Laser Distance Measuring Systems

LRFS-0040

User Manual

Dear User

You are advised to read this User Manual carefully before you start using the LRFS-0040 laser distance measurement module.

This is necessary to ensure that you will be able to utilize all the capabilities which your new acquisition provides.

This technology is subject to continuously ongoing development.

NOTE

Table of Contents

1. General

The LRFS-0040 laser distance measurement module is designed for mobile and stationary distance measurement.

Particular features are:

- Operation under extreme outdoor temperatures with high accuracy and great reach
- Great range of operating voltages (10 V= to 30 V=) from on-board vehicle supply, a direct voltage industrial supply net or a DC power pack
- Small stable power consumption <1.5 W (without I_{Alarm})
- Up to 30 m reach for distance measurement, and more than 100 m reach with additional reflectors[1] mounted onto target (depending on reflectance and environmental conditions)
- Simple sighting with visible laser beam
- Flexible extendible interface cable for voltage supply, bidirectional data interface, switching output and analog output
- Input of commands for available measuring functions and output of measured readings via PC or laptop
- Switching output and analog output are separately programmed and with different parameters
- Positive and negative excession of distance is signalled with adjustable distance barrier at switching output
- Measured values are displayed in meters, decimeters, centimeters, feet, inches, etc. due to free scaling
- Option for remote triggering of measurement from external trigger device

[1] 3M, Typ 3270, 3290, 5290

2. Safety Instructions

These safety and operating instructions should be carefully read and followed during operation and handling of the LRFS-0040.

There is danger from laser radiation or electrical shock!
For repair work, the LRFS-0040 may not be opened by anyone other than Manufacturer personnel or expressly authorized and duly instructed persons. Please note that dangerous high voltage and laser radiation is present in the inner product space.

Compliance with the prescribed operating conditions is necessary.

Failure to observe advice or information contained herein or non-conforming usage of the LMC-J-0040 may cause physical injury to operating personnel or material damage to the measuring module.

To operate the LRFS-0040, use only 10 V to 30 V direct voltage supply in all cases.

Important operating advice

To be able to fully utilize the system's capabilities, you should strictly follow these rules:

- Do not operate the module if there is fogging or contamination on optical parts.
- Do not touch the module's optical parts with bare hands.
- Use caution when removing dust or soiling from optical components.
- Prevent exposure to shock impacts during transportation and operation.
- Prevent overheating of the module. Do not expose the module to direct sun radiation while it is stored in a motor vehicle.
- The LRFS-0040 is splashproof and dustproof as required under IP 65 internal protection standards.
- The LRFS-0040 laser distance measurement module is a class 2 laser product under DIN EN 60825-1:2001-11.

Warning:
There is class 2 laser radiation when the cover is removed. Do not look into the beam!

3. Performance Data

Measuring range[2]:	0.2 m to 50 m with natural surfaces, more than 100 m achievable depending on target reflectance
Measuring accuracy[3]:	± 3 mm, ± 2 mm under defined measuring conditions[4], in a distance range from 0.2 to 30 m
Meas. value resolution:	0.1 mm, user scalable
Measuring rate[5,6]:	typically 5 Hz (up to 10 Hz possible[7])
Laser divergence[8]:	0.6 mrad
Operating temperature[9]:	- 10 °C to + 50 °C
Storage temperature:	- 20 °C to + 70 °C
Supply voltage:	10 V to 30 V direct voltage
Power consumption:	depending on operating mode < 0.4 W for standby, < 1 W for distance tracking
Data interface[10]:	RS 232/RS 422, baud rate: 2400 to 38400, format: 8N1 (fixed)
Digital switching output:	programmable switching threshold and hysteresis, "high-side switch", rated for max. load of 0.5 A
Analog output:	4 mA to 20 mA current output, programmable distance range limits, load resistance ≤ 500 Ω, accuracy: ± 0.15%, Temperature drift: < 50 ppm/°C
Trigger input:	external triggering, 5 V pulse height, trigger flank adjustable, trigger delay adjustable
Eye safety class:	laser class 2 under DIN EN 60825-1:2001-11
Wavelength:	650 nm (visible)
Dimensions (L x W x H):	182 mm x 96 mm x 50 mm
Weight:	850 g
Internal protection class:	IP 65

