case.

4.4.2 Write-Data Request

WRITE-DATA (DATA-ID, DATA-VALUE)

The master is writing a data value, specified by the data identifier, to the slave. The message type sent by the master is 'Write-Data', as shown above.

The slave should make one of the three possible responses listed below: (Note that DATA-VALUE may be modified by the slave in some circumstances.)

- WRITE-ACK (DATA-ID, DATA-VALUE)

If the data ID is recognised by the slave and the data sent is valid.

- DATA-INVALID (DATA-ID, DATA-VALUE)

If the data ID is recognised by the slave but the data sent is invalid.

- UNKNOWN-DATAID (DATA-ID, DATA-VALUE)

If the slave does not recognise or does not support the data identifier.

4.4.3 Writing Invalid Data

INVALID-DATA (DATA-ID, DATA-VALUE)

A data item to be sent by the master may be invalid in a particular application, but may still require to be sent. In this case the master may use the message type 'data invalid'.

The slave should make one of the two possible responses listed below: (Note that DATA-VALUE may be modified by the slave in some circumstances.)

- DATA-INVALID (DATA-ID, DATA-VALUE)

If the data ID is recognised by the slave.

- UNKNOWN-DATAID (DATA-ID, DATA-VALUE)

If the slave does not recognise or does not support the data identifier.

4.5 Frame Error Handling

In all cases of errors being detected in the incoming frame, the partial frame is rejected and the conversation should be terminated. No errors are treated as recoverable.

If the slave does not respond, then the master should note that the conversation is incomplete.

If a conversation is terminated the master should re-attempt the same conversation at the next appropriate scheduled time for communications.

5. OpenTherm/plus Application Layer Protocol

5.1 Overview

The Application Layer of the OpenTherm protocol is divided into an Open-Area of data-item id's and a Test & Diagnostic area for Member use. Id's 0 .. 127 are reserved for OpenTherm pre-defined information, while id's from 128 .. 255 can be used by manufacturers (members of the association) for test & diagnostic purposes only. The MemberID codes of the master and slave can be used to handshake between two compatible devices and enable the use of the Test & Diagnostic-Area data-items. MemberID codes are assigned and managed by The OpenTherm Association.

There are seven classes of information defined in the Application Layer :

Class 1. **Control and Status Information**
This class contains basic control information from the master and status information exchange (including fault status) and incorporates all the mandatory OpenTherm data.

Class 2. **Configuration Information**
Information relating to the configuration of the master and slave and Member identification.

Class 3. **Remote Commands**
This class allows for commands to be passed from the master to the slave.

Class 4. **Sensor and Informational Data**
This class covers typically sensor temperatures, pressures etc.

Class 5. **Remote Boiler Parameters**
These are parameters of the slave device which may be read or set by the master and are specific to boiler applications.

Class 6. **Transparent Slave Parameters**
This class allows slave parameters to be read or set by the master without knowledge of their physical or application-specific meaning.

Class 7. **Fault History Information**
This data allows historical fault information to be passed from the slave to the master.

Class 8. **Control of Special Applications**
This class defines data id's to be exchanged between the master and a application specific slave.

Special abbreviations and data-types are used in the Application Layer Protocol section and are defined below :

LB	low-byte of the 16-bit data field.
HB	high-byte of the 16-bit data field.
S>M	information flow from slave to master
M>S	information flow from master to slave
flag8	byte composed of 8 single-bit flags
u8	unsigned 8-bit integer 0 .. 255
s8	signed 8-bit integer -128 .. 127 (two's compliment)
f8.8	signed fixed point value : 1 sign bit, 7 integer bit, 8 fractional bits (two's compliment ie. the LSB of the 16bit binary number represents 1/256th of a unit).
u16	unsigned 16-bit integer 0..65535
s16	signed 16-bit integer -32768..32767

Example : A temperature of 21.5°C in f8.8 format is represented by the 2-byte value `1580` hex
(1580hex = 5504dec, dividing by 256 gives 21.5)
A temperature of -5.25°C in f8.8 format is represented by the 2-byte value `FAC0` hex
(FAC0hex = - (10000hex-FACOhex) = - 0540hex = - 1344dec, dividing by 256 gives -5.25)

- All data-item ID's are in decimal unless denoted otherwise.
- "00" is used to represent the dummy data byte as defined in the Data-Link Layer and is transmitted when valid data-values are not available or appropriate.
- For future compatibility, a bit or byte is marked as unused or reserved, should be set to 0 (zero) by the transmitter; however the receiver should ignore these bits/bytes, since they may be set in future versions of the protocol.
- 'R' and 'W' under the column labelled 'Msg', indicate whether the data object is supported with a Read or a Write command.

