HiTECH Technologies, Inc.

Installation and operating instructions

MODEL LL 102

Short Pulse Radar Level Transmitter

CONTINUOUS LEVEL MEASUREMENT

For

LIQUIDS, POWDERS and SOLIDS

HiTECH Technologies, Inc.

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CONTENTS

General advice on safety:

When **handling** the LL 102 avoid hard shocks, jolts, impacts, etc.

Product liability and warranty:

The LL 102 level gauge is designed solely for measuring the distance, level and volume of liquids, solids and particulate materials.
The LL 102 level gauge does not form part of an overfill protection system as defined in WHG.
Special codes and regulations apply to its use in hazardous areas.
Responsibility as to suitability and intended use of these level gauges rests solely with the user.
Improper installation and operation of our level gauges may lead to loss of warranty.
In addition, the "General conditions of sale", forming the basis of the purchasing contract, are applicable.
If you need to return the level gauge to the manufacturer or supplier, please refer to the information given in Annex D.

Items supplied:

- Signal converter bolted to sensor.
  Factory settings sheet for the signal converter.

Documentation supplied:

- **Installation and operating instructions** (this manual): detailed user manual and reference book, including description of special versions and functions. This documentation is structured on lines similar to those given in the DIN V 19259 Standard.
- **Approval documents**, unless reproduced in the installation and operating instructions.

Software history

Introduction	Signal converter		User program			Instructions	
Mth./Yr.	Hardware	Firmware	Hardware	Operating-system	Software	Device	User program
04/00	LL 102	1.10	P.C.	Win 3.x Win 95 / 98	PC STAR 2	v0.42a	Online help
07/00	LL 102	1.20				v0.43a	Online help

1. Range of application

The HiTECH Short Pulse LL 102 level gauging system is designed to measure the distance, level and volume of liquids, slurries, solids and particulate materials. It can be operated on storage, process tanks and also on stilling wells.

The use of the LL 102 is restricted for use in closed tanks or containers made of metal or concrete because of EMC compliance. Because of the low output involved, the microwaves are not harmful to humans for the case of coax probe.

2. Mode of operation and system structure

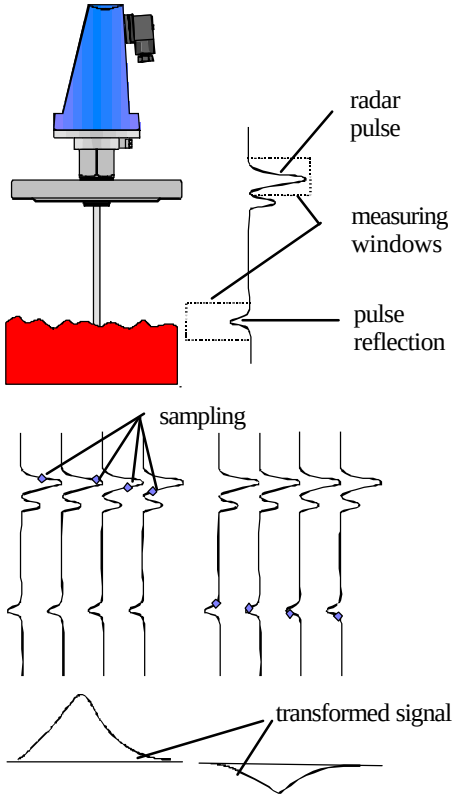
2.1 Measuring principle (TDR MICROFLEX)

(TDR = Time Domain Reflectometry)
The converter electronics sends an electromagnetic pulse to the probe system. That electromagnetic pulse travels at the speed of light down to the product surface. Here the pulse gets partially reflected and travels back to the converter electronics. The distance between the converter flange and product surface is therefore directly proportional to time. For a distance of 1m, the pulse's travel time is 6.7ns ($6.7*10^{-9}$ seconds).

The polarity and the amplitude of the partially reflected HiTECH Short pulse depends on the ε_r (epsilon r) of the two mediums, which are above and below the reflecting surface. Under normal circumstances the medium above the surface is a gas with an ε_r close to 1.0 and the medium below is the process medium with an higher ε_r. The figure on the right shows a typical pulse reflection of such a standard application. The advantage of the TDR measuring principle is that the travel time of the pulse and therefore the accuracy of the level measurement is completely independent of the ε_r and the density of the process medium.
One of the front-end electronics' main tasks is to sample the complete measurement signal at the upper probe end. As the signal is too fast to get sampled with a sufficient resolution in time, the electronics sends continuous electromagnetic pulses down the probe and samples each signal a fraction of time later than the previous signal (sampling). The so generated audio signal is a direct copy of the real time measuring signal with a 228 000 times slower time base.

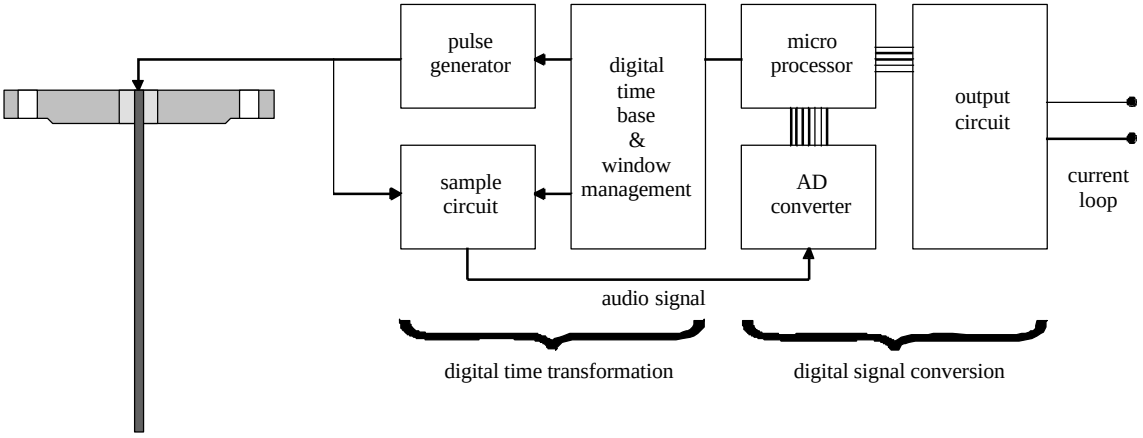
This means that 1m of distance between converter flange and process surface is not anymore equivalent to a time of 6.7ns but to a time of 1.5ms. This time transformed audio signal is now sufficiently slow and can be directly processed. In order to save electrical power, the converter samples the measuring signal only in the relevant areas.

Two "plausibility" Windows, one for the emitted pulse, and one for the reflection define them.



2.2 Signal processing (digital)

The figure below shows the digital signal processing of the LL 102. It can be split up into two main blocks. The function of the first block with its pulse generator, sample circuit and digital **PLL** (Phase Locked Loop) time base that was already referred to in the previous chapter. It is linked via the audio signal to the second block that completes the signal processing of the electronics. An analogue to digital converter samples the audio signal before the microprocessor processes the data with different filter and measurement algorithms. In a final step the processor calculates the product level and sends this information to the output circuit.



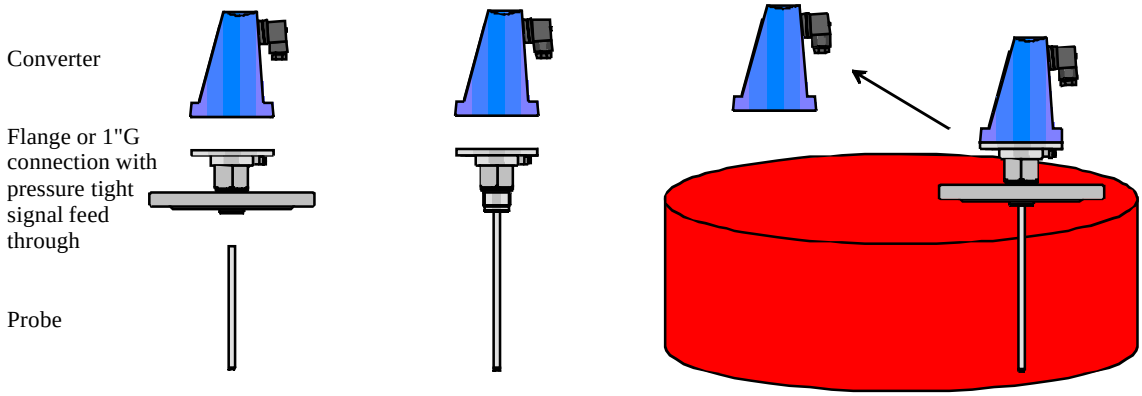
2.3 Modularity (signal converter, 1" NPT, probe system)

The measuring system consists of the sensor system and the signal converter.

The flange system is made up of the probe support, the sealing system with signal contact, and the process connection.

The compact signal converter contains the TDR measuring circuit and the entire signal processing system, including the provision of a standardised output signal (4 - 20 mA or digital interface).

The signal converter can be separated from the sensor system under process conditions, without compromising tank integrity.



3. Input

3.1 Measured variable (distance, level, volume)

The primary measured variable is the distance between a reference point (as standard: tank mounting flange) and a reflecting surface (surface of the liquid).
Level is calculated from the measured distance value, and the tank height.
Volume output is possible by entering a conversion table (max. 20 points).
The strength of the reflected signal can be measured for qualitative assessment of the tank product or its surface. (Only available with HART® communication).

3.2 Measuring range [0.15 - 24 m (0.50 - 72 ft)]

Minimum tank height: 0.15 m (0.5 ft).

The useful range will depend on the sensor type, the reflection properties of the tank product, the installation position, and the presence of interfering reflections.

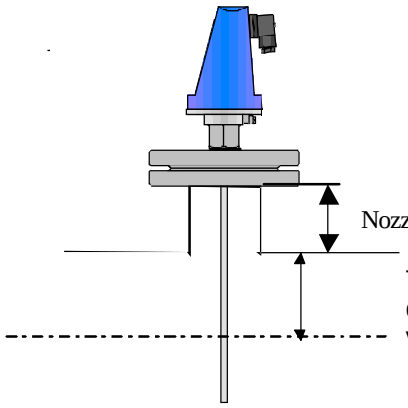
3.3 Dead zone

The dead zone distance is the minimum measured distance between the mounting flange (reference point) and surface of the tank product.

For twin cable	ε_r>10	150 mm. (5.9 ")
For twin cable	ε_r<10	300 mm. (11.8 ")
For mono cable	ε_r<10	400 mm. (15.8 ")
For mono cable	ε_r>10	300 mm. (11.8 ")
For coax system	= 0	for all ε_r

→ These are min. values. Default value 400mm. (15.8 ") .

Recommended minimum values: see following sketches.



To set the right dead zone and detection delay add the height of the nozzle to the values mentioned in the table.

3.4 Out-of-range performance

When the level measuring range is exceeded (including flooding) the output value will stay at the (adjustable) dead zone (see Sect. 8.5.3).
If the measured value drops below the level range, the output will stay at the set lower range limit (distance = tank height).

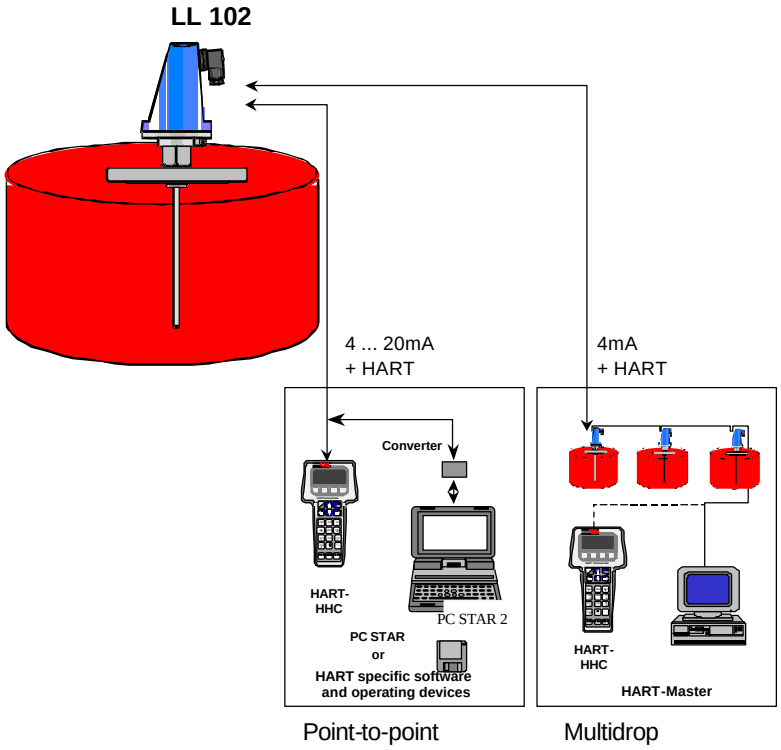
4. Output

4.1 Variants

Variants	Remarks	Described in Section
Current output HART®	Passive ; HART® protocol	4.2
Ex-ia current output HART®	Intrinsically safe; Passive ; HART® protocol	4.2

All versions with HART® protocol can be operated with the PC-STAR 2 PC program (see Section 8.11).

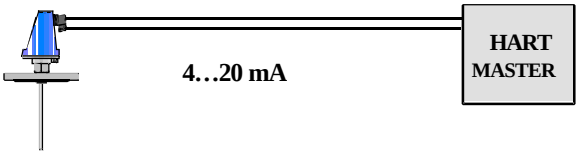
Overview of digital communication possibilities:



4.2 HART® communication

The HART® communications protocol can, in accordance with the Rosemount Standards, be used with a LL 102. Electrical connection: see Section 7.6.
There are two ways of using the HART® communication:

a) As a **point-to-point** connection between the LL 102 and the HART® Master equipment.



b) As a **multipoint connection (multidrop)** with up to 5 devices (LL 102 or other HART® equipment), in parallel on a 2-wire **bus**:

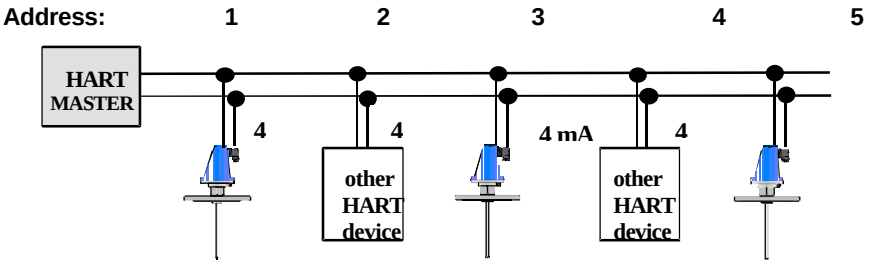
Theoretically, we can plug up to 15 instruments. But in practice, we do only 5. When configuring instruments in multidrop mode, all instruments must have previously been configured with addresses different from each other (address must be other than "0" because "0" is an address solely used for point-to-point mode (4-20 mA output valid.).
Before switching to multidrop mode, one has to make an address configuration for each instrument in point-to-point mode. On multidrop mode, only digital information is used (4-20 mA output been not valid in this case, the current output of each instrument is set to 4 mA).

Step 1:

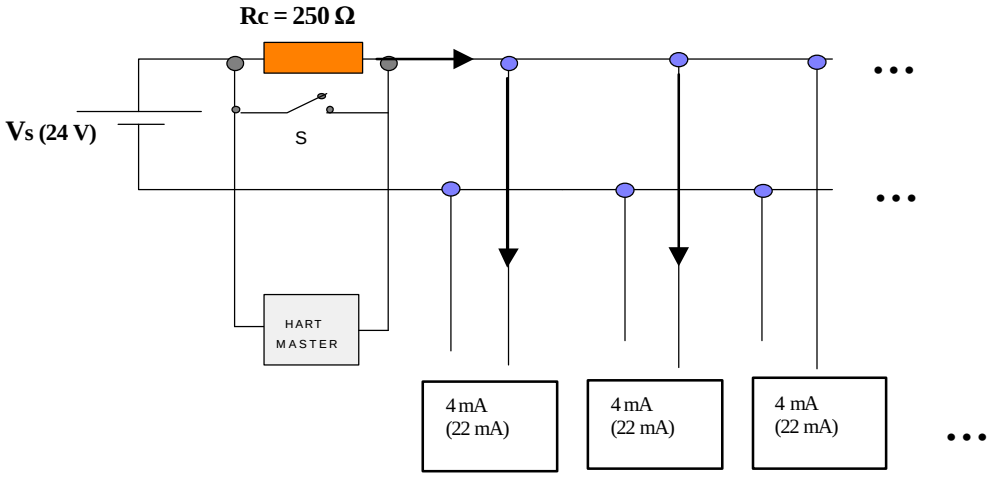
We fix the address of the device (different from "0").

Step 2:

Multidrop connection of 5 devices (LL 102 or other HART® equipment), in parallel or on a 2-wire bus:



During start-up, on multidrop mode, it should be noticed that each instrument needs a current value of 22 mA (see section 5.7). After this start-up, the instruments comes back to a fixed value of 4 mA in multidrop mode. After the instruments are powered on(for instance : LL 102), the current output remains fixed to 22 mA during 15 seconds. Then, it changes to 4 mA.
If we look at the example of the start-up: assuming that we have connected 5 Instruments. That means that we need a current of 5 * 22 mA. That it to say 110 mA during 15 seconds.



Taking account of the Resistor load (250Ω) and the constant power supply (24 V), we notice that the power supply is not sufficient enough (Voltage drop within the resistor 110 mA * 250Ω = 27.5 V!!). Hence, it appears that it is necessary to make a short-circuit of the resistor of 250 Ω during start-up. That explain the use of **S** . With that design, we can grant good liability of our instruments.

4.3 Service information

Service information can be called up via the following interfaces:

- Current output: 22 mA in case of error signal.
- Digital interfaces: interrogation of error flags

5. Measuring accuracy

5.1 Reference conditions

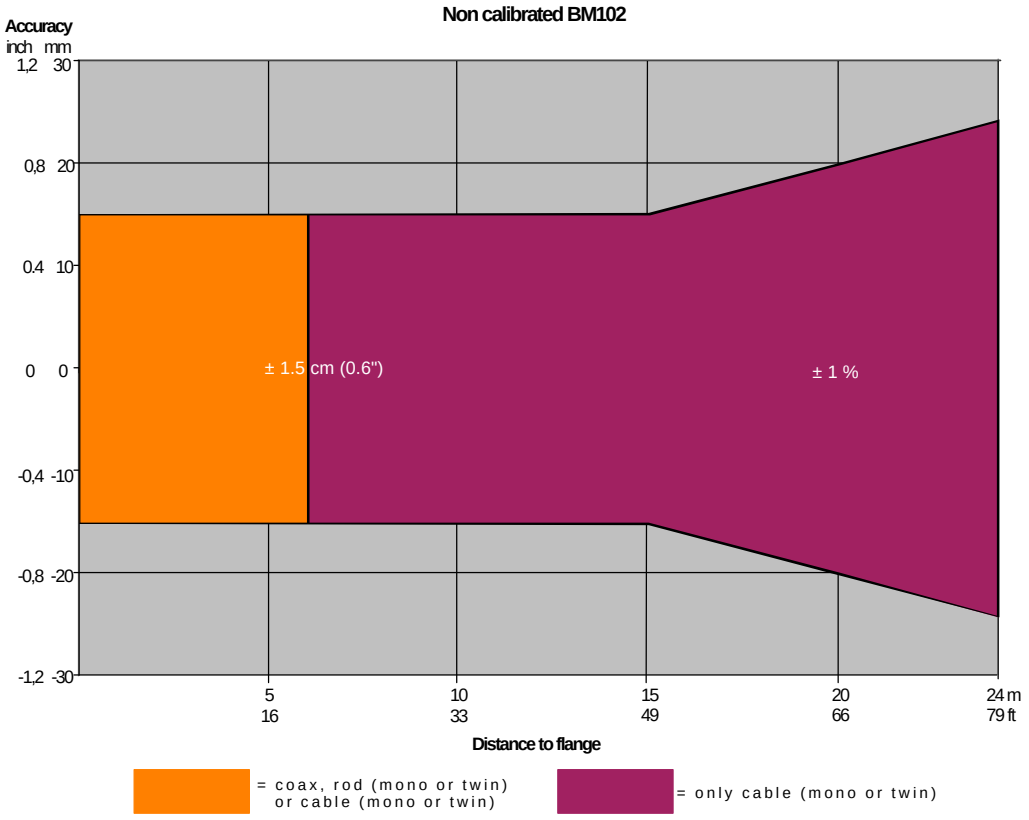
- Temperature = +20°C (68 °F).
- Pressure = 1013 mbar abs (14.5 psia.).
- Air humidity = 65%.
- Highly reflecting product (e.g. water) with calm surface.
- Tank diameter > 1 m (3.28 ft).
- Mounted at least 300 mm (12 ") away from tank wall.
- Mounted flat on the tank (no nozzle).

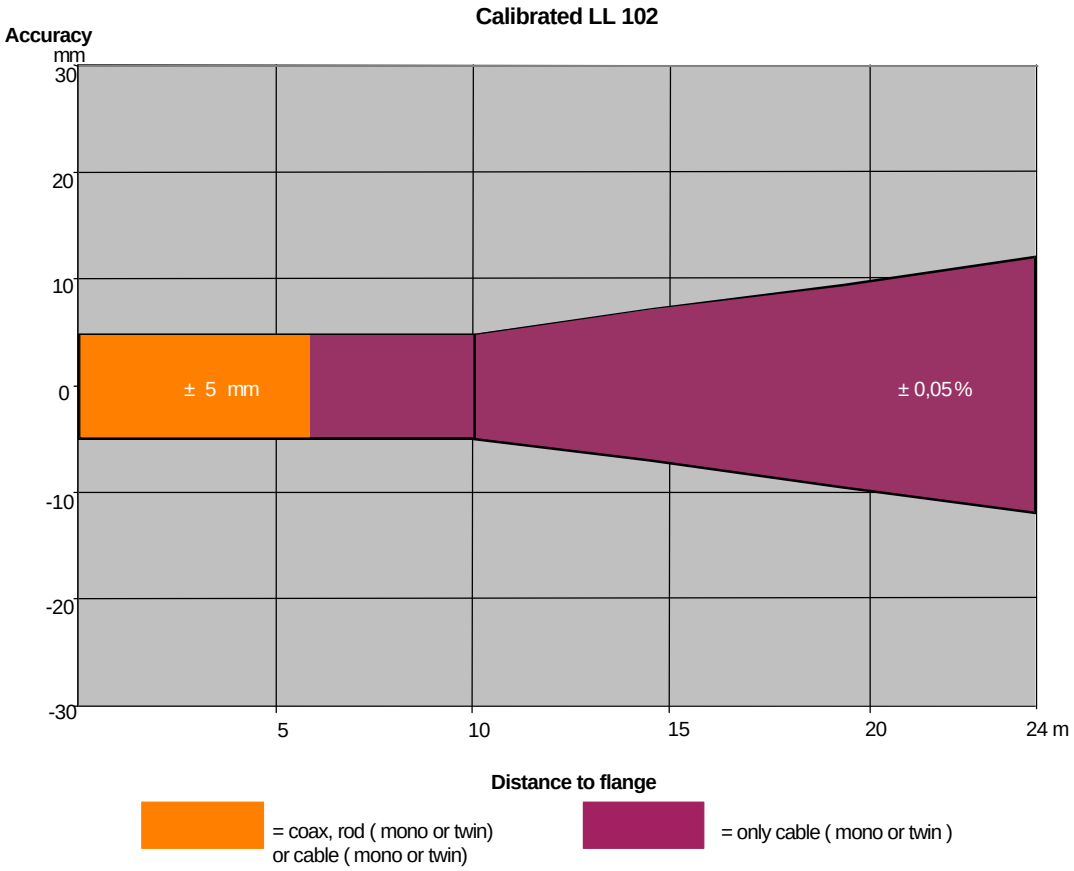
5.2 Current output accuracy

The accuracy of the 4-20 mA output is 0.01% of measured value.

5.3 Error of measurement

Since the measuring process primarily determines distance, measuring accuracy can only be specified as a function of the distance. For that reason, all figures given in this Section 5 refer to the measured distance.





5.4 Repeatability

Repeatability is equal to half the value of the error of measurement.

5.5 Measured value resolution

Measured value resolution is: 1 mm / 0.04".

5.6 Transient recovery time

The transient recovery time is determined by the setting parameter "time constant" (1 ... 100 s).

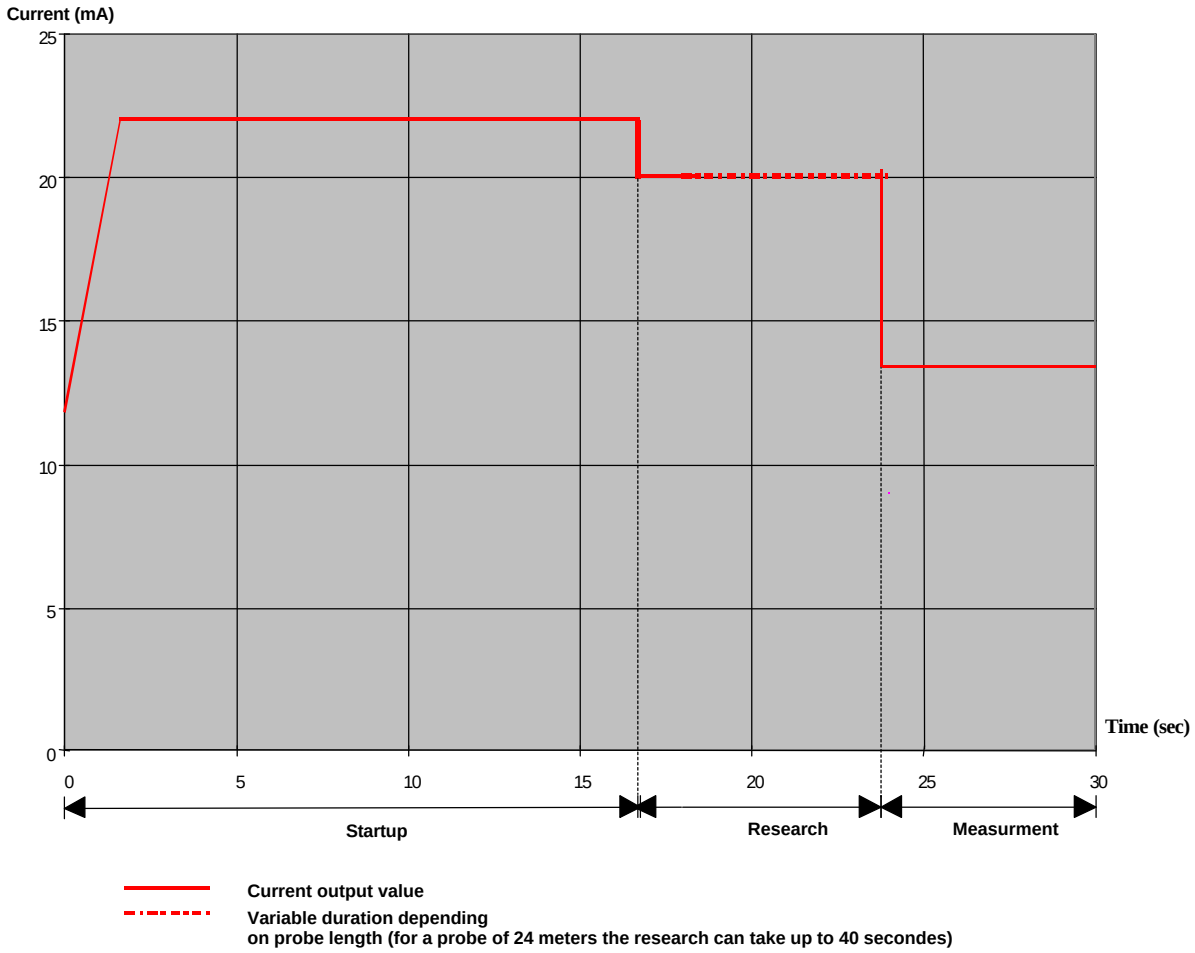
The transient recovery time relative to 1% deviation from the steady-state value is approx. 4.6 times the time constant.

However, in the case of unusual rapid changes in level, the transient recovery time may deviate from this figure.

5.7 Turn-on characteristics/turn-on drift

After the LL 102 has been switched on, the current output is fixed to 22 mA during 15 seconds. Next, the current output is driven to probe length until a product reflection is detected. The current output will then rise to the measured value. Full measuring accuracy is obtained after 23 seconds operating time with default parameters (time constant = 5 seconds).

Typical turn-on drift (example):



5.8 Long-term drift

The long-term drift is within the specified error of measurement.

5.9 Effect of ambient temperature

Temperature coefficient, signal output:

Current output with HART® signal: < 0.01 % / °K (typically: 0.003 % / °K)

The temperature has no effect on the measured value as the device carries out a regular self-calibration.

The temperature effect of the atmosphere above the liquid product results theoretically in 1ppm/°K for air.

In respect of reference measurements in liquid tanks, it needs to be borne in mind that liquids generally have a high coefficient of thermal expansion (organic liquids: typically 0.15 %/°K)!

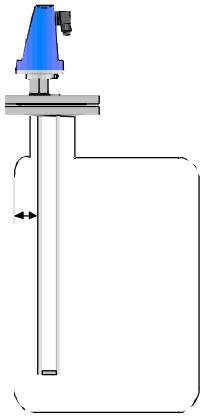
6. Operating conditions

6.1 Installation conditions

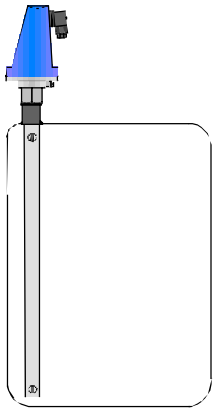
Refer to Section 7.4 for selection of the optimal sensor type

6.1.1 First mounting of device

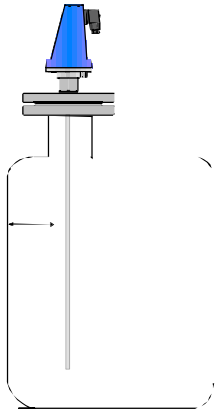
Before installing the device, please refer to the following guidelines:



100 mm.(3.9 ") MIN
Twin rod cable



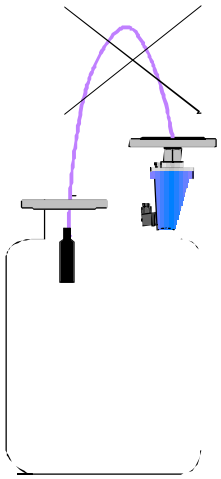
0 mm. (0 ") MIN
Coax cable



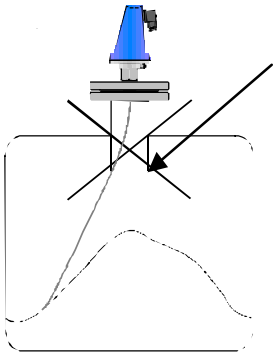
300 mm.(11.8 ") MIN
Mono rod cable

6.1.1.1 Excessive bending of the cable

BE CAREFULL DON'T BEND CABLES TOO MUCH

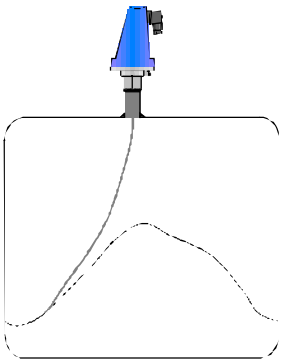


6.1.1.2 No penetrating nozzle

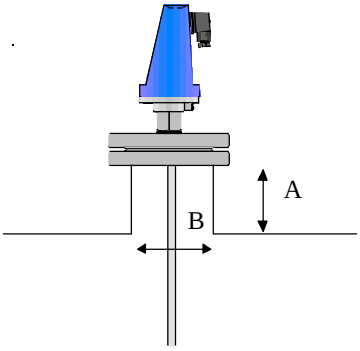


Penetrating nozzle is forbiden

Ideally the LL 102 is mounted without a nozzle and directly mounted in a 1" NPT welding socket, this gives the best measuring results at the lowest installation cost.



6.1.1.3 Mounting on a nozzle

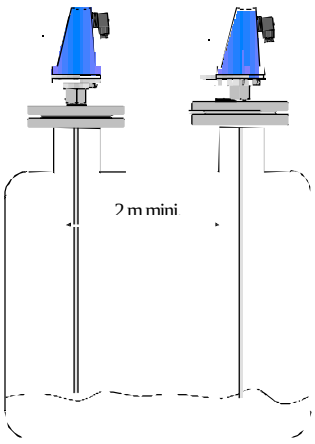


Avoid nozzle size higher than 150 mm (5.9 "), especially when B < 80mm (3.1").

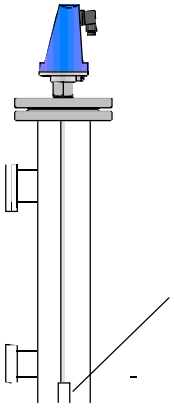
Generally respect B>A.

6.1.1.4 Interference between two LL 102

There must be 2 meters mini. between two LL 102 if we want no interference.

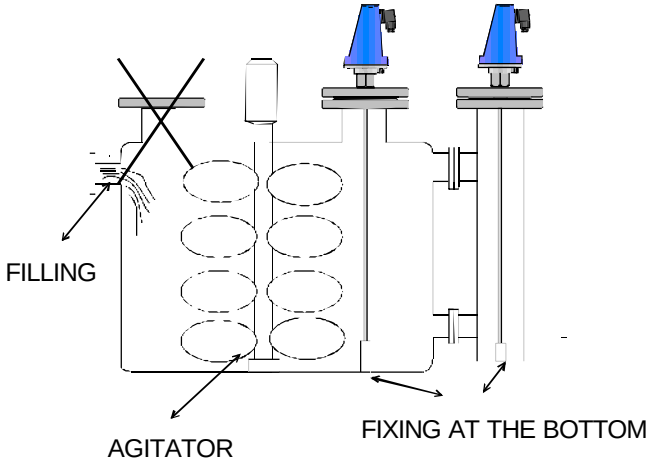


6.1.1.5 Mounting inside side mounted vessel or stilling well

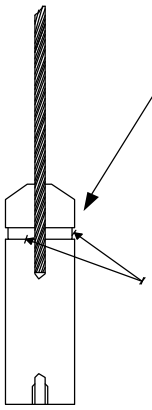


Here we have an optimal mounting inside vessel or stilling well. Take care of fixing or centering the probe end to prevent this one from touching the vessel wall. In case of the rod or cable type process, "T" probe end for rods or large dimensions height are advised.

6.1.1.6 Preferential mounting in agitated tank.



6.1.1.7 Shortening of probe



Screw A4 70 HC , M6-10 DIN 913

Loosen the screws take out the cable shorten the length of the cable and enter the cable in the weight and tighten the screws. Reduce probe length in the parameter setting of the device.

* only for liquid applications

6.1.1.9 Sunshade

In case of direct exposure to sunshine a sunshade is recommended.

6.2 Ambient conditions

6.2.1 Hazardous locations

Approvals:	1G EEx ia IIC T6…T3
	1G EEx ia IIB T6…T3
	1/2 D T 100°C EEx ia

6.2.2 Ambient temperature of signal converter and process temperature

For the LL 102 the max. and min temperature of the converter and the flange are linked.

Minimum converter temperature-30°C (-22 °F)	⟺	Minimum product temperature -50°C (-58 °F)

Maximum converter temperature+55°C (+131 °F)	⟺	Maximum flange temperature +90°C(+195°F)
Special High temperature version – 30ºC – 250º C	⟺	Maximum flange temperature 250°C(+482°F)

6.2.3 Storage temperature

-40 °C ≤ T ≤ 80 °C / -22 °F ≤ T ≤ 195 °F

6.2.4 Environmental class

Installation in free air level DI according EN60654-1

6.2.5 Protection category

IP65 NEMA 4

6.2.6 Shock resistance

Resist to shocks according EN61010 §8.2 0.5 J

6.2.7 Vibration endurance limit

IEC 68-2-6 and pr EN50178 (10-57 Hz: 0.075 mm/57-150 Hz: 1G)

6.2.8 EMC (Electromagnetic Compatibility)

The devices satisfy the requirements of EN 50081-1, EN 50082-2

6.3 Product conditions

6.3.1 Physical properties of the products

Physical properties (such as density, viscosity, conductivity, relative di-electric constant, magnetic properties, etc.) have no effect on measurement results.
The relative epsilon is merely required to have a minimum value in order to ensure reliable measurements (see Section 6.3.2).

6.3.2 Relative di-electric constant

The (relative) di-electric constant of the product (ε_r, Epsilon-R) determines the strength of the reflected signal. Measurement results are not affected so long as the reflected signal is strong enough. Reliability and the maximum measuring range are dependent upon the relative di-electric constant.

The minimum di-electric constant depends on the type of probe being used, recommendation:

Mono ≥ 2.3

Twin > 1.8

Coax ≥ 1.5

6.3.3 Product limitations

TDR-based level measuring devices are not suitable for products with severe deposit characteristics. This, with the limitation mentioned in §6.3.2, are the only limitations of the device.

6.3.4 Maximum allowable operating pressure (max. 40 bar)

The maximum allowable operating pressure for the standard version is 16 bar / 58 psig.

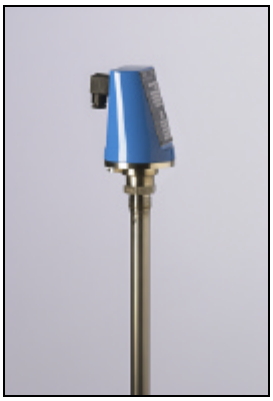
Option: 40 bar./ 580 psig

6.3.5 Maintenance

Maintenance is not necessary in standard applications, however when the sensor is heavily contaminated, this can lead to measurement errors.

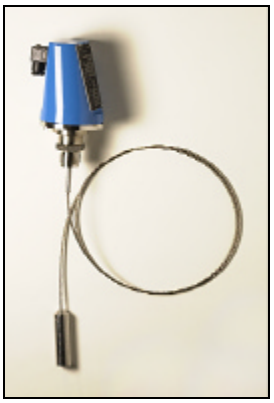
7. Design

7.1 Models



LL 102 coax

LL 102 rod

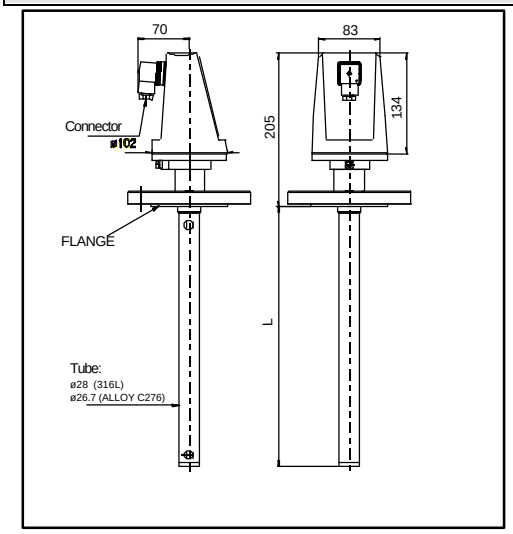


LL 102 cable

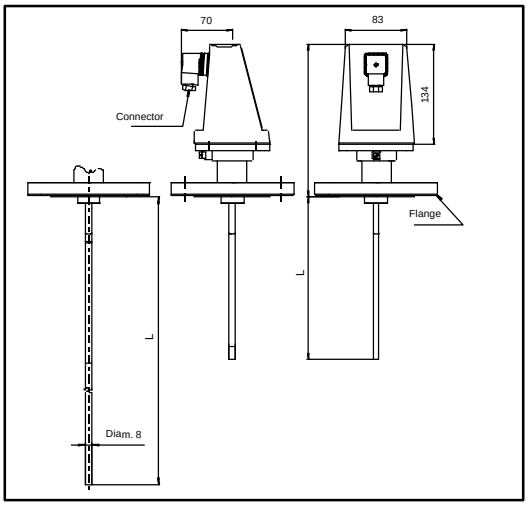
7.2 Dimensions, weights

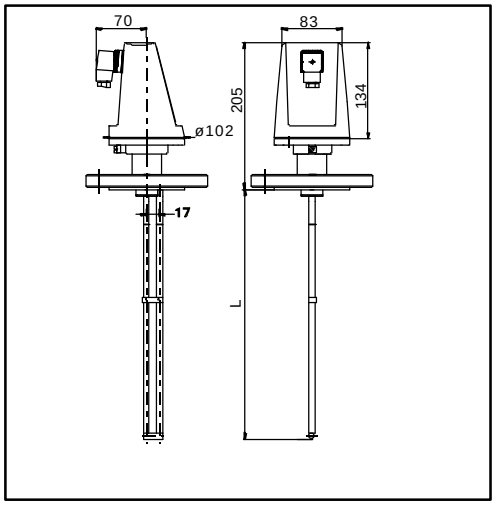
SENSOR TYPE	Weight converter + 1 m probe	Extra Weight Per m.
Mono-rod	≅ 2 kg / 4.4 lb	1.24 kg/m
Mono-cable	≅ 2 kg / 4.4 lb	0.14 kg/m
Twin-cable	≅ 2 kg /4.4 lb	0.28 kg/m
Coax	≅ 3 kg / 6.6 lb	≅ 1.1 kg/m

Coax

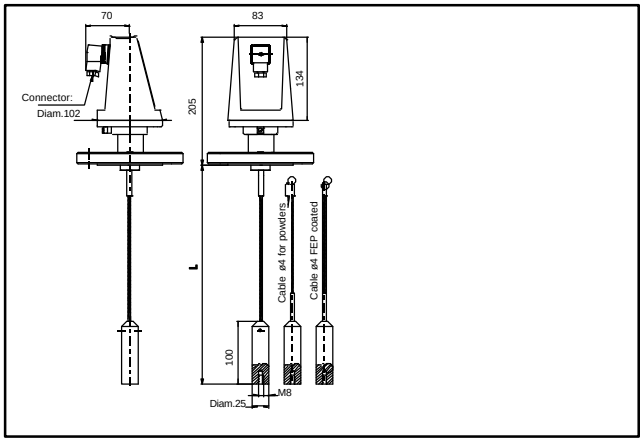


Mono rod	Twin rod

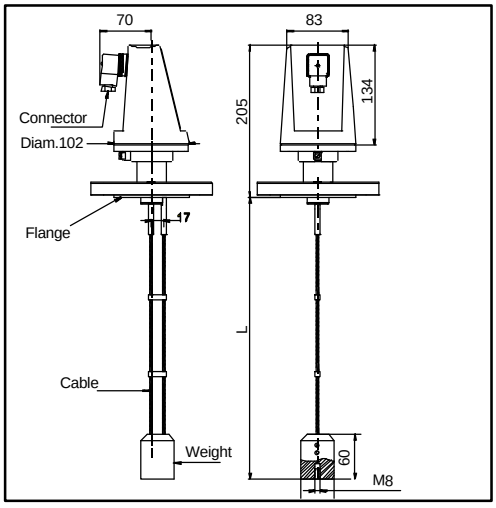




mono cable



Twin cable



7.3 Replacement of the signal converter

Always disconnect power before assembling the signal converter.

Hazardous-duty systems

Before replacing the signal converter (instrument "head") in a hazardous location, make absolutely certain that there is no explosion hazard (gas-free certificate).

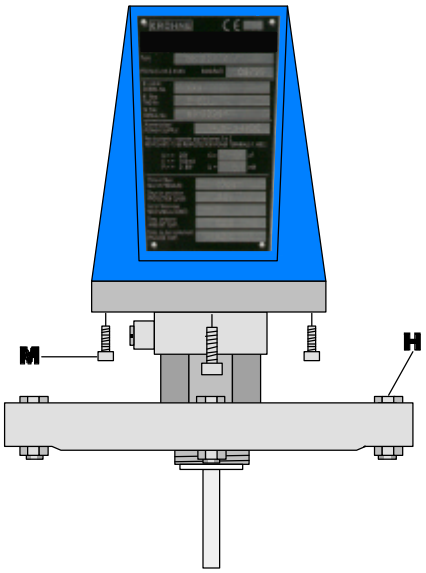
1. Disconnect all cables from the instrument. See Section 7.6.
2. Remove the 4 Allen screws **M** (Allen key size 4 mm / 0.16") and lift off the signal converter. The flange system will remain sealed.

DANGER!

On pressurised tanks, do not in any case remove the 4 screws **H** connecting the BM 102 flanges with the tank!

3. Install the new LL 102 signal converter (take care of the signal contact tip).
4. Screw the 4 Allen screws **M** (Allen key size 4 mm / 0.16").
6. Check power voltage.
7. Reconnect all cables in the terminal compartment as described in Sect. 7.6.

Important:
Ensure that the 'O' sealing of the signal converter is well greased.



Probe selection guide

MONO ROD	COAX	TWIN CABLES	MONO CABLE
Recommended when			
For liquid, powder or granules level < 6 m – small distance 1. To be used complementary to coaxial for all others applications. 2. For contactless measurement through the plastic wall of tanks or in a sheath plastic tube for high corrosive fluids or crystallisation problems (high dielectric). 3. For exotic application material as tantalum. 4. For specific probe shape with angles. 5. For minimum bottom dead zone in small tanks. 6. For full level measurement.	**Only for clean liquids level** 1. Connection size is < DN80 mm (3"). 2. Liquid agitated, acting like stillwell. 3. Liquid or vapours spray near the probe. 4. High flow inside vessel For example: oil/water separators. 5. Can be heat traced. 6. Contact with metallic part or tank wall possible. 7.High magnetic field in tank. 8. CE approval in plastic tanks. 9. Very low ε_r liquids. 10. Foam applications.	**For high silos or tanks with liquids or granules** 1. Same as rods, but up to 24 meters and over 6 meters. 2. For smaller tanks with no clearance for rigid probes (coax or rod). 3. For side installations with allowed probe max. 6m/20ft on liquids only.	**For all fine powder applications** 1. For all fine powder applications > 6 metres. 2. For all very viscous liquids like liquid sugar. 3. For building a coaxial version with an existing stillwell (Calibration required). 4. Very corrosive liquids with FEP coating. 5. Crystallising acids with FEP coating.
Avoid when			
1. Contact inside the tank 2. Temperature > 240°C	1. Crystallising liquids. 2. High deposit product applications. 3. Powders.	1. Small connection flange with nozzle. 2. Agitated tank without anchoring.	1. Long and small diameter nozzle installation - min recommended flange 4" or mounted with 2" flange. 1. Max nozzle height base on its diameter, calculation is: $h = \frac{(L \times d) + 140mm}{4 \times a}$ L = Probe length (mm) d = Nozzle diameter (mm) a = Flange eccentricity from tank center (mm)
Main Applications are			
1. Tanks < 6 meters 2. > 6 meters under request 3. Viscous fluid for very high viscosity use single probe 4. All application, NH3, solvents, oil, LPG, etc. 5. For OEM integration, molded in plastic liner or welded in the tank 6. For multifluids storage tank	1. Tanks < 6 meters. 2. LPG, LNG, Solvent, NH3, Fuel oil, Foam, Alcohol, Displacer, open channel measurement replacement, threat connection installation...	1. Tank farm. 2. LPG, LNG, NH3. spheres, beer, alcohol.	1. Cement, limestone, fly ash, alumina, etc... 2. Acids. 3. Liquid sugar, honey, sirups. 4. For very high temperature with single cable construction.

7.5 Materials of construction

Check that the materials of the sensor, extension, flange, gaskets (Viton/Kalrez), and PTFE (contained in all versions) are compatible with the product!

7.5.1 Signal converter

Housing: Aluminium with epoxy or powder coating.

7.5.2 Flange system

1" NPT Standard; all other flanges on request.

7.5.3 Materials in contact with the product.

*Stainless steel 316 for the cable, Hastelloy optional.

*Stainless steel 316 L standard for all the process connections, others on request.

*PTFE.

*Viton O-Ring, Kalrez optional.

7.6 Electrical connection

The electrical connection for the power supply is made in the terminal compartment of the signal converter. Observe requirements specified in VDE 165.

In case of installation in hazardous areas, only certified **intrinsically safe** equipment may be connected to the LL 102.

Two kinds of electrical connection are available:

1. DIN Connector:

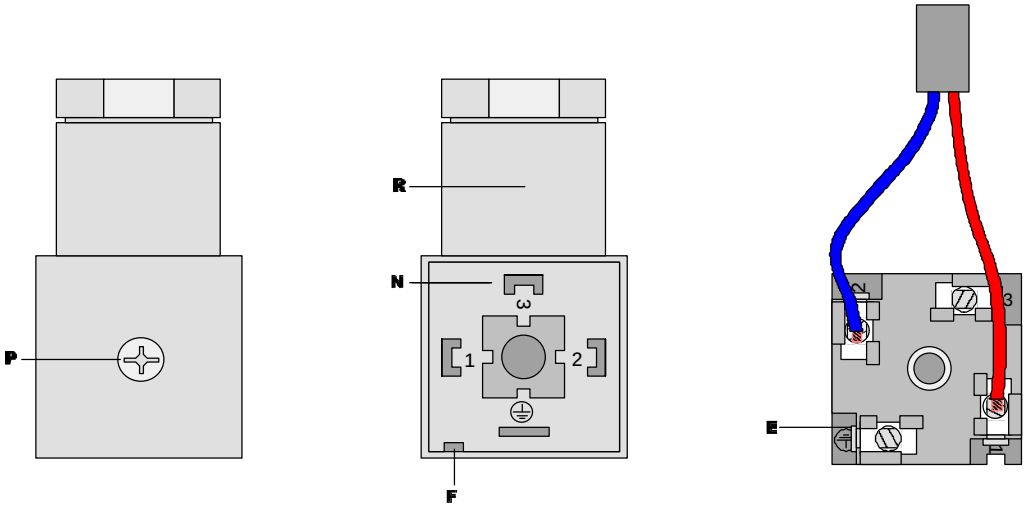
Terminals:	3 poles + ground. Wire cross-section max 1.5 $mm^2 \approx$ (AWG 16).
Ex-equipotential bonding:	U-clamp terminal (max. 4 mm^2 conductor cross-section) at neck of signal converter.
Cable entries:	M25x1.5 (PG11). Standard cable gland: cable clamping area = 8-10 mm).IP65
Signal cable shielding:	No shielding needed.

Power supply:

1. Remove the screw **P** and lift off the connector from the signal converter.
2. Put a screwdriver in **F** and separate **N** from **R**.
3. Connect the current loop to terminal 1 and 2 (there's no polarity to respect). Use ferrules to protect cable ends. The terminal 3 and **E** remain non-connected.
4. Re-assemble **N** and **R.**
5. Put the seal in place, connect **R** to the signal converter tighten and screw **P.**

The terminal **E** is not connected with the signal connector housing or with the flange system of the instrument.

For standard and Ex applications only the intrinsically safe 2-wire loop must be connected to the terminals 1 and 2. The terminal **E** as well as terminal 3 remains non-connected.



2. ISO16:

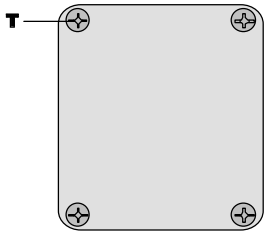
Terminals:	wire cross-section max 1.5 mm^2=(AWG 16)
Ex equipotential bonding:	U-clamp terminal (max. 4 mm^2 ≈ conductor cross-section) at neck of signal converter.
Cable entries:	M16x1.5. With standard cable gland: cable clamping area = 8 -10 mm).
	IP65
Signal cable :	No shielding needed.

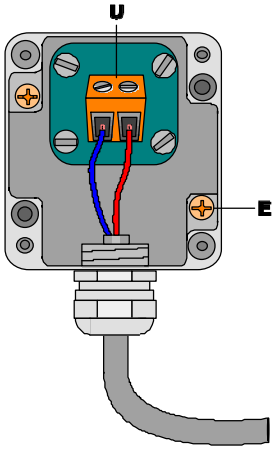
Power supply:

1. Remove the 4 screws **T** and open the terminal compartment.
2. Connect the current loop to the terminal **U** (there's no polarity to respect). Use ferrules to protect cable ends.
3. Close the terminal compartment.

The terminal **E** is not connected with the signal connector housing or with the flange system of the instrument.

For standard and Ex applications only the intrinsically safe 2-wire loop must be connected to the terminals 1 and 2. The terminal **E** remains non-connected.





8. User interface

8.1 HART® Communicator

No local display is available for the installation and configuration of the LL 102. Configuration can be carried out with a HART® communicator or the PC-STAR 2 program.

8.2 Description of functions via HART® Communicator HC 275 (Version 1.00)

Function (Fct.)	Enter range	Default value	Description
1.0 PROCESS VAR.			
1.1.0 MEASUREMENTS			
1.1.1 LEVEL			Level value.
1.1.2 DISTANCE			Distance value.
1.1.3 VOLUME			Volume value if a strapping table is programmed.
1.1.4 ULLAGE VOLUME			Ullage Volume value if a strapping table is programmed.
1.2.0 Inputs/ Outputs			
1.2.1 FUNCTION I			Function associated to the current output (Primary Variable).
1.2.2 I			Current output value (mA)
1.2.3 %			Percentage of PV range.
2.0 CONFIG./TEST			
2.1.0 OPERATION			
2.1.1.0 BASIS PARAMETER			
2.1.1.1 TANK HEIGHT	Min value : Probe Length Max value : 60000 mm	6000 mm /2362 "	Tank height. The tank height is defined as the distance between the bottom of the tank and the lower flange surface.
2.1.1.2 PROBE LENGTH	Min value : 0 mm Max value : Tank height and < 27000 mm	6000 mm / 2362"	This value has to be equal to the exact length of the probe. The only situations for changing this value is if the probe length has been changed.
2.1.1.3 TIME CONSTANT	Min value : 1 second Max value : 100 seconds	5 seconds	The time constant allows to filter possible signal fluctuations when the product surface is turbulent.
2.1.1.4 DEAD ZONE	Min value : 0 mm Max value : Probe length	400 mm / 15.8 "	Measurements near the flange may not be precise or reliable. Therefore, the Dead Zone prevents measurements in this area. Measurement may not be precise in an area less than this recommended value, depending on the probe type.
2.1.1.5 Sensor info			
2.1.1.5.1 Sensor upper limit			Read only Menu. Upper sensor limit.
2.1.1.5.2 Sensor lower limit			Read only Menu. Lower sensor limit.
2.1.1.5.3 Sensor min. span			Read only Menu. Sensor minimum span.
2.1.2.0 DISPLAY			
2.1.2.1 LENGTH			
2.1.2.1.1 LENGTH UNIT	Options m cm mm inch Ft Optional Unit	millimeter [mm]	Length unit of displayed value (level / distance). The optional unit allows the user to define a new unit (name and factor) see menu 2.1.2.1.3
2.1.2.1.2 DISPLAY FORMAT	Options (number of decimal places) 0 1 2 3 4 5 6	2 decimal places	Defines the displayed length values format (option of the HART® communicator H275).
2.1.2.1.3.0 DEFINE NEW UNIT			
2.1.2.1.3.1 UNIT NAME	4 ASCII characters	"unit"	Optional unit name. User has to enter the unit name before using it in the menu "LENGTH UNIT".
2.1.2.1.3.2 UNIT FACTOR	Min value : > 0.0	1.0	Optional unit factor. User has to enter the

	Max value : 100000		Unit Factor before using it in the menu "LENGTH UNIT". With a factor 1.0, the unit is equivalent to one millimeter. With a factor 1000.0, the unit is equivalent to one meter.
2.1.2.2.0 VOLUME			
2.1.2.2.1 VOLUME UNIT	Options m3 l US Gal Ft3 bbl M3/h Ft3/h kg Metric Tons US Tons	Liter [l]	Unit for conversion values ("volume table"). The selected unit is only used to display the conversion value from the strapping table.
2.1.2.2.2 DISPLAY FORMAT	Options (number of decimal places) 0 1 2 3 4 5 6	2 decimal places	Defines the displayed volume value format. (Option of the HART® communicator H275).
2.1.3.0 ANALOG OUTPUT			
2.1.3.1 FUNCTION I	Options Level Distance Volume Ullage Volume	Level	Current output function (measured value to be displayed).
2.1.3.2 RANGE I	Options 4-20 mA 4-20 mA + 22 mA if Error	4-20 mA	Current output range. 4 to 20 mA (1st choice). When the BM 102 is in error mode, the current output is frozen except if the second choice is selected and then the current output is fixed at 22 mA.
2.1.3.3 ERROR DELAY	Options No delay 10 seconds 20 seconds 30 seconds 1 minute 2 minutes 5 minutes 15 minutes	No delay	This menu is available in case the range I menu is set to 4-20 mA with error 22 mA. This parameter sets the delay before the current output goes to 22 mA after the error mode occurred.
2.1.3.4 SCALE I min. 4 mA	Min value : 0 Max value : Scale I max	0	Input the lower range value (corresponding to 4 mA) depending of the parameter 2.1.3.1 choosen.
2.1.3.5 SCALE I max. 20 mA	Min value : Scale I min Max value : Tank Height	6000 mm / 236 "	Input the upper range value (corresponding to 24 mA) depending of the parameter 2.1.3.1 choosen.
2.1.4.0 USER DATA			
2.1.4.1 TAG		BM 102 00	Tag number of device.
2.1.4.2 SERIAL NUMBER			Read only menu. Each device has its proper serial number.
2.1.4.3 FRENCH COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
2.1.4.4 GERMAN COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
2.1.4.5 RELEASE NUMBER			Read only menu. Release number of the device (Software and Hardware version).
2.1.4.5 PROBE TYPE	Options : Rod Twin Rod Cable	Rod	Read only menu. Probe type attached to the flange.

	Cable +counterweight Twin Cable Twin Cable + counterweight Coax Special 1 Special 2 Special 3		
2.1.4.5 CHECKSUM			Read Only menu. Similar to the release number. This parameter allows to identify the software version of device.
2.1.5.0 APPLICATION			
2.1.5.1.0 THRESHOLD			
2.1.5.1.1 LEV. PULSE AMP.			Read only value. Dynamic value. Amplitude of level pulse in millivolts.
2.1.5.1.2 LEV. PULSE GAIN			Read only value. Dynamic value. Amplification of level pulse (gain 0,1,2, or 3)
2.1.5.1.3 THRESHOLD		200 mV; amplification factor: 3 at 1 meter.	Threshold of the level pulse (in millivolts). The threshold évolutes in terms of gain amplification factor changing by the electronic converter.
2.1.5.2 DISTANCE INPUT 2.1.5.3 DETECTION DELAY			This function allows forcing the LL 102 to search for the product surface in a particular zone other than the actual measuring zone. If there is no level signal, you can enter an estimated value. This function forces the instrument not to analyse reflections in a zone directly below the flange. The entered value of the detection delay must be smaller than the "dead zone" value.
2.1.5.4 SEARCH PROBE END			Measures automatically the probe length.
2.1.5.5 RESET BM 102			Restarts the LL 102.
2.1.6.0 SERIAL I/O			
2.1.6.1 ADDRESS	Options Address from 0 to 15	0	Sets the address of the device when this latter is connected on a HART Multidrop networks. The current output drifts to 4 mA.
2.1.7.0 STRAP TABLE			
2.1.7.1 VOLUME UNIT	Options m3 l US Gal Ft3 bbl M3/h Ft3/h kg Metric Tons US Tons	Liter [l]	Unit for conversion values ("volume table"). The selected unit is used to define the strapping table values. .
2.1.7.2 INPUT TABLE	Options : Contains from 0 to 20 points.	0 point (No volume table)	This function defines the strapping table. The maximum number of points is 20. The 4 mA current output in volume is the first value in the table. Each subsequent value must be greater than the previous one. The length and volume units can be changed later without affecting the settings in the table. Calculations are done automatically in the instrument.
2.1.7.3 DELETE TABLE			This function deletes the strapping table.
2.2.0 TESTS			
2.2.1 TEST OUTPUT	Options : 4 mA 12mA 20 mA Other		This function allows the current output to be tested. The output can be set to one of the listed values. With a reference ammeter, the calibration of the current output can be verified.

2.3.0 SERVICE			
2.3.1.0 BASIS PARAMETERS			
2.3.1.1 OFFSET OF MEASURE	Min value : 0 Max value : 24000 mm/ 1448 "	263 mm / 10.4 "	Correction for time the pulse takes to travel from the electronics to the flange.
2.3.1.2 PROBE TYPE	Options : Rod Twin Rod Cable Cable + counterweight Twin Cable Twin Cable + counterweight Coax Special 1 Special 2 Special 3	Rod	Your LL 102 has been ordered with one of these probe types. This probe type can be changed only in the service menu.
2.3.1.3 APPLICATION TYPE	Options : 1 Product, 1 Level 2 Products , 1 Level	1 Product, 1 Level	Process configuration (1 or 2 liquids). Note: for the specification of 2 liquids, the top liquid must have an $\varepsilon_r < 5$, and be always at the flange.
2.3.1.4 EPSILON R	Min value : 0.8 Max value : 99.0	1.0	This menu is available if "application type" is "2 products, 1 Level". Enter the Epsilon R value of the product above the surface to be measured. This menu is not valid for the "reverse probe type".
2.3.2.0 APPLICATION			
2.3.2.1 VOLTAGES VALUES			This function displays the voltage values within the device : Power supply (+/- 3 Volts) Time base supply (VCO)
2.3.2.2 WATCH PULSES			This function displays information about each pulse (Reference pulse, flange pulse and level pulse). For each pulse there are set values. For example window number, pulse amplitude, position of the pulse inside the window etc.
2.3.2.3 MEAS. STAT. HIST.			This function indicates the 24 last process status. Markers : . Level Normal . Full Tank . Empty Tank . Level Lost
2.3.2.4 PROBLEM HISTORY			This function indicates the last 24 device errors.
2.3.3.0 CALIBRATION			
2.3.3.1 CURRENT OUTPUT			This function allows to calibrate the current output. Factory set.
2.3.3.2 ELEC. CALSPEED	Min value : 0.7 Max value : 3.0	1.5189	Electronics speed constant. Not necessary to change in any circumstance. This is factory set and is specific to each electronics. It is always necessary to record this before an EEPROM 'Factory' reset, so that it can be re-entered.
2.3.3.3 MECH. CALSPEED	Min value : 0.7 Max value : 9.999	1.0	Mechanical speed constant. This is the correction factor relating to the actual probe type and the pulse propagation speed. This is factory calibrated, and needs to be recalibrated only if the probe is changed or extended.
2.3.3.4 ELECTRONIC OFFSET	Min value : -250 mV Max value : +250 mV	0 mV	Electronic offset. Signal offset. This parameter Sets the offset value of the audio signal. This parameter alllows to adjust the level of signal amplitude to mask non-valid pulses. BM 102 uses this value to control electrically the level of signal amplitude: The higher this value, the higher the non-valid signal amplitude is.
2.3.3.5 AUTO OFFSET MEASURE			This function calculates automatically the offset (Parameter 2.3.1.1). After having used this function, a manual calibration is possible.

2.3.3.6 SET REF. FREQUENCY	Min value : 0 Max value : 255	128	This parameter sets a value for the digital / analogue converter. Calibration of reference frequency is done only during manufacturing (factory set).
2.3.4.0 EEPROM RESET			
2.3.4.1 USER RESET			This function allows a reset of the user parameters to their default values. This can be used in case the service engineer wants to reprogram the default parameter settings. A forgotten password can be disabled by this method.
2.3.4.2 FACTORY RESET			Note: Before using this function, contact HiTECH's Service Department. This function resets all the factory parameters. It is essential to record the Offset of measure, the electronic offset, Electronics Speed Calibration and Mechanical Speed Calibration values and reference frequency value before this function is activated. These values can be then re-entered after the reset. After a reset, the current output must be calibrated again.
2.3.4.3 IDENTIFICATION			French and German command numbers.
3.0 ACCESS RIGHTS			
3.1 MAINTENANCE PSW			Disables the access lock on the configuration menu. The password must contain exactly 9 characters. E, R or U are used only. The password is displayed in a scrambled format. It allows HiTECH to decode the password in case it was forgotten.
3.2 SPECIALIST PSW			Specialist access to the Service Parameters.
4.0 WATCH STATUS			This function allows displays the status of the device.
5.0 HART® VARIABLES			
5.1 MANUFACTURER		HITECH	Read only menu.
5.2 MODEL		BM 102	Read only menu.
5.3 FLD DEV REV		1.0	Field device revision. Read only menu.
5.4 SOFTWARE REV 5.5 HARDWARE REV		1.0 1.0	Software revision. Read only menu. Hardware revision. Read only menu.
5.6 DEVICE ID			Read only menu. The device ID is also the serial number of the device.
5.7 MESSAGE			32 bytes of ASCII characters.
5.8 DESCRIPTOR			16 bytes of ASCII characters.
5.9 DATE			Month Day Year (xx / xx / xx).
5.10 NUM RESP PREAM			Number of preamble in the response frame of the device.
5.11 TAG			Tag name of the LL 102.
5.12 POLL ADDRESS			Address of the device.

8.3 Table of settable functions of PC STAR 2 (Version 1.00)

Function (Fct.)	Enter range	Default value	Description
1.0.0 OPERATION			
1.1.0 BASIS PARAMETER			
1.1.1 TANK HEIGHT	Min value : Probe Length Max value : 60000 mm/ 2362 "	6000 mm / 236 "	Tank height. The tank height is defined as the distance between the bottom of the tank and lower flange surface.
1.1.2 DEAD ZONE	Min value : 0 mm / 0 " Max value : Probe length	400 mm / 15.8 "	Measurements near the flange may not be precise or reliable. Therefore, the Dead Zone prevents measurements in this area. Measurement may not be precise in an area less than this recommended value.
1.1.3 TIME CONSTANT	Min value : 1 second Max value : 100 seconds	5 seconds	The time constant allows to filter possible signal fluctuations when the product surface is turbulent. The minimum and maximum values are 1 and 100 seconds respectively. The factory default value is 5 seconds.
1.1.6 PROBE LENGTH	Min value : 0 mm / 0 " Max value : Tank height and < 27000 mm / 1063 "	6000 mm / 236 "	This value has to be equal to the exact length of the probe. The only situation for changing this value is if the probe length has been changed.
1.2.0 DISPLAY			
1.2.4 LENGTH UNIT	Options m cm mm inch Ft Optional Unit	mm (Millimeter)	Length unit of displayed value (level / distance). The selected unit is only valid for the length values. The optional unit allows the user to define a new unit (name and factor) see menu 2.1.2.1.3
1.2.5 VOLUME UNIT	Options m3 l US Gal Ft3 bbl M3/h Ft3/h kg Metric Tons US Tons	Liter [l]	Unit for conversion values ("volume table"). The selected unit is only used to display the conversion value.
1.2.6 DEFINE NEW UNIT			
1.2.6.1 UNIT NAME	4 ASCII characters	"unit"	Optional unit name. User has to enter the unit name before to use it in the menu "LENGTH UNIT".
1.2.6.2 UNIT FACTOR	Min value : > 0.0 Max value : 100000	1.0	Optional unit factor. User has to enter the Unit Factor before using it in the menu "LENGTH UNIT". With a factor 1.0, the unit is equivalent to one millimeter. With a factor 1000.0, the unit is equivalent to one meter.
1.3 ANALOG OUTPUT			
1.3.1 FUNCTION I	Options Level Distance Volume Ullage Volume	Level	Current output function (measured value to be displayed).
1.3.2 RANGE I	Options 4-20 mA 4-20 mA + 22 mA if Error	4-20 mA	Current output range. 4 to 20 mA (1st choice). When the LL 102 is in error mode, the current output is frozen except if the second choice is selected and then the current output is fixed at 22 mA.
1.3.3 SCALE I min	Min value : 0 Max value : Scale I max	0	Sets the lower range value for the current output (4 mA).
1.3.4 SCALE I max (20 mA)	Min value : 0 Max value : tank Height	6000 mm / 236. 2 "	Sets the full-scale range for the current output (20 mA).

1.3.5 ERROR DELAY	Options No delay 10 seconds 20 seconds 30 seconds 1 minute 2 minutes 5 minutes 15 minutes	No delay	This function is available in case the range I menu is set to 4-20 mA with error 22 mA. This parameter sets the delay before the current output goes to 22 mA after the error mode occurred.
1.4.0 USER DATA			
1.4.4 TAG		BM 102 00	Affects the tag name to the device.
1.4.5 SERIAL NUMBER			Read only menu. Unique serial number of the device ID. Each device has therefore its individual address (HART® protocol).
1.4.6 FRENCH COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
1.4.7 GERMAN COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
1.4.8 OPTION			Up to 15 bytes of ASCII characters permitted.
1.4.9 PROBE TYPE	Options : Rod Twin Rod Cable Cable +counterweight Twin Cable Twin Cable + counterweight Coax Special 1 Special 2 Special 3	Rod	Read only menu. Release number of the device (Software and Hardware version). Probe type attached to the flange.
1.5.0 APPLICATION			
1.5.1 DETECTION DELAY	Min value: 0 mm Max value: dead zone	0	This function forces the instrument not to analyse reflections in a zone directly below the flange. The entered value of the detection delay must be smaller than the "dead zone" value.
1.6.0 SERIAL I/O			
1.6.2 POLL ADDRESS	Options Address from 0 to 15	0	Sets the device address of each instrument on HART® Multidrop mode. In this mode the current output is fixed to 4 mA.
1.7.0 STRAP TABLE			
1.7.2 INPUT TABLE	Options : Contains from 0 to 20 points.	0 point (No volume table)	This function defines the strapping table. The maximum number of points is 20. The 4 mA current output in volume is the first value in the table. Each subsequent value must be greater than the previous one. The length and volume units can be changed later without affecting the settings in the table. Calculations are done automatically in the instrument.

DYNAMIC CONFIGURATION	F11		
THRESHOLD			
LEVEL PULSE GAIN			Read only value. Dynamic value. Amplification of level pulse (gain 0,1,2, or 3)
LEVEL PULSE AMP.			Read only value. Dynamic value. Amplitude of level pulse in millivolts.
LEVEL PULSE DISTANCE			Read only value. Dynamic value. Distance of the level pulse.
DISPLAY AND SET		200 mV;	Threshold of the level pulse (in millivolts).

THRESHOLD VALUE		amplification factor: 3 at 1 meter.	The threshold is always displayed in terms of the same gain amplification factor as the product pulse.
DISTANCE INPUT			The function forces the BM 102 to search for the product surface in a particular zone. Therefore, if there is no level signal, you can enter an estimated value. If you are sure of what your indication should be, and there is still no reading, contact HiTECH about decreasing the "Level Threshold" value. CAUTION: Use of this function is not recommended, except for trained HiTECH service representatives.
SEARCH PROBE END			Allows to calculate automatically the probe length
ADD POINT TO VOLUME TABLE	Options : Contains from 0 to 20 points.	0 point (No volume table)	This function defines the strapping table. The maximum number of points is 20. The 4 mA current output in volume is the first value in the table. Each subsequent value must be greater than the previous one. The length and volume units can be changed later without affecting the settings in the table. Calculations are done automatically in the instrument.
DELETE POINT OF THE VOLUME TABLE			This function deletes the strapping table.
TEST CURRENT OUTPUT	Options : 4 mA 8 mA 12 mA 16 mA 20 mA 22 mA		This function allows the current output to be tested. The output can be set to one of the listed values. With a reference ammeter, the calibration of the current output can be verified.
RESET LL 102	Key : CTRL + ALT + R		Restarts the LL 102.

SERVICE			
1.1 BASIS PARAMETERS			
1.1.1 PROBE TYPE	Options : Rod Twin Rod Cable Cable + counterweight Twin Cable Twin Cable + counterweight Coax Special 1 Special 2 Special 3	Rod	Probe type specification as mounted to the flange, per the purchase order.
1.1.2 OFFSET OF MEASURE	Min value : 0 Max value : 24000 mm / 944.9 "	263 mm / 10.35 "	Correction for time the pulse takes to travel from the electronics to the flange.
1.1.3 APPLICATION TYPE	Options : 1 Product, 1 Level 2 Products , 1 Level	1 Product, 1 Level	Process configuration (1 or 2 liquids). Note: for the specification of 2 liquids, the top liquid must have an $\varepsilon_r < 5$, and be always at the flange.
1.1.4 EPSILON R	Min value : 0.8 Max value : 99.0	1.0	This menu is available if "application type" is "2 products, 1 Level". Enter the Epsilon R value of the products above the surface to be measured. This menu is not valid for the "reverse probe type" , (probe type 5).
2.0 CALIBRATION			
2.1 ELECTRONIC OFFSET	Min value : -250mV Max value : +250mV	0 mV	Sets the offset value of the audio signal. Allows to hide non-valid pulses. This parameter sets the value of the electronic offset. The LL 102 uses this value to control electronically the level pulse amplitude. As higher the level pulse amplitude is as higher the non-valid pulses amplitude will be too. This parameter allows adjusting the level pulse amplitude in order to hide non-valid pulses.

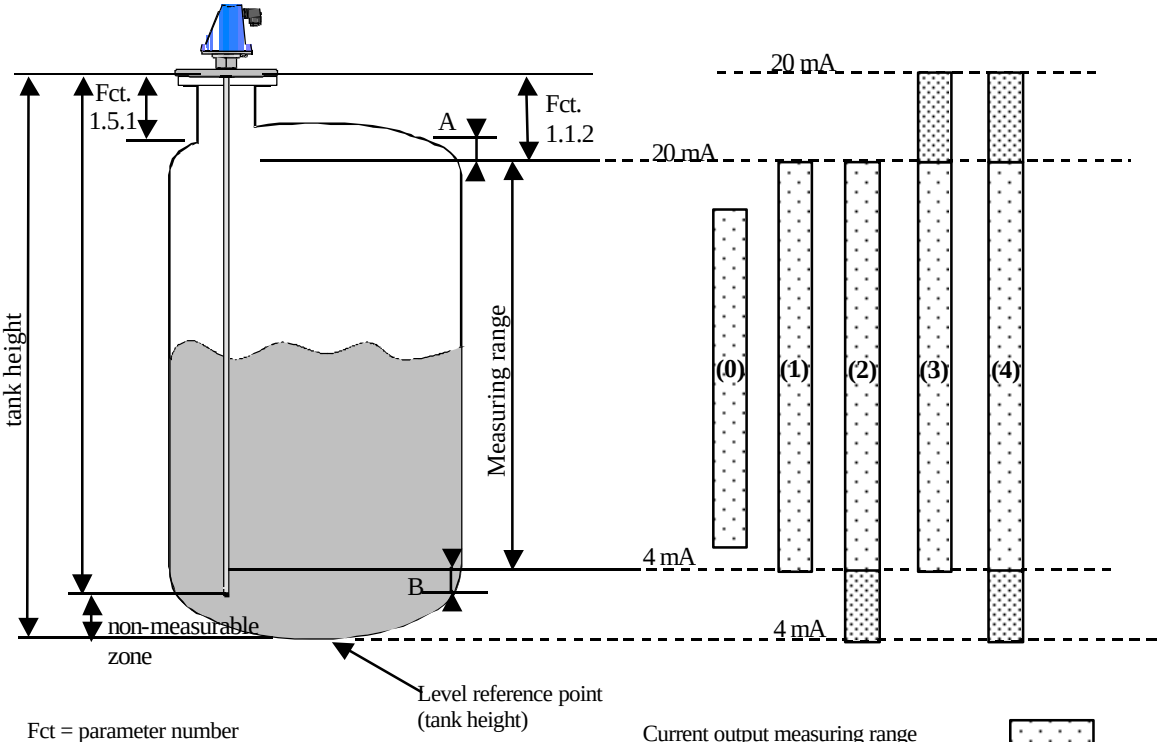
2.4 ELEC. CALSPEED	Min value : 0.7 Max value : 3.0	1.5189	Electronics speed constant. Not necessary to change in any circumstance. This is factory set and is specific to each electronics. It is always necessary to record this before an EEPROM 'Factory' reset, so that it can be re-entered.
2.5 MECH. CALSPEED	Min value : 0.7 Max value : 9.999	1.0	Mechanical speed constant. This is the correction factor relating to the actual probe type and the pulse propagation speed. This is factory calibrated, and needs to be recalibrated only if the probe is changed or extended.
2.6 SET REF. FREQUENCY	Min value : 0 Max value : 255	128	Reference frequency setting for the digital to analogue converter. Factory set Change **only** with the agreement of a HiTECH Service Engineer.
3.0 EEPROM RESET			
3.3 SERIAL NUMBER			Read only menu. Unique serial number of the device and device ID. Each device has therefore it's individual address (HART® protocol).
3.4 FRENCH COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
3.5 GERMAN COMMISSION NUMBER			Read only menu. This number is factory set. Refer to this number in case of warranty or service claims.
3.6 HARDWARE RELEASE NUMBER			Release number of the instrument.

DYNAMIC CONFIGURATION			
VOLTAGES VALUES			This function displays the voltage values within the device: Power supply (+/- 3 Volts) Time base supply (VCO).
WATCH PULSES			This function displays information about each pulse (Reference pulse, flange pulse and level pulse). For each pulse there are set values. For example window number, pulse amplitude, position of the pulse inside the window etc.
AUTO OFFSET MEASURE			This function calculates automatically the offset (parameter 2.3.1.1). After having used this function, a manual calibration is possible.
USER RESET			This function allows a reset of the user parameters to their default values. This can be used in case the service engineer wants to reprogram the default parameter settings. A forgotten password can be disabled by this method.
FACTORY RESET			Note: Before using this function, contact the HiTECH Service Department. This function resets all the factory parameters. It is essential to record the Offset of measure, the electronic offset, Electronics Speed Calibration and Mechanical Speed Calibration values and reference frequency value before this function is activated. These values can be then re-entered after the reset. After a reset, the current output must be calibrated again.

8.4 Configuration examples

NOTE: The menu items (e.g. Fct 1.1.3) of the examples refer to the menu structure of the PC program: PC STAR 2.

8.4.1 Level measurement (example)



Fct = parameter number
A= Minimum recommended distance between detection delay and dead zone (Fct 1.1.2 – Fct 1.5.1)
(150 mm)
B = Dead zone at the end of the probe

Current output measuring range

Non measurable zone

(Refer to a representation of the physical dimensions of the probe ends: cable twin, cable coax, etc. see BM 100A Manuel)

Level configuration example:

Fct 1.3.1 = Level

(0) current output range is smaller than the measuring range.

(1) current output range is equal to the measuring range :
min scale 4 mA (fct 1.3.4) = tank height – probe length + B
max scale 20 mA (fct 1.3.5) = tank height – dead zone

(2) current output range is larger than the measuring range :
min scale 4 mA (fct 1.3.4) = 0.0
max scale 20 mA (fct 1.3.5) = tank height – dead zone

(3) current output range is larger than the measuring range :
min scale 4 mA (fct 1.3.4) = tank height – probe length + B
max scale 20 mA (fct 1.3.5) = tank height

(4) current output range is larger than the measuring range :
min scale 4 mA (fct 1.3.4) = 0.0
max scale 20 mA (fct 1.3.5) = tank height

Please note:

For distance measurement, the reference point is the bottom surface of the flange.

8.4.2 Volume measurement (example)

- In order to be able to measure volume with the LL 102, a conversion table (strapping table) needs to be entered via the PC-STAR 2 program or HART® communicator (see Sect. 8.3).
- By means of the strapping table, level values are allocated to specific volumes previously calculated or measured.
- In the case of non-symmetrical tanks, e.g. tanks with dished bottom, the accuracy of volume measurement will depend on the number of entered "level/volume pairs". The maximum number of pairs (points) that can be set is 20; the volume is linearly determined (interpolated) between 2 points.
- The table is generally used for volume, but can be used for mass or volume flow too.
- In the following example, 4 sets of data have been programmed.

Volume table Unit volume (Fct. 1.2.5): m^3
Input table (PC STAR 2):

Point	Level	Volume
①	0.20 m / 0.66 ft	0.5 m³ / 17.6 ft³
❷	0.75 m / 2.46 ft	1.0 m³ / 35.3 ft³
③	1.00 m / 3.28 ft	1.5 m³ / 53 ft³
❹	5.60 m / 18.4 ft	16.80 m³ / 593.3 ft³

Tank height (Fct. 1.1.1): 6.00 m / 19.7 ft

Probe length (Fct. 1.1.6): 5.80 m / 19.3 ft

Dead zone (Fct. 1.1.2): 0.40 m / 1.31 ft

Maximum measurable level = tank height - dead zone – (tank height – probe length)
=6,00 m - 0,40 m - (6.00 m – 5.80)= **5.40 m (17.7 ft),** equivalent to a volume **of 16.30 m³**

Note: The real level can be measured between 0.20 m to 5.60 m. When the level of the product is lower than the probe end the LL 102 indicates "tank empty". The LL 102 is programmed on the basis of a level range between 0 m and 5.60 m but it can only give a measuring value between 0.2 m(0.44 ft) and 5.60 m(18.4 ft). The size of the Dead Zone (0 m to 0.2 m), depends of the installation and the probe type of the LL 102.

Current output I	Function I (Fct 1.3.1):	VOLUME
	Range I (Fct. 1.3.2):	4 - 20 mA
	Scaling 4 mA (Fct. 1.3.3):	0.50 m^3 , corresponds to 4 mA
	Scaling 20 mA (Fct. 1.3.4):	16.80 m^3 , corresponds to 20 mA
Display	Unit, conversion (Fct. 1.2.5):	m^3 (cubic meter)

8.5. Description of functions

NOTE: The menu structure is of the structure of the PC program: PC STAR 2 refered to.

8.5.1 Choice of units

Level/distance units

Select Fct. 1.2.4 Length Unit

- m • cm • mm
- inch • Ft • Optional unit

The selected unit is then used for the following functions:
- Dead zone Fct. 1.1.2
- Probe length, Fct. 1.1.6
- Scaling 4 mA value, current output, Fct. 1.3.3
- Scaling 20 mA value, current output, Fct. 1.3.4

The optional unit can only be used as a function of length. Before selecting this unit in Fct. 1.2.4, it is necessary to enter the new unit parameters:
. The name of the unit (4 characters), Fct. 1.2.6.1
. The factor of the unit, Fct. 1.2.6.2
The reference of the factor is the millimeter:
If the factor is 10, the optional unit is equivalent to the centimeter (10 mm).
If the factor is 0.1, the optional unit is equivalent to one tenth of a millimeter (0.1 mm).

Conversion units

The conversion unit can be used to convert the level measurement into a different unit (usually volume). It is possible to realise a non-linear function as a factor of the level.

Options under Fct. 1.2.5 VOLUME UNIT
- m^3 l (liter)
- US Gal Ft3
- bbl (petroleum barrels)
- metric Tons US Tons
- Kg m^3/h
- Ft3/h

The selected unit is also valid for the following functions:
- Scaling 4 mA value, current output, Fct. 1.3.3
- Scaling 20 mA value, current output, Fct. 1.3.4

- Display range:

0.00 - 30000.00	m^3
0 - 9999999	Liter
0 - 7925161	(US Gal)
0 - 6599265	(GB Gal)
0.0 - 999999.9	Ft3
0.0 - 99999.9	bbl (petroleum barrel)

Conversion measurement requires a conversion table entered with the PC-STAR 2 program or HART® communicator. By means of this table a conversion value is allocated to each level value (level / conversion pairs). The values are linearly interpolated between 2 points.

Examples of application and setting: see Sect. 8.4.2

8.5.2 Tank height

Fct. 1.1.1 TANK HEIGHT
The entered value is a fundamental variable for the calculation of level measurement and its equivalent current value.
The tank height is defined as the distance between the bottom of the tank and lower flange surface. The value must be greater or equivalent to the "probe length". The minimum and maximum values are 0 and 60 m (200 ft) respectively.
The factory default value is per your sales order.

NOTE: The LL 102 does not measure beyond its probe length.

- Selection of unit, see Sect. 8.5.1.
- Setting ranges for the tank height BM 102 :
  - Tank height: 60.00 m
  - Tank height: 6000 cm
  - Tank height: 60000 mm
  - Tank height: 2362.2 inch
  - Tank height: 196.85 ft
- The tank height setting is also the max limit for the following function :
  - Scale I max. 20 mA, Fct. 1.3.4
- The tank height must be greater or equal to the probe length.

8.5.3 Dead zone/ Time constant / Probe length

Fct. 1.1.2 DEAD ZONE

- Measurements near the flange may not be precise or reliable. Therefore, the Dead zone prevents measurements in this area. The minimum value is equal to those shown in the table below. Measurement may not be precise in an area less than this recommended value. The factory default value is 0.40 m.
- Unit and setting range: same as Fct. 1.1.1 TANKHEIGHT.

Probe type	Top Dead zone for an ε_r<10	Top Dead zone for an ε_r >10
Mono Rod	400 mm / 15.75 "	300 / 11.81 "
Twin rod	300 mm / 11.81 "	150 / 5.9 "
Mono Cable	400 mm / 15.75 "	300 / 11.81 "
Twin cable	300 mm / 11.81 "	150 / 5.9 "
Coax	0 mm / 0 "	0 mm / 0 "

Fct. 1.1.3 TIME CONSTANT

- The measurement is filtered with the time constant so as to avoid abrupt changes in measured values and thus also in the current output value.
- Range: 001 - 100 Sec

Default value and recommended setting: 5 Sec

Fct. 1.1.6 PROBE LENGTH

- This value has to equal to the exact length of the probe. The only situations for changing this value is if the probe length has been changed.
- Selection of unit, see Sect. 8.5.1.
- Setting ranges for the probe length LL 102 :
  - 0 to 27.00 m
  - 0 to 2700 cm
  - 0 to 27000 mm
  - 0 to 1063 inch
  - 0 to 88.594 ft
- The probe length is at the same time the min limit of the range for the following function:
  - Tank height, Fct. 1.1.1
- The probe length is at the same time the max limit of the range for the following function:
  - Dead zone, Fct. 1.1.2

Note: When tank is empty, it is possible with software PC STAR 2 (function F11) to execute an automatic calculation of the probe length from the dynamic configuration window.

8.5.4 Display with the PC program "PCSTAR 2"

Fct. 1.2.4 LENGTH UNIT
Use this function to select the unit for displaying level and distance.

- m • cm • mm
- inch • Ft • optional unit

If you want to select the optional unit, you have to initialise:
- the name of the new unit (4 character max.) fct. 1.2.6.1
- the conversion factor, fct. 1.2.6.2.

The conversion factor reference is the millimeter:
If the conversion factor is equal to 10, then the new unit is equivalent to centimeter (10 mm).
If the conversion factor is equal to 0.1, the new unit is equivalent to one tenth of millimeter (0.1mm).

Fct. 1.2.5 VOLUME UNIT

Use this function to select the unit for volume display.

- m3
- l (litres)
- US Gal
- GB Gal (Gal = gallons)
- ft3
- bbl (petroleum barrels)
- m3/h
- ft^3/h
- metric tons
- US tons
- Kg

Fct.1.2.6 NEW LENGTH UNIT
Appears only if new unit is chosen in fct. 1.2.4
'' Length Unit''

Fct. 1.2.6.1 NAME OF NEW LENGTH UNIT
Name of new unit (max. 4 characters)

Fct. 1.2.6.2 CONVERSION FACTOR
The conversion factor reference is the millimeter:
If the conversion factor is equal to 10, then the new unit is equivalent to centimeter (10 mm).
If the conversion factor is equal to 0.1, the new unit is equivalent to one tenth of millimeter (0.1mm).

8.5.5 Analog Output

Fct. 1.3.1. FUNCTION I

Use this function to select the measured variable.

- LEVEL
- DISTANCE
- VOLUME
- ULLAGE VOLUME

Fct. 1.3.2 RANGE I

Use this function to define the current output value during error condition.
E = Error at 22 mA.

- 4-20 mA (hold last measured value when error occurs)
- 4-20 mA / E=22 mA (drift to 22 mA in case of error).

Fct. 1.3.3 SCALE I_1 min. 4 mA

- This function is used for I_{min} = 4 mA to define the lower value for level, distance, volume or ullage volume (scaling 4 mA).
- Setting LEVEL or DISTANCE in Fct. 1.3.1:
  Unit for SCALE 4 mA same as in Fct. 1.1.1 TANKHEIGHT. Value must be smaller than SCALE 20 mA
- Setting VOLUME or ULLAGE VOLUME under Fct. 1.3.1:
  Unit for SCALE 4 mA same as in Fct. 1.2.5 VOLUME UNIT. But Value must be smaller than the maximum value in the conversion table and smaller than the SCALE 20 mA (Fct. 1.3.4).

Fct. 1.3.4 SCALE 20 mA

- This function is used for I_{max} = 20 mA to define the upper value for level, distance, volume or ullage volume
- Setting LEVEL or DISTANCE in Fct. 1.3.1: Unit for SCALE 20 mA as in Fct. 1.1.1 TANKHEIGHT. The value set has not to be greater than the tank height (Fct. 1.1.1)
- Setting VOLUME OR ULLAGE VOLUME in Fct. 1.3.1: Unit for SCALE 20 mA same as in Fct. 1.2.5 VOLUME UNIT. The value set must be greater than the SCALE 4 mA (Fct. 1.3.3), otherwise error during Parameter Check.

Application and programming examples: see Sect. 8.5

Fct. 1.3.5 ERROR DELAY

This function is available on the HART® communicator when 4-20 mA / E=22 mA is chosen.
The delay defines the amount of time, in the event of an error, before the BM 102 goes to 22 mA. After the problem occurs and before the end of the delay, the measurement value (and also the current value) is frozen.

8.5.6 User Data

Fct. 1.4.4 TAG
Tag name of the device can be displayed 8 ASCII characters.
Note: Not all the characters can be used. "Tag name", "descriptor" and message are recorded in a special format (Packed ASCII). Only the characters in the following table can be used.

@	P	Space	0
A	Q	!	1
B	R	“	2
C	S	#	3
D	T	$	4
E	U	%	5
F	V	&	6
G	W	’	7
H	X	(	8
I	Y	)	9
J	Z	*	:
K	[	+	;
L	\	’	<
M	]	-	=
N	^	.	>
O		/	?

Fct. 1.4.5 SERIAL NUMBER
Identifies each BM 102. Can not be changed. This number defines the "Device ID" of the HART® Long Address.

Fct. 1.4.6 FRENCH COMMISSION NUMBER
This number is factory set. Refer to this number in case of warranty or service claims.

Fct. 1.4.7 GERMAN COMMISSION NUMBER
This number is factory set. Refer to this number in case of warranty or service claims.

Fct. 1.4.8 Optional
Up to 15 optional ASCII characters can be written.

Fct. 1.4.9 PROBE TYPE
Probe type attached to the flange, as specified in the order.

Fct. 1.4.10 CHECKSUM
ROM Checksum. Identifies the software version of the device. It allows also to detect problems with the micro controller. A test of this checksum is performed in the factory.

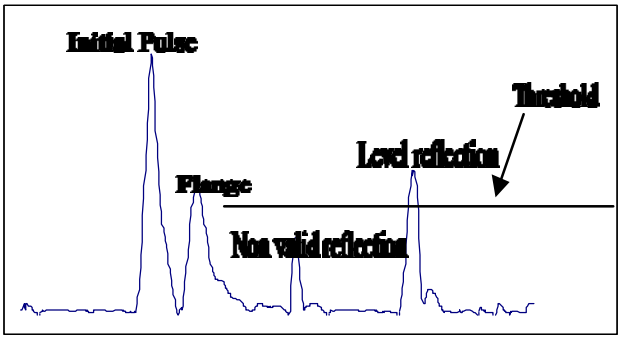
8.5.7 Threshold / Distance input/ Search Probe End

Dynamic Configuration
The amplitude and the amplification of the level pulse give an indication whether the device is following the correct pulse. For a product with ε_r > 80, the amplification factor should be 0 or 1 (depending on the probe type). For ε_r< 10 the amplification factor should be 2 or 3 (gain 2 or 3).

Normally the threshold does not need to be adapted. In some applications where reflections occur due to nozzles etc, a higher threshold setting can be necessary.

Note: It is recommended to not have a full (or empty) tank when setting the threshold.

To understand the principal use of this parameter, it is important to study the measuring principle:



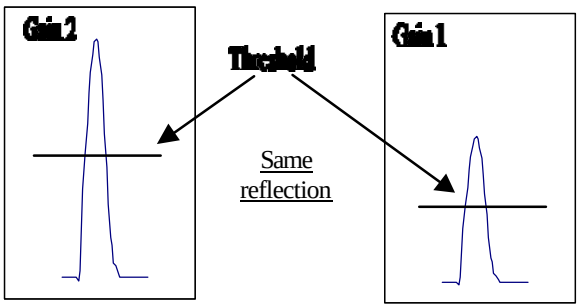
The threshold filters non-valid reflections (example: heating tube). The LL 102 measures only those pulses with an amplitude above the threshold.
The amplitude of the reflections is related to the dielectric constant of the product.
To set the threshold correctly, it is necessary to know approximately the amplitude of all reflections along the probe (level reflection and also non-valid reflections). An oscilloscope function which gives a view of all the reflections along the probe.

Default value for threshold is 200 mV in amplification factor 3 (gain 3).
The minimum threshold is 50 mV Gain 3.
The maximum threshold is 2500 mV Gain 0.

Gain	Amplification
0	1.05
1	2.10
2	4.37
3	8.93

The gain stage is assigned according to the strength of the reflection.
With amplification factor 0 (gain 0), the reflection is not amplified.
With gain 3, the reflection is amplified nearly by 9.
The LL 102 automatically changes the gain. In order to ensure that the processed reflection is maintained within a range of values that the electronics can most efficiently track.

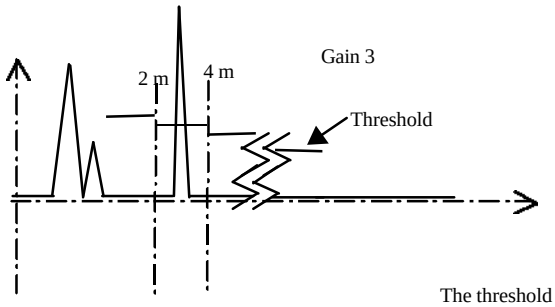
The threshold is recorded with the same amplification factor as the reflection.
If the reflection level gets smaller, the BM 102 will increase the gain and the reflection will be amplified. The threshold level will be equally amplified.



The example shows that when the reflection level gain changes, the threshold in both cases rises approximately to a level of 50% signal amplitude.

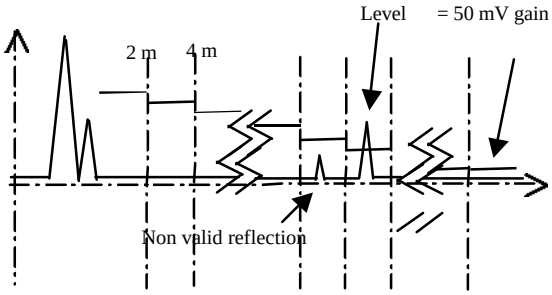
As the distance between the flange and the product surface rises, the amplitude of the reflected pulse gets smaller. The threshold adapts automatically in the same manner.

The level in the tank is between 2 and 4 meters:



The level value in the tank decreases:

The threshold can not decrease anymore than Minimum value = 50 mV gain 3



This function of the device allows the threshold to remain in the same proportion as the reflection amplitudes.

Refer to the annexe for further information on how to adjust the threshold.

Fct. Distance Input
It is not recommended to use this function in normal circumstances. Only in case of problems, it is to be used. This function forces the LL 102 to search for the product in a certain area along the probe. For instance, if the LL 102 probe is mounted on a tank while this latter is switched on, it may display permanently a full tank. To resolve such a problem, two way exist:

1. switch off the LL 102 and then switch it on.
2. Enter in a distance value where the product is supposed to be.

Fct. Detection Delay
Allows to define a zone below the flange in order to mask noise. This value has to be smaller or equal to the value of the dead zone set in 1.1.2.
The detection delay is especially useful for eliminating reflections due to the nozzle.

Fct. Search Probe End
The probe length can be measured automatically. This is necessary when the probe length was modified (cut).
If the LL102 does not succeed in finding automatically the probe length, there are three possibilities:

1. The threshold is not set correctly. Follow instructions to set it to a lower value.
2. The electronic offset is incorrect (Service Menu).
3. The probe type selected is incorrect (Service Menu).
4. The tank is not empty.

Contact the Service Department in case of an unsuccessful auto-measurement of the probe.

Fct. Reset LL 102

Restarts the device.

8.5.8 SERIAL I/O

HART® PROTOCOL:
The HART® protocol is a communications protocol of the "HART® Communication Foundation". In addition to the "universal commands" and "common practice commands" there are "device-specific commands" to access all the rest of the parameters and functions of the BM 102. Furthermore ask for the "device description" (DD) for the BM 102, which can be used for universal HART® control units, such as the HART® Communicator or SIPROM.
The standard hardware platform for HART® is the current output 4-20 mA with superimposed FSK signals. For HART®-Multidrop (max. 15 devices on one bus), the current output is automatically set to a constant 4 mA

Fct. 1.6.2 ADDRESS

- This function is used for entering valid addresses from 0 to 15 (HART® protocol).
- If several devices are operated on one digital bus or via HART®-Multidrop, each device must be set to an individual address under which it can then be addressed on the bus.
- The default value is the address "0".

8.5.9 STRAPPING TABLE

See Volume Measurements section.

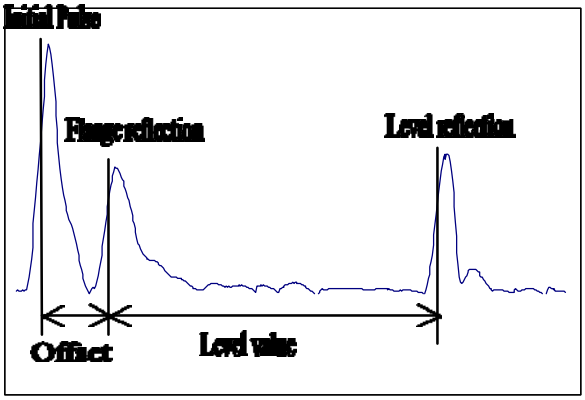
8.5.10 TESTS

Fct. Test Output
This function tests the current output. It forces the output to a certain value while the accuracy can be checked with a reference ammeter:

- An ammeter must be connected to the loop for this test.
- Select a current value (for PC STAR 2)
  4 mA
  8 mA
  12 mA
  16 mA
  20 mA
  22 mA
- The connected ammeter shows the measured current value.
- When exiting the test, the current output will return to the measured or previous value.

8.5.11 SERVICE

Fct. 1.1.2 Measurement Offset
Function for manual zero adjustment. Reference point for all measurements is the lower flange surface of the instrument. It is not recommended to modify this parameter, except for HiTECH Service Personnel.



For calibration, you can modify the offset in order to adjust value supplied by BM 102:
If the value indicated by the BM 102 is for example 2505 mm (98.6 "), and the true value is 2500 mm(98.43") then 5 mm /0.2 " (2505 – 2500) has to be added to the offset.

An automatic measurement of the offset can be performed with the dynamic configuration function.
This automatic function does not give an accurate value. It has to be adjusted manually.

Fct. 1.1.3 Application Type

Sets the process configuration.

A. 1 product, 1 level
B. 2 products, 1 level

Option A is the standard mode. Only one product is in the tank and the dielectric constant of the upper medium between the flange and the lower product level is 1.0 (air)
The second option is used in case the dielectric constant of the upper medium between the flange and the lower product level is not 1.0 . In this second case the function 1.1.4 can be used to specify the ε_r of the upper product.

8.5.12 APPLICATION

Fct. Voltages values

The voltage values are:
Power supply (+/- 3 volts)
Time Base supply (Voltage Control Oscillator)
These values are used only by the HiTECH Service Department.

Fct. Watch Pulses
This function can be only used by the HiTECH Service Department.
This function gives additional information on the captured signal. It is useful in analysing if the BM 102 is tracking the right level reflection.

Fct. Histories
These two functions record the status history of the device. The two functions store the last 24 status or error messages in a special non volatile memory.

8.5.13 CALIBRATION

Fct. Current Output
This function is used to calibrate the current output. First a reference ammeter has to be connected to the BM 102 in order to measure the actual loop current. The function fixes the current to 4.0 mA. Enter the actual current value measured with the ammeter (e.g. 4.01 mA). The BM 102 then calibrates automatically the current output. Repeat this operation in case the accuracy of the displayed current output value is not satisfactory. As a final step repeat the same procedure for the 20 mA value.

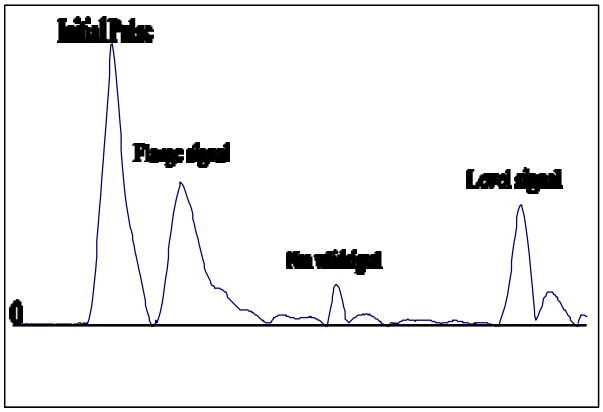
Fct. 2.4 and 2.5 Electronical / Mechanical Calspeed

These two constants are calibration factors which convert the measured time between the reference pulse and the level pulse into a distance (length).
There are 2 calibration factors. One because the pulse crosses the electronic board before entering the probe, and the other one because there are several probe types and each probe type geometry has an influence on the propagation of the wave.
Each electronic block has its own electronic factor.
Each probe type has his own mechanical factor.
Hence each device is calibrated with its specific probe.

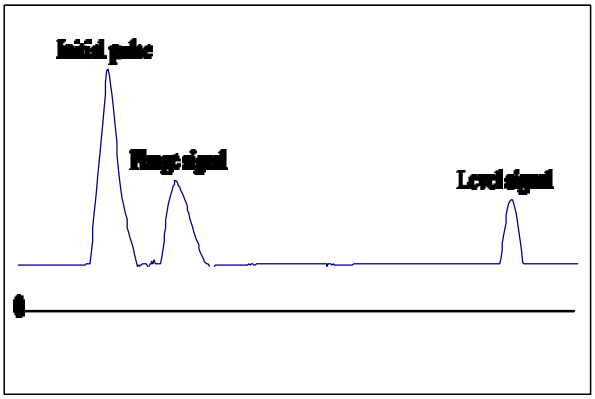
Fct. 2.1 Electronic Offset

This parameter allows to move the signal vertically. Says to add or to substract an offset to the signal zero reference. It allows to hide non valid signal noise, because only positive signals are measured.

In the example below the amplitude of the non valid pulse is about 30 mV. Increasing the offset by 30 mV, maskes the noise completely.



The non-valid signal disappeared, but the amplitude of the level pulse decreased too.



Normally for standard application this parameter should not be modified.
This parameter should be only modified under supervision of HiTECH Service.

Fct. Auto Offset Measure

See Section Fct 1.1.2

Fct. 2.6 Set Ref. Frequency

The function allows to re-enter the frequency reference parameter after a factory reset. The value must be recorded before the reset and re-entered to make sure that the instruments works correctly. The parameter was measured during the assembly process of the instrument and cannot be determined without special equipment.

8.5.14 EEPROM RESET

Fct. User Reset

Allows to set all user parameters to their default values. This can be useful to reconfigure completely a device, which also disables the maintenance password, in case it was forgotten.

Fct. Factory Reset

Note: Before using this function, contact the HiTECH0 Service Department. This function resets all the factory parameters. It is essential to record the Offset of Measure, the Electronic Offset, Electronics Speed Calibration and Mechanical Speed Calibration values and Reference Frequency value before this function is activated. These values can be then re-entered after the reset. After a reset, the current output must be calibrated again.

8.5.15 ACCESS RIGHTS

Fct. Maintenance Password

The maintenance password is a customer password. It allows to protect the access of the device configuration menu. Read only values can only then be accessed, like the measurement values and the status, without the password.

The password must contain exactly 9 characters and these characters must be E, R or U. The password is displayed in a scrambled format. It allows HiTECH to decode the password in case it was forgotten.

The password must contain exactly 9 characters and the only usable characters are E, R or U.

	R	E	U
1st character	***I***	***T***	***U***
2nd character	***T***	***J***	***Z***
3rd character	***I***	***T***	***U***
4th character	***Q***	***F***	***V***
5th character	***R***	***E***	***U***
6th character	***R***	***E***	***U***
7th character	***Q***	***F***	***V***
8th character	***R***	***E***	***U***
9th character	***Q***	***F***	***V***

The above table can be used to decode the password.

8.5.16 WATCH STATUS

Displays the status of the device.

Tank Full
Tank Empty
Level Lost
EEPROM Error
RAM Error
ROM Error
Digitising Error
Gain Error
Offset Error
Positive Voltage Error
Negative Voltage Error
VCO1 Voltage Error
VCO2 Voltage Error
Checksum Error Bank Customer 0
Checksum Error Bank Factory 0
Checksum Error Bank Customer 1
Checksum Error Bank Factory 1
Delay out of limits
Reference Not Found
Flange Not Found
Reference Lost
First Start
Error reprogramming FPGA
Error Parity FPGA

Each status is explained in sections 8.2 and 8.3.

8.5.17 Display of the PC program (PC STAR 2)

Language of displayed texts

Choose one of the following languages for the display ;

- GB/USA : English
- D : German
- F : French

8.5.18 Hardware test

At each start up, the LL 102 executes automatically a hardware test. Several voltage values as well as other tests of the audio signal are performed.

During normal operation, the LL 102 performs real time tests in order to guarantee a correct and reliable operation. In case of an unlikely problem within the electronics, the LL 102 records into a non-volatile memory. The function watch status can be used to access this memory.

8.6 Warning and error messages during configuration

Status Message	Meaning
Invalid selection	Non valid item was chosen
Entered parameter too large	Value too large
Entered parameter too small Too few data bytes	Value too small There were not enough bytes transmitted received
In write protect mode	Write protected
Update failure	Measurement failure of the BM 102
Lower range value too high	Lower range value must be smaller
Applied process too high	Message appears when the PV range values are not adapted (method Apply values)
Not in proper current mode	Appears if the current output is not fixed when we execute method DAC Trim
Cannot change active password	Appears in the case the password is incorrect
Table non dull	Appears if the volume table is not dull
Lower range value too low	Lower range value must be bigger
Applied process too low	Message appears when the PV range values are not adapted (method Apply values)
Upper range value too high	The value of the range is incorrect. Upper range value must be smaller
Multidrop mode	Appears in multidrop mode when wanting to fix a value on the current output. In this mode it is not possible to set the current output to certain value
Illegal password symbol	The characters of the passed password are incorrect. They must be 'E', 'R' or 'U'
Upper range value too low	Upper range value must be higher
Invalid units code	The unit is not supported by the BM 102
Invalid function	The result of the function is incorrect.
Invalid password	Specialist menu blocked because the password is incorrect.
Access restricted	This message appears when trying to modify a parameter and the customer password is enabled.
Invalid range units code	Appears if the unit of the range is incorrect
Device busy	Appears when the device is in search mode or if it is executing a function.
Not implemented	Appears if the command sent to the device is not implemented in the device.
First Parameter too high (first member of the pair too high) First Parameter too low (first member of the pair too low) Second Parameter too high (second member of the pair too high) Second Parameter too low (second member of the pair too low)	Some parameters are handled in pairs. The two items are updated at the same time when one of the following messages appears and one of the items is incorrect. These pairs are : • Tank height / Probe length • Dead zone / Detection delay • Threshold value / Threshold distance • Optional unit name / Optional unit factor • Offset of measure / Period of measure • Electronics Calspeed / mechanical calspeed • Epsilon R / "Set value" of Electronic offset

8.7 Warning messages during measurement

Message	Meaning
Configuration Changed	Configuration parameter was changed.
More Status Available	Command 48 must be executed to detail the status better. (menu Watch Status)
Primary Variable Analog Output Fixed	Is displayed when: • Device is set in Multidrop Mode (Polling Address ≠ 0) • Fixed Current Mode is entered (during Loop Test and DAC Trim)
Analog Output Saturated	During normal operation the maximum value for the analogue output is 20 mA. The analogue output saturation error flag is set in case the measurement exceeds the signal current output range.
First Start	This message appears only when the serial number is 0 or 16777215. Normally this message can occur only in production before the calibration of the device.
Tank Full	The LL102 indicates that the product level is in the "dead zone", meaning that the tank is full.
Tank Empty	The LL 102 indicates that the level is bellow the probe end. The LL 102 cannot measure down to the tank bottom but only down to the end of the probe.
Level Lost	The LL 102 indicates when it loses the level reflection. This can occur in case there is no reflection with an amplitude higher than the threshold value. Measuring values are frozen. If the mode 4-20 mA / error 22 mA is selected then the current output is fixed to 22 mA after the selected delay time.

8.8 Error messages during start up or measurement

The following list table all error messages that can trigger the current output to be set 22 mA if the mode 4-20/Error22 is selected. Measuring values are then frozen.

Message	Meaning
EEPROM Error	This message can occur during start up of the device (after Hardware tests). If it occurs, there is a problem with the non-volatile memory. Please contact HITECH Service.
RAM Error	This message can occur during the start up of the device (after Hardware tests). If it occurs, there is a problem with the internal micro-controller memory. Please contact HiTECH Service.
ROM Error	This message can occur during the start up of the device (after Hardware tests). If it occurs, there is a problem with the internal micro-controller memory. Please contact HiTECH Service.
Checksum Error Bank Customer 0	This message can occur during the start up of the device (after Hardware tests). If it occurs, there is a problem with the EEPROM or with the function which recalls the parameters saved in the EEPROM. Parameters are saved in a non-volatile memory (EEPROM). There are 4 banks, 2 for each type of parameters (customer or factory). If there is a problem with the first bank (0), then the LL 102 gets the parameters values from the second bank (1). If the LL 102 indicates only a problem with the first bank, it means that it succeeded in getting all the parameters thanks to the second bank. In this case the device can measure.
Checksum Error Bank Factory 0	This message can occur during start up of the device (after Hardware tests). If it occurs, there is a problem with the EEPROM or with the recalling of the parameters saved in EEPROM. Parameters are saved in a non volatile memory (EEPROM). There are 4 banks, 2 for each type of parameters (customer or factory). If there is a problem with the first bank (0), then the LL 102 tries to get the parameters values from the second bank (1). If the LL 102 indicates only a problem with the first bank, it means that it succeeded in getting all the parameters thanks to the second bank. In this case the device can measure.
Checksum Error Bank Customer 1	This message can occur at the start up of the device (after Hardware tests). Refer to Bank 0 and re-start the device several times. If the problem remains then contact HiTECH Service.
Checksum Error Bank factory 1	This message can occur at the start up of the device (after Hardware tests). Refer to Bank 0 and re-start the device several times. If the problem remains then contact HiTECH Service.
Digitizing Error	This message occurs in case of a problem during sampling the audio signal. The electronics doesn't get a valid image of the audio signal. The measurement may be incorrect. Please contact HiTECH Service.
Reprogramming FPGA	Reset of the component FPGA.
Gain Error	This message occurs in case of Hardware problems with the signal front-end amplifier. The error occurs in case one of the 4 amplifications, do not work correctly. Please contact HiTECH Service.
Offset Error	As with the sampling and the Gain errors, this message occurs in case of a problem with the electronic offset of the audio signal. Please contact HiTECH Service.
Positive Voltage Error	Occurs when the +3 Volts power supply is out of limit. Please contact HiTECH Service.
Negative Voltage Error	Occurs when the -3 Volts power supply is out of limit. Please contact HiTECH Service.
VCO1 Voltage Error	Occurs during a problem with the time base. Please contact HiTECH Service.
VCO2 Voltage Error	Occurs during a problem with the time base. Please contact HiTECH Service.
Delay Out of Limits	Occurs during a problem with the time base. Please contact HiTECH Service.
Reference Not Found	Occurs during a problem with the time base. Please contact HiTECH Service.
Flange Not Found	Occurs in the case of a problem with the time base. The error indicates a mechanical problem (bad contact) between the converter's electronic block and the flange connection. Please contact the HiTECH Service Department.
Update failure	Warning message to indicate that the LL 102 is not able to measure.

8.9 Start-up

Please refer to following table in case of problems.

8.10 Faults and symptoms during start-up and measurement

- All possible failures are listed in this section, with a corrective action.
- Please read this section before contacting HiTECH Service.

Fault / Symptom	Cause	Corrective action
Current Output value < 4 mA	The calibration of the current output is incorrect.	Execute the calibration if you have the specialist access or contact HiTECH Service.
	Connection of the device is incorrect.	Check the connection between the device and the power supply.
	No power supply.	
Reads 22 mA.	An error has occurred.	This happens in case the range 4-20 mA / error 22 mA is selected. Check the status of the device by selecting the status window (F8) or enter the status (4.O) menu of the HART® communicator.
	The device is in its start-up phase.	Wait 50 seconds. If the current value drop to a value between 4 and 20 mA, and goes immediately back to 22 mA, consult HiTECH Service.
The value at the current output does not correspond to the value at the display (PC STAR 2 or HART® communicator).	Settings of the current output are incorrect.	Configure output as described in Sect. 8.6.8 (Fct.1.3.0).
Data communication via the digital interface is not working.	The communication parameters of the computer are set incorrectly.	Check computer setting (polling address).
	Bad connection to the interface.	Check connection.
	Current output value is < 4 mA	Consult HiTECH Service.
	Current output value is = 22 mA	LL 102 is in its start up phase, wait 50 seconds and try again. If the problem persists then contact HiTECH Service.

Fault / Symptom	Cause	Corrective action
The LL 102 indicates an incorrect level value.	The LL 102 measures a non-valid reflection.	In the case the indicated level is close to the nozzle, increase the detection delay and the dead zone with the same ratio or increase the threshold level if the full measurement range is essential. In any case use the PC STAR 2 oscilloscope function to visualise and to analyse the application. The threshold level must be adjusted so that it masks the disturbances. It permits also to give enough margin for the level pulse. Very large pulses along the measurement signal (same amplitude as the initial pulse) can be caused by a probe which is touching the nozzle or the tank side (see mounting guideline section).
The tank is empty, and the LL 102 indicates a level.	In case the LL 102 indicates a level, a valid pulse was found. Check the probe for disturbances such as heating tubes or product build up (clogging).	Analyse the signal with PC STAR 2. Simply adjust the threshold (dynamic configuration window). See section (8.5.7)
The tank is full, and the LL 102 indicates a level or empty tank.	The threshold is not adapted.	See section (8.5.7) to adjust it.
The tank is not empty nor full, and the LL 102 indicates an empty or full tank.	The threshold is not adapted.	See section (8.5.7) to adjust it.

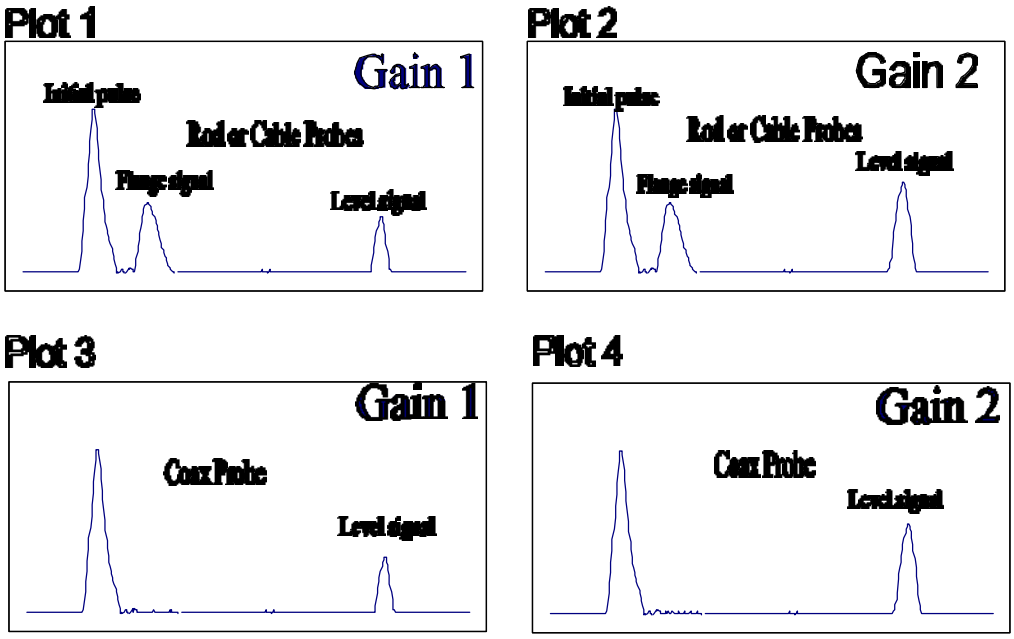
8.11 Oscilloscope Function of PC STAR 2 and Threshold

What's the purpose of the signal oscilloscope of PC STAR 2 ?

This function analyses the position and amplitude of each pulse between the initial pulse and the probe end. It helps in analysing incorrect measurements by visualising the threshold and pulse together.
In case of a measurement problem, do not hesitate to use this function. It visualises all pulses along the probe, including the initial pulse, flange and level pulses (if not empty) and non product reflections!
The signal function of PC STAR 2 helps to adapt measurement-related settings like the detection delay, or the threshold level.
Moreover it helps to understand how the LL 102 works. A screen plot of this function will help in understanding the instrument's application. The signal can be printed or saved as an Excel file and sent by Email.

How to use the Signal Function:

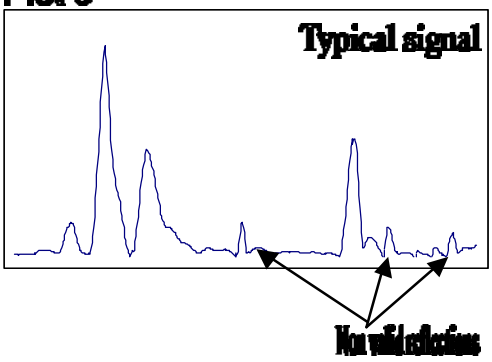
The plots below show typical measurement signals recorded with the PC STAR 2-oscilloscope function. Plot 1 is a signal captured with a rod or a cable probe and an amplification factor of 1 (gain 1). Plot 2 shows the same probe with an amplification factor 2 (gain 2). Plot 3 and 4 are traces recorded with a coaxial probe and the same amplification factors as plot 1 and 2.



The difference between the coax probe and the other probe types is the missing flange pulse. The missing pulse explains why it is advantageous to use a coax probe for applications where a certain dead zone at the top of the probe is not acceptable. The level reflections of the coax probe can move up to the top of the flange without being disturbed by the flange pulse.
The signal plots of both probe types show how the level reflection amplitude changes with two different amplification factors gain 1 and gain 2. Remark that only the amplitude of the level reflections changes but not the amplitude of the initial, neither the flange reflections. Amplification is only applied in the measuring zone.
In certain application, the signal along the probe contains non-valid reflections as shown in the following plot. The reflections can have various origins but have always the characteristic of a real product surface pulse. This means that the non-valid reflections get amplified like real level reflections.

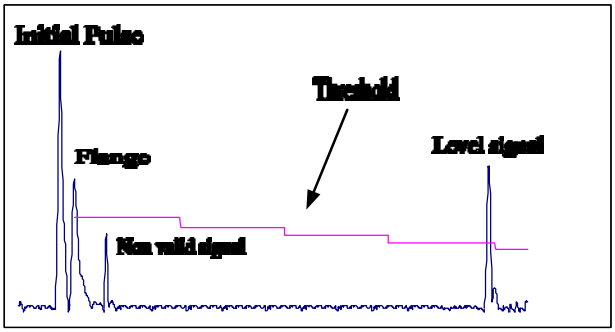
What is the use of the Threshold?

Plot 5



The purpose of the threshold level of the LL 102 is to mask such non-valid reflections.
The threshold level, as shown in plot 6 is not a constant level along probe signal, but an exponentially falling function.
If the amplitude of the threshold level was set at 1 m to 400 mV, it will be reduced to 250 mV at 10 m probe length. The exponentially falling function was chosen because the amplitude of the level pulse as well as the amplitude of the non-valid reflections decrease with the same kind of function, and the amplitude/threshold ratio remains the same along the probe (following the same attenuation curve as the level pulse).
In the case the probe is short (<Ω 3m), the reduction of the threshold amplitude is not very significant.
The factory threshold setting will be suitable in all normal applications. Adjustment is only necessary in situations where the ε_r is very low and installation conditions are difficult.

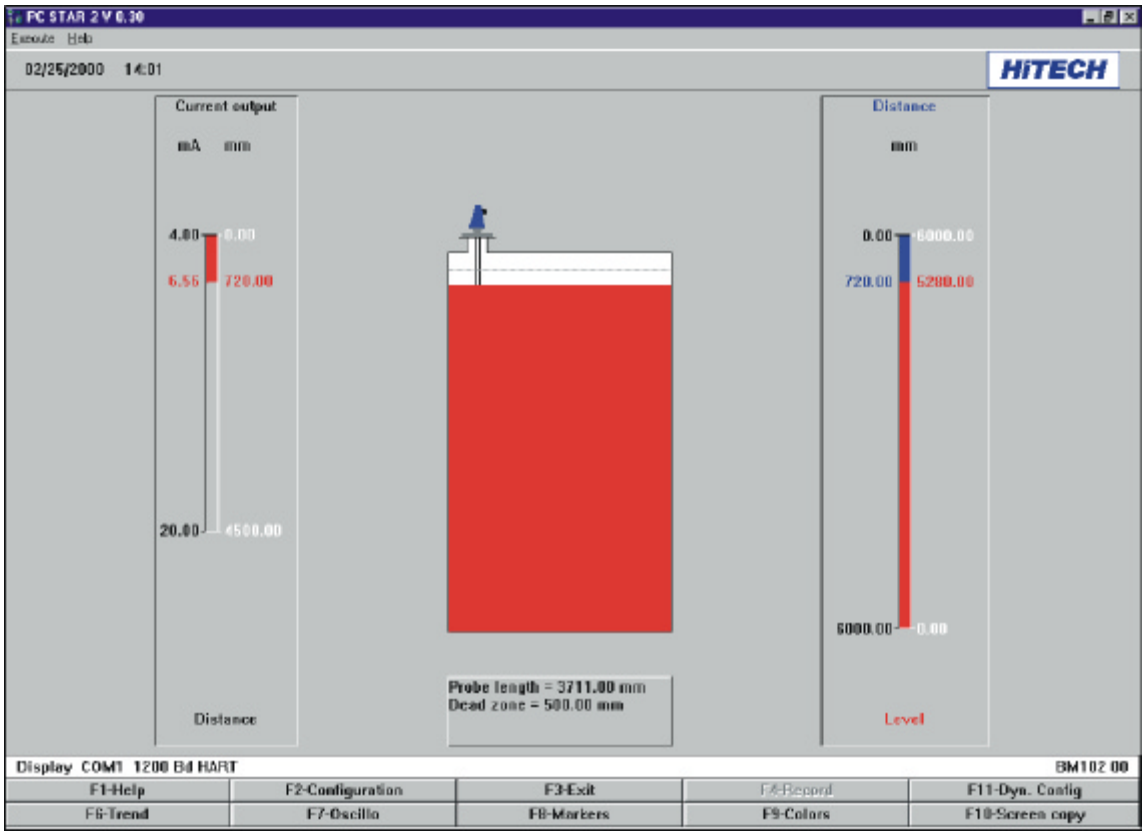
Plot 6

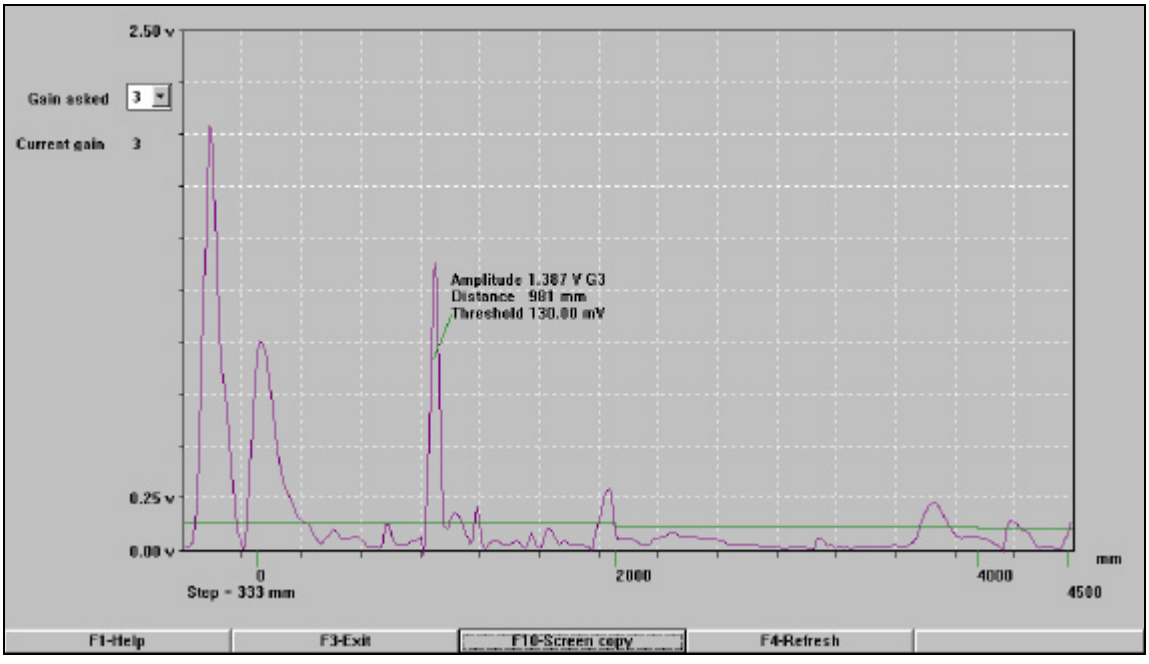


How to use the Threshold?

The smaller the ε_r of the product is, the more important the correct threshold setting will be. In order to adjust the threshold level, it is absolutely necessary to know the product level (reflection amplitude) inside the tank. The ideal point where to make a threshold adjustment is when the product covers about 50 cm the probe end. If the level is to high, the product will mask the non-valid reflection. And if the product doesn't reach the probe end, one won't manage to evaluate the ratio of the level pulse and the non-valid pulses. In this case, The easiest way to adjust the threshold level is to capture a complete trace of the probe signal (trace from the initial pulse down to the probe end) with the oscilloscope function (F7) of the PC STAR 2 software.
The threshold level is adjusted correctly so that all non-valid reflections are below and the product surface pulse is above the threshold level. If possible, the threshold level should be half way between the non-valid signal and level signal. If the ε_r of the product is low, it is possible that the pulse of the probe end is visible too on the screen. This pulse does not have to be masked by the threshold level (as it will be seen moving further away in time as the product level increases). Adjust now the threshold level according the different pulse amplitudes. It is advised to keep a margin between the threshold level and the pulse amplitudes in order to cope with possible fluctuations in terms of amplitude. The amplitude of the product reflection increases with increasing level, and vice-versa.
In case the threshold level was adjusted to a value higher than the product pulse, the LL 102 will not find the pulse, even after changing the amplification factor. In case the threshold level was adjusted too low (below non-valid pulse amplitude level), the LL 102 will find a non-valid pulse next time the product level drops below the probe end.

The minimum threshold is 50 mV at gain factor 3.


PC STAR 2 V 0.30
Execute Help
02/25/2000 14:01
HITECH
Current output
mA mm
4.00 0.00
6.56 720.00
20.00 4500.00
Distance
Distance
mm
0.00 6000.00
720.00 5280.00
6000.00 0.00
Level
Probe length = 3711.00 mm
Dead zone = 500.00 mm
Display COM1 1200 Bd HART
BM102 00
F1-Help
F2-Configuration
F3-Exit
F4-Report
F11-Dyn. Config
F6-Trend
F7-Oscillo
F8-Markers
F9-Colors
F10-Screen copy


2.50 v
Gain asked 3
Current gain 3
Amplitude 1.387 V G3
Distance 981 mm
Threshold 130.00 mV
0.25 v
0.00 v
0
Step = 333 mm
2000
4000
4500
mm
F1-Help
F3-Exit
F10-Screen copy
F4-Refresh

8.12 Calculation of the measured value

BM 102 measures the time between reflections and converts it into a distance or a level value with the following formulas:

Delta T = (Time between Initial Pulse and Level Pulse) / 2 (µS)
Calspeeds = (Electronic Calspeed) * (Mechanic Calspeed) (µS/mm)
Offset = Distance between Initial pulse and bottom surface of the flange (mm)
Ɛr = Dielectric constant of first medium under the flange, normally 1.00.

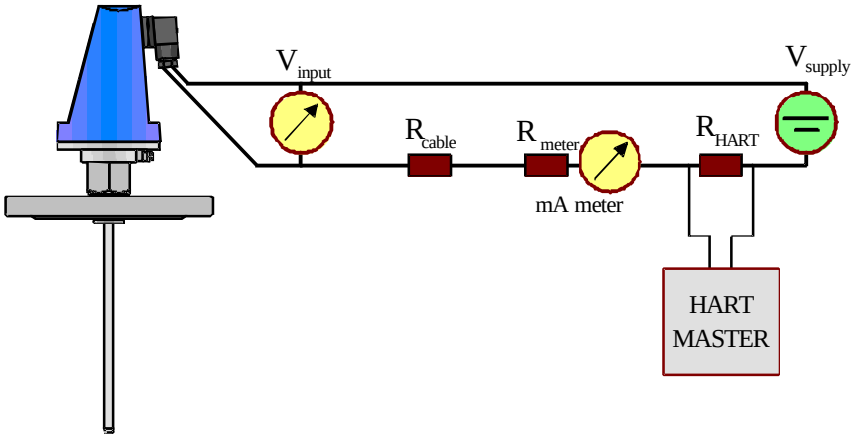
$$\text{Distance} = \frac{\frac{\text{DeltaT}}{\text{Calspeeds}} - \text{Offset}}{\sqrt{\varepsilon_r}}$$

$$\text{Level} = \text{Tank Height} - \text{Distance}$$

The measured time between the initial pulse and the level pulse is translated into length by the Calspeeds product. This primary distance is corrected by the offset and is thus standardised to the reference point (= flange). This primary distance is divided by the square root of ε_R (if there is only one product in the tank, the εr is 1.00 (air)).
The level is calculated as the difference between tank height and distance. All items of information (excepted Delta T) can be accessed via the digital communication.

9. Power supply

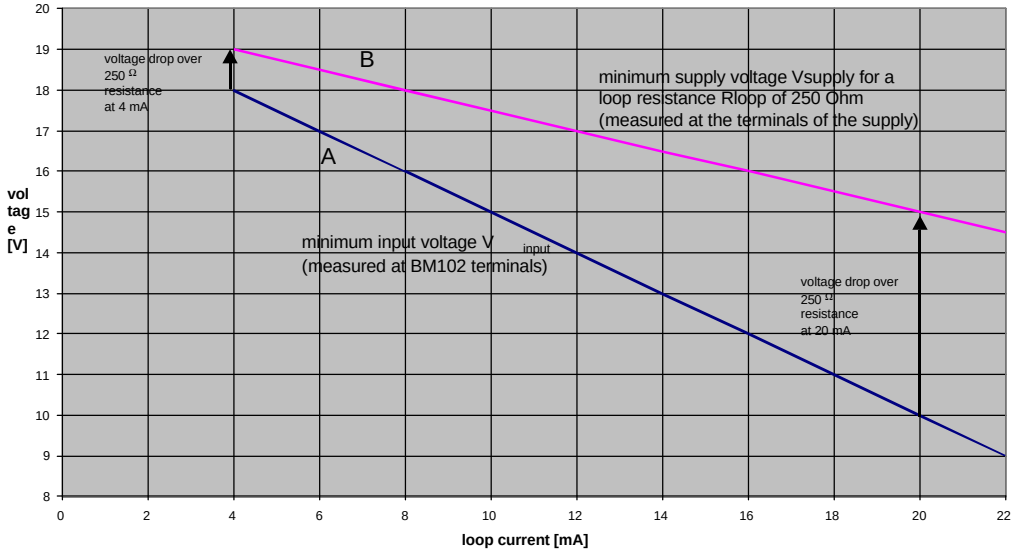
9.1 Technical data



nominal power supply voltage V_{input}	24 VDC
maximum V_{input}	35 VDC
minimum V_{input}	see graph below

Input voltages above 35 VDC may damage the instrument. Furthermore, input voltages above 35VDC or below the specified voltage may cause a faulty measurement or may trigger the instrument to reset cycles.

loop resistance R_{loop}	$R_{HART®}$ + R_{cable} + R_{meter}
minimum R_{loop}	0 Ω
maximum R_{loop}	750 Ω
HART® communication resistor $R_{HART®}$	250 Ω (recommended)



The function A in the diagram above specifies the minimum voltage at the terminals of the LL 102. The voltage drop over the total loop resistance (Ampere-meter resistance R_{meter} plus wiring resistance R_{cable} plus HART® communication resistance $R_{HART®}$) has to be taken in consideration for the calculation of the minimum power supply voltage. Function B gives an example of a voltage drop caused by a 250 Ω resistance. The voltage of the power supply has to be at a loop current of 20 mA at least:

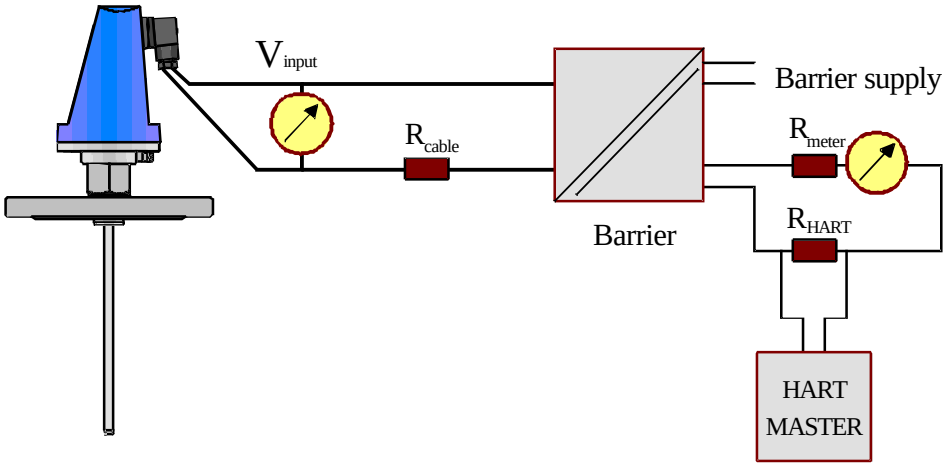
$$V_{supply\ min20} = 20\ mA * 250\ \Omega + V_{input\ min20} = 5\ V + 10\ V = 15\ V$$

In order to cover the full current range of 4 to 22 mA the voltage drop at 4 mA has to be verified.

$$V_{supply\ min4} = 4\ mA * 250\ \Omega + V_{input\ min4} = 1\ V + 18\ V = 19\ V$$

This means that with a loop resistance of 250 Ω a power supply voltage of 19 V will be sufficient to cover the 4 to 20 mA range of the instrument.

9.2 4 to 20 mA converters



Function A in the graph above (chapter 9.1) can be also used to find out whether a certain 4 to 20 mA converter is adequate for the operation with the LL 102.

Most of the converters are specified to deliver a minimum output voltage at 20 mA loop current $V_{out\ min20}$. This voltage must be above function A at 20 mA loop current, means greater than 10 V. The second condition for the converter is the output voltage at 4 mA. Either it is specified too or it can be calculated with the value of the internal series converter resistance.

It is important to use only converters, which are equipped with a SMART function. Neither the PCSTAR software nor the HART® communication run when the converter is not equipped with this option.

9.3 Sunshade

If the device is exposed direct sun exposition a sunshade is recommended.

9.4 Ex Applications

Ex approved LL 102 instruments must be used with certified Ex equipment only. The maximum electrical safety values of the LL 102 that are listed on the data plate must be respected in any circumstances. The minimum voltage supply values that are described in 9.1 must be respected for the proper functionality of the LL 102. Furthermore, the connected equipment must be HART compatible in order to use communication software or the HiTECH Connect communicator.

10. Certificates and approvals

10.1 CE Manufacturer's declaration

DECLARATION OF CONFORMITY

We, **HiTECH Technologies, Inc.**
301 Oxford Valley Road
Yardley, PA 19067-7706 USA

declare on our own responsibility that the product

LL 102 24V DC

to which this declaration refers, is in conformity with the following standards:

- EN 50081 - 1 : 1993 - 3
- EN 50082 - 2 : 1995 - 3
- EN 50178 : 1994 - 8
- EN 61010 - 1 : 1993 - 4

in accordance with the provisions of Directives 89 / 336 / EEC and 73 / 23 / EEC.

11. Order information

Technical information relevant to the order

HiTECH SHORT PULSE LL 102

- Process connection or flange:..... _____
- Sensor material:..... _____
- Seal:..... Viton Kalrez Other _____
- Sensor type:..... :_____
- Power supply: ..... 24V DC Standard 24 V DC Exi Brand :
- Sensor length
- Connection..... DIN connector M16 Connector

Special items

Additional calibration

Others: ..... _____

12. External standards, codes and directives

EN 500014: 1977 (VDE 0170/0171 part 1/1.87). Electrical apparatus for potentially explosive atmospheres; General requirements

EN 500020: 1977 (VDE 0170/0171 part 7/4.92). Electrical apparatus for potentially explosive atmospheres; Intrinsic Safety "i"

DIN **VDE 0170/0171** part 13/11.86. Requirements for equipment of Zone 10 [in German}

DIN **EN 50081-1** (VDE 0839 part 81-1): 1993-03. Electromagnetic compatibility (EMC); General emission standard, Part 1: Residential, commercial and light industry

EN 50082-2: 1995-03. Electromagnetic compatibility; generic immunity standard, Part 2: industrial environment

NAMUR Recommendation for the interference immunity of electronic devices (EMC), 18-05-1999 [in English}

DIN **EN 61010-1** (VDE 0411 part 1): 1993-04. Safety requirements for electrical equipment for measurement, control and laboratory use; General requirements [in German]

Directive 89/336/EEC (**CE** marking)

13. Quality assurance

- DIN ISO 9001 / EN 29001

Annex A: Technical specifications

1	**Range of application**	Distance, level, volume and reflection measurement of liquids, slurries, solids and particulate material on storage and process tanks or containers made of metal or concrete, and also in stilling wells	
2	**Mode of operation / system structure**	HiTECH Short Pulse TDR, with digital signal processing; compact device, modular design	
3	**Input**		
	Measured variable	Primary variables: distance, reflection; derived variables: level, volume	
	Measuring range	Min. tank height: 0.15 m Max. measuring range: 24 m	
	Rate of change in level	≤ 10/min	
4	**Output**		
	Ex-ia current output HART®	Type: Current range: Temperature drift: Accuracy/linearity: Supply voltage 2: Load impedance: Max. electrical values Same characteristic	Passive (current sink); 4-20 mA (error 22 mA); 4 mA constant for HART®-Multidrop ≤ 0.02 % / °K 0.05 % (rel. 20 mA; 25°C) 20-30 V (terminals 1 and 2 see 9. Power supply). 0 – 750 Ω see certificates
5	**Measuring accuracy**		
	Error of measurement Repeatability Measured-value resolution	Reference conditions and error curves: see Sect. 5.1 and 5.2 ≤ 0.5 × error of measurement LL 102: 1 mm.	
	Effect of ambient temperature	No significant effect on measured value(1 ppm / °K); (see also signal output accuracy).	
6	**Operating conditions**		
6.1	**Installation conditions**	Avoid interference reflections and multiple reflections	
6.2	**Ambient conditions**		
	Hazardous locations CENELEC	Approvals for: 1G EEx ia IIC T6…T3 1G EEx ia IIB T6…T3 1/2 D T 100°C EEx ia	
	Ambient temperature at signal converter	-20°C to +55°C	
	Product temperature	-50°C to + 90°C High Temp version up to 250º C	
	Environment class	Locations exposed direct to open-air climate, D1 Severity in conformity with EN 60654-1	
	Protection category	(signal converter) IP65	
	Shock resistance	Impact test according to EN 61010, Sect. 8.2 with 0.5 J energy; drop test to prEN 50178	
	Vibration endurance limit	IEC 68-2-6 and prEN 50178 (10-57Hz:0.075mm/57-150 Hz:1g)	
	EMC	EN 50081-1, EN 50082-2	
6.3	**Product conditions**		
	Physical properties	No effect on measurement results; to ensure reliable measurements, the relative permittivity (ε_r) should have the following minimum values:	
	Relative permittivity	$\varepsilon_r \geq 1.5$; for coax probes $\varepsilon_r \geq 1.8$; for twin cable probes $\varepsilon_r \geq 2.3$; for mono cable probes	
	Limitations	Sticky products	
	Operating pressure	Standard: max. 4 bar (higher on request)	
	Electrical connection	DIN Connector. PG 13.5	
	User language	German, English, French	
	Units of measurement	Length: m, cm, mm, inch, ft, % Volume: m³, Liter, US Gal, GB Gal, ft3, bbl, % Conversion unit: any text	
7	**Design**		
8	**User interface**		
9	**Power supply**		
	24 V DC	20-30 V DC	
	Power consumption	Typically <70 mW.	

Annex B: Type code / nameplates

Type code

See nameplate on signal converter (blanks and slashes may be omitted)

VF03 / X /. / . / . / . / . / . / . / . / . / . / . / . / . / . /
1 2 3 4 5 6 7 8 9 10 11 12 13 14

1: Order code of LL 102

2: Probe type of instrument

0	without
1	single rod
2	single cable 4 mm
3	coax
4	twin cable
5	revers
6	single cable 8 mm
7	double tige

3: Material of probe

0	without
1	316
2	316L
3	HC276
4	HC22
5	FEP coated
6	PVDF(non E.x)
7	PVC (non E.x)

4: Process connection

0	without
1	1"G
2	1"NPT
3	1" ½ NPT
5	DN50, PN40
6	DN80, PN16
7	DN100, PN16
8	DN150, PN16
A	2" 150 lbs
B	2" ½ 150 lbs
C	3" 150 lbs
D	4" 150 lbs
E	6" 150 lbs
N	SMS DN38
P	DIN 11851 DN40
R	Tri-clamp DN40

5: Probe length meter

0	without
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
A	9
B	10
C	11
D	12
E	13
F	14
G	15
H	16
K	17
L	18
M	19
N	20
P	21
R	22
S	23
T	24

6: Probe length 100 mm

0	without
1	100
2	200
3	300
4	400
5	500
6	600
7	700
8	800
A	900

7: Pressure

0	without
1	16 bar
2	40 bar

8: Sealing

0	without (max. 4bar)
1	Viton
2	Kalrez

9: Counter weight

0	without
1	Standard
2	Twin cable
3	Powder weight
4	Hastelloy weight 276
5	Turnbuckle
6	Ring
7	Hastelloy 22

10: Cable gland

0	without
1	DIN
2	M16
3	M16 with 1/2" NPT connector

11: Application

0	without
1	Liquids
2	Powders

12: Approval

0	without
1	CENELEC (zone 0 and 2)
2	FM
3	CSA

13: Precision

0	without
1	Standard
2	+/- 5 mm

14: Temperature

0	without
1	standard 90°C
2	135°C

Annex D: Signed declaration to accompany a device returned to HiTECH Technologies, Inc.

If you need to return level gauges for testing or repair
to HiTECH Technologies, Inc.

If installed and operated in accordance with these operating instructions, your level gauges will rarely present any problems.

Should you nevertheless need to return a device for inspection or repair, please pay strict attention to the following points.

Due to statutory regulations concerning protection of the environment and the health and safety of our personnel, HiTECH can only handle, test and repair returned level gauges that have been in contact with products which do not pose a risk to personnel and environment. This means that HiTECH can only service your unit if it is accompanied by a certificate in line with the following model confirming that the device is safe to handle. If the unit has been operated on toxic, caustic, flammable or water-endangering products, you are kindly requested

- to check and ensure, if necessary by rinsing or neutralising, that all cavities are free from such dangerous substances,
- to enclose a certificate with the level gauge confirming that it is safe to handle and stating the product used.

HiTECH regrets that service can not be performed on your level gauge unless such a certificate accompanies it.

S P E C I M E N certificate

Company: ..... Address: .....

Department: ..... Name: .....

Tel. No.: .....

The enclosed level gauge

LL 102: ..... HiTECH Order No. or Series No.:
.....

has been operated with the following
liquid.....

Because this liquid is

water-endangering * / toxic * / caustic * / flammable *

We have

- Checked that all cavities in the unit are free from such substances *

- Flushed out and neutralised all cavities in the unit *

(* delete where not applicable)

We confirm that there is no risk to man or environment through any residual liquid contained in this level gauge.

Date: ..... Signature: .....

Annex E: Tables on documentation of device configuration

CHECK LIST PARAMETERS LL 102.....to: .....Date:					
Device No. ..... : **Comm. No.**.....:					
Location ..... :					
Contact person ..... : **Telephone** .... :					
Remarks:					
....					
Menu item..... Changed on .....**:** ..... : ..... :					
Fct.	Configuration parameters (customer)				
1.1.1	**Tank height**..... **:** .....**:** ..... **:** .....**:**				
1.1.2	**Dead zone** ..... **:** .....**:** ..... **:** .....**:**				
1.1.3	**Time constant**..... **:** .....**:** ..... **:** .....**:**				
1.1.6	**Probe length**..... **:** .....**:** ..... **:** .....**:**				
1.2.4	**Length unit**..... **:** .....**:** ..... **:** .....**:**				
1.2.6.1	**Unit name** ..... **:** .....**:** ..... **:** .....**:**				
1.2.6.2	**Unit factor**..... **:** .....**:** ..... **:** .....**:**				
1.2.5	**Volume unit**..... **:** .....**:** ..... **:** .....**:**				
1.3.1	**Current output, function** ..... **:** .....**:** ..... **:** .....**:**				
1.3.2	**Current output, range/error** ..... **:** .....**:** ..... **:** .....**:**				
1.3.3	**Min. scale for current** ..... **:** .....**:** ..... **:** .....**:**				
1.3.4	**Max. scale for current**..... **:** .....**:** ..... **:** .....**:**				
1.3.5	**Error delay**..... **:** .....**:** ..... **:** .....**:**				
1.4.4	**Tag name** ..... **:** .....**:** ..... **:** .....**:**				
1.5.1	**Detection delay** ..... **:** .....**:** ..... **:** .....**:**				
1.6.2	**Address** ..... **:** .....**:** ..... **:** .....**:**				
	Threshold..... **:** .....**:** ..... **:** .....**:**				
Fct.	Configuration parameters (factory)				
1.1.1	**Probe type**..... **:** .....**:** ..... **:** .....**:**				
1.1.2	**Offset of measure**..... **:** .....**:** ..... **:** .....**:**				
1.1.3	**Application type** ..... **:** .....**:** ..... **:** .....**:**				
1.1.4	**Epsilon R**..... **:** .....**:** ..... **:** .....**:**				
2.1	**Set value of electronic offset** ..... **:** .....**:** ..... **:** .....**:**				
2.4	**Electronic Calspeed**..... **:** .....**:** ..... **:**				
2.5	**Mechanic Calspeed** ..... **:** .....**:** ..... **:** .....**:**				
2.6	**Reference frequency** ..... **:** .....**:** ..... **:** .....**:**				

Fct.	Strap table configuration (20 points)	
Point 0	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 1	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 2	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 3	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 4	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 5	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 6	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 7	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 8	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 9	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 10	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 11	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 12	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 13	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 14	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 15	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 16	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 17	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 18	**Level**..... **:** .....**:**	**Volume**... **:** .....
Point 19	**Level**..... **:** .....**:**	**Volume**... **:** .....

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