[2] dependent on target reflectance, straylight influences and atmospheric conditions
[3] typical measuring accuracy under average conditions within specified measuring range
[4] you should consult the Manufacturer or your local distributor!
[5] reflection coefficient ρ: > 20%
[6] for measurement of a planar white target surface that is orthogonal to the direction of sighting
[7] with defined stable environmental conditions
[8] at 10 m distance the beam diameter is 6 mm, at a distance of 100 m it is 6 cm
[9] in single-shot mode
[10] convertible, conversion to be carried out by certified personnel

4. Working Principle

The LRFS-0040 works based on comparative phase measurement. To achieve this, it emits visible laser beams in different frequencies. The target being measured returns diffusely reflected light that is subse-quently compared with a reference signal. Finally, a microprocessor uses the recorded phase shift to calculate a required distance with mm accuracy.

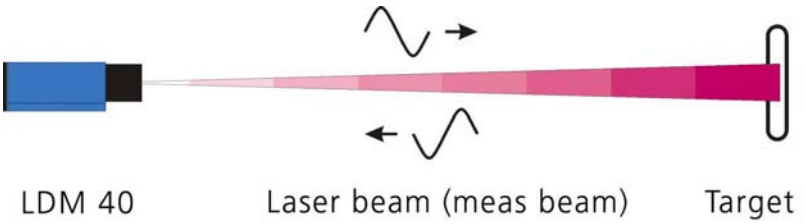

Figure 1 Working principle

A distance measurement can be triggered in different ways:

- manually at the PC with terminal program
- automatically after parametrization of autostart command
- continuously by selecting distance tracking mode
- remotely controlled with external triggering

For a description of these trigger options, refer to → sections 9 "Parameters" and → 10 "Functions" of this Manual.

5. Setup

The laser distance measurement module is shipped together with an interface cable (about 2 m in length) and a User Manual in a padded cardboard box which can also be used for safe transportation of the LRFS-0040.

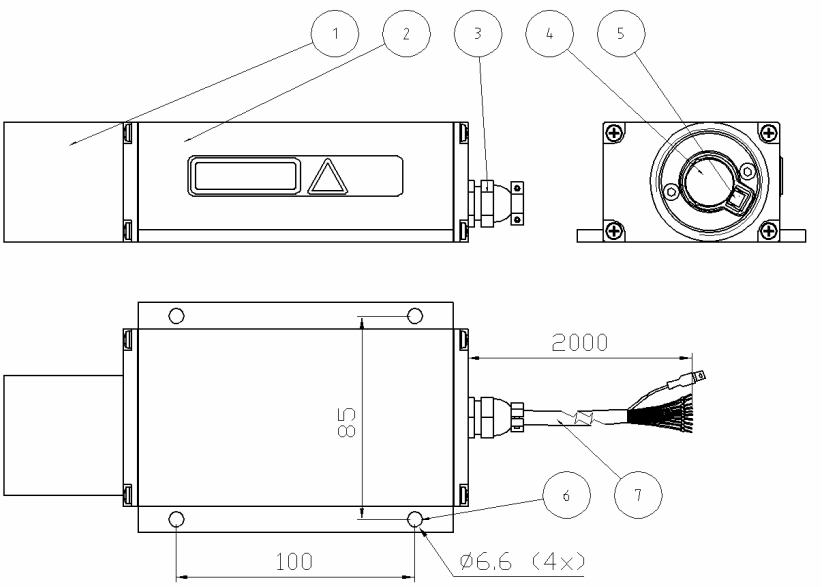

Figure 2 Technical drawing

1	Choke at front cover
2	Casing
3	Gland seal for feedthrough of interface cable in back cover
4	Receiver optics
5	Transmitter optics
6	Holes for mechanical attachment (four)
7	Interface cable

The casing consists of a robust, non-corroding continuously cast aluminum part with front and back cover, also non-corroding. The baseplate contains four holes for mechanical attachment of the LRFS-0040 (→ Figure 2 Technical drawing).