5.2 Mandatory OT/+ Application-Layer Support

It is required that OpenTherm-compliant devices support the following data items.

ID	Description	Master	Slave
0	Master and slave status flags	• Must sent message with READ_DATA • Must support all bits in master status	• Must respond with READ_ACK • Must support all bits in slave status
1	Control setpoint ie CH water temp. setpoint	• Must sent message with WRITE_DATA or INVALID_DATA (not recommended)	• Must respond with WRITE_ACK
3	Slave configuration flags	• Must sent message with READ_DATA (at least at start up)	• Must respond with READ_ACK • Must support all slave configuration flags
14	Maximum relative modulation level setting	• Not mandatory • Recommended for use in on-off control mode.	• Must respond with WRITE_ACK
17	Relative modulation level	• Not mandatory	• Must respond with READ_ACK or DATA_INVALID
25	Boiler temperature	• Not mandatory	• Must respond with READ_ACK or DATA_INVALID (for example if sensor fault)

The slave can respond to all other read/write requests, if not supported, with an UNKNOWN-DATAID reply. Master units (typically room controllers) should be designed to act in a manner consistent with this rule.

5.3 Data Classes

5.3.1 Class 1 : Control and Status Information

This group of data-items contains important control and status information relating to the slave and master. The slave status contains a mandatory fault-indication flag and there is an optional application-specific set of fault flags which relate to specific faults in boiler-related applications, and an OEM fault code whose meaning is unknown to the master but can be used for display purposes.

ID	Msg	Name	Type	Range	Description
0	R -	HB: Master status	flag8		*bit: description [clear/0, set/1]* 0: CH enable [CH is disabled, CH is enabled] 1: DHW enable [DHW is disabled, DHW is enabled] 2: Cooling enable [Cooling is disabled, Cooling is enabled] 3: OTC active [OTC not active, OTC is active] 4: CH2 enable [CH2 is disabled, CH2 is enabled] 5: reserved 6: reserved 7: reserved
		LB: Slave status	flag8		*bit: description [clear/0, set/1]* 0: fault indication [no fault, fault] 1: CH mode [CH not active, CH active] 2: DHW mode [DHW not active, DHW active] 3: Flame status [flame off, flame on] 4: Cooling status [cooling mode not active, cooling mode active] 5: CH2 mode [CH2 not active, CH2 active] 6: diagnostic indication [no diagnostics, diagnostic event] 7: reserved
1	- W	Control setpoint	f8.8	0..100	degrees C (see notes below)
5	R -	HB: Application-specific fault flags	flag8		*bit: description [clear/0, set/1]* 0: Service request [service not req'd, service required] 1: Lockout-reset [remote reset disabled, rr enabled] 2: Low water press [no WP fault, water pressure fault] 3: Gas/flame fault [no G/F fault, gas/flame fault] 4: Air press fault [no AP fault, air pressure fault] 5: Water over-temp[no OvT fault, over-temperat. Fault] 6: reserved 7: reserved
		LB: OEM fault code	u8	0..255	An OEM-specific fault/error code
8	- W	Control setpoint 2 (TsetCH2)	f8.8	0..100	degrees C
115	R -	OEM diagnostic code	u16	0..65535	An OEM-specific diagnostic/service code

Note : The master decides the actual range over which the control setpoint is defined. The default range is assumed to be 0 to 100.

There is only one control value defined - data-id=01, the control setpoint. The control setpoint ranges between a minimum of 0 and maximum of 100. It represents directly a temperature setpoint for the supply from the boiler. The slave does not need to know how the master has calculated the control setpoint, e.g. whether it used room control or OTC, it only needs to control to the value. Likewise, the master does not need to know how the slave is controlling the supply.

The CHenable bit has priority over the Control Setpoint. The master can indicate that no CH demand is required by putting the CHenable bit = 0 (ie CH is disabled), even if the Control Setpoint is non-zero.

The status exchange is a special form of conversation which should be initiated by the master by sending a READ-DATA(id=0,MasterStatus,00) message. The slave must respond with READ-ACK(id=0,MasterStatus, SlaveStatus) to send back the Slave Status information in the same single conversation. Since it is mandatory to support this data object, the slave cannot respond with DATA-INVALID or UNKNOWN-DATAID. A WRITE-DATA(id=0,…) from the master should not be used.

