BANDELIN
Ultraschall seit 1955

SONOPULS
HD mini20
HD 3000 Series
HD 4000 Series

Protocol and instruction set for remote control

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1 Technical Principles

An asynchronous serial interface is provided for service and remote control to facilitate the transfer of instructions or data between an external device, e.g. a PC, and the ultrasonic generator. In the HD mini20 and the HD 3000 devices, the physical connection is realised via an optical interface (half duplex) based on the IrDA standard. The HD 4000 devices use a Sub-D connector (full duplex - 9 pin male). The assignment corresponds with RS-232 specifications.

Transmission parameters:

- 9600 Baud, 7 bit, 1 stop bit, even parity
- Hardware handshake signals (RTS, DTS, etc.) are not evaluated.
- Pulse shaping with 1.627µs pulses
- Only characters from the standard ASCII set (7-bit) are used.
- Within the character set, the characters "0...9" and "a ...f, A...F" are reserved for hexadecimal input.
- The characters “g ... z” and “G ... Z” are used as the first characters of an identifier (device code) or instruction.

2 Protocol

Nomenclature:

h	hexadecimal character (0 ... 9, A ... F)
z	alphanumeric character (0 ... 9, a ... z, A ... Z)
d	decimal digit (0 ... 9)
s	seconds
[]	(sequences of) characters in square brackets may be omitted
<>	control characters, e.g. <LF> = Line Feed
xx	(underlined) echo of instruction input

- Transmitted characters are returned as an echo. All telegrams must be preceded by a hash mark ‘#’. This is not returned as an echo.
- In the dialogue by and to the generator, all values are transmitted as hexadecimals.
- Upper and lower cases are equally valid (A ... F or a ... f).
- Instructions for the generator are concluded with <CR>.
- Responses from the generator are concluded with <CR><LF>.
- Control characters (01h .. 1Fh) where present are ignored.
- Unless otherwise noted, all information on the sizes used internally in the computer is given in hexadecimal format.
- The space character <Space> (20h) may be used in entries.
- For reasons of plausibility testing, hexadecimal characters are normally not used as the first character of an instruction.

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Telegram structure:

#	Instruction	<CR>

Starting character

End of instruction

- An instruction starts with a character for the instruction group (e.g. Q for frequency). For ease of distinction, upper case is used for the instruction group in this documentation.

  Q Fre**Q**uency

  P **P**ower

  H Temperature (**H**eating)

- The character for the instruction group is followed by a differentiation character. The meaning of the differentiation character is generally the same for each instruction group. For ease of distinction, the differentiation character is given in lower case in this documentation.

  r reset value is the value assumed after turning on the device.
  Example: Q**r** – Reset value for frequency

  n nominal is the value that is specified as a (temporary) target value for control in the current operation. Generally speaking, it reverts to the reset value after resetting and can then be (temporarily) changed in operation.
  Example: P**n%** – (temporary) target value for amplitude

  m actual value is the current measured value. It cannot be changed by the user and is thus read-only.
  Example: H**m** – current temperature on the external temperature sensor.

  Instead of the differentiation character, the functions OFF and ON may be realised by means of 0 and 1 (switch instruction).
  Example: P1- Power ON

- A read instruction consists of the instruction character(s) alone (without a subsequent hex number). Once the instruction has been concluded with <CR>, the value in question is read and transferred to the master.
  Example: query nominal amplitude (set value = 30 %)

characters transmitted:	#	P	n	%	<CR>				
characters received:		P	n	%		1	E	<CR>	<LF>

- A write instruction consists of the instruction and the directly attached value.
  Example: Set the nominal amplitude to 20%

characters transmitted:	#	P	n	%	1	4	<CR>		
characters received:		P	n	%	1	4		<CR>	<LF>

