Thelma Biotel

Live

The TB Live is a digital multi-frequency acoustic receiver that spans 63kHz through 77kHz with precise millisecond timestamping allowing for fine scale positioning. It immediately relays acoustic detections to the surface using the robust and versatile industrial standard RS-485. The compact and rugged form factor of the receiver allows for installation in rough environments where space may be limited while also keeping the sensitive acoustic element protected. TB Live is designed with a strong emphasis on low power consumption such that it may operate directly on your field laptop or for months and years on small battery packs.

By utilizing an advanced digital signal processing unit, the receiver can offer maximum reception and flexibility. The processing algorithm dynamically adjusts to maintain high acoustic performance even in noisy environments. The digital signal processing along with a broad-range acoustic element enables the unit to be configured for operation at multiple frequency channels simultaneously. This greatly reduces the problem of signal collisions in densely populated settings. The algorithm also further reduces signal collision events by singling out the strongest when multiple signals are present.

*TB Live is hardware configured as a full transponder with the ability to receive and transmit acoustic communication signals. The transmit ability is not supported in firmware version 1.0.1 and hence not covered in this datasheet.

2 Features

- Advanced digital signal processing
- 15 channels, 63-77kHz frequency range
- Designed for very low power consumption
- Simultaneous use of up to 3 frequency channels
- Millisecond timestamping
- Real-time data output over RS-485
- *Transmit ability
- *Transponder ranging ability

3 Applications

- Real time monitoring
- Manual tracking
- Positioning
- Autonomous vessels
- Dunking hydrophone
- *Transponder interrogation
- *Acoustic modem

4 Absolute Max Ratings

Exceeding these limits may cause permanent damage to the device.

	Min	Max	
Supply Voltage,V_in	-9	9	V
RS485+, RS485-	-7	12	V
Temperature(storage)	-20	80	°C
Temperature(operation)	-5	50	°C

Power inputs are equipped with reverse polarity protection.

5 Electrical

5.1 Powering

Operating voltages

	Min	Max	
V_{in}	3.5	9	V

For battery powered applications batteries should be selected such that their voltage is kept close to the minimum input voltage. This minimizes the energy losses caused by down conversion.

For non-battery powered applications a linear power supply is recommended to ensure a smooth input voltage. Input voltage ripples and noise may negatively impact the acoustic listening performance.

V_{in}		Min	Typ. Average	Peak	
3.6V	1 active channel	4.0	5.5	8.6	mA
	2 active channels		6.2		
	3 active channels		7.0		
	Command mode	5.6	6.7	7.4	
5V	1 active channel	4.0	5.6	9.0	
	2 active channel		6.4		
	3 active channel		7.1		
	Command mode	5.6	6.7	8.0	

TB Live has been optimized to maintain a low power state and wakes up only momentarily to process data. The peak current seen in the table is while processing. By enabling multiple acoustic channels more time is needed for processing, and an increase in the average power consumption is expected.

Efforts should be made when installing the device to avoid running the cable near other high current cables as they may introduce noise both onto the input voltage and the RS-485 communication line.

Reverse polarity protection is built into the device.

5.2 RS-485

The RS-485 commmunication with TB Live uses the common 2-wire half duplex configuration. An ASCII-character based command interface runs on top of this at 9600 baud.
Both input data lines have been equipped with transient voltage suppression (TVS) diodes for surge, ESD and EFT protection. Sustained voltages beyond the absolute max ratings may rapidly degrade the diodes.

5.2.1 Termination and Bias resistors

The RS-485 line is terminated by a 120 Ohm resistor between the signal lines inside the device. Apply proper termination at the opposite end of the RS-485 line to mitigate signal reflections.

The RS-485 driver in TB Live is designed with fail safe and bias resistors should not be needed. However, depending on the driver compatibility, number of drivers and length of cable this may be required in some settings. Some cables supplied by Thelma Biotel come with 680 Ohm bias resistors preinstalled.

5.3 Clock

The internal clock is used for timestamping acoustic detections. The clock is designed and tuned with dedicated hardware for high precision and low drift. As the internal timekeeping is based on a tuned Quartz crystal the amount of drift observed is temperature dependent. Clock drift is typically close to 10 ppm, and normally less 20 ppm.