5.3.2 Class 2 : Configuration Information

This group of data-items defines configuration information on both the slave and master sides. Each has a group of configuration flags (8 bits) and an MemberID code (1 byte). A valid *Read Slave Configuration* and *Write Master Configuration* message exchange is recommended before control and status information is transmitted.

ID	Msg	Name	Type	Range	Description
2	- W	HB: Master configuration	flag8		*bit: description [clear/0, set/1]* 0: reserved 1: reserved 2: reserved 3: reserved 4: reserved 5: reserved 6: reserved 7: reserved
		LB: Master MemberID code	u8	0..255	MemberID code of the master
3	R -	HB: Slave configuration	flag8		*bit: description [clear/0, set/1]* 0: DHW present [dhw not present, dhw is present] 1: Control type [modulating, on/off] 2: Cooling config [cooling not supported, cooling supported] 3: DHW config [instantaneous or not-specified, storage tank] 4: Master low-off&pump control function [allowed, not allowed] 5: CH2 present [CH2 not present, CH2 present] 6: reserved 7: reserved
		LB: Slave MemberID code	u8	0..255	MemberID code of the slave
124	- W	OpenTherm version Master	f8.8	0..127	The implemented version of the OpenTherm Protocol Specification in the master.
125	R -	OpenTherm version Slave	f8.8	0..127	The implemented version of the OpenTherm Protocol Specification in the slave.
126	- W	Master product version number and type HB : product type LB : product version	 u8 u8	 0..255 0..255	The master device product version number and type as defined by the manufacturer.
127	R -	Slave product version number and type HB : product type LB : product version	 u8 u8	 0..255 0..255	The slave device product version number and type as defined by the manufacturer.

Note 1 An MemberID code of zero signifies a customer non-specific device.
Note 2 The product version number/type should be used in conjunction with the "Member ID code", which identifies the manufacturer of the device.

5.3.3 Class 3 : Remote Commands

This class of data represents commands sent by the master to the slave. There is a single data-id for a command "packet", with the Command-Code embedded in the high-byte of the data-value field.

ID	Msg	Name	Type	Range	Description
4	- W	HB: Command-Code	u8	0..255	*Command code* 0 :- Reserved - 1 : "BLOR"= Boiler Lock-out Reset command 2 : "CHWF"=CH water filling 3..255 : -Reserved - for future use
	R -	LB: Cmd-Response-Code	u8	0..255	Response to the command 0..127 : Command failed. 128..255 : Command completed.

Example

The master will send a WRITE-DATA(id=4,Cmd=BLOR,00) message.
The slave response will be either :

1. WRITE-ACK (id=4,Cmd=BLOR,Cmd-Resp) The command was accepted; Cmd-Resp indicates completion status.
2. DATA-INVALID (id=4,BLOR,00) The command was not recognised, Cmd-reponse=00;
3. UNKNOWN-DATAID (id=4, BLOR,00) Remote Commands not supported, Cmd-response=00;.

5.3.4 Class 4 : Sensor and Informational Data

This group of data-items contains sensor data (temperatures, pressures etc.) and other informational data from one unit to the other.

ID	Msg	Name	Type	Range	Description
16	- W	Room Setpoint	f8.8	-40..127	Current room temperature setpoint (°C)
17	R -	Relative Modulation Level	f8.8	0..100	Percent modulation between min and max modulation levels. i.e. 0% = Minimum modulation level 100% = Maximum modulation level
18	R -	CH water pressure	f8.8	0..5	Water pressure of the boiler CH circuit (bar)
19	R -	DHW flow rate	f8.8	0..16	Water flow rate through the DHW circuit (l/min)
20	R W	Day of Week & Time of Day HB : bits 7,6,5 : day of week bits 4,3,2,1,0 : hours LB : minutes	special u8	1..7 0..23 0..59	1=Monday, etc…. (0=no DoW info available)
21	R W	Date HB : Month LB : Day of Month	u8 u8	1..12 1..31	1=January, etc
22	R W	Year	u16	0..65535	note : 1999-2099 will normally be sufficient
23	- W	Room Setpoint CH2	f8.8	-40..127	Current room setpoint for 2nd CH circuit (°C)
24	- W	Room temperature	f8.8	-40..127	Current sensed room temperature (°C)
25	R -	Boiler water temp.	f8.8	-40..127	Flow water temperature from boiler (°C)
26	R -	DHW temperature	f8.8	-40..127	Domestic hot water temperature (°C)
27	R -	Outside temperature	f8.8	-40..127	Outside air temperature (°C)
28	R -	Return water temperature	f8.8	-40..127	Return water temperature to boiler (°C)
29	R -	Solar storage temperature	f8.8	-40..127	Solar storage temperature (°C)
30	R -	Solar collector temperature	s16	-40..250	Solar collector temperature (°C)
31	R -	Flow temperature CH2	f8.8	-40..127	Flow water temperature of the second central