To protect the optical components from dust, physical contact, mechanical impacts, etc., a choke is fixed to the casing. Depending on the customer's request, the LRFS-0040 may be shipped with a choke of any greater length or with no choke at all[11]. In the event of unqualified choke removal, measurement can no more be warranted to function correctly!
The back cover contains a feedthrough port for the interface cable (2 m in length) as required by IP 65 standards.
Where local conditions necessitate a greater distance between the actual measuring location and the PC / voltage supply, an extended interface cable[12] can be provided. You should however consult us in any case before you start working under modified operating conditions!

[11] please get in touch with your contact person!
[12] may deviate from interfacing specifications!

6. Interface Cable Wire Assignments

⚠ Caution: The cable ends are uncovered! It's the user's responsibility to prevent shorts!

Interface cable wiring assignments are as follows:

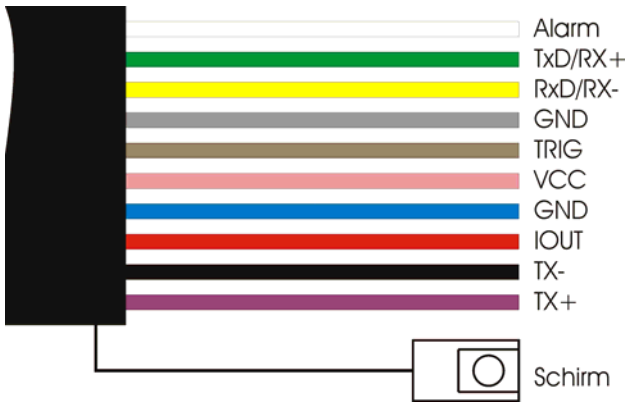

Figure 3 Interface cable color codes

No.	Color code	Designation	Function if RS232	Function if RS422
1	white	ALARM	Digital switching output	Digital switching output
2	green	TxD / RX+	RS 232 send data	RS 422 receive data +
3	yellow	RxD / RX-	RS 232 receive data	RS 422 receive data -
4	gray	GND	Ground potential	Ground potential
5	brown	TRIG	External synchronization	External synchronization
6	pink	VCC	Supply voltage	Supply voltage
7	blue	GND	Ground potential	Ground potential
8	red	IOUT	Current output	Current output
9	black	TX-		RS 422 send data -
10	violet	TX+		RS 422 send data +

The GND wires are internally combined to serve as reference potential for all voltage values specified below.
If data transfers are accomplished via RS 232, we recommend using cable 4 (gray, GND) as signal ground and cable 7 (blue, GND) as supply ground!

The limiting values for voltages, load rates and logic levels are identical with those specified for RS 232 or RS 422 operation.
All outputs are sustained-short-circuit-proof.

7. Limiting Values for Voltages

Input voltages:

Terminal point	Voltage	Comment
VCC	30 V	pole-reversal-protected
TxD	± 13.2 V	short-circuit-proof
RxD	± 25 V	short-circuit-proof
TX+	± 14 V	short-circuit-proof
TX-	± 14 V	short-circuit-proof
RX+	± 14 V	short-circuit-proof
RX-	± 14 V	short-circuit-proof
TRIG	± 25 V	short-circuit-proof

Output voltages:

Terminal point	Voltage	Comment
TxD	± 5.4 V	± 5 V at 3 kΩ load
TX+, TX-	≥ 2V	differentially at 2 x 50 Ω load
Alarm	≥ VCC – 2 V	

All outputs are sustained-short-circuit-proof.

8. Starting Up

Protect all cable ends against short-circuit effects before you turn voltage supply on!

Necessary cable connections must be established in accordance with table specifications on the previous page.

You require a PC with corresponding data interface port and a terminal program to perform start-up of the LRFS-0040.

For starting up, the LRFS-0040 needs to be installed at the measuring site, aligned until pointing to a desired target, and kept stable in this position. The target should preferentially have a homogeneous white surface.

Caution: Do not use any retroreflectors!

Alignment of the LRFS-0040 is facilitated by a laser beam[13] that is visible and can easily be turned on at the PC.

Operating voltage supply must be connected to the corresponding ends of the interface cable. A pole-reversal protection is integrated to prevent the destruction of electronic components.

[13] depending on ambient light and target conditions

9. Parameters

A comprehensive set of LRFS-0040 configuration functions can be triggered at the PC. This variety provides the user with a broad range of potential applications.
By selecting ID[Enter] command, you may call up the menu with available setup commands.

