

**LE-xD Seismometer Family**  
**Document Number: 990-0073**

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Updated for  
MkIII !

## Revision history

- 2005-06-10 First version (vastly expanded and edited from previous release)
- 2005-11-22 Added information on LE-3Dlite MkII, added Appendix thus incorporating documentation for open-ended cable
- 2006-02-15 Added Appendix 2 (what can happen in the case of inverted polarity)
- 2006-04-28 Clarified differential signal information
- 2006-06-01 Corrected error about polarity of CAL pulses, clarified info on operation mode of CAL signal
- 2006-09-28 removed wire colour table in body text (was in conflict with wire colours given in Appendix 1); added MkII information in connector drawings. Changed some illustrations from b/w to colour because document is now printed in color anyway; removed Index
- 2007-02-20 Added information about open-ended cable 390-0056c in Appendix 1 (KPTC female for LE-1DV)
- 2007-08-02 Added information on LE-1DV MkII, modified pole/zero information, added connector handling hint in Appendix 3.
- 2008-05-16 Revised information on “J” pin
- 2009-01-21 Slightly readjusted 3<sup>rd</sup> pole for 5s version (was: .220, now: .290)
- 2009-10-26 Added information on re-calibration tag
- 2011-02-07 Added information on LE-1DV/5s
- 2014-03-03 Introduced MkIII (true differential output)
- 2014-09-09 Retired LE-3D/20s
- 2015-09-23 Added information on LE-3D/5s MkIII
- 2016-05-12 Added clarification on maximum p-p voltage on output

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# 1 Introduction

This document describes the following members of the LE-xD seismometer family (the x means that the description applies to all models; whenever there is a specific feature that applies to one particular model only, the name of the individual model is given):

- 223-0047 LE-3Dlite MkIII (like MkII, but with true differential output and, consequently, 800 V/m/s transduction factor)
- 223-0041 LE-3Dlite MkII (with female connector on lid, and no attached cable)
- 223-0048 LE-1DV MkIII (like MkII, but with true differential output and, consequently, 800 V/m/s transduction factor)
- 223-0044 LE-1DV MkII (with female connector on lid, and no attached cable)
- 223-0049 LE-3D/5s MkIII (with true differential output and, consequently, 800 V/m/s transduction factor)
- 223-0043 LE-1DV/5s

Models out of production (most of the present document applies to those models as well):

- 223-0000 3D “classic”. Three directional active seismometer with 1 Hz natural frequency. Out of production since April 1998. Calibration input added in 1994. For instruments manufactured before 1994, ignore the paragraph about calibration.
- 223-0022 LE-3D/5s
- 223-0039 LE-1DH. The horizontal version of 223-0035.
- 223-0034 LE-3Dlite – the original LE-3Dlite with cable permanently attached
- 223-0035 LE-1DV – the original LE-1DV with cable permanently attached
- 223-0030 LE-3D/20s

## 2 General description

The LE-xD is a compact, rugged and lightweight family of three directional and single component seismometers for field and observatory use. Although different in many details, the whole family shares one principle: Use rugged, off-the-shelf exploration grade sensors and enhance them electronically to get rid of their inherent shortcomings and problems, and to match the desired transfer function of a 1 Hz, 5 sec, or 20 sec seismometer.

The main advantages of the LE-xD family are:

- Very robust mechanical design
- No need for mechanical clamping; can be transported in any spatial orientation

- Exactly identical transduction factor (400, 800, or 1000 V/m/s depending on model) between components and between individual sensors; no need to keep records about which sensor was connected to which datalogger at which times
- Superior long-term stability means fewer recalibration visits to the factory
- Low power consumption

### 3 Preface: Water tightness

We are putting this chapter before the chapters dealing with practical handling issues just so nobody misses it.

Lennartz seismometers (with the exception of the borehole model LE-3D/BH) are specified to comply with protection class IP65. While there is no 1:1 relationship between IPxx and NEMA protection ratings, IP65 is roughly equivalent to NEMA4X.

In the IP protection rating, the first digit stands for protection against dust intrusion. “6” means complete protection against dust. The second digit stands for protection against water intrusion. “5” means “Protected against low pressure jets of water from all directions”.



Please note that the surface sensors do NOT comply with higher water intrusion protection figures! IPx6 would mean “protected against high pressure jets of water from all directions”; IPx7 would mean “protected against temporary immersion (30 min.) between 15 cm and 1 m”; and finally, IPx8 would mean “protected against long periods of immersion under pressure”.



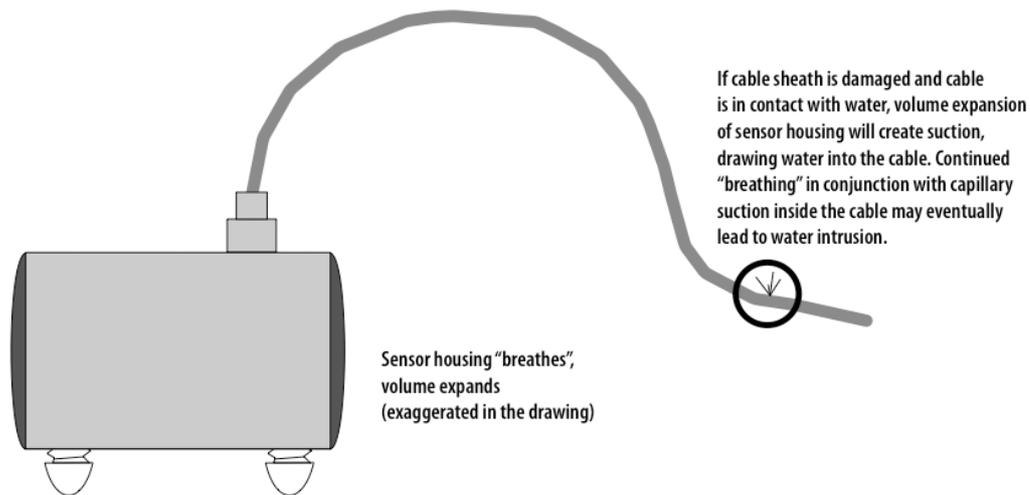
Another caveat: The IP65 rating is valid only for a factory sealed sensor with its cable (if applicable, i.e. only for LE-1DV and LE-3Dlite) intact and uncut, and the cable connector attached. **Once the sensor has been opened, there is NO WAY for the average user to reseal the sensor housing in a suitable way so as to guarantee compliance with IP65.**

#### 3.1 Special precautions for LE-3Dlite (pre-MkII!) and LE-1DV (pre-MkII!)

These two types have a short length of cable permanently attached. The attached cable and connector assembly does not harm IP65 in any way as long as two conditions are fulfilled:

1. The cable sheath is intact, i.e. no little (sometimes barely visible) holes or scratches
2. The original, Lennartz-supplied KPTC connector is attached

Unlike the MkII models and the larger sized models LE-3D/5s and LE-3D/20s, there is no connector between the cable and the inside of the sensor housing – any water entering the cable can, and will eventually, be drawn into the sensor. This is due to “breathing” of the sensor housing with temperature and pressure changes, as illustrated in the following sketch:



Consequently, it is of utmost importance to control the integrity of the outer cable shell before deploying an LE-3Dlite or LE-1DV in a location where water could be a problem. From the previous discussion it should be clear that water entry can happen even if the sensor body itself is not under water.

### 3.2 *DIY water proofing*



A factory sealed LE-xD sensor equipped with an intact cable will NOT require extra protection when used in the conditions that it has been specified for. You do not need to apply silicon grease or other chemicals. Applying such chemicals to the sensor housing or connectors is strongly discouraged, and may incur additional problems such as unwanted chemical reactions between housing and/or cable material and the chemical(s).

## 4 Handling instructions

### 4.1 Unpacking, packing

As mentioned previously, no special precautions are required for transportation, packing, and unpacking. However, the different sensor models come in different types of transport cases, so let's have a more detailed look at the various transport boxes.

#### 4.1.1 The LE-3Dlite and LE-1DV (including 1DV/5s) models

come in a plastic carrying box, with a styrofoam cutout to accommodate the seismometer and the short length of cable that is permanently attached to these models. The MkII and later models do not have a length of cable permanently attached.

In older versions of the carrying box, the cutout has the exact dimensions of the LE-3Dlite; the LE-1DV being somewhat smaller than the 3D version, it has got some room to move in there, but once the lid is closed the foam in the lid holds the sensor in place. Lately, the transport box has been reworked to provide an extra cutout for LE-1DV which now provides a tight fit.

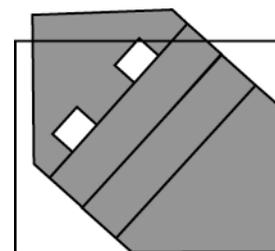
For these models, both **unpacking** and **packing** are trivial operations that do not require further explanation.

#### 4.1.2 The LE-3D/5s and LE-3D/20s models

come in a resinated plywood box, with a two-part clamshell-type styrofoam cutout to accommodate the seismometer. The styrofoam structure holds the seismometer in a somewhat awkward, upside-down-tilted-sideways position. This strange position was chosen in reverence to old, purely mechanical design seismometers. Some of these instruments needed to be transported in this position so as to force all three sensors to a well-defined end position.