					heating circuit.
ID	**Msg**	**Name**	**Type**	**Range**	**Description**
32	R -	DHW2 temperature	f8.8	-40..127	Domestic hot water temperature 2 (°C)
33	R -	Exhaust temperature	s16	-40..500	Exhaust temperature (°C)
116	R W	Burner starts	u16	0..65535	Number of starts burner. Reset by writing zero is optional for slave.
117	R W	CH pump starts	u16	0..65535	Number of starts CH pump. Reset by writing zero is optional for slave.
118	R W	DHW pump/valve starts	u16	0..65535	Number of starts DHW pump/valve. Reset by writing zero is optional for slave.
119	R W	DHW burner starts	u16	0..65535	Number of starts burner in DHW mode. Reset by writing zero is optional for slave.
120	R W	Burner operation hours	u16	0..65535	Number of hours that burner is in operation (i.e. flame on). Reset by writing zero is optional for slave.
121	R W	CH pump operation hours	u16	0..65535	Number of hours that CH pump has been running. Reset by writing zero is optional for slave.
122	R W	DHW pump/valve operation hours	u16	0..65535	Number of hours that DHW pump has been running or DHW valve has been opened. Reset by writing zero is optional for slave.
123	R W	DHW burner operation hours	u16	0..65535	Number of hours that burner is in operation during DHW mode. Reset by writing zero is optional for slave.

5.3.5 Class 5 : Pre-Defined Remote Boiler Parameters

This group of data-items defines specific parameters of the slave device (setpoints, etc.) which may be available to the master device and may, or may not, be adjusted remotely. These parameters are pre-specified in the protocol and are specifically related to boiler/room controller applications. There is a maximum of 8 remote boiler parameters. Each remote-boiler-parameter has a upper- and lower-bound (max and min values) which the master should read from the slave in order to make sure they are not set outside the valid range. If the slave does not support sending the upper- and lower-bounds, the master can apply default bounds as it chooses.

The remote-parameter transfer-enable flags indicate which remote parameters are supported by the slave. The remote-parameter read/write flags indicate whether the master can only read the parameter from the slave, or whether it can also modify the parameter and write it back to the slave. An Unknown Data-Id response to a Read Remote-Parameter-Flags message indicates no support for remote-parameters (equivalent to all transfer-enable flags equal to zero). In these flag bytes bit 0 corresponds to remote-boiler-parameter 1 and bit 7 to remote-boiler-parameter 8.

ID	Msg	Name	Type	Range	Description
6	R -	HB: Remote-parameter transfer-enable flags	flag8	n/a	*bit: description [clear/0, set/1]* 0: DHW setpoint [transfer disabled, transfer enabled] 1: max CHsetpoint [transfer disabled, transfer enabled] 2: reserved 3: reserved 4: reserved 5: reserved 6: reserved 7: reserved
	R -	LB: Remote-parameter read/write flags	flag8	n/a	*bit: description [clear/0, set/1]* 0: DHW setpoint [read-only, read/write] 1: max CHsetpoint [read-only, read/write] 2: reserved 3: reserved 4: reserved 5: reserved 6: reserved 7: reserved

ID	Msg	Name	Type	Range	Description
48	R -	HB: DHWsetp upp-bound	s8	0..127	Upper bound for adjustment of DHW setp (℃)
		LB: DHWsetp low-bound	s8	0..127	Lower bound for adjustment of DHW setp (℃)
49	R -	HB: max CHsetp upp-bnd	s8	0..127	Upper bound for adjustment of maxCHsetp (℃)
		LB: max CHsetp low-bnd	s8	0..127	Lower bound for adjustment of maxCHsetp (℃)
50	-	reserved	-	-	Reserved for remote parameter 3 - upp/low bnd
51	-	reserved	-	-	Reserved for remote parameter 3 - upp/low bnd
52	-	reserved	-	-	Reserved for remote-parameter 4 - upp/low bnd
53	-	reserved	-	-	Reserved for remote-parameter 5 - upp/low bnd
54	-	reserved	-	-	Reserved for remote-parameter 6 - upp/low bnd
55	-	reserved	-	-	Reserved for remote-parameter 7 - upp/low bnd
56	R W	**DHW setpoint**	f8.8	0..127	Domestic hot water temperature setpoint (℃)
57	R W	**max CH water setpoint**	f8.8	0..127	Maximum allowable CH water setpoint (℃)
58	-	reserved	-	-	Reserved for remote parameter 3
59	-	reserved	-	-	Reserved for remote parameter 3
60	-	reserved	-	-	Reserved for remote-parameter 4
61	-	reserved	-	-	Reserved for remote-parameter 5
62	-	reserved	-	-	Reserved for remote-parameter 6
63	-	reserved	-	-	Reserved for remote-parameter 7

