

EMIfix

Two line artificial mains network
with additional CM and DIFF splitter



User manual

Introduction

EMIfix is an Artificial Mains Network, also called a Line Impedance Stabilization Network (LISN). It is used for measurement of conducted ElectroMagnetic Interference (EMI) from an AC mains supplied or a DC supplied device in the frequency range 9kHz - 30MHz. Measurement can be done with an EMI receiver or a spectrum analyzer via a 50Ω cable.

EMIfix is intended for pre-compliance tests in an electronics research laboratory but can be used in an EMC test room as well. Despite the small and handy size it can handle currents up to 16A rms and ±55A peak.

As other LISNs, the EMIfix allows you to measure noise on Line and Neutral according to CISPR 16.

The special feature of EMIfix is two extra buttons enabling you to split up and individually measure the Common Mode part and the Differential part of the noise on Line and Neutral.

Knowledge of CM and Diff noise is essential to a power supply and EMI filter designer because the means to mitigate emitted noise are completely different for CM and Diff noise.



CAUTION - high leakage current



EMIfix should be operated only by skilled persons familiar with the risks and limitations involved in the use of a LISN.

With AC supply the earth leakage current of the LISN exceeds the limits given in the safety standard EN 61010-1. Therefore it is mandatory to connect the chassis of EMIfix securely to protective earth before inserting the plug into a mains outlet. This is done via the three threaded holes on the back side.

Due to risk of electric shock from high earth leakage current, unauthorized use of EMIfix can cause severe injury or death.

The user holds full responsibility for the safety of persons with access to the test setup.

There is no circuit breaker or fuse inside EMIfix.

The power source must be protected by a circuit breaker or fuse with a maximum rating of 16A.

The LISN is for indoor use in dry conditions only.

Ambient temperature: 5 - 40 degrees C, relative humidity not above 80%.

To be used at a max. altitude of 2000 meters above sea level.

There is no power switch in EMIfix. For user safety, EMIfix must always be placed with easy access to the power input plug.

If replacement of input power cord is necessary, always use a cord rated for 16A rms with three conductors, LINE, NEUTRAL, and EARTH, each conductor having a cross section of 1,5 mm².



DISPOSAL

EMIfix must be disposed of as electronics waste in accordance with national rules.

How to use EMifix

The EMI receiver or spectrum analyzer is connected to RF OUT via a 50Ω cable.

There are six push buttons on the front panel (figure 2):

1. L Press this button to measure noise on Line.
2. N Press this button to measure noise on Neutral.
3. CM Press this button to split up the noise and only measure common mode noise on Line and Neutral. CM is the mean value of noise on Line and Neutral:

$$CM = \frac{1}{2} (L + N).$$
4. DIFF Press this button to measure the differential noise between Line and Neutral.
 DIFF is half of the noise difference between Line and Neutral:

$$DIFF = \frac{1}{2} (L - N).$$
5. HP FILTER Press this button to insert a 5th order high pass filter, cutting off noise below 150kHz. Most EMC standards only require to measure above 150 kHz. Use the filter to avoid overdrive of an EMI receiver or a spectrum analyzer with high noise components at low frequency. Also use it when you feed the noise to an oscilloscope, allowing you to study a cleaner noise picture.
6. Earth switch The button below the mains outlet connects the earth (side) terminals in the Schuko outlet to the metal chassis. **This button should usually be pressed.** If unpressed, there is no HF connection between earth terminals and chassis, but still there is a DC and 50/60Hz connection via a 1,6 mH inductor, so safety connection to earth is never broken. This function is suggested as an option in CISPR16-1-2. An alternative option in CISPR16-1-2 is an impedance of 50μH || 50Ω instead of 1,6 mH. The PC board is prepared for this option too.

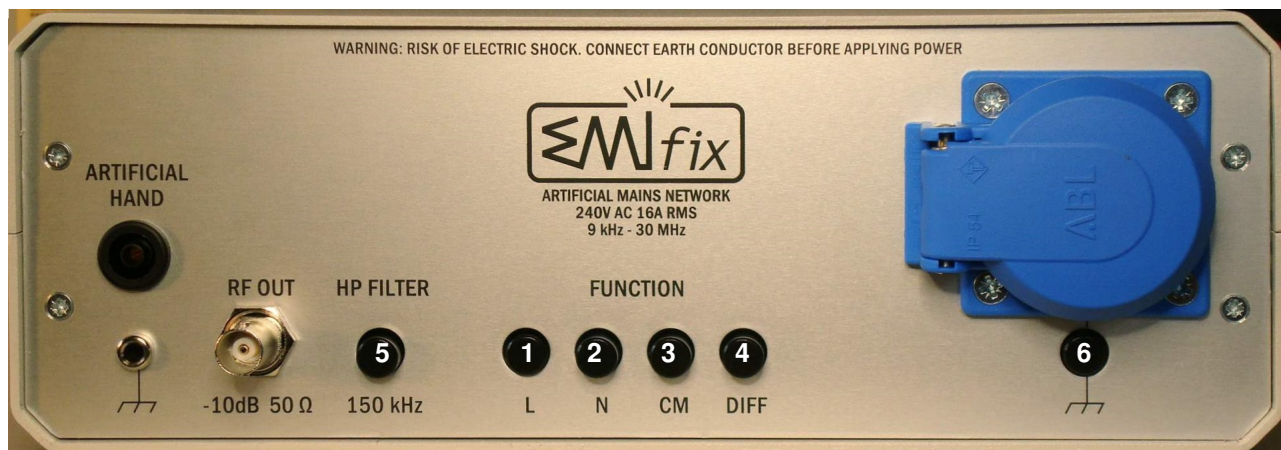


Figure 2

If there is no differential noise, L, N, and CM will give the same display. DIFF will show zero noise.

If all noise is differential, L, N, and DIFF will give the same display. CM will show zero noise.

Attenuator and transient limiter

EMIfix has a built-in 10dB attenuator which is always active. You must compensate for this attenuation in your measurement setup.

EMIfix also has a built-in transient limiter to protect your spectrum analyzer from voltage spikes when connecting a load or pushing a button. You do not need an external protection. A series of oppositely directed small signal diodes (1N4148) connected from output to chassis are used to clamp voltage spikes. Protection level is selectable in four steps: approx. $\pm 1\text{V}$ (one diode), $\pm 2\text{V}$, $\pm 4\text{V}$, and $\pm 6\text{V}$ (6 diodes) by means of jumpers soldered into the board. Factory setting is $\pm 4\text{V} = 25\text{dBm}$. If you need better protection or want to allow higher spikes you must open the EMIfix and move or remove the jumper.

Additional features

There is an additional 5 kHz high-pass filter on the output which is always active. Its purpose is to reduce 50/60Hz on the output to facilitate noise studies on an oscilloscope and to prevent 50/60Hz from activating the transient limiter.

It may be instructive to let a spectrum analyzer measure above 30MHz to get an early warning of EMI trouble up to 100MHz, even though measurements above 30MHz are only indicative. Therefore EMIfix does not contain a low pass filter to cut off noise above 30MHz. However, provisions have been made for a 2nd order low pass filter on the output: insert C17 = 82pF and L10 = 180nH (air coil: 7 turns of 0,56mm insulated copper wire. Dimensions = 6 x 6 mm).

If a $50\Omega \parallel (50\mu\text{H} + 5\Omega)$ LISN is used for assessment of EMI from low voltage DC switching power supplies, the large inductors in the LISN will often cause the power supply to become unstable and oscillate. In EMIfix you can short the two 250uH inductors by inserting two jumpers J1 and J2. This may make a reasonable measurement possible.

Reference earth rail

The bottom of the rear panel is a metal bar with three M4 screw holes. **Always connect this bar to safety earth before applying power.** For best accuracy connect it to the metal wall of the EMC room via a wide and short (low inductive) metal sheet.

In the research laboratory you can still get good pre-compliance results without connection to an earthed room. **For safety in the laboratory and to avoid tripping an earth fault switch, you must insert a separating mains transformer before the LISN.**

Power outlet, AC or DC

A goal was to keep the EMIfix compact and handy. Due to its flatness the power outlet has been rotated 90 degrees, so that an angled mains cable will not collide with your working table. Line is the upper pole, Neutral is the lower pole, and earth is the side connectors.

If you use EMIfix for DC, you should assure that polarity is correct. For instance let Line be the positive terminal and let Neutral be the negative terminal. If polarity is opposite, turn the input power connector upside down before connecting the device you want to test. I suggest to put a + and - mark on the input power connector.

Block diagram

A LISN as specified in CISPR16 must contain basically the following components.

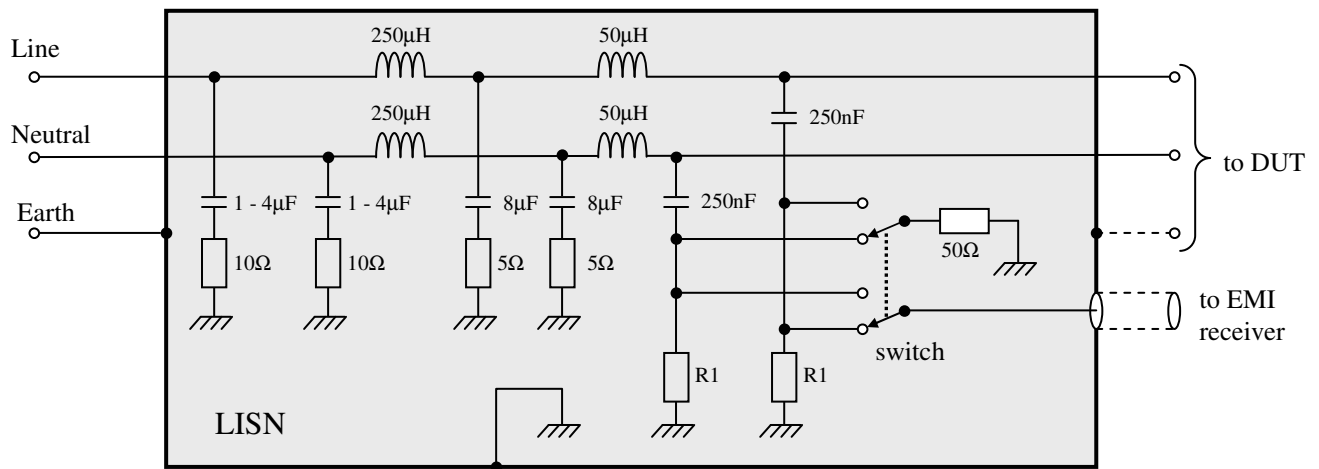


Figure 3 LISN for 9kHz - 30MHz

EMIfix further contains a CM + DIFF separator, a selectable high-pass filter, and a switchable HF earth connection.

There is also an "artificial hand" connector to be used for test of handheld equipment.

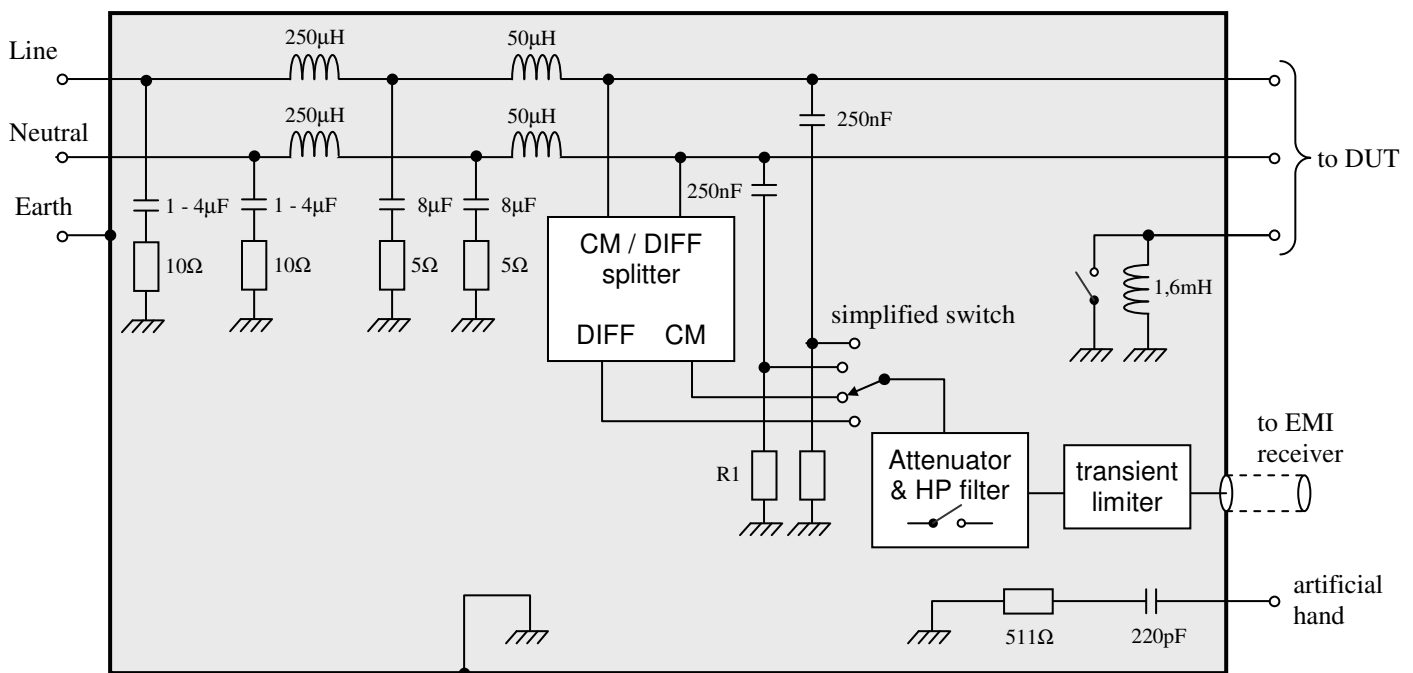



Figure 4 EMIfix block diagram

The block diagram is simplified and does not explain how the proper input impedance from DUT into Line and Neutral (figure 5) is established in all four settings of the switch.

Technical data

EMIfix Line Impedance Stabilization Network		
Frequency range	9kHz - 30MHz	
Impedance characteristics	$50\Omega \parallel (50\mu\text{H} + 5\Omega)$	*)
Max. current	16A rms	55A peak (inductor saturation)
Line voltage	0 - 275V rms, 50 or 60Hz	
DC input voltage	0 - 400V DC	
Output	50 Ω BNC connector	
Attenuation L & N	10dB \pm 0,3dB	@ 200kHz - 30MHz Additional attenuation @ < 200kHz due to impedance reduction at low frequency (50 Ω source)
Attenuation CM & DIFF	10dB \pm 0,6dB	
Measure modes	Line	L
	Neutral	N
	Common Mode	CM = $\frac{1}{2}$ (L + N)
	Differential	DIFF = $\frac{1}{2}$ (L - N)
High pass filter Selectable on/off	5th order 130kHz	typ. 0dB @ 150kHz typ. -10dB @ 100kHz typ. -40dB @ 50kHz
Outlet socket earth terminal	shorted to chassis earth (push button in)	1,6 mH to chassis earth (push button out)
Artificial hand	511 Ω + 220pF to earth	4 mm banana socket on front panel
Chassis earth connector		4 mm banana socket on front panel + three M4 screws on rear panel
Dimensions (W x H x D)	260 x 90 x 250 mm	+ mains cord from rear panel
Weight	approx. 3,8 kg	
Compliance		EN 61010-1 Safety requirements for electrical equipment for measurement, control, and laboratory use.

*) In CISPR16 the resistors R1 in figure 3 and 4 are suggested to be 1k Ω , which would result in 47,6 Ω impedance into Line and Neutral above 1MHz.

This disagrees with nominal 50 Ω as also specified in CISPR16.

In EMIfix R1 = 47k Ω .

Impedance characteristics are shown in figure 5.

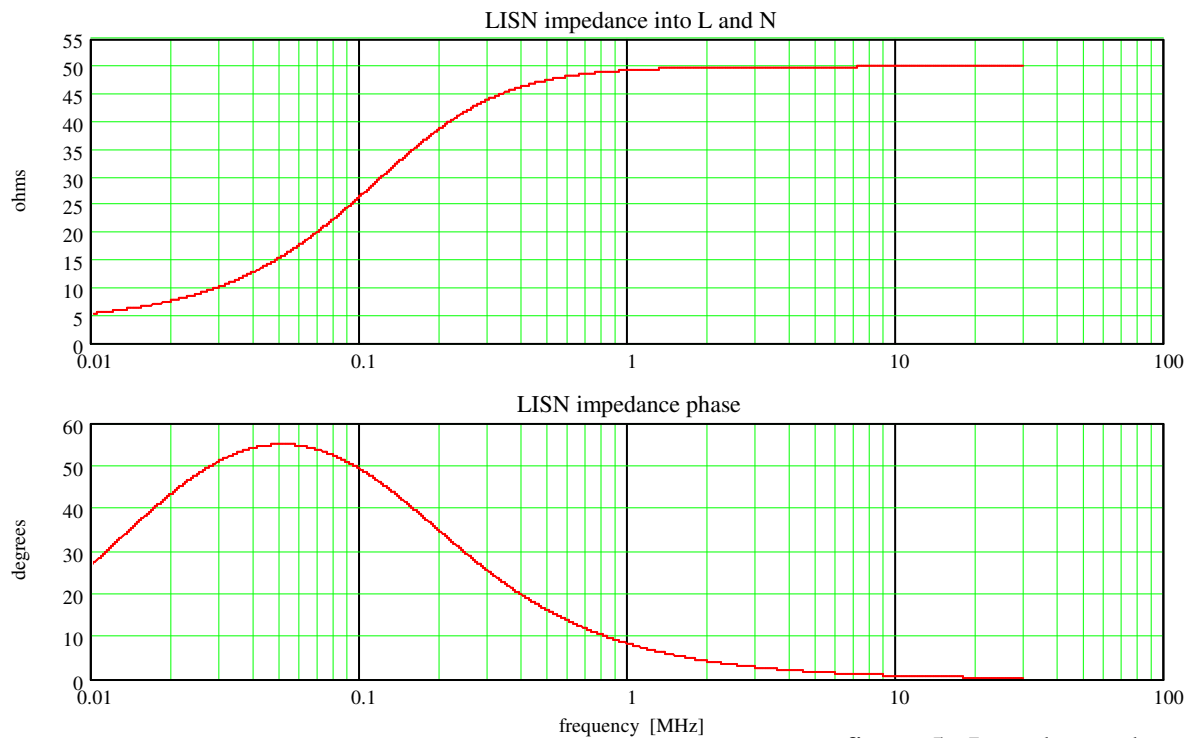


figure 5 Impedance characteristics

With HP filter activated, LISN impedance changes slightly but less than $\pm 5\%$ from 10 kHz to 1 MHz.

Disassembly

If you need to modify your EMIfix, you must disassemble it.

Level 1:

- Remove the top cover by unscrewing four M3 bolts in the side walls.

Level 2: dismantling PCB and front panel:

- Start with level 1.
- Unplug three spade connectors in the mains inlet.
- Unscrew eight M4 bolts fixing the PCB to the chassis bottom.
- Unscrew four M3 bolts fixing the front panel to the chassis.
- Lift PCB and front panel out.
- Take care not to lose the four square nuts that could drop out of the side panel slits.

Level 3: complete dismantling:

- Start with level 1 and 2.
- Unplug four spade connectors for mains outlet and one spade connector for "artificial hand".
- Unscrew BNC connector from front panel. Be careful not to scratch the front panel surface.
- Disconnect earth terminal on front panel by unscrewing an M3 bolt from the PCB.
- Unscrew rear panel and reference earth rail if necessary.

Re-assembly:

Follow the instructions above in opposite order. Remember to tighten screws for BNC connector to front panel and front panel to chassis before tightening the eight screws to the chassis bottom. This is to avoid imposing mechanical stress to the BNC connector. Eventually, the four nuts must be slid into the right position in the side panels to fit into the four M3 bolts for the side walls.

Cleaning

For cleaning of the exterior surface of EMIfix use a damp soft cloth and, if necessary, a mild detergent. Avoid liquid entering into openings and gaps in the cabinet. Always unplug EMIfix before cleaning.

Photo of EMIfix inside

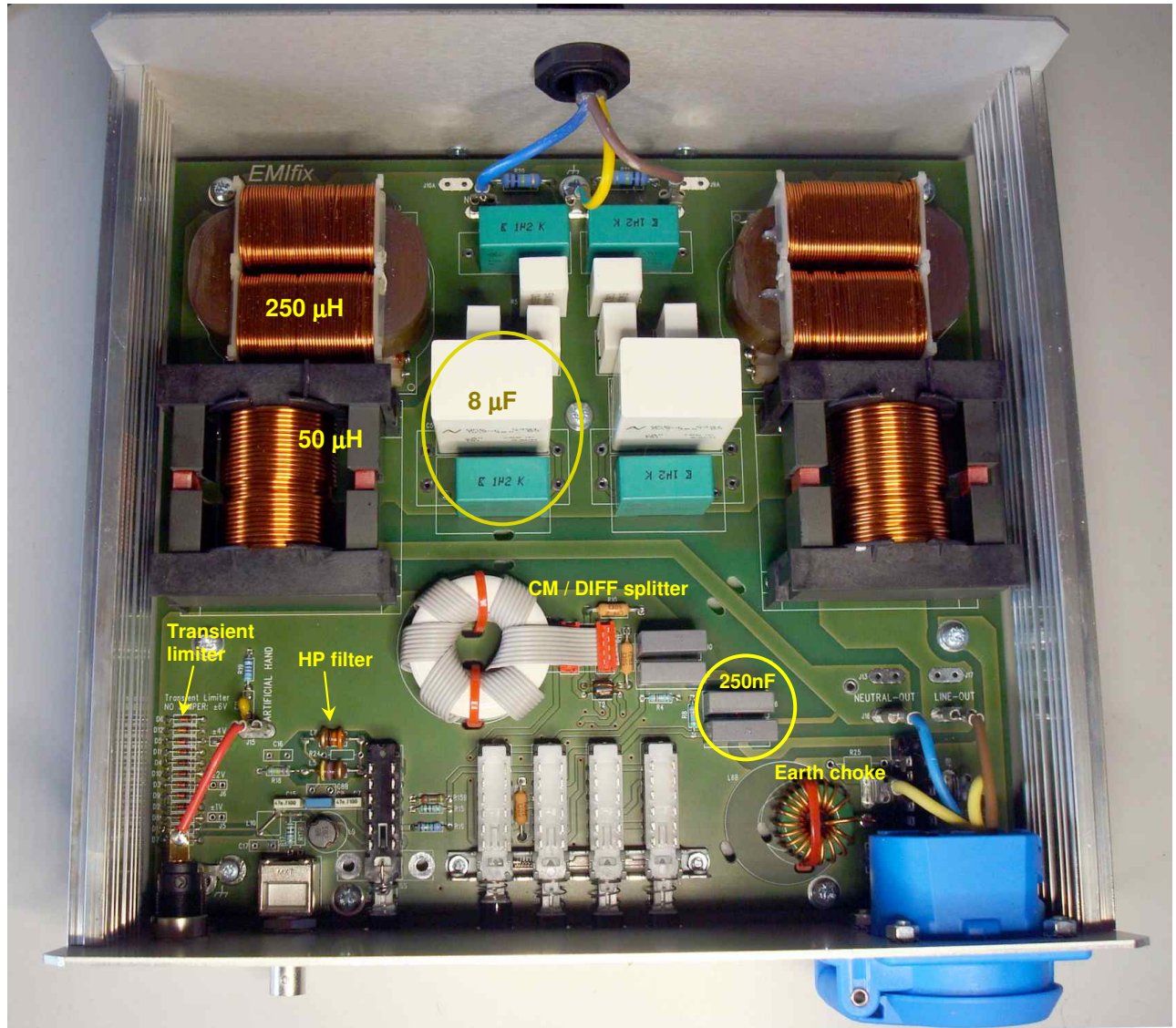


Figure 6

EMIfix was made in Denmark by
Runo's Power Design
Kildebjerggaard 3
5690 Tommerup
Denmark

More information

Further information can be found in http://www.runonielsen.dk/LISN_article.pdf.