We want to make it very clear that for LE-3D/5s and LE-3D/20s it is NOT a technical requirement to transport the sensor in this manner; at the time of introduction of these new sensor designs it seemed like a good idea to maintain the tradition.

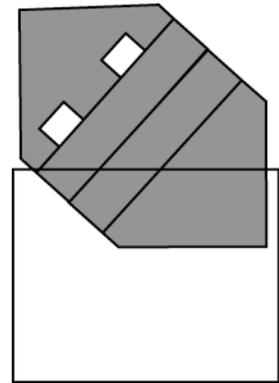
The following sketch shows the two halves assembled and inside the wooden box.



To **unpack** the sensor it is best to reach down into the wooden box and grab the lower half of the clamshell styrofoam cutout, then lift out the whole thing (styrofoam cutout plus sensor) as shown:

Next, lift off the top half of the cutout and remove the sensor.

To **pack** the sensor, simply execute these steps in the reverse sequence. Of course you need to disconnect the sensor cable before packing the sensor. The bottom half of the clamshell styrofoam cutouts has a cylindrical recess to accommodate the sensor cable jack.



## 4.2 Connecting the cable (sensor side)

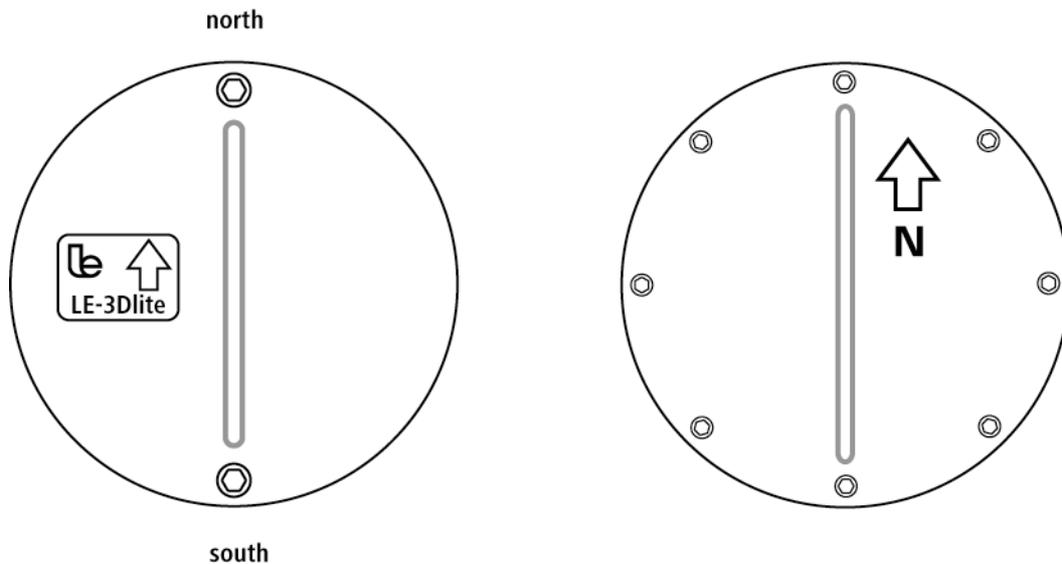
For LE-3Dlite (pre-MkII) and LE-1DV (pre-MkII), a short length of cable (approx. 1.5 m) is permanently attached to the seismometer, so there is no need to connect anything directly to the sensor. For LE-1DV MkII, LE-3Dlite MkII/III, LE-1DV/5s, LE-3D/5s and LE-3D/20s, a suitable cable needs to be connected directly to the 10-pin KPTC female connector that is located on the lid. It is recommended to connect the cable (at least on the sensor side, not necessarily on the datalogger side) BEFORE performing the following steps of azimuthal orientation and leveling. Connecting a cable after you have oriented and leveled your sensor may require you to repeat these steps.

## 4.3 Azimuthal orientation

All LE-3D sensors use three orthogonal sensors. These are commonly oriented in the classical Z, N, E pattern.

To facilitate azimuthal orientation, the North direction is indicated on the sensor lid. On all sensor models, a line indicating north-south is machined into the lid (for LE-1DV and LE-1DV/5s it is obviously useless).

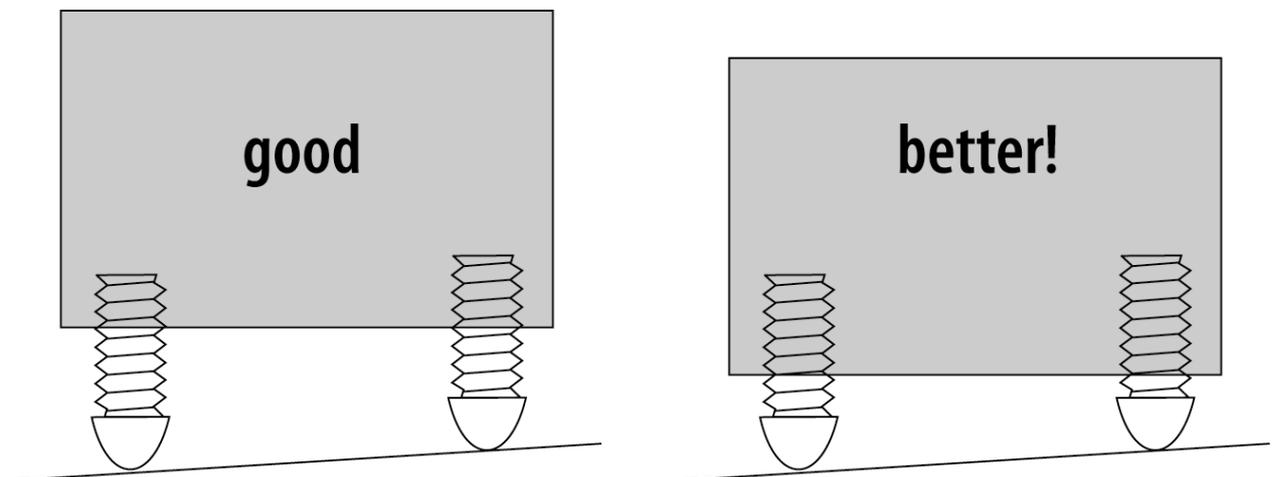
For LE-3Dlite (shown on the left), an arrow on a permanently attached label points north. For LE-3D/5s and /20s (shown on the right), north is indicated by an arrow and the letter N machined into the lid.



## 4.4 Leveling

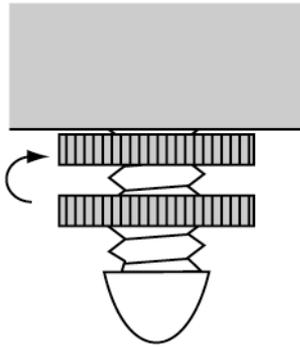
Unlike many other seismometer designs, the LE-xD sensors are not extremely sensitive to improper leveling. Of course, it always makes sense to try to achieve the best possible leveling; however, there are situations where less than ideal leveling will have to make do.

All LE-xD models have three adjustable feet and a bubble level. For best results, always try to adjust the feet so that the bubble is in the center, and with the feet screwed in as far as possible. The next illustration (which is very schematic...) should make the idea clear. The less distance between the earth's surface and the sensor, the better.



If you can, use the additional thumbscrews provided for fastening the adjustable feet in their final position (this may not always be an option, depending on the particular situation).

Once you have the sensor leveled, try to fix the feet by countering them with the knurled disc.



## 4.5 Connecting the cable (datalogger side)

With the sensor in place, oriented, and leveled, and with the cable already connected on the sensor side, we can now attach the cable to the datalogger side. At this point (if the datalogger has been switched on, and the cable and connector have been set up properly) the seismometer receives its 12 V DC power supply. There is no indicator of 12 V power on the sensor (simply because the sensors consume so little that even the few milliamps consumed by an LED would hurt badly!).



After applying 12 V DC power to the sensor, you should wait for at least 30 seconds (LE-1DV, LE-3Dlite, LE-1DV/5s, LE-3D/5s); for LE-3D/20s, you should wait for at least two minutes before expecting meaningful data at the output. Compared to other electronic sensors, this grace period is ridiculously small, but nevertheless it should be mentioned.

Longer waiting periods are recommended if the sensor has not reached ambient temperature at the time of deployment. While the sensor will produce a meaningful signal after the wait periods indicated above, signal quality will not be optimal during a period of rapid thermal change. Full compliance with the sensor's specifications will be achieved only after the sensor has reached ambient temperature.

## 4.6 Insulation from weather induced effects

Unlike other sensors, the LE-xD sensors are remarkably insensitive to (gentle) temperature and air pressure variations. Consequently it is not necessary to construct complicated styrofoam / copper foil / glass jar contraptions to seal the sensor from the elements. Obviously you would try to pick a place where the sensor is not directly exposed to sunlight – but that's just seismological common sense. Other than that, no special precautions are required.

## 4.7 *LE-3Dlite MkII / MkIII : Posthole installation*

The new version of LE-3Dlite (as well as LE-1DV/5s) has a stainless steel eyelet suitable for lowering the sensor into a shallow posthole. It is strongly discouraged to use the cable for this purpose – please affix a length of steel wire, or, better still, a solid rod. Using a rod, you can orient the sensor remotely (assuming you have visual contact, and can determine which way the north arrow points). Using steel wire it will be difficult if not impossible to exert enough torque to force the sensor into a particular azimuthal orientation.