5.3.6 Class 6 : Transparent Slave Parameters

This group of data-items defines parameters of the slave device which may (or may not) be remotely set by the master device. These parameters are not pre-specified in the protocol and are "transparent" to the master in the sense that it has no knowledge about their application meaning.

ID	Msg	Name	Type	Range	Description
10	R -	HB: Number of TSPs	u8	0..255	Number of transparent-slave-parameter supported by the slave device.
		LB: Not used	u8		-Reserved-
11	R W	HB: TSP index no.	u8	0..255	Index number of following TSP
		LB: TSP value	u8	0..255	Value of above referenced TSP

The first data-item (id=10) allows the master to read the number of transparent-slave-parameters supported by the slave. The second data-item (ID=11) allows the master to read and write individual transparent-slave-parameters from/to the slave.

Example

To read a TSP, the master uses the following command: READ-DATA (id=11,TSP-index,00).
The slave response will be either :
1. READ-ACK (id=11,TSP-index,TSP-value) Everything OK, the requested data-value is returned.
2. DATA-INVALID (id=11,TSP-index,00) The TSP-index is out-of-range or undefined, 00 is returned.
3. UNKNOWN-DATAID (id=11, TSP-index,00) The slave does not support transparent-slave-parameters.

To write a TSP, the master uses the following command: WRITE-DATA(id=11,TSP-index, TSP-value)
The slave response will be either :
1. WRITE-ACK (id=11,TSP-index,TSP-value) Everything OK, the value is echoed back. Note however, that the TSP-value may be changed by the slave if it is out-of-range.
2. DATA-INVALID (id=11,TSP-index,00) The TSP-index is out-of-range or undefined, 00 is returned.
3. UNKNOWN-DATAID (id=11,TSP-index,00) The slave does not support transparent-slave-parameters.

5.3.7 Class 7 : Fault History Data

This group of data-items contains information relating to the past fault condition of the slave device.

ID	Msg	Name	Type	Range	Description
12	R -	HB: Size of Fault Buffer	u8	0..255	The size of the fault history buffer..
		LB: Not used	u8		-Reserved-
13	R -	HB: FHB-entry index no.	u8	0..255	Index number of following Fault Buffer entry
		LB: FHB-entry value	u8	0..255	Value of above referenced Fault Buffer entry

The first data-item (id=12) allows the master to read the size of the fault history buffer supported by the slave. The second data-item (ID=13) allows the master to read individual entries from the buffer.

Example

To read an entry from the fault history buffer, the master uses the following command:
READ-DATA (id=13,FHB-index,00).
The slave response will be either :
1. READ-ACK (id=13,FHB-index,FHB-value) Everything OK, the requested value is returned.
2. DATA-INVALID (id=13,FHB-index,00) The FHB-index is out-of-range or undefined, 00 is returned.
3. UNKNOWN-DATAID (id=13, FHB-index,00) The slave does not support a fault history buffer.

5.3.8 Class 8 : Control of Special Applications

5.3.8.1 Cooling Control

ID	Msg	Name	Type	Range	Description
7	- W	Cooling control signal	f8.8	0..100%	Signal for cooling plant.

The cooling control signal is to be used for cooling applications. First the master should determine if the slave supports cooling by reading the slave configuration. Then the master can use the cooling control signal and the cooling-enable flag (status) to control the cooling plant. The status of the cooling plant can be read from the slave cooling status bit.

5.3.8.2 Boiler Sequencer Control

ID	Msg	Name	Type	Range	Description
14	- W	Maximum relative modulation level setting	f8.8	0..100%	Maximum relative boiler modulation level setting for sequencer and off-low&pump control applications.
15	R -	Maximum boiler capacity & Minimum modulation level HB : max. boiler capacity LB : min. modulation level	 u8 u8	 0..255kW 0..100%	 expressed as a percentage of the maximum capacity.