LRFS-0040, s/n xxxxxx, V x.xx

DT[Enter].....distance tracking
DF[Enter].....distance tracking with external trigger
DW[Enter].....distance tracking on white target
DM[Enter].....distance measurement TP[Enter].....internal temperature [C]
SA[Enter] / SAxx[Enter]..display / set average value [1..20]
SD[Enter] / SDd[Enter]...display / set display format [d/h]
ST[Enter] / SAxx[Enter]..display / set measure time [0..25]
SF[Enter] / SFx.x[Enter].display / set scale factor
AC[Enter] / ACx.x[Enter].display / set ALARM center
AH[Enter] / AHx.x[Enter].display / set ALARM hysteresis
RB[Enter] / RBx.x[Enter].display / set distance of Iout=4mA
RE[Enter] / REx.x[Enter].display / set distance of Iout=20mA
TD[Enter] / TDxx x[Enter]display / set trigger delay [0..9999ms] trigger level [0,1]
BR[Enter] / BRxxxx[Enter]display / set baud rate [2400..38400]
AS[Enter] / ASdd[Enter]..display / set autostart command
OF[Enter] / OFx.x[Enter].display / set distance offset
LO[Enter].....laser on
LF[Enter].....laser off
PA[Enter].....display settings
PR[Enter].....reset settings

This allows you to optimally match the measuring module's performance to a particular measuring site environment and sighting task, which is achieved by intelligent parametrization before measurement actually begins.

Your parameter setups will be preserved after the LRFS-0040 has been shut down!
They can only be changed by selecting a new value or initializing the standard parameter set.

Parameter	Abbreviation	Relevance
Distance tracking	DW	Distance measurement
Mean value	SA	Distance measurement
Output format	SD	Distance measurement
Time to measure	ST	Distance measurement
Scale factor	SF	Distance measurement
Alarm center	AC	Digital switching output
Alarm hysteresis	AH	Digital switching output
Range Begin	RB	Analog output
Range End	RE	Analog output
Trigger delay	TD	External triggering
Baud rate	BR	All serial communications
Autostart	AS	Behavior on turning the LRFS-0040 on
Distance offset	OF	Distance measurement

- Distance Tracking (DW)
  For a constant measuring rate of 10 Hz, a white target board must be affixed to the target.

- Mean Value (SA)
  For a specified range, the mean value is obtained as follows:

$$\text{Mean value } x = \frac{x_1 + x_2 + x_3 + \ldots + x_{n\ (20)}}{n}$$

- Distance Value Output Format (SD)
  For output of measured distance values, decimal (D) or hexadecimal (H) output mode can be selected.
  The output mode has an influence on all commands that display a distance value.
  Hex format: <SPACE>xxxxxx<CR><LF>, x=0...F, 1 mm resolution (SF1),
  Negative numbers: two's complement,
  Error: Exx<CR><LF>,
  Dist.: 34.56789...m, SF 1, output: _008708<CR><LF>
  Dist.: 34.56789...m, SF10, output:_05464F<CR><LF>

- Time to Measure (ST)
  The time to measure is directly conditional on the measuring technique. As a general rule: for target surfaces with poorer reflectance, the LRFS-0040 takes longer to determine the distance with a given specified accuracy. With poor reflectance and too small a time to measure, an error message E15[14] may be output (among other possibilities). You should increase the setting for time to measure in this case. The range of available time-to-measure values is 0 to 25. Please note: the greater the selected value, the greater will be time to measure and the smaller the measuring frequency.

[14] see → section 12."Error Messages"

An exception is 0 value. If set to 0, the LRFS-0040 automatically determines the minimal time to measure!
The LRFS-0040 comes with measuring time set to zero (ST = 0).

In addition, the user may configure a desired measuring frequency via the time to measure, for example, in order to limit the amount of data or for synchronization purposes. The time to measure can approximately calculated using this equation:

Time to measure ≈ ST·240 ms (except ST=0)

Example:
The distance to be determined is 25 m. The target's reflectance is not ideal. If ST 2 is selected for time to measure, E15 will be output. You should choose a greater time-to-measure value in this case!