## 5 Operation

### 5.1 Definition of polarity

All LE-xD sensors follow the simple (and, as one would think, obvious) convention:

Positive voltage on Z: upward motion

Positive voltage on N: north motion

Positive voltage on E: east motion

While it may seem obvious to choose polarity this way, there have been some mechanical sensors in the past that had their polarity inverted, so we wanted to make a clear and unmistakable statement here.

### 5.2 Transduction factor

LE-1DV (except MkIII), LE-3Dlite (except MkIII), LE-1DV/5s, and LE-3D/5s (except MkIII) have a transduction factor of 400 V/m/s. LE-3D/20s has a transduction factor of 1000 V/m/s.

**All models of generation MkIII, having true differential output, deliver 800 V/m/s into a differential input. If the input is single-ended, transduction factor for MkIII is 400 V/m/s.**

The transduction factor is the value to be multiplied with the transfer function (see following section) in order to obtain the absolute voltage produced by the sensor at any given frequency. In the flat part of the transfer function (i.e. for frequencies higher than approx. 3 times the eigenfrequency), the sensor outputs the nominal value of the transduction factor.

Since each component of every sensor has been individually calibrated on a shaketable, the transduction factor has been set with an accuracy of  $\pm 1\%$ . Compared to traditional mechanical sensors, this is a breakthrough in accuracy. All the typical factors that contribute to a large variance of the transduction factor (differences in magnetic properties and coil material) have been evened out by the calibration process.

### 5.3 Transfer function

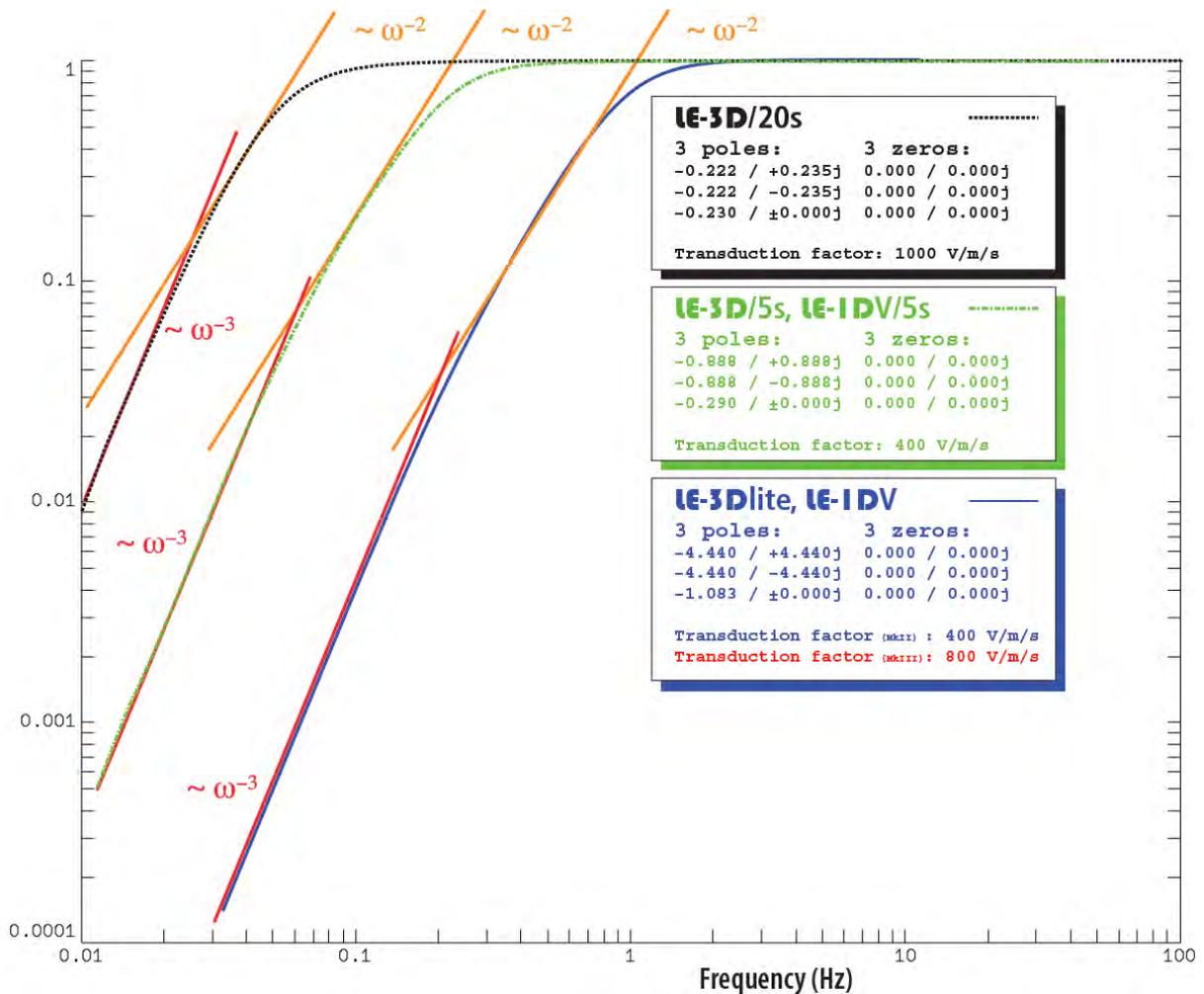
The transfer function of a seismometer can be described in various ways. Describing it graphically (by showing the phase and/or amplitude transfer function) is intuitive but not very precise. Describing it in frequency / phase / amplitude triplets is scientifically exact but not very intuitive and also not necessarily the best method for using this information in the context of a waveform processing program. Then, there is the possibility of describing the seismometer's impulse response in the time domain. We have chosen to use the method of poles and zeros (in addition to the graphical method).

The complex transfer function of a seismometer can be described as the quotient of two polynomials in  $s$  ( $s$  is the complex angular frequency  $j\omega$ ):

$$F(s) = P(s) / Q(s)$$

The zeros of  $P(s)$  are also the zeros of  $F(s)$ ; the zeros of  $Q(s)$  are the poles of  $F(s)$ .

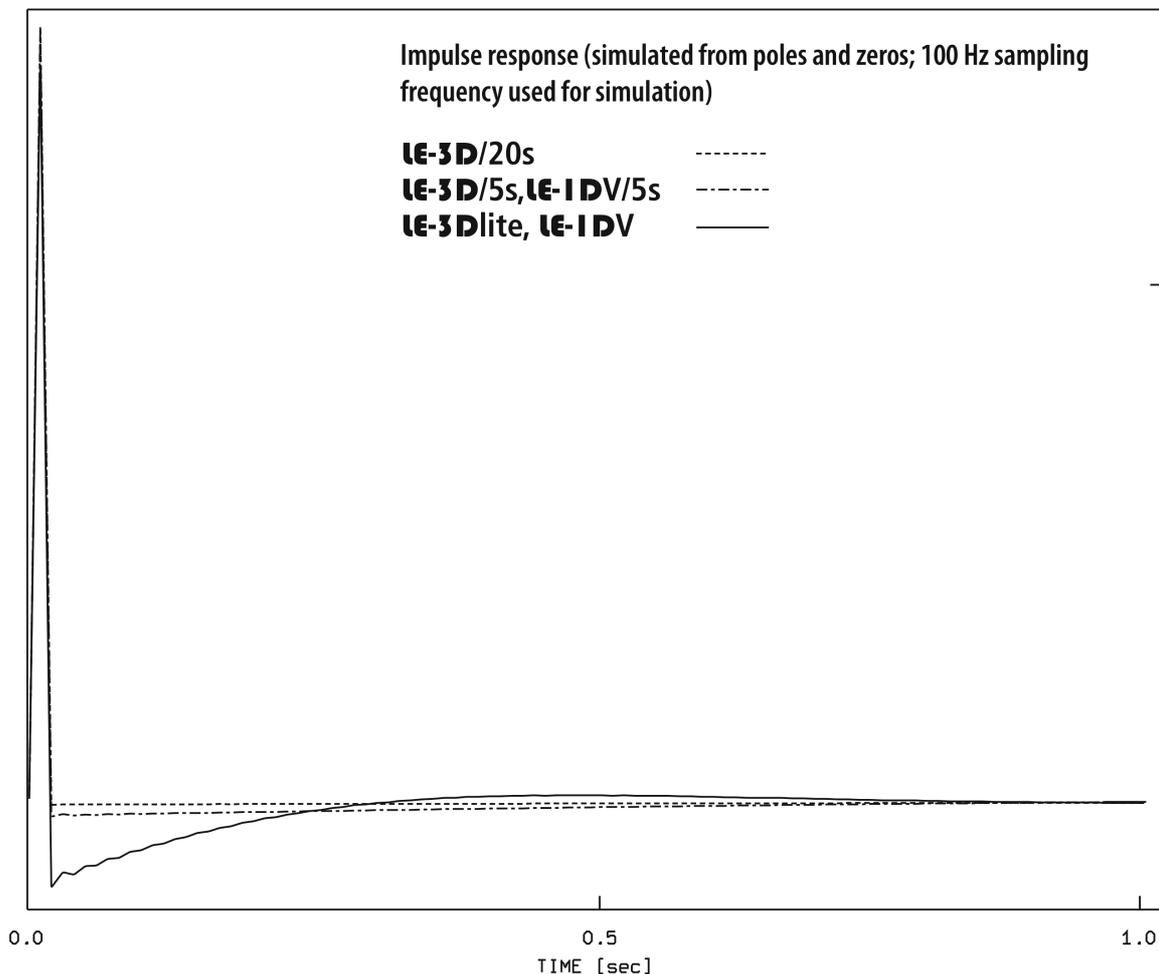
The following sketch shows the amplitude transfer functions as well as the numerical poles and zeros of the three different sensor types:



For the sake of completeness, here are the poles again in tabular form. All seismometer types have a triple zero at the origin, so the zeros are not listed separately here.

	LE-3D/20s	LE-3D/5s, LE-1DV/5s	LE-3Dlite, LE-1DV
Pole # 1	-0.222 / +0.235j	-0.888 / +0.888j	-4.440 / +4.440j
Pole # 2	-0.222 / -0.235j	-0.888 / -0.888j	-4.440 / -4.440j
Pole # 3	-0.230 / ±0.000j	-0.290 / ±0.000j	-1.083 / ±0.000j

For purely informational purposes, let's also include the impulse response waveforms here. Please note that these are not measured waveforms but these have been numerically calculated from the poles and zeros given above.



While the transfer functions reveal drastical differences between the various sensor models in the spectral domain, the time domain representation does not look all that different, specifically for the /5s and /20s models – the impulse response curves look nearly identical. But that is of course due to the logarithmic vs. linear amplitude scaling – the transfer function spectra would look a lot more similar if the amplitude axis was not on logarithmic scale.

A final word about the high frequency behavior of the sensors: The circuitry used for shaping the sensor's transfer function includes an intrinsic (and very benign) low pass filter. While the exact characteristics of the low pass filter are not easily determined, suffice it to say that for the /5s and /20s models it starts to work around 50 Hz whereas for the 1 Hz models (3Dlite and 1DV) it starts to work around 100 Hz. This is why the high frequency part of the transfer function is shaded in the transfer function graph above. The poles and zeros given for the transfer functions do not model the high frequency behavior, they only model the low frequency rolloff. Hence you are advised to exercise some care when trying to evaluate high frequency signals higher than the limits given above.

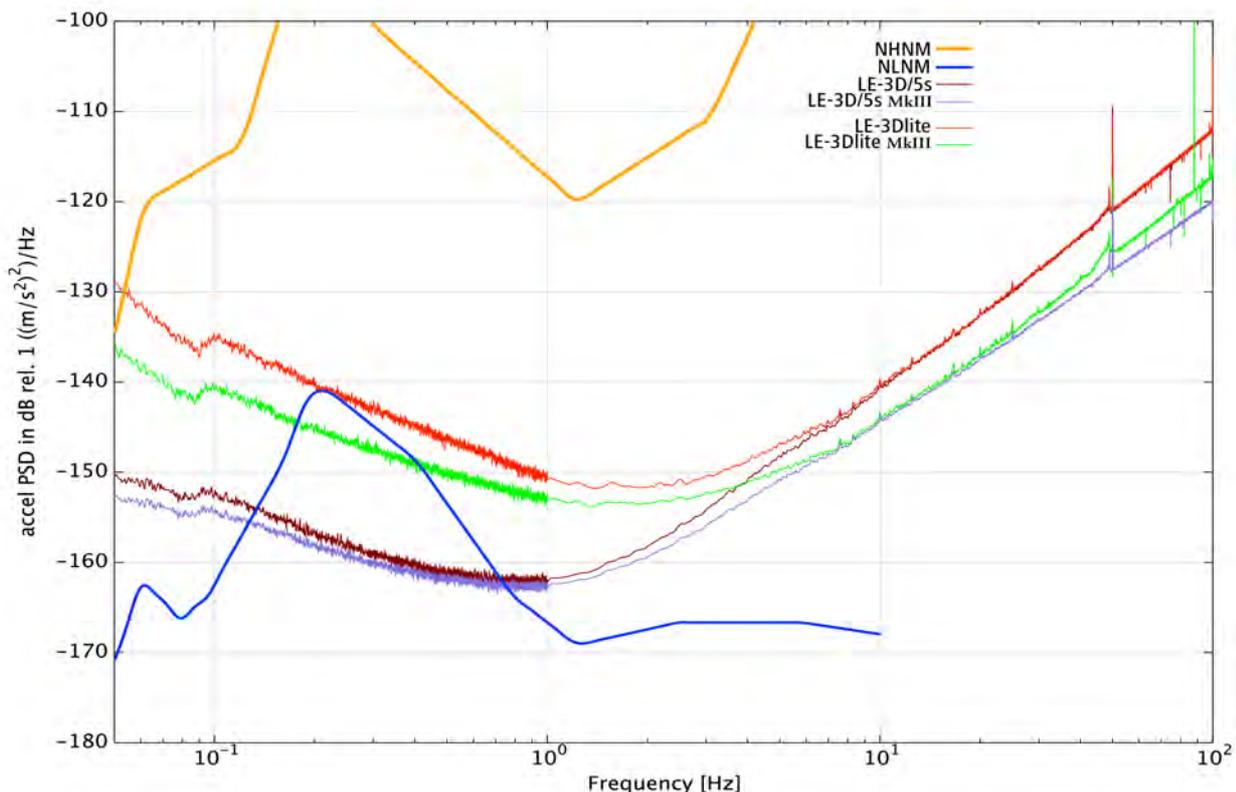
However, we assume that in practice these limitations will not have great significance. The frequency limits (50 and 100 Hz, respectively) are actually a great match for two popular

sampling frequencies, i.e. 100 and 200 Hz, respectively. Since most if not all digital data acquisition systems available today have a passband of  $0.4 \cdot f_s$ , the 50 and 100 Hz high frequency limits are outside the overall system bandwidth anyway.

Again, as noted in the section about the transduction factor, there is no need to give individual transfer function poles and zeros for each sensor. All sensor transfer functions are calibrated to be identical. Formally, transfer function deviations are guaranteed to be within the  $\pm 0.2$  dB range. Typically, though, such deviations will be in the  $\pm 0.1$  dB range.  $\pm 0.1$  dB translates to  $\pm 1.1\%$  approximately.

## 5.4 Self noise

Since all LE-xD models have onboard electronics, self noise (the noise created by the equalizer, filter and amplifier circuitry) is an issue to be considered. The following graph shows the intrinsic noise as determined by Prof. Erhard Wielandt and Dr. Rudolf Widmer-Schmidrig, shown in the popular “dB relative to  $1 \text{ m/s}^2$ ” format. USGS High and Low Noise Model curves have been added for reference. Graphics supplied by Dr. Widmer-Schmidrig. The LE-3Dlite curves are equally valid for LE-1DV and LE-3D/BH(s). The LE-3D/5s curve is equally valid for LE-1DV/5s.



We see that, regardless of the LE-xD model that you choose, you will be hard pressed to find a deployment location that is silent enough to make the intrinsic electronic noise of the sensor become a consideration. In most locations, sensor self noise will be far below ground noise anyway.

## 5.5 *Electrical interface*

This chapter is of prime interest for those connecting a Lennartz sensor to a third party datalogger – these people need to know the pinout of the sensor and/or interconnecting cable as well as the electrical characteristics of the interface.

Those people connecting a Lennartz sensor to a Lennartz datalogger do not need to care about pinout; all they need for a complete description of the sensor has been given already, i.e. the transfer function and the transduction factor.

### 5.5.1 Suitable for differential operation

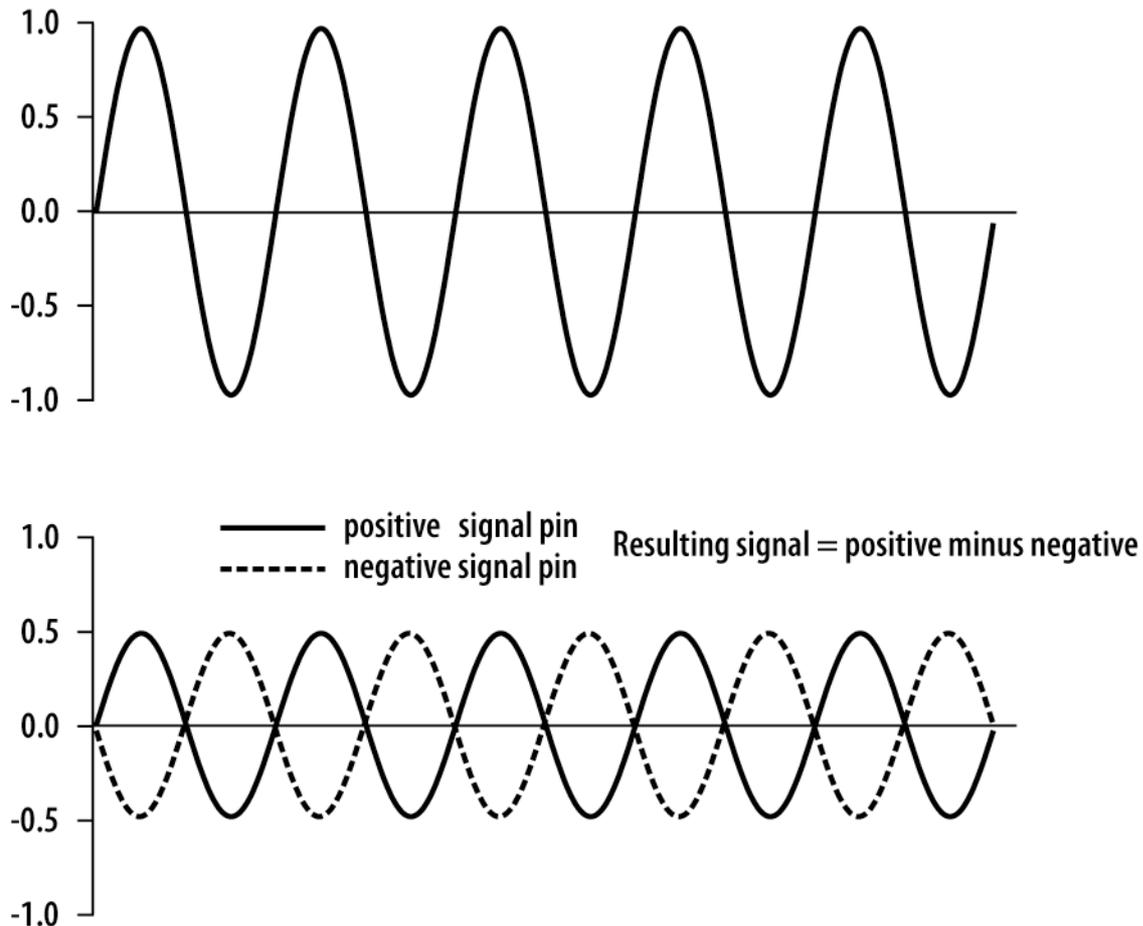
All LE-xD seismometers can be connected to dataloggers featuring differential (balanced) inputs, i.e. the two signal lines (positive and negative) usually float symmetrically with respect to ground; there is no fixed ground line. The advantage over the conventional (“single-ended”) technique is that differential lines are immune against offset induced by high frequency noise (if there is a common offset on both the positive and the negative signal line, such offset will be canceled out in the input amplifier which calculates the difference between positive and negative signal lines). Of course there is also a disadvantage: Since there is no common ground (which could be used for several signal lines), the number of pins required for a multi-channel setup is larger than in a single-ended configuration.

Since most seismological data loggers are set up for differential operation anyway, the distinction between differential and single-ended is mostly of importance for situations where the sensor is connected to, say, a PC data acquisition card or an oscilloscope.

It should be noted, though, that pre-MkIII LE-xD seismometers do not implement a true differential output signal. In practice this means that the negative signal line(s) will remain static; only the positive signal line(s) will show a dynamic time signal.

**For all models carrying the MkIII label, true differential operation has been implemented.**

The following sketch shows a sine wave with a fictitious amplitude of  $\pm 1.0$  in single-ended and differential setups:



### 5.5.2 Maximum output voltage

For the LE-3Dlite, LE-1DV, LE-3D/BH(s), LE-1DV/5s, and LE-3D/5s, the maximum output voltage is  $\pm 7V$ .

For the LE-3D/20s, the maximum output voltage is  $\pm 10V$ .

**For all MkIII models, when used with a differential input, the above figures need to be doubled.**

**And to be very clear: The p-p (peak-to-peak) voltage is again double that value. This is of relevance when connecting the sensor to an unprotected input. For example, the LE-3Dlite MkIII is specified at max  $\pm 7V$ . This means that both on the positive and on the negative signal pins, the voltage may vary between plus and minus seven volts, resulting in a p-p range of 14V. Since, however, the differential input circuit subtracts the negative from the positive value, that value needs again to be doubled, resulting in a maximum p-p range of 28V.**

### 5.5.3 The CAL input



When looking at the pinout (later in this document) you will see a line described as CAL (Calibration). This is NOT an input for a true calibration signal (none of the LE-xD sensors has a classical calibration coil that would allow you to imprint a calibration signal of your choice). Rather, it is an

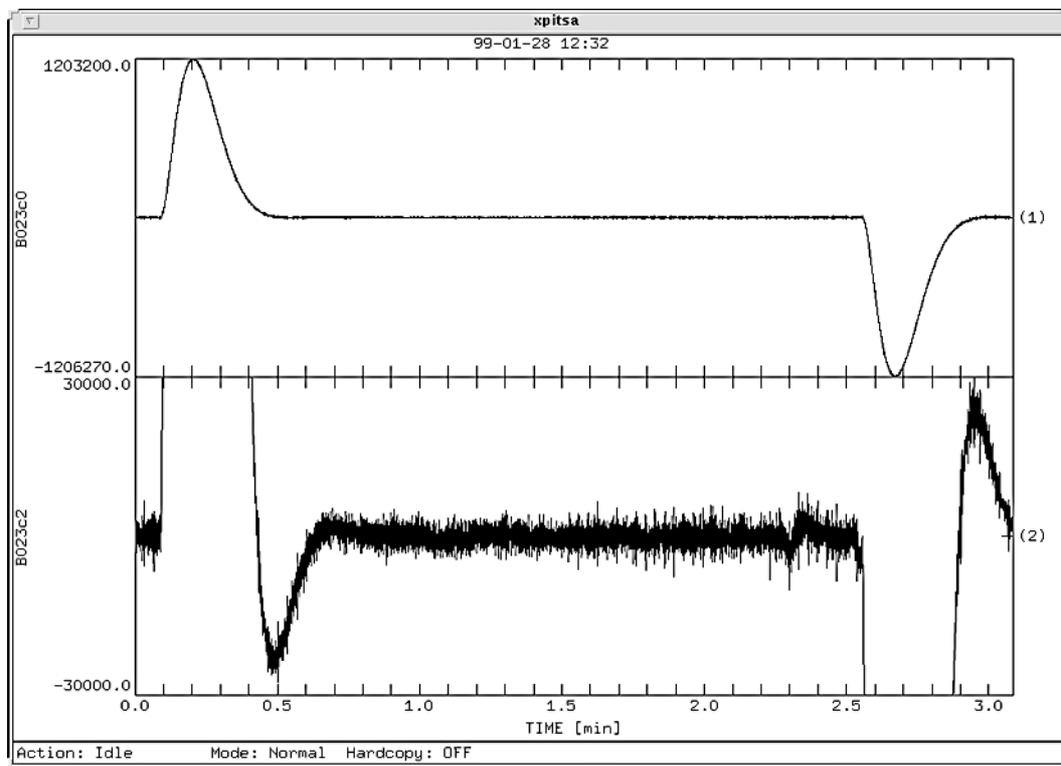
input that, when pulled to GND, activates an electronic circuit that simulates the effect of the classical “weight lift” test – the mass gets displaced then released so that you can observe the step response of the sensor.



Once the CAL pin has been activated (pulled to GND for a short period of time, NOT permanently kept there!), there are actually two “weight lifts” executed in sequence. The behavior is different for different sensor types. For LE-3Dlite, LE-1DV, LE-1DV/5s, and LE-3D/5s, the first pulse goes in the negative direction (down, south, or west, respectively) whereas the second pulse goes in the positive direction (up, north, or east, respectively). For LE-3D/20s (shown in the picture below), the positive pulse comes first.

The two pulses are spaced far enough apart so as to allow the sensor to completely settle back to zero in between. The exact spacing of the two pulses is not specified but is roughly 6 times the natural period. Also, the amplitude of the pulses is not specified but can be expected to be around 1 V peak (2 V pp).

For the LE-3D/20s model (where settling time is obviously largest), there are approx. 2.5 minutes between the two pulses as shown here:



It also becomes obvious from the picture that normal signal registration continues during the calibration sequence; in other words, the calibration pulses are simply superimposed on the usual input signal. The picture shows the same trace from an LE-3D/20s vertical component; the top trace has been automatically scaled while the bottom trace has been manually scaled up by a factor of approximately 40 so that background seismic noise becomes visible.

If your datalogger does not have a suitable output to service the CAL line, simply leave it unconnected – no harm will ensue.

The CAL feature has been incorporated into LE-xD seismometers from day one, predominantly for our own in-house testing purposes. It has been made for use from the outside starting at serial number 300 of LE-3D classic. It may be useful for observation of the long-term behavior of the sensor. You should be aware, however, that the CAL feature on the horizontal components is extremely sensitive to imperfect leveling. Minor differences in leveling may lead to drastically different CAL responses. Not surprisingly, no such dependence on leveling exists for the vertical component. Therefore you are advised to judge the results, especially for the horizontal components, with care and with the proverbial grain of salt.

## 5.5.4 Power supply

All LE-xD sensors have onboard electronics and thus require external power. Nominal input voltage is 12 V DC; however, an onboard DC/DC converter accommodates supply voltages in the 9...15 V DC range. Typical quiescent current drains (when the sensor “sees” just background seismic noise) at 12 V DC are: LE-1DV (pre-MkIII), LE-1DV/5s: 3 mA. LE-1DV MkIII: 2.2 mA. LE-3Dlite (pre-MkIII), LE-3D/5s: 8 mA. LE-3Dlite MkIII: 6 mA. LE-3D/20s: 50 mA.

Although the supply voltage gets stabilized by the onboard circuitry, there are limits to what the stabilizer can do. If you see artifacts on your seismometer signal that may relate to sudden surges in power consumption (such as a hard disk spinning up) it is advisable to supply the sensor from a different, separate battery or power supply.

## 5.5.5 Pinout

The LE-1DV MkII, LE-3Dlite MkII, LE-1DV/5s, LE-3D/5s and LE-3D/20s models have a 10-pole female Cannon KPTC receptacle flanged onto the seismometer lid. LE-3Dlite (pre-MkII) and LE-1DV (pre-MkII) seismometers have a short length of cable (> 1.5 m) permanently attached to the seismometer lid, terminating in a 10-pole male Cannon KPTC connector.

When connecting either of these sensors to a Lennartz datalogger using either the native cable (3Dlite or 1DV) or using a Lennartz-supplied connection or prolongation cable you won't have to worry about the details described in this section. This section is for those users wishing to connect a Lennartz seismometer to a third party datalogger.

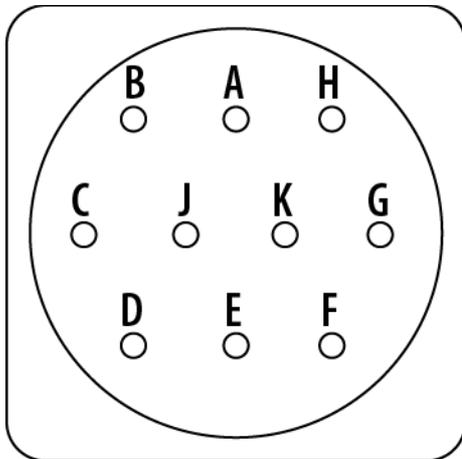


We would like to repeat here what has been clearly stated previously in this document: **The practice of cutting the connector off the LE-3Dlite (pre-MkII) or LE-1DV (pre-MkII) cable and then fitting your own connector is strongly discouraged, and will void the IP65 protection specification.**

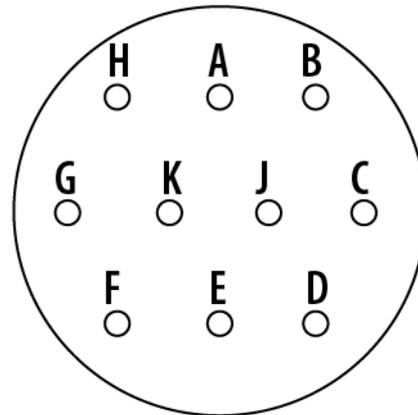
We can supply an open-ended prolongation cable with the mating female KPTC connector on one side, and open wires on the other side. In this configuration, water can not enter the seismometer through the core of the “native” cable even if the user's connector is not fully waterproof.

The open-ended cables come with their own documentation (see Appendix 1!) but for the sake of completeness we would like to include the wire assignment here.

Mechanically, pins are assigned as follows (when looking at the connector from the outside):



**female connector on  
seismometer housing  
for models  
LE-1DV Mk II / Mk III,  
LE-3Dlite Mk II / Mk III,  
LE-1DV/5s, LE-3D/5s,  
LE-3D/20s**



**male connector on  
seismometer cable  
for models  
LE-1DV (pre-Mk II!),  
LE-3Dlite (pre-Mk II!)**

The following table lists the pin names and the signals found on these connectors.

Pin	Signal	Remarks
A	+Z (positive wire, Vertical component)	
B	-Z (negative wire, Vertical component)	
C	+N (positive wire, North component)	n/c for LE-1DV and LE-1DV/5s
D	-N (negative wire, North component)	ditto
E	+E (positive wire, East component)	ditto
F	-E (negative wire, East component)	ditto
G	+12V (power supply)	9...15 V
H	-CAL	Leave unconnected if not required
J	GND and SHLD	Signal ground and cable shield
K	0V	for 12 V supply



When you connect the sensor to external 12 V power (as opposed to 12 V coming directly from your datalogger), AND you use the same battery for the

sensor and for your datalogger, please be extra careful not to invert polarity. Be sure to read and understand Appendix 2 which illustrates the problem that may ensue.

## 5.6 *The RF suppressor*

On LE-3Dlite and LE-1DV models (those that have the cable permanently attached) as well as on other Lennartz-supplied seismometer cables you'll find one or two cylindrical objects, attached to the cable by black heat-shrink tube. These are ferrite RF (radio frequency) suppressors. They serve to eliminate (or at least greatly diminish) the effects caused by high frequency interference. Typical sources of such interference are cellular phones, WiFi (WLAN), telemetry transmitters. Without the ferrite suppressor, such sources (especially those that work in pulsed mode) may create weird effects in the seismometer, ranging from offset to sudden surges that look like calibration pulse responses.

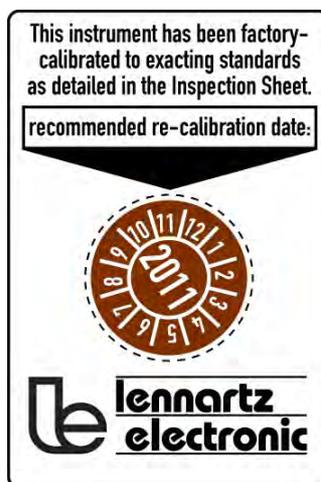
## 6 Care and service

### 6.1 Routine checks

As mentioned previously, before deploying the sensor in an environment where excessive humidity could be a problem you should check thoroughly if the outer cable shell is intact, i.e. free from scratches and cuts.

This is of utmost importance for LE-3Dlite and LE-1DV (pre-MkII) – for the other sensor types, a damaged cable may jeopardize the integrity of your recordings but will not lead to the sensor proper being damaged.

### 6.2 Routine recalibration



Beginning in the second half of 2009, all Lennartz sensors display a sticker indicating when the next routine recalibration should be performed.

Of course, the year and month will vary, depending on the date of delivery. We recommend recalibration in two year intervals.

Whenever a sensor undergoes non-trivial repair it will automatically become a recalibration candidate. The recalibration procedure includes a thorough visual and mechanical check.

### 6.3 If it doesn't work...



If you get no output signal from the sensor, **there is only one thing you can do: verify if the sensor gets 12 V DC power supply.** If you have checked that this is the case, and the sensor still does not work, **PLEASE, BY ALL MEANS RESIST THE TEMPTATION OF OPENING THE SENSOR!**

As we have stated previously, there are (very literally!) no user serviceable parts inside, and you will only make things worse. Once the sensor has been opened, the average user is unable to reseal the sensor properly. The special washers used for sealing the lid screws have an o-ring that is easily damaged when opening the sensor, and need to be replaced before closing the sensor again. Hence, .... please don't. Send the sensor back to the factory (see further down in this document for details). If you have the possibility you may want to check the current that flows into the sensor when supplied with 12 V DC. If the current is 0 mA, the internal fuse is blown but probably there is more damage than just that (see Appendix 2 for details).

## 6.4 Long term stability

With a track record of over 5,000 sensors in over 20 years we should be able to judge long term stability ☺, and our records show that LE-xD sensors perform outstandingly well. There is no need for periodic user recalibration. However, we offer a recalibration service for a flat fee (please inquire). This service includes inspection, recalibration, and the issue of a Calibration Certificate that is good for those operating in an ISO 9001:2000 context. Should we detect problems or defects that require additional work you will be contacted for approval.

Factory recalibration is recommended in **two-year intervals for indoor or moderate field use**; sensors that travel a lot and are **used in very difficult conditions** (extreme temperature, humidity, or atmospheric conditions) should be recalibrated **as frequently as once per year**.

## 6.5 If the sensor requires factory service

Whether the sensor is damaged or just in need of an inspection and recalibration – the same guidelines apply:

- You can greatly accelerate processing by getting in touch with us (info@lennartz-electronic.de) before shipping the sensor, and telling us the nature of the problem. We will issue an RMA number which you should then use to label the return shipment and its accompanying documents.
- Clean the sensor at least superficially.
- Use the original transport box for shipping if at all possible.
- Do not include the original Sensor Inspection Sheet in the shipment. We have copies here.
- Include a sheet of paper indicating the name, postal address, e-mail and telephone number of the person responsible for the shipment (we need all of this information for sending the seismometer back to you – and yes, we DO need the phone number!)
- Also indicate the type of service required – in the case of damage, please describe the problem as accurately as possible.

With all these points considered, send the sensor to:

Lennartz electronic GmbH  
Bismarckstrasse 136  
72072 Tuebingen  
Germany  
info@lennartz-electronic.de  
Phone: +49-7071-93550 (some courier services require you to give a phone number)

## 7 Technical data

	LE-1DV	LE-3Dlite	LE-1DV/5s	LE-3D/5s	LE-3D/20s
<b>Sensitivity</b>	400 V/m/s ( <b>800 V/m/s for MkIII models when used with a differential input</b> )				1000 V/m/s
<b>Natural frequency</b>	1 Hz		0.2 Hz		0.05 Hz
<b>Upper corner frequency</b>	~100 Hz		~50 Hz		
<b>Full scale output voltage</b>	$\pm 7$ V (suitable for differential operation) <b>differential for MkIII models when used with a differential input (resulting in max 28Vpp)</b>				$\pm 6.5$ V (suitable for differential operation)
<b>Damping</b>	0.707 critical				
<b>Dimensions</b>	85 mm diameter, 55 mm height	97 mm diameter, 68 mm height	97 mm diameter, 140 mm height	195 mm diameter, 165 mm height	
<b>Weight (not including transport box)</b>	0.9 kg	1.8 kg	2.5 kg	6 kg	
<b>Temperature range</b>	-15 ... +65 °C				
<b>Supply current @ 12 V DC</b> (quiescent current with only background seismic noise present; at full scale, supply current may be up to 2 times that value)	3 mA <b>2.2 mA for MkIII</b>	8 mA <b>6 mA for MkIII</b>	3 mA	8 mA	50 mA
<b>Warm-up time</b>	30 seconds				2 minutes

## 8 Appendix 1: Open-ended cables

### 8.1 Open-ended 3D sensor cables

This appendix describes the open-ended 3D Sensor Cables (Lennartz part nos. 352-0020 EMV for the 5 m cable, 352-0058 EMV for the 20 m cable). These cables are used to connect an LE-3Dlite MkII/MkIII, LE-3D/5s, or LE-3D/20s seismometer to a third-party datalogger.

The seismometer end of these cables is fitted with a 10-pin male Cannon KPTC connector while the datalogger end terminates in open wires.

The following table describes the individual wires. Input and output designations are to be understood from the sensor side, not from the datalogger side.

Pin <i>Kontakt</i>	Name	Description <i>Beschreibung</i>	Color <i>Farbe</i>
A	+OUT0 ( Z )	Positive output Z (vertical) <i>Positiver Ausgang Z (Vertikal)</i>	white <i>weiss</i>
B	-OUT0	Negative output Z (vertical) <i>Negativer Ausgang Z (Vertikal)</i>	brown <i>braun</i>
C	+OUT1 ( N )	Positive output N (north) <i>Positiver Ausgang N (Norden)</i>	yellow <i>gelb</i>
D	-OUT1	Negative output N (north) <i>Negativer Ausgang N (Norden)</i>	green <i>grün</i>
E	+OUT2 ( E )	Positive output E (east) <i>Positiver Ausgang E (Osten)</i>	pink <i>rosa</i>
F	-OUT2	Negative output E (east) <i>Negativer Ausgang E (Osten)</i>	grey <i>grau</i>
G	+GSUP	12V DC supply input <i>12 V DC Versorgungseingang</i>	violet <i>violett</i>
H	-CAL	“Calibration” input <i>“Kalibrier“-Eingang</i>	blue <i>blau</i>
J	GND	Signal ground <i>Signalmasse</i>	red <i>rot</i>
K	0V	Ground (0 V) for supply voltage <i>Masse (0 V) für die Versorgungsspannung</i>	black <i>schwarz</i>
case	SHLD	Signal shield <i>Schirm für die Signalleitungen</i>	metallic braid <i>Schirmgeflecht</i>

## 8.2 Open-ended female or male 1D sensor cable

This appendix describes the open-ended 1D Sensor Cable (Lennartz part no. 390-0074 EMV [female] or 352-0020a EMV [male]). The female cable is used to connect an LE-1DV pre-MkII seismometer to a third-party datalogger. The male cable is used to connect an LE-1DV MkII/MkIII or LE-1DV/5s seismometer to a third-party datalogger. This cable can not be used for 3D sensors (if it is used, only the vertical [Z] component will be “seen” by the datalogger).

The seismometer end of 390-0074 EMV is fitted with a 10-pin female Cannon KPTC connector (to mate with the male Cannon connector on the end of the cable permanently attached to the seismometer) while the datalogger end terminates in open wires.

The seismometer end of 352-0020a EMV is fitted with a 10-pin male Cannon KPTC connector (to mate with the female connector on the lid of LE-1DV MkII/MkIII and LE-1DV/5s).

The following table describes the individual wires. Input and output designations are to be understood from the sensor side, not from the datalogger side.



NOT ALL WIRE COLORS are identical to the 3D cable on the previous page! Please make sure to use ONLY the table shown below for wiring a 1D cable!

Also, special care should be taken when soldering your own connector to make sure you catch the two wires for GSUP and GND, respectively. Since the individual wires are fairly thin, having these lines double-wired helps keep the ohmic resistance low.

Pin <i>Kontakt</i>	Name	Description <i>Beschreibung</i>	Color <i>Farbe</i>
A	+OUT0 ( Z )	Positive output Z (vertical) <i>Positiver Ausgang Z (Vertikal)</i>	white <i>weiss</i>
B	-OUT0	Negative output Z (vertical) <i>Negativer Ausgang Z (Vertikal)</i>	brown <i>braun</i>
C		<i>Nicht verbunden</i>	--
D		Not connected	--
E		<i>Nicht verbunden</i>	--
F		Not connected	--
G	+GSUP	12V DC supply input <i>12 V DC Versorgungseingang</i>	<b>red and blue</b> <b><i>rot und blau</i></b>
H	-CAL	“Calibration” input <i>“Kalibrier“-Eingang</i>	green <i>grün</i>
J	GND	Signal ground <i>Signalmasse</i>	yellow <i>gelb</i>
K	0V	Ground (0 V) for supply voltage <i>Masse (0 V) für die Versorgungsspannung</i>	<b>grey and pink</b> <b><i>grau und rosa</i></b>
case	SHLD	Signal shield <i>Schirm für die Signalleitungen</i>	metallic braid <i>Schirmgeflecht</i>

## 9 Appendix 2: Mind the polarity!

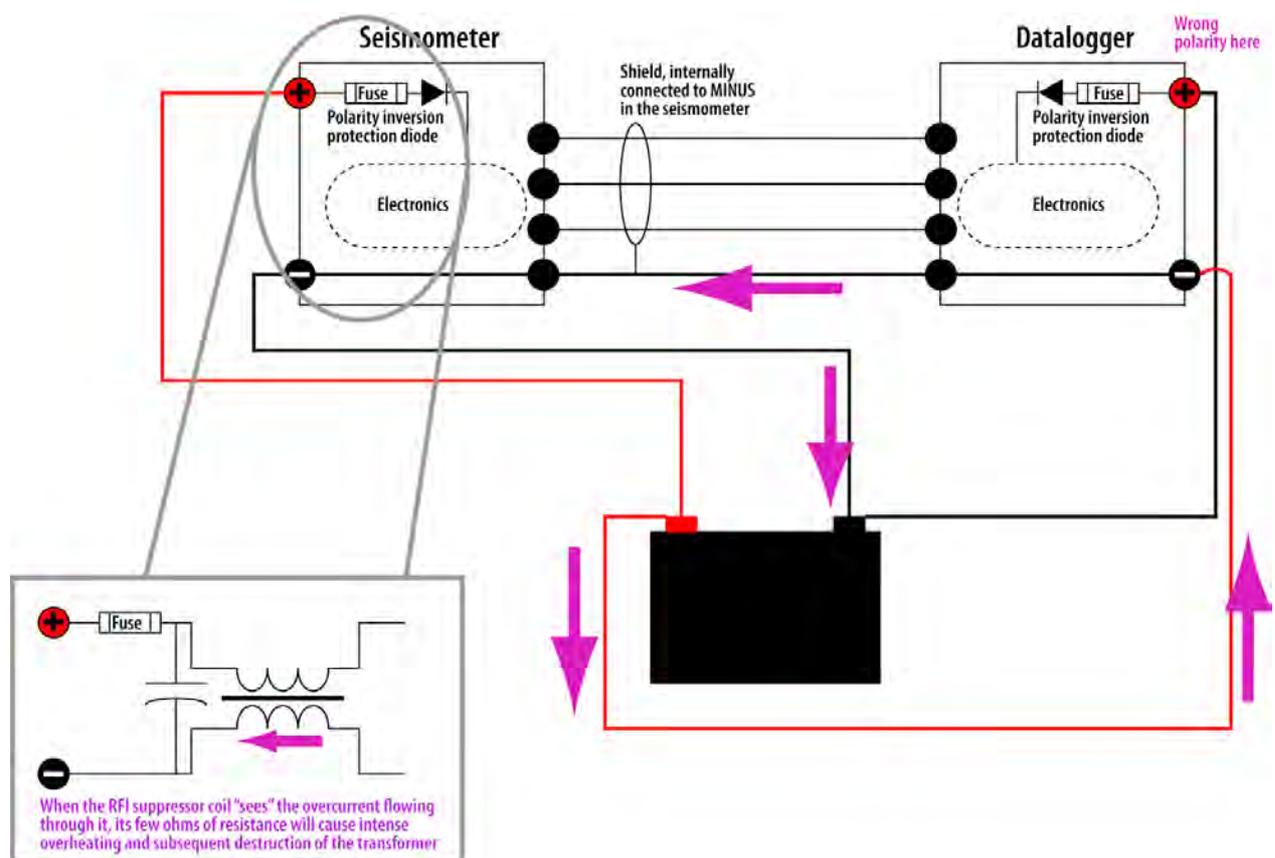
This appendix deals with a particularly unfavorable type of setup where despite the fact that the sensor is protected against inverted power polarity, serious damage may occur in the case of polarity inversion.

The built-in polarity inversion protection works well except when ALL of the following conditions are met:

1. Sensor and datalogger have a common ground (usually, the shielding braid of the data cable)
2. Sensor and datalogger are supplied from the same battery
3. Either sensor or datalogger (but not both) are connected to the battery with polarity reversed

This type of damage typically manifests itself in a completely „dead“ sensor (0 mA input current) which is usually due to a totally or partially destroyed RFI suppressor transformer.

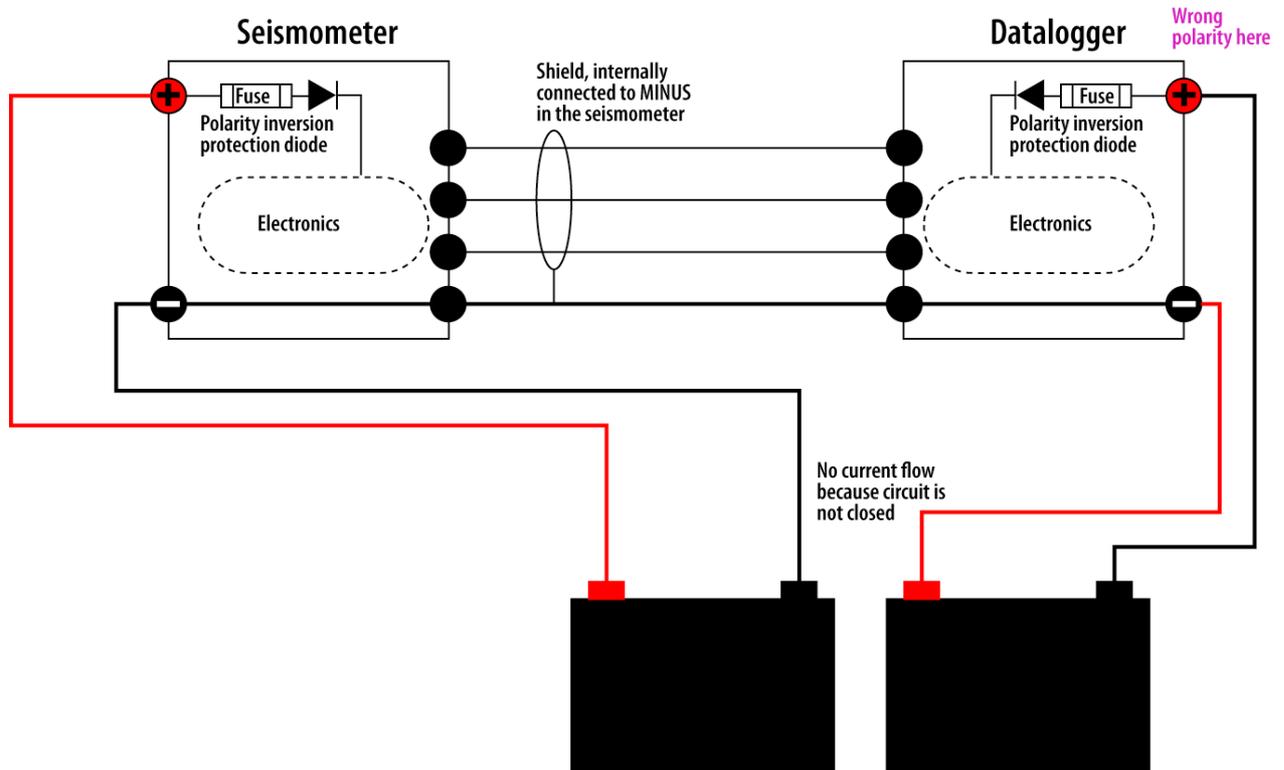
The following sketch shows the details – in our example we have inverted polarity for the datalogger but it might just as well be the sensor that’s inverted, the result would be the same:



The purple arrows show the current flowing from the battery's PLUS pole to the MINUS pole. The detail loupe shows the effect of the overcurrent on the RFI (Radio Frequency Interference) suppressor in the sensor's power input circuitry.

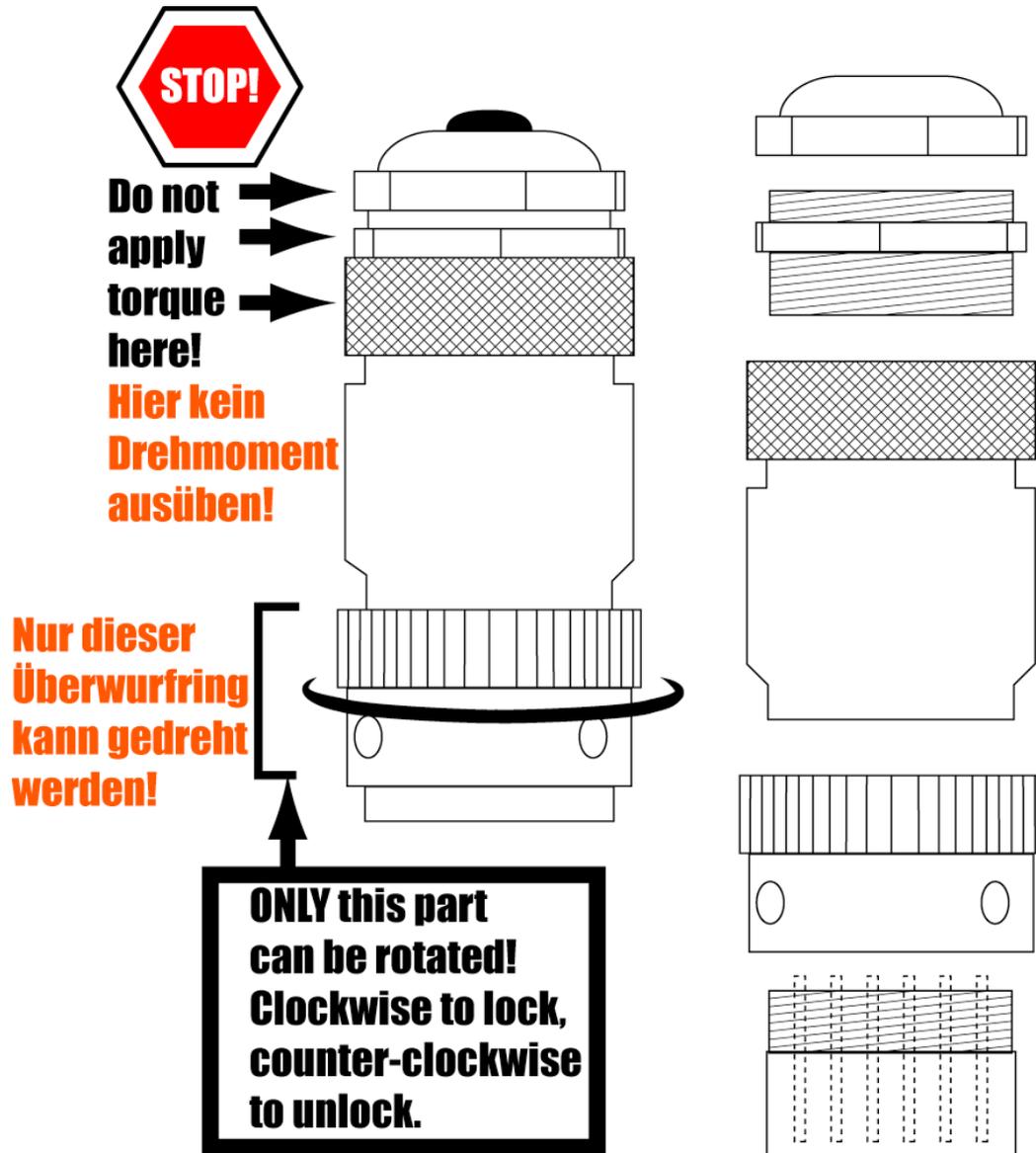
When the user detects the erroneous polarity and then connects the battery properly, it is quite likely that the input fuse blows (because the transformer may act as a short, resulting in a very high current flowing for a few milliseconds until the fuse reacts).

The next sketch shows the same erroneous polarity inversion, but this time with the seismometer and datalogger being supplied from two different batteries:



No problem this time – we don't have a closed circuit, and hence there is no overcurrent. No damage should occur if the datalogger's polarity inversion protection circuit works correctly.

## 10 Appendix 3: Handling the connector



**By applying torque to the upper part of the connector housing you run a very high risk of shearing off some or all wires from the connector pins, thus creating a short circuit that can damage your sensor and/or datalogger.**

**Wenn auf einen der oberen Teile des Steckergehäuses ein Drehmoment ausgeübt wird, besteht ein hohes Risiko, dass einer oder mehrere der Anschlussdrähte abgerissen werden, was zu Signalunterbrechungen und/oder Kurzschlüssen führt. Hierdurch können die beteiligten Geräte beschädigt werden.**

\*\*\* End of document \*\*\*