The boiler capacity level setting is to be used for boiler sequencer applications. The control setpoint should be set to maximum, and then the capacity level setting throttled back to the required value. The default value in the slave device should be 100% (ie no throttling back of the capacity). The master can read the maximum boiler capacity and minimum modulation levels from the slave if it supports these.

5.3.8.3 Remote override room setpoint

ID*	Msg. Type	NAME	Format	Range	DESCRIPTION
9	R -	Remote override room setpoint	f8.8	0..30	0= No override 1..30= Remote override room setpoint
100	R -	LB: Remote override function	flag8	0..255	*bit: description [clear/0, set/1]* 0: Manual change priority [disable overruling remote setpoint by manual setpoint change, enable overruling remote setpoint by manual setpoint change] 1: Program change priority [disable overruling remote setpoint by program setpoint change, enable overruling remote setpoint by program setpoint change] 2: reserved 3: reserved 4: reserved 5: reserved 6: reserved 7: reserved
		HB: reserved	u8	0	reserved

There are applications where it's necessary to override the room setpoint of the master (room-unit).
For instance in situations where room controls are connected to home or building controls or room controls in holiday houses which are activated/controlled remotely.

The master can read on Data ID 9 the remote override room setpoint. A value unequal to zero is a valid remote override room setpoint. A value of zero means no remote override room setpoint. ID100 defines how the master should react while remote room setpoint is active and there is a manual setpoint change and/or a program setpoint change.

5.4 Data-Id Overview Map

Nr.	Msg	Data Object	Type	Description
0	R -	Status	flag8 / flag8	Master and Slave Status flags.
1	- W	TSet	f8.8	Control setpoint ie CH water temperature setpoint (°C)
2	- W	M-Config / M-MemberIDcode	flag8 / u8	Master Configuration Flags / Master MemberID Code
3	R -	S-Config / S-MemberIDcode	flag8 / u8	Slave Configuration Flags / Slave MemberID Code
4	- W	Command	u8 / u8	Remote Command
5	R -	ASF-flags / OEM-fault-code	flag8 / u8	Application-specific fault flags and OEM fault code
6	R -	RBP-flags	flag8 / flag8	Remote boiler parameter transfer-enable & read/write flags
7	- W	Cooling-control	f8.8	Cooling control signal (%)
8	- W	TsetCH2	f8.8	Control setpoint for 2e CH circuit (°C)
9	R -	TrOverride	f8.8	Remote override room setpoint
10	R -	TSP	u8 / u8	Number of Transparent-Slave-Parameters supported by slave
11	R W	TSP-index / TSP-value	u8 / u8	Index number / Value of referred-to transparent slave parameter.
12	R -	FHB-size	u8 / u8	Size of Fault-History-Buffer supported by slave
13	R -	FHB-index / FHB-value	u8 / u8	Index number / Value of referred-to fault-history buffer entry.
14	- W	Max-rel-mod-level-setting	f8.8	Maximum relative modulation level setting (%)
15	R -	Max-Capacity / Min-Mod-Level	u8 / u8	Maximum boiler capacity (kW) / Minimum boiler modulation level(%)
16	- W	TrSet	f8.8	Room Setpoint (°C)
17	R -	Rel.-mod-level	f8.8	Relative Modulation Level (%)
18	R -	CH-pressure	f8.8	Water pressure in CH circuit (bar)
19	R -	DHW-flow-rate	f8.8	Water flow rate in DHW circuit. (litres/minute)
20	R W	Day-Time	special / u8	Day of Week and Time of Day
21	R W	Date	u8 / u8	Calendar date
22	R W	Year	u16	Calendar year
23	- W	TrSetCH2	f8.8	Room Setpoint for 2nd CH circuit (°C)
24	- W	Tr	f8.8	Room temperature (°C)
25	R -	Tboiler	f8.8	Boiler flow water temperature (°C)
26	R -	Tdhw	f8.8	DHW temperature (°C)
27	R -	Toutside	f8.8	Outside temperature (°C)
28	R -	Tret	f8.8	Return water temperature (°C)
29	R -	Tstorage	f8.8	Solar storage temperature (°C)
30	R -	Tcollector	f8.8	Solar collector temperature (°C)
31	R -	TflowCH2	f8.8	Flow water temperature CH2 circuit (°C)
32	R -	Tdhw2	f8.8	Domestic hot water temperature 2 (°C)
33	R -	Texhaust	s16	Boiler exhaust temperature (°C)
48	R -	TdhwSet-UB / TdhwSet-LB	s8 / s8	DHW setpoint upper & lower bounds for adjustment (°C)
49	R -	MaxTSet-UB / MaxTSet-LB	s8 / s8	Max CH water setpoint upper & lower bounds for adjustment (°C)
50	R -	Hcratio-UB / Hcratio-LB	s8 / s8	OTC heat curve ratio upper & lower bounds for adjustment
56	R W	TdhwSet	f8.8	DHW setpoint (°C) (Remote parameter 1)
57	R W	MaxTSet	f8.8	Max CH water setpoint (°C) (Remote parameters 2)
58	R W	Hcratio	f8.8	OTC heat curve ratio (°C) (Remote parameter 3)