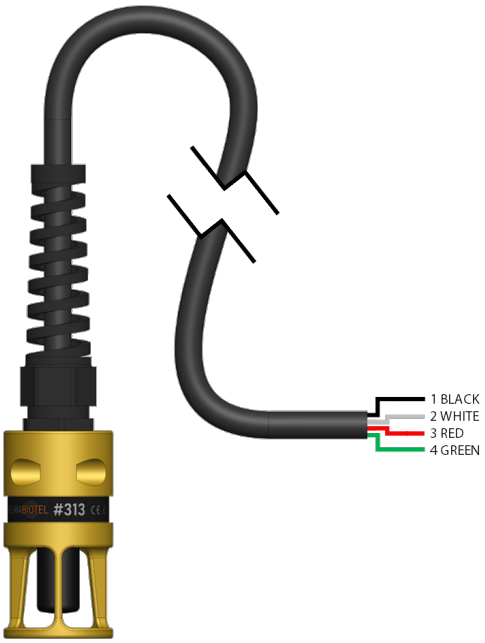
5.4 Temperature Measurement

TB Live is fitted with temperature sensor places on the inside of the housing. The sensor is calibrated and delivers 0.1°C precision in the operating temperature range of the device. The selection of input voltage may affect the temperature reading as the power dissipated in the unit increases with input voltage.

6 Pinout

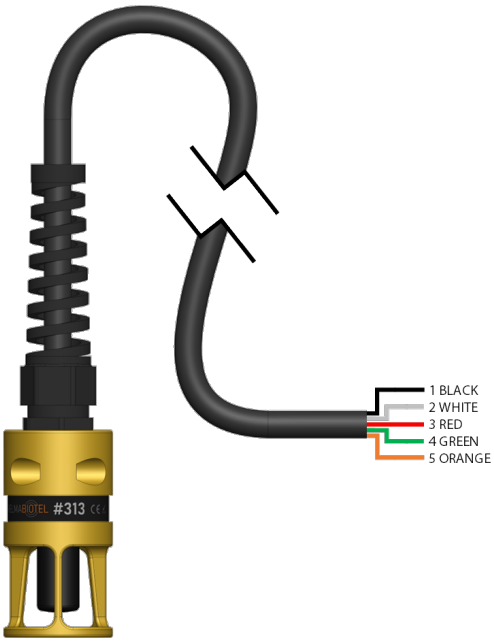
6.1 Wet Cable Unterminated

6.1.1 4 Pin



Wire #	Description	Color
1	Gnd	Black
2	485+	White
3	V_{in} @ 5V	Red
4	485-	Green

6.1.2 5 Pin



Wire #	Description	Color
1	Gnd	Black
2	485+	White
3	V_{in} @ 5V	Red
4	485-	Green
5	PPS	Orange

6.2 Wet Cable Connectors

6.2.1 4 Pin Male (Face View)

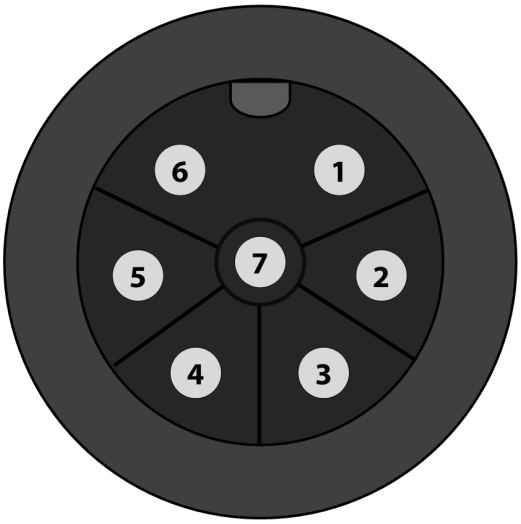
Pin #	Description	Color
1	Gnd	Black
2	485+	White
3	V_{in} @ 5V	Red
4	485-	Green

6.2.2 5 Pin Male (Face View)

Pin #	Description	Color
1	Gnd	Black
2	485+	White
3	V_{in} @ 5V	Red
4	485-	Green
5	PPS	Orange