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3 Standard Instructions

Instruction **with response**	**Meaning**	**Remarks**
Hn ***…hh***	Read out / set maximum process temperature	Measurement sensor Pt1000 unit [°C] with prefix (i.e. -128 to +127°C → 80h ... 7Fh)
Hn hh		
Hm ***…hh***	Read out actual temperature	
H0 | 1 | 2	Temperature monitoring OFF | Alarm | Stop	Once the nominal temperature is reached or exceeded, the LED turns red, an audible signal and ultrasonic operation is stopped if specified.
I ***…[zz] [d]ddd.ddddddddd.ddd***	Identification (serial number) response e.g. 3670.00001324.007	The device type can be recognised by the serial number
Ih ***…hh***	Read out HD type	(h) HD type, (h) not used
Is ***…hh:aaaaa***	Read out / write sonotrode type	Number (h) Description (a)
Is hh		
Iw ***…hh:aaaaa***	Read out ultrasonic converter type **(only HD 4000)**	Number (h) Description (a)
Je ***…hhhh***	Query error bytes	For the meaning of error, option and status bytes, see Chapter 4
Je? ***…hhhh*** ***<plain text>***	Output of bits with explanation in plain text **(only HD 4000)**	
Jo ***…hhhh***	Query option bytes **(2 bytes only for HD 4000)**	
Jo? ***…hhhh*** ***<plain text>***	Output of bits with explanation in plain text **(only HD 4000)**	
Js ***…hhhh***	Query status bytes	
Js? **…hhhh** **<plain text>**	Output of bits with explanation in plain text **(only HD 4000)**	
Jp0 | 1	0→ amplitude control, 1→ power control,	Read in status byte
Jr0 | 1 ***…hhhh***	Remote off | on. Status bytes are transmitted as echo	Remote off | on Read in status byte

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Instruction with response	Meaning	Remarks
Pn hhhh	Set the nominal power	Unit [W]
Pn ***…hhhh***	Read out the nominal power	
Pm **…hhhh**	Read out the actual power	
Pn% hh	Set the nominal amplitude	Unit [%]
Pn% **…hh**	Read out the nominal amplitude	
Pm% ***…hh***	Read out the actual amplitude	
Pl ***…hhhhhhhh***	Output energy	Unit [Ws]
Pl0	Reset energy **(only HD 4000)**	
P0 | 1	Power OFF | ON	
Qm ***…hhhh***	Read out the actual frequency	Unit [Hz]
Qn ***…hhhh***	Read out the nominal frequency	
Qr ***…hhhh***	Read out restart frequency	
Qs1	Start (resonance) scan	
Qs0 | 1 | 2	Stop (0), start (1/2) (resonance) scan **(only HD 4000)**	1 long scan 2 short scan
Tn hhhh	Runtime specification for the HF power output	Unit [s] up to 9h59m59s Tn0[000] → Continuous operation
Tn ***…hhhh***	Display runtime specification	
Tn0 | 1	Continuous operation ON / OFF	(only HD 4000)
Tm ***…hhhh***	Time elapsed for (ultrasound) power output	Unit [s] up to runtime (Tnxxxx)
Tm0	Reset the runtime counter	
Tp hhhh	Set pulsation ON time	T = Value * 0.1 [s]
Tp **…hhhh**	Read out pulsation ON time	
Tb hhhh	Set pulsation OFF time	
Tb **…hhhh**	Read out pulsation OFF time	
Tp0 | 1 | 2	Pulsation OFF | ON | key	Key = by hand key

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Instruction with response	Meaning	Remarks
Tt hh	Enter timeout for monitoring	Time between two ‘signs of life’ from master default FFh = 255s 0 → w/o monitoring
Tt **…hh**	Issue timeout for monitoring	
V **… dd.dd - MMM DD YYYY**	Read out generator software version (plain text)	Response format Version - Date
X	Reset of the device	

4 Error, Option and Status Bytes

4.1 Error bytes

Generator errors are recorded in the error bytes and queried with the instruction Je. The error bytes are read-only. Error bytes are deleted when generator is switched on and off.

W = warning, E = error

Error byte 1

bit		Meaning
0	W	Nominal power / amplitude not reached
1	E	Frequency setting / measurement disrupted
2	E	Temperature limit value at heat sink exceeded
3	E	Transmission error
4	E	No response signal from the UT
5	E	No resonance found
6	W	Runtime overrun
7	W	Power display overrun

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Error byte 2

bit		Meaning
8	W	I²C Transmission error
9	E	Mains voltage below minimum
10	E	Frequency synchronisation error
11	E	-
12	E	-
13	E	-
14	W	-
15	W	-

Please note: The error bits 8 to 15 are not allocated in HD mini20 and HD 3000.

4.2 Option bytes

The option bytes can be used to query the status of certain device-specific switches for the HD 4000 with the Jo command. Only Customer Service can make changes.
In the HD mini20 and the HD 3000 only 1 byte is output, corresponds to byte 2 and refers to the interface settings. For normal operation of the ultrasound generator, the state of the option byte is irrelevant here.
Options changed in the option byte are only activated when the device is turned on.
The response is made in the format Jo [byte2|byte1].

Option byte 1

bit	Meaning
0	batch operation activated
1	display frequency (instead of power)
2	--
3	--
4	Fixed frequency
5	Amplitude control deactivated
6	Phase control deactivated
7	Frequency control off

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Option byte 2

bit	Meaning
8	<unused> formerly, no parity
9	<unused> formerly, uneven parity (0 → even)
10	<unused> formerly, no hash mark needed in front of the instruction
11	Sending start and error messages
12	--
13	--
14	--
15	--

4.3 Status bytes

The status bytes allow for various states of the device to be tested during runtime. The status bytes are read-only and are queried with the instruction Js [byte2|byte1].

a) HD mini20 and HD 3000

Status byte 1

bit	def	Meaning
		bit = 1
0	0	Remote on
1	0	Frequency synchronisation (afc) on
2	0	Temperature monitoring on (Alarm or Stop)
3	0	Pulsation on
4	0	Resonance scan active
5	0	HF power on
6	0	Max. temperature exceeded
7	0	1→ power control / 0 → Amplitude regulation

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Status byte 2

bit	def	Meaning
		bit = 1
8	0	Pt1000 detected (external temperature measurement possible)
9	0	Frequency control disabled (1→ control off !)
10	0	Power control disabled (1→ control off !)
11	0	n.a.
12	0	n.a.
13	0	n.a.
14	0	Service mode active
15	0	Full write authorisation

b) HD 4000

Status byte 1

bit	def	Meaning
		bit = 1
0	0	Pt1000 detected (external temperature measurement possible)
1	0	Frequency control disabled (1→ control off !)
2	0	Power control disabled (1→ control off !)
3	0	Power control deactivated (1→ control off !)
4	0	Pulsation with hand key at UT
5	0	Continuous operation (non-stop)
6	0	Service mode active
7	0	Full write authorisation

Status byte 2

bit	def	Meaning
		bit = 1
8	0	Remote on
9	0	Frequency synchronisation (afc) on
10	0	Temperature monitoring on (Alarm or Stop)
11	0	Pulsation on
12	0	Resonance scan active
13	0	HF power on
14	0	Max. temperature exceeded
15	0	1→ power control / 0 → Amplitude regulation

5 Error Messages

Various errors that can be detected by the system are reported to the serial interface. The error message takes the form Error <error number>. Individual errors are distinguished between serious errors or warnings that only limit device function.

Description	Error no.	Error LCD	E/W	Error bit	Response
LCD display not connected	001		W	-	Switch to remote control mode
Frequency setting not possible	002	002	E	1	Stop and indication on LCD display (may require service)
Power setting not possible	003	003	E	-	
Frequency synchronisation disrupted	010		E	10	
No response signal from the UT	011	011	E	4	
Error during resonance scan	012	012	E	5	
Heat sink temperature exceeded	014	014	E	2	
Unknown instruction	020		W	-	Communication error Remote control instruction is not executed (ignored)
Incorrect instruction length	021		W	-	
Unknown type (e.g. sonotrode)	022		W	-	

Error no. is transferred to the serial interface (e.g. error 002)
Error LCD error number is indicated on the LCD display (e.g. Error 002)
E/W indicates the severity of the error. E → Error, W → Warning
Error bit place in error bit which is set (0 → LSB, 7 → MSB)

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