Nr.	Msg	Data Object	Type	Description
100	R -	Remote override function	flag8 / -	Function of manual and program changes in master and remote room setpoint.
115	R -	OEM diagnostic code	u16	OEM-specific diagnostic/service code
116	R W	Burner starts	u16	Number of starts burner
117	R W	CH pump starts	u16	Number of starts CH pump
118	R W	DHW pump/valve starts	u16	Number of starts DHW pump/valve
119	R W	DHW burner starts	u16	Number of starts burner during DHW mode
120	R W	Burner operation hours	u16	Number of hours that burner is in operation (i.e. flame on)
121	R W	CH pump operation hours	u16	Number of hours that CH pump has been running
122	R W	DHW pump/valve operation hours	u16	Number of hours that DHW pump has been running or DHW valve has been opened
123	R W	DHW burner operation hours	u16	Number of hours that burner is in operation during DHW mode
124	- W	OpenTherm version Master	f8.8	The implemented version of the OpenTherm Protocol Specification in the master.
125	R -	OpenTherm version Slave	f8.8	The implemented version of the OpenTherm Protocol Specification in the slave.
126	- W	Master-version	u8 / u8	Master product version number and type
127	R -	Slave-version	u8 / u8	Slave product version number and type

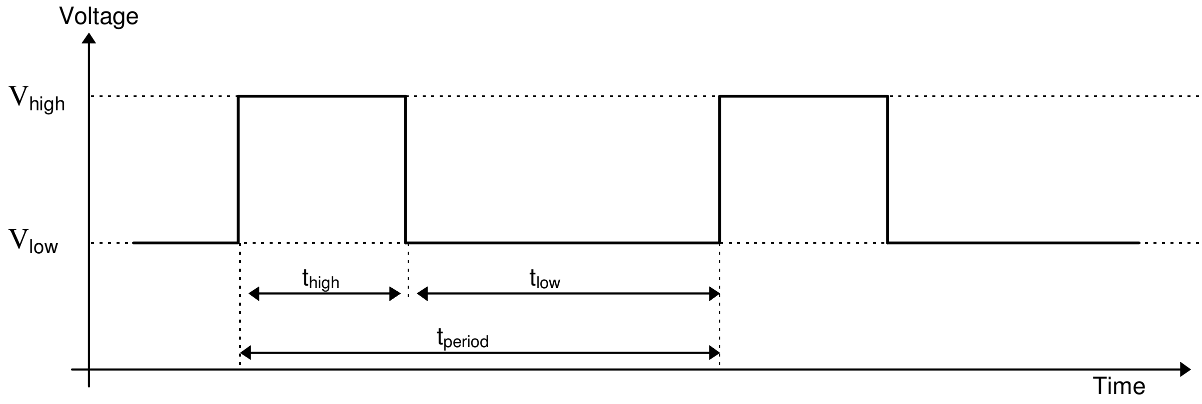
All data id's not defined above are reserved for future use.

6. OpenTherm/Lite Data Encoding and Application Support

OpenTherm / Lite uses the same medium and physical signalling levels as OpenTherm/plus as described in section 3. It can be implemented using the same hardware as for OT/+.

6.1 Room Unit to Boiler Signalling

The room unit transmits a PWM signal to the boiler.

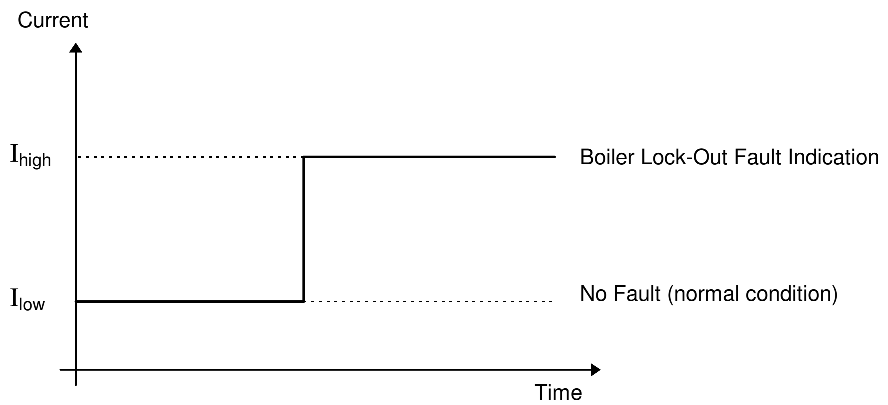


Duty Cycle (%) = t_{low} / t_{period} ie. the % time over the period that the line is **low**.

The Duty Cycle Period (t_{period}) does not require to be constant. The frequency of the PWM signal must lie between 100Hz and 500Hz (2ms < t_{period} < 10ms). The duty cycle can vary between 0% and 100%.

6.2 Boiler to Room Unit Signalling

The boiler signals only by changing the current between the I_{low} and I_{high} states. The high current state represents the presence of a boiler lock-out fault. Different from OpenTherm/plus, it can permanently keep the line in the high current state. It is mandatory for the room and boiler controller to support the transmission and detection of this feature.

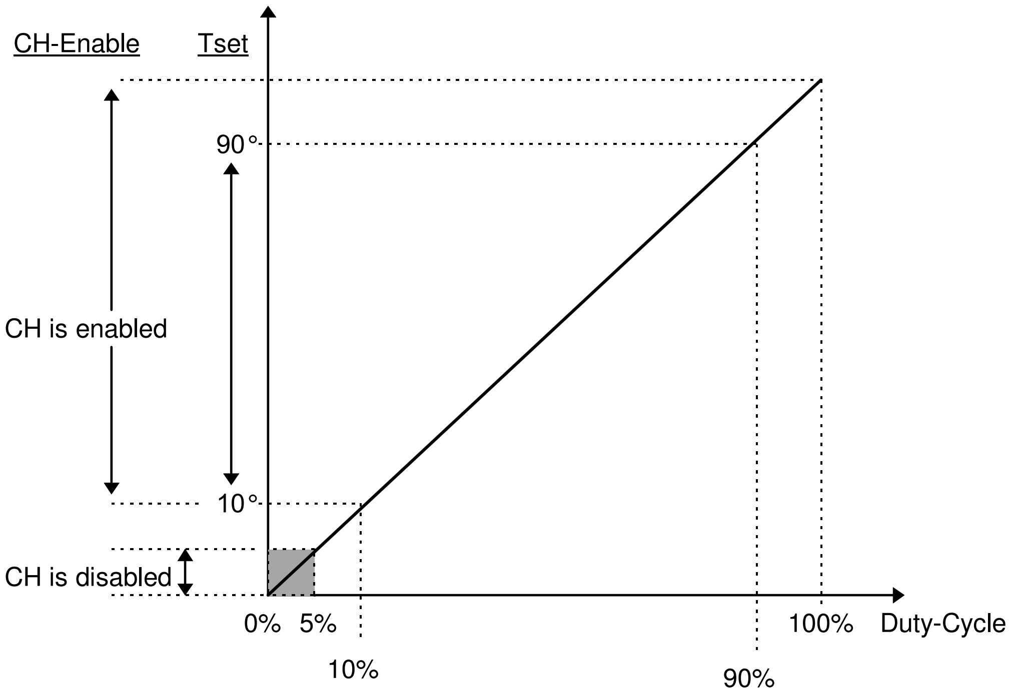


6.3 OT/- Application Data Equivalence to OT/+

The PWM voltage signal sent from the room unit to the boiler unit, principally represents the water temperature Control Setpoint It is mandatory for both the room and boiler units to support the transmission and detection of this signal.

OpenTherm/Lite supports the following application data items, which are shown with their equivalent OT/+ Application Data-IDs.

OpenTherm/Lite Data Item	**Equivalent OT/+ Data Item and Data-ID**	
Tset Control SetPoint *(mandatory)*	id=1	Tset Control Setpoint *(mandatory)*
CH-Enable *(mandatory)*	id=0, bit 0.0	Master Status : CH-Enable flag *(mandatory)*
Boiler Lock-Out Fault *(mandatory)*	id=0, bit 1.0	Slave Status : Fault Indication *(mandatory)*



The tolerance of both generation and measurement of the Duty-Cycle signal should be less than ±2%.

A Duty-Cycle less than 5% is used to indicate a CH-disabled state (ie "positive-off" or no CH-demand condition). It is not mandatory for the boiler controller to support this feature, or for the room unit to use it.