- Scale Factor (SF)

The scale factor multiplies a calculated distance value with a user-selectable factor to change resolution or to switch the output to a different unit of measure.

The scale factor setting has an influence on the output of the measured value, the distance offset (OF), the Alarm Center (AC), the Alarm Hysteresis (AH), the Range Beginning (RB) and the
Range End (RE)!

Resolution	**Numerical measure**	**Unit of measure**	**Scale factor**
1 mm	134.567	m	SF1
0.1 mm	1345.671	dm	SF10
0.01 yard	147.162	yard	SF1.0936
0.01 feet	441.493	feet	SF3.28084
1 inch	52.979	100 inches	SF0.3937

- Alarm Center (AC)

Alarm Center corresponds to the distance threshold of the switching output. Alarm Center is input in meters. On negative or positive excession of the preset switching threshold, the alarm output will switch from „High" to „Low" or vice versa depending on the alarm hysteresis setting.
„High" corresponds to about VCC – 1 V, „Low" to 0 V.

- Alarm Hysteresis (AH)

Alarm Hysteresis defines the response hysteresis of the switching output. Alarm Hysteresis settings are made in units of a meter. The value of a hysteresis setting corresponds to the delay in switching (in m), its mathematical sign describes the logic level.

- Range Beginning (RB)
  Range Beginning corresponds to the lower range limit of the analog output. Range Beginning settings are made in units of a meter. Range Beginning corresponds to a current of 4 mA.

- Range End (RE)
  Range End corresponds to the upper distance limit of the analog output. Range End settings are made in units of a meter. Range End corresponds to a current of 20 mA.

- Trigger Delay (TD)
  Trigger Delay consists of two subparameters – the actual delay, i.e. the waiting time, and the trigger level.
  Delay corresponds to the time from the point when a trigger signal is received to the moment at which a measured value is output. It may take on a maximum value of 9999 ms. The trigger level allows you to define if measurement is to be triggered at a low-high flank (0) or a high-low flank (1).
  Your selections for trigger delay and trigger level must be separated by space (20h) (see → 11. "Transmission Protocol")!

- Baud Rate (BR)
  For baud rate, the following settings are available: 2400, 4800, 9600, 19200, 38400. Faulty inputs are automatically rounded to the nearest available baud rate. The data format is fixed. It includes eight data bits, no parity and one stop bit.

- Autostart (AS)
  Allows you to define a function which the LRFS-0040 is to carry out when voltage supply becomes available. All inputs are possible.
  For example, if ASDT has been parametrized, the LRFS-0040 will start with distance tracking immediately after power is available.

- Distance Offset (OF)
  With the help of this parameter the user may conveniently define a zero point of his/her measuring setup.

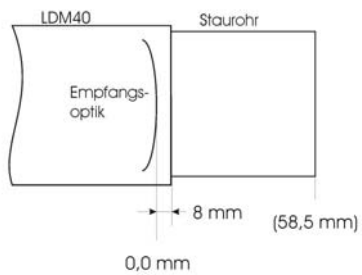

Figure 4 Front edge of LRFS-0040

Zero point of the LRFS-0040 (OF = 0.000000e+00) coincides with the front edge of the receiving lens (see → Figure 4 Front edge of LRFS-0040").

- Digital Switching Output (Alarm)

The purpose of the digital switching output is to allow monitoring of targets or scenes for positive or negative excession of a user-parametrizable distance threshold.

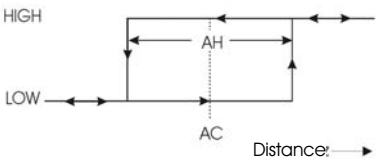

Figure 5 Alarm hysteresis, positive

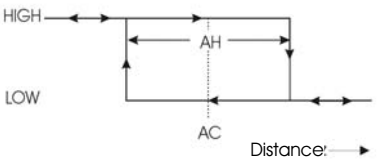

Figure 6 Alarm hysteresis, negative

Configuration is performed by choosing appropriate settings for "Alarm Hysteresis" and "Alarm Center" (see → sections 9 "Parameter").
The logic state of the switching output essentially depends on the mathematical sign of your hysteresis setting.
If the setting for hysteresis is positive, the output will switch to high on positive excession of the switching threshold + hysteresis/2 and to low on negative excession of the switching threshold - hysteresis/2.
If the setting for hysteresis is negative, the output will switch to low on positive excession of the switching threshold + hysteresis/2 and to high on negative excession of the switching threshold - hysteresis/2.