6.3 Surface Cable Connectors

6.3.1 Amphenol C016 30H00610010 (Face View)

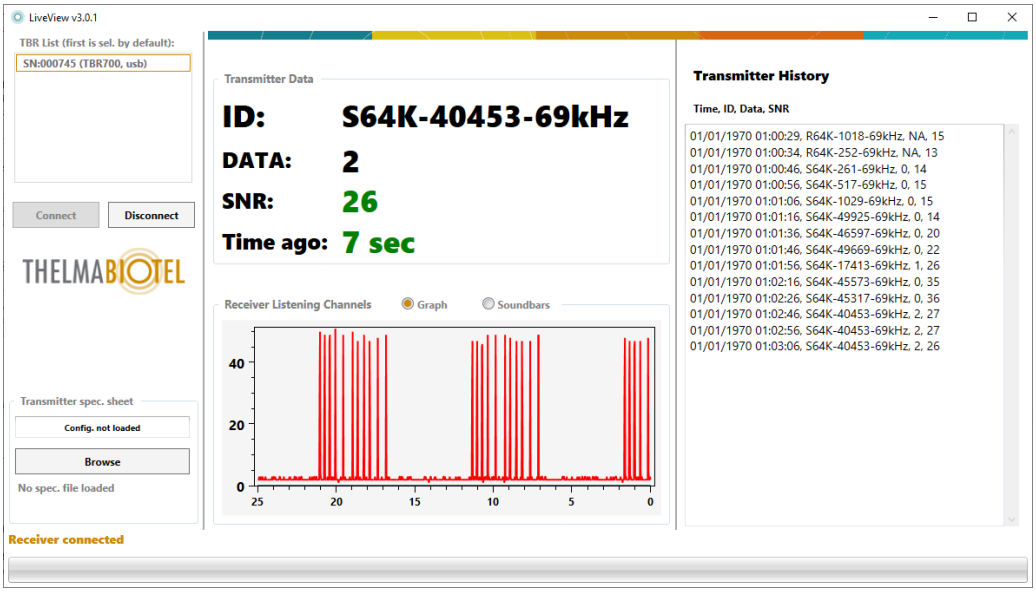


Pin #	Description
1	V_{in} @ 5V
2	PSS[1]
3	N/C
4	485+
5	485-
6	N/C
7	GND

[1] Only for devices delivered with PPS. N/C otherwise.

7 LiveView

Using the LiveView software is a quick way of getting started with the TB Live . LiveView is made to connect to a single TB Live and display the real-time feed of detections and acoustic data. It is also your perfect companion in the field when you are using TB Live with your field computer as a dunking receiver/transponder.



Connect the TB Live to the computer running LiveView using an RS485 to USB converter, or an adapter from RS485 to the computers serial port.

8 Serial interface

For custom applications and system integration the serial command interface should be used.

8.1 Setting up the serial interface

The serial port must be configured as follows

Baud	9600
Data Bits	8
Stop Bits	1
Parity	OFF
Flow Control	OFF

Do ensure that the terminal or custom application does not append any control characters to the end of the transmitted string, such as carrier return \r or line feed \n

8.2 Listening Mode (Normal operation)

TB Live boots into listening mode once power is applied. This is the normal operation mode of the device.

Collisions may occur on the RS-485 bus if more than one unit attempts to drive the bus lines. To reduce the chance of collisions some protections have been implemented. To not interfere with commands, TB Live will not transmit anything on the bus for 10 ms after it last received a character. It will also remain silent between 09.500 seconds since last character received and 10.500 seconds since last character recieved to allow for undisturbed clock synchonizations. Any detections or outbound messages during this time window will simply be delayed until 10.500 seconds since the last character has passed. If a command is received within the time window the counter will reset and wait for 10 ms after the last character before transmitting.

8.2.1 Acoustic Detections

When a coded acoustic signal has been detected and recognized by TB Live a CSV-formatted ASCII-string is printed on the serial line. The string leads with *$* and terminates with *\r*.

```
$1000042,1589557202,615,S64K,1285,0,24,69,11
```

CSV #	Sample	Description
-	$	Start of String
0	1000042	TB Live serial number
1	1589557202	Timestamp in seconds since Epoch[2]
2	615	Timestamp in milliseconds
3	S64K	Transmitter Protocol
4	1285	Transmitter ID number
5	0	Transmitter Data Value
6	24	Detection Signal-to-Noise Ratio (SNR)
7	69	Detection Frequency in kHz
8	11	Number of strings sent since power up
-	\r	End of String

8.2.2 Logs

With regular intervals TB Live will print a sensor log message. Like detections they are CSV-formatted. The interval may be configured, or turned off all together. Example

```
$1000042,1589557600,TBR Sensor,297,15,29,69,6
```

CSV #	Sample	Description
-	$	Start of String
0	1000042	TB Live serial number
1	1589557600	Timestamp in seconds since Epoch[2]
2	TBR Sensor	Identifier for Log Messages
3	297	Temperature
4	15	Average background noise
5	29	Peak background noise
6	69	Detection Signal-to-Noise Ratio (SNR)
7	6	Number of strings sent since power up
-	\r	End of String

[2] If the clock has not been set the timestamp is in seconds since power up.

8.2.3 Output Examples

Here are some sample outputs from TB Live in listening mode. First some log outputs

```
$1000042,0000000600,TBR Sensor,297,15,29,69,6
$1000042,0000001200,TBR Sensor,300,17,38,69,7
$1000042,0000001800,TBR Sensor,303,19,44,69,8
```

followed by a couple of *R64K* and *S64K* detections.

```
$1000042,0000002185,897,R64K,1023,,24,69,9
$1000042,0000002190,733,R64K,265,,25,69,10
$1000042,0000002202,615,S64K,1285,0,24,69,11
$1000042,0000002212,615,S64K,1285,0,18,69,12
```

8.2.4 Command List

Query	Sample Response	Description
?	SN=000745 ><>	Returns the serial number.
(+)	ack01	Rounds clock to the nearest 10 seconds.
(+)TTTTTTTTTC	ack02	Sets the clock.

All responses are ended with \r.

▷ **?**
TB Live responds to a question mark with a 6-digit serial number and an ASCII fish. This may be utilized both to quickly check the connection and to fetch the serial number without entering command mode.

```
SN=000745 ><>
```

where AAAAAA is a 6-digit unsigned integer.

▷ **(+)**
This command rounds up or down the internal clock to the nearest 10 seconds. The time synchonization event takes place when the last character of the command has been received. Can be used to mitigate clock drift when an external precise clock is available.

```
ack01
```

is returned from the device as a confirmation that the clock has been synchronzied.
E.g. the internal clock is 1589551139.642 when the last character of this command is received. The clock will then be adjusted to 1589551140.500. Note that the millisecond part of the clock is set to 500 milliseconds, and not 0 milliseconds. This offset is caused by the clock synchronization hardware module and is a consistent offset for all TB Live . This offset should be accounted for cases where absolute time is important. For most cases it may be ignored as all TB Live will have this offset and thus their relative time will be the synchronized.

▷ **(+)TTTTTTTTTC**
This is an extension of the command above which sets the clock to a specific timestamp in seconds since the Unix epoch

```
(+)TTTTTTTTTC
```

TTTTTTTTT is a 9-digit timestamp using tens of seconds since Unix Epoch. 10-digit seconds since Unix epoch divided by 10, leaving a 9-digit tens of seconds since epoch.
The time synchronizaton event triggers when the last character is received, i.e. when the check digit has been received. *C* is Luhn's check digit of the 9-digit timestamp above.

As an example,

```
(+)1589557113
```

will set the clock to 2020-05-15T15:38:30.000 (UTC).

After issuing the command TB Live will first confirm the *(+)* with

```
ack01
```

then confirm the remaining numerical part of the command with

```
ack02
```

The responses are not transmitted until 10 ms after the last received character, and the outbound *ack01* will not interfere with the remaining numerical part.

Luhn's check digit Assume a timestamp 1589557113. As only a 10 second precision is desired here this then becomes a 9-digit timestamp 158955711. To calculate Luhn's check digit every other digit is multiplied by two. If any digit is greater than 9, then subtract 9. The sum of digits is then multiplied by 9. The remainder when divided by 10 is Luhn's check digit.

										SUM
9-digit timestamp	1	5	8	9	5	5	7	1	1	42
double every other	2	1	14	5	10	9	16	5	2	64
subtract 9 if >9	2	1	5	5	1	9	7	5	2	37

$$C = (37 * 9)\ mod\ 10$$
$$C = 333\ mod\ 10$$
$$C = 3$$

Sample calculation of Luhn's check digit in C

```c
uint32_t time = 1182513540; // Unix Time Stamp
uint16_t digitSum = 0;
uint32_t digit = 0;
for (uint8_t i = 0; i<9;i++)
{
    time /= 10;
    digit = time % 10;
    if ((i % 2) == 0) {
        digit *= 2;
    }
    if (digit > 9) {
        digit -= 9;
    }
    digitSum += digit;
}
uint8_t luhnsCheckDigit = (digitSum * 9) % 10;
```

Do make sure to use only the 9 most significant digits of the common 10-digit seconds since epoch timestamp, both in the calculation of check digit and in the command itself.

8.3 Command Mode

8.3.1 Entering Command Mode

Switching from listening mode to command mode is done by sending the following sequence of characters

```
LIVECM
```

to which the TB Live will respond with the same sequence

```
LIVECM
```

after which command mode has been entered.

8.3.2 Exiting Command Mode

To resume listening and normal operation do send

```
EX !
```

TB Live will also return to listening mode after about 60 minutes of inactivity.

8.3.3 Default configuration

This is the default configuration for the device and is applied upon boot.

Setting	Default Value	Description
FC?	69	69 kHz
LM?	01	Protocols R64K, R01M, S256, S64K. 1 active channel
LI?	02	Log printed every 10 minutes
UT	0000000000	Counts upward from zero. Increments every second.

8.3.4 Command List

Query	Sample Response	Description
HE?		Returns a list of commands and their usage
SN?	SN=1000045	Returns the 7-digit serial number.
UT?	UT=1589561768	Returns current time in seconds since epoch, or seconds since power up if clock is not set
FV?	FV=1.0.1	Returns firmware version.
FC?	FC=69	Returns listening frequency
LM?	LM=02	Returns recognized protocols
LI?	LI=01	Returns logging interval.
UT=1589561768	UT=1589561768	Sets clock in seconds since Epoch
FC=71	FC=71	Sets listening frequency in kHz.
LM=02	LM=02	Sets recognized protocols.
LI=02	LI=02	Sets logging interval.
EX!	EX!	Return to listening mode
RR!	RR!	Restarts device
FS!	FS!	Resets device to factory settings
UF!	UF!	Enters device firmware update mode

▷ **SN [R]**
Serial number of the device. 7 digit positive integer.

▷ **FV [R]**
Firmware version of the device as a text string. For firmware 1.0.1 this will return *FV=v1.0.1*.

▷ **UT [R/W]**
Current time in seconds since Epoch if clock has been set, otherwise this will give seconds since power up. Time is set to 0 (Epoch) upon power up, such that it may be used a system run-time clock when absolute time is not required.

▷ **FC [R/W]**
Acoustic listening frequency of the device in kiloHertz. Vaild frequencies are 63 kHz through 77 kHz.

For devices with multiple active channels their listening frequencies are spaced 2 kHz apart, and the bottom frequency is the one set through *FC=ff*. As an example, setting *FC=67* will with 3 active channels listening for acoustic protocols on 67 kHz, 69 kHz and 71 kHz.

▷ **LM [R/W]**

LM (Listening Mode) is used to set active protocols and number of channels.
TB Live is set to LM=01 by default, meaning it will decode protocols R64K, R01M, S256 and S64K.
To enable multiple frequency listening add +30 to LM for two active channels, or add +60 to LM for three active channels. All possible options for LM are shown in the table below.

Single Channel

	ID Protocols					Data Protocols				
LM	R256	R04K	R64K	R01M	OPi	S256	S64K	OPs	HS256	DS256
00	✓	✓	✓			✓				
01			✓	✓		✓	✓			
02				✓			✓			
03				✓						
04							✓			
05									✓	
06										✓
07					✓			✓		
08			✓	✓	✓	✓	✓	✓		

Dual Channel

	ID Protocols					Data Protocols				
LM	R256	R04K	R64K	R01M	OPi	S256	S64K	OPs	HS256	DS256
30	✓	✓	✓			✓				
31			✓	✓		✓	✓			
32				✓			✓			
33				✓						
34							✓			
35									✓	
36										✓
37					✓			✓		
38			✓	✓	✓	✓	✓	✓		

Triple Channel

	ID Protocols					Data Protocols				
LM	R256	R04K	R64K	R01M	OPi	S256	S64K	OPs	HS256	DS256
60	✓	✓	✓			✓				
61			✓	✓		✓	✓			
62				✓			✓			
63				✓						
64							✓			
65									✓	
66										✓
67					✓			✓		
68			✓	✓	✓	✓	✓	✓		

▷ **LI [R/W]**
Sets the interval for log message print out

LI	Time Interval
00	Disabled
01	5 minutes
02	10 minutes
03	30 minutes
04	60 minutes
05	2 hours
06	12 hours
07	24 hours

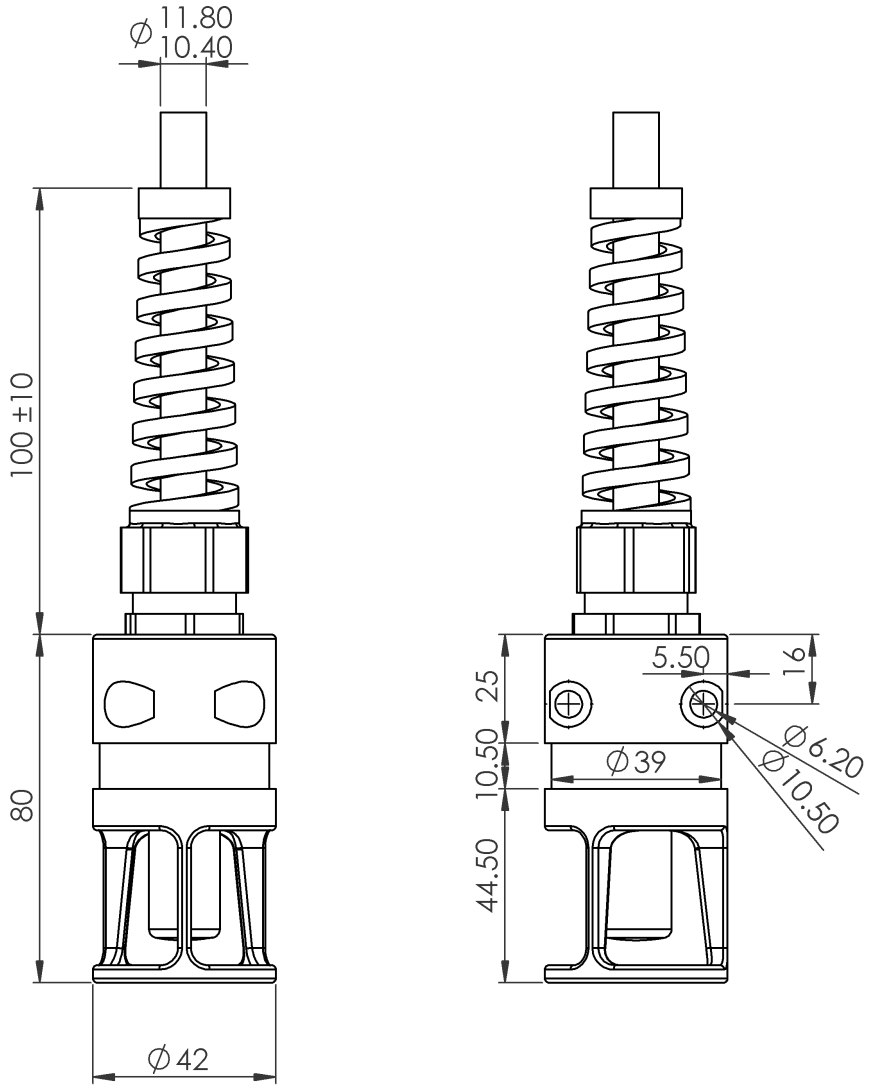
▷ **EX! [W]**
Exits command mode and resumes listening.

▷ **RR! [W]**
Restarts the device. It will return to listening mode upon restart.

▷ **FS! [W]**
Return to factory settings.

▷ **UF! [W]**
Puts the device in firmware update mode. This mode is not easily exited without DFU software. Incorrect commands in DFU mode may potentially brick the device. Do not to use this command unless you have a firmware update ready, or know what you are doing.

9 Dimensions



All dimensions are in millimeters unless otherwise specified.
CAD files are available upon request.

Dry weight of the receiver including a short cable and wet connector is approximately 545 grams.