Example:

AC	**AH**	**0.8 m**	**0.9 m**	**1.0 m**	**1.1 m**	**1.2 m**	**1.1 m**	**1.0 m**	**0.9 m**	**0.8 m**
1 m	(+) 0.2m	L	L	L	H	H	H	H	H	L
1 m	- 0.2 m	H	H	H	L	L	L	L	L	H

L = low, H = high, with distance increasing from left to right

Analog Output

The analog output allows a standardized long-distance transmission of analog distance data with the help of a two-wire cable.
The level of current which is output to this cable is proportional to the measured distance value within a distance interval that is defined by "Range Beginning" and "Range End" (see → sections 9 "Parameter").
The output current value (in mA) can be calculated according to this equation:

$$IOUT = 4\,mA + 16 \cdot \left(\frac{\text{Distance Value - Range Beginning}}{\text{Range End - Range Beginning}} \right) mA$$

Where these calculation rules would result in an output current less than 20 mA in the case of negative excession of "Range End" or an output current of more than 4 mA in the case of positive excession of "Range Beginning", the corresponding limit value, i.e. 20 mA and 4 mA will be output.

Example:

RB	**RE**	**0 m**	**2 m**	**4 m**	**6 m**	**8 m**	**10 m**	**11 m**
2 m	10 m	4 mA	4 mA	8 mA	12 mA	16 mA	20 mA	20 mA

Remote Triggering

This function allows distance measurement to be triggered with an external signal in the form of a 5 V voltage pulse. The user may configure a desired delay time and a pulse flank he/she wants to use for triggering (see section → "Trigger Delay (TD)"). Having done this, he/she must switch the LRFS-0040 to remote triggering mode.

11. Transmission Protocol

ASCII string	Completion	Description
ID	Enter (0Dh)	Calls up a list of commands
DT	Enter (0Dh)	Starts distance tracking
DF	Enter (0Dh)	Sets distance measurement mode with remote triggering
DM	Enter (0Dh)	Sets single distance measurement
TP	Enter (0Dh)	Inner temperature [°C]
SA	Enter (0Dh)	Sets / displays time to measure 0...25
SA	Enter (0Dh)	Sets / displays mean value
SF	Enter (0Dh)	Sets / displays scale factor
AC	Enter (0Dh)	Sets / displays alarm center [m]
AH	Enter (0Dh)	Sets / displays alarm hysteresis [m]
RB	Enter (0Dh)	Sets / displays distance [m] for Iout= 4 mA
RE	Enter (0Dh)	Sets / displays distance [m] for Iout= 20 mA
TD	Enter (0Dh)	Sets / displays trigger delay [ms] and trigger level
BR	Enter (0Dh)	Sets / displays baud rate (1200...38400)
AS	Enter (0Dh)	Sets / displays autostart command
OF	Enter (0Dh)	Sets / displays distance offset
LO	Enter (0Dh)	Turns the laser on
LF	Enter (0Dh)	Turns the laser off
PA	Enter (0Dh)	Displays selected setups
PR	Enter (0Dh)	Resets selected setups

12. Error Messages

Code	Description
E15	Reflexes are too weak, use target board or distance between LRFS-0040 (front edge) and target < 0.1 m
E16	Reflexes are too strong, use target board
E17	Too much steady light (e.g. sun)
E23	Temperature below – 10°C
E24	Temperature above + 50°C
E31	Notify service!
E51	Notify service!
E52	Notify service!
E53	Notify service!
E54	Notify service!
E55	Notify service!
E61	Illegal command
E62	Notify service!
E63	Notify service!
E64	Notify service!

13. Service, Maintenance, Warranty

The warranty period is one year.
To ensure that all functions are regularly checked and your LRFS-0040 operates faultlessly over a long period of time, you are advised to have the LRFS-0040 laser distance measurement module inspected at our location at annual intervals. If a repair becomes necessary, you should carefully pack and send the LRFS-0040 to our address: