ELECTRICAL ENGINEERING

How to simulate the impedance for this LISN circuit in LTspice?

Asked 2 years, 5 months ago Active 2 years, 5 months ago Viewed 4k times

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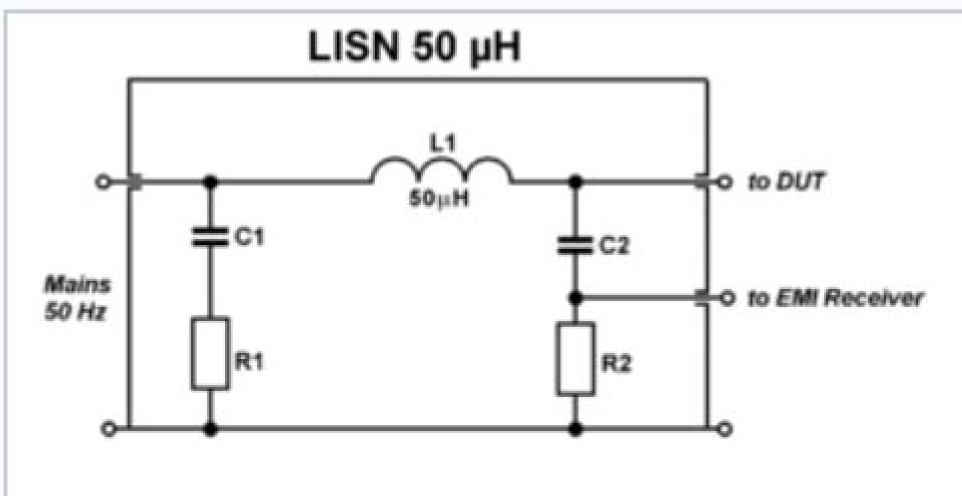
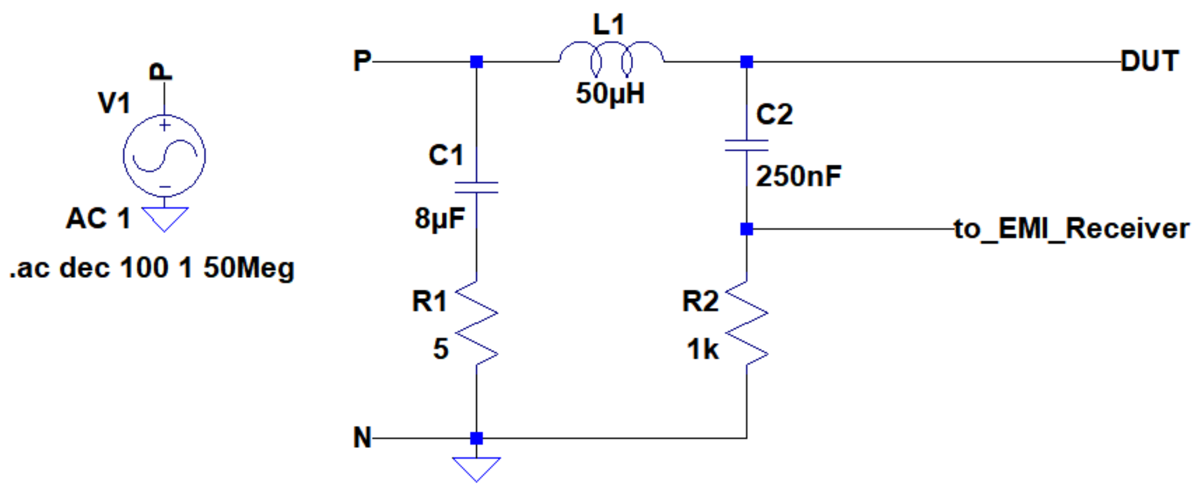
I tried to simulate the following simplistic LISN circuit:

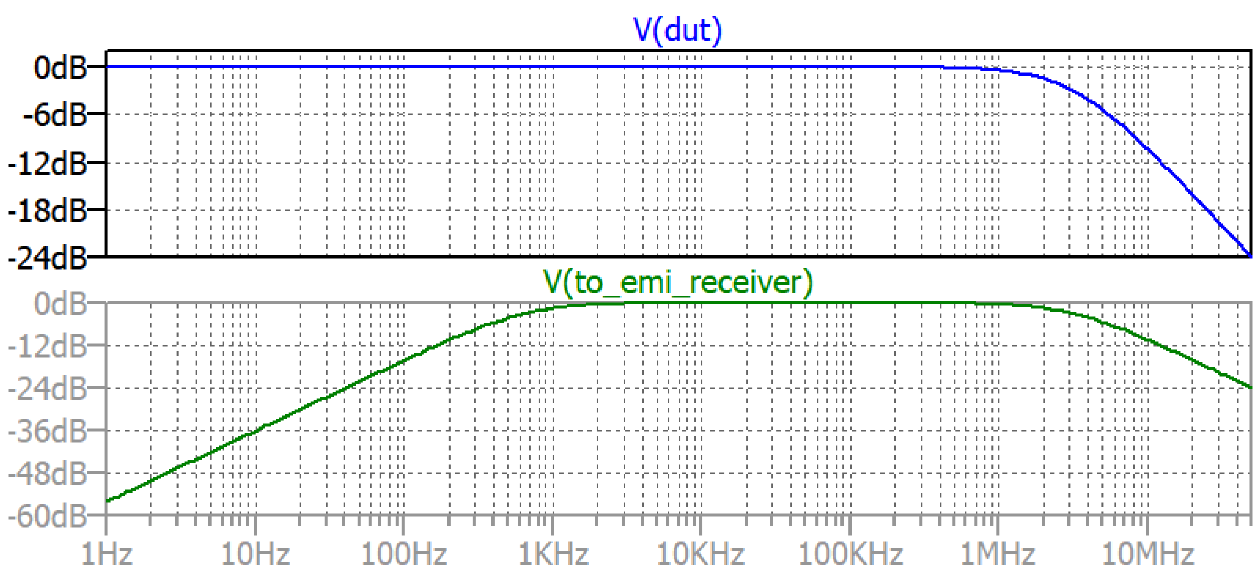


LISN block diagram. This is standard diagram of a typical LISN. Part values for a particular standard (MIL-STD 461E): C1=8µF, R1=5Ω

> C2=250nF, R2=1kΩ

Below is the AC analysis with LTspice for two nodes:





But these above plots do not tell me anything related to the purpose of LISN which is impedance balancing. The idea of LISN to raise the grid impedance to around 50 Ohm, isn't it?. How can this circuit be modified so that we can see the impedance settles/stabilizes after a certain frequency? Can someone simulate and obtain that?

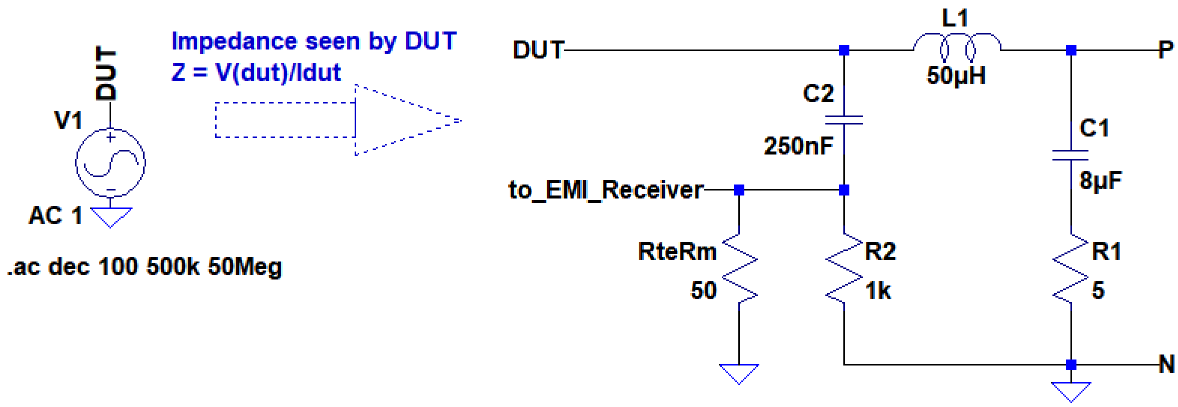
Edit:

I might have found the answer after I read the following:

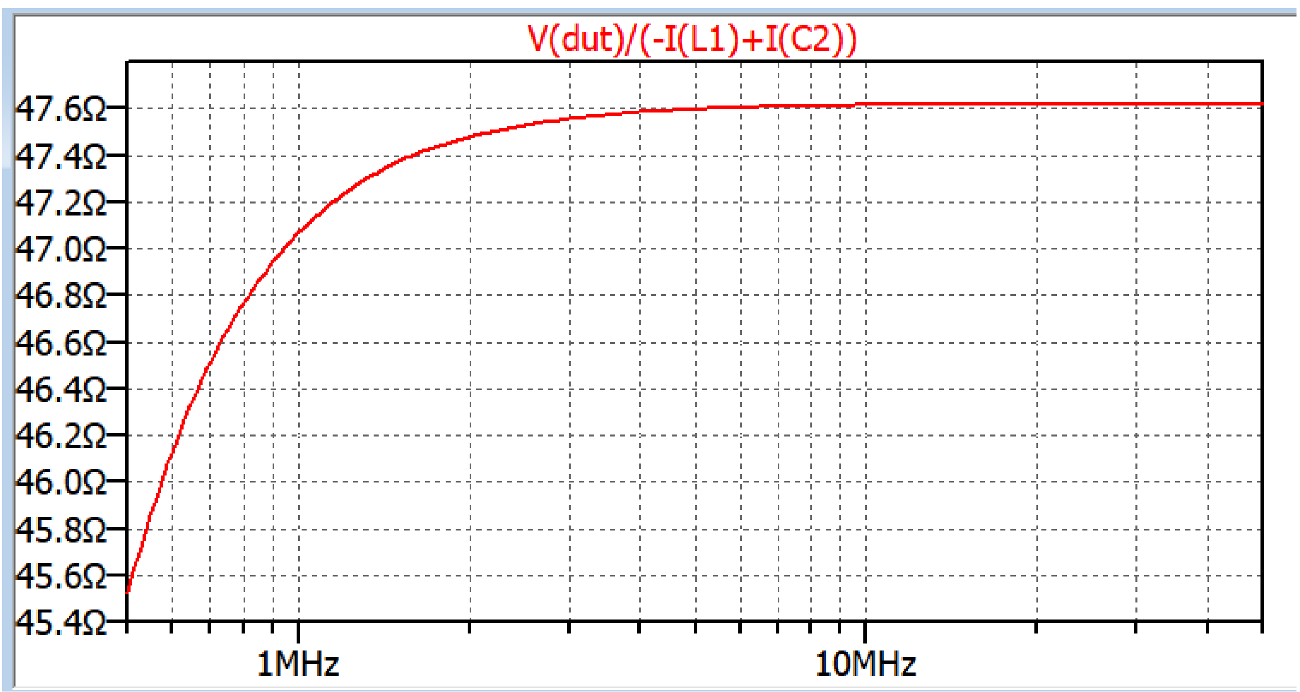
> Since the currents exiting the device under test are dependent on the load on the ac power cord, and this load is the impedance seen by the device looking into the ac power outlet, which varies considerably over the measurement frequency range from outlet to

> outlet and from building to building, it is not sufficient to measure the noise currents on the power cord with a current probe. Instead, the product under test is connected to a LISN, which stabilizes the impedance seen by the product looking out the ac power cord.

So instead, I simulated the Z = Voltage/Current at DUT node:



The impedance seen approaches to 47 Ohm and I increase R2 to infinity it approaches to 50 Ohm.



What do you think? Is this a correct way of demonstrating it?

ltspice emc

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edited Dec 21 '18 at 14:07

asked Dec 21 '18 at 12:32

cm64
1,054 9 24

If you want the output impedance which is 50 ohms along the considered frequencies, you have to short the input source connections when ac-sweeping the DUT connectors. I would add a small resistance r_L in series with L_1. Also, the sweeping source must be a 1-A ac source and the voltage across its terminals is the image of the impedance you want. – Verbal Kint Dec 21 '18 at 14:23

Thanks for the comment, could you be more explicit about these: 1-) Which nodes to be shorted? P and N? 2-) Do you mean the sweeping source should be a 1A current source? – cm64 Dec 21 '18 at 14:39

Oui, P and N should be shorted and an impedance is a transfer function in which the stimulus is a current source while the response is the voltage across its terminals. If you plot the voltage across the 1-A ac source, then the curve you'll display is the impedance you want, probably in dBohms. – Verbal Kint Dec 21 '18 at 14:58

3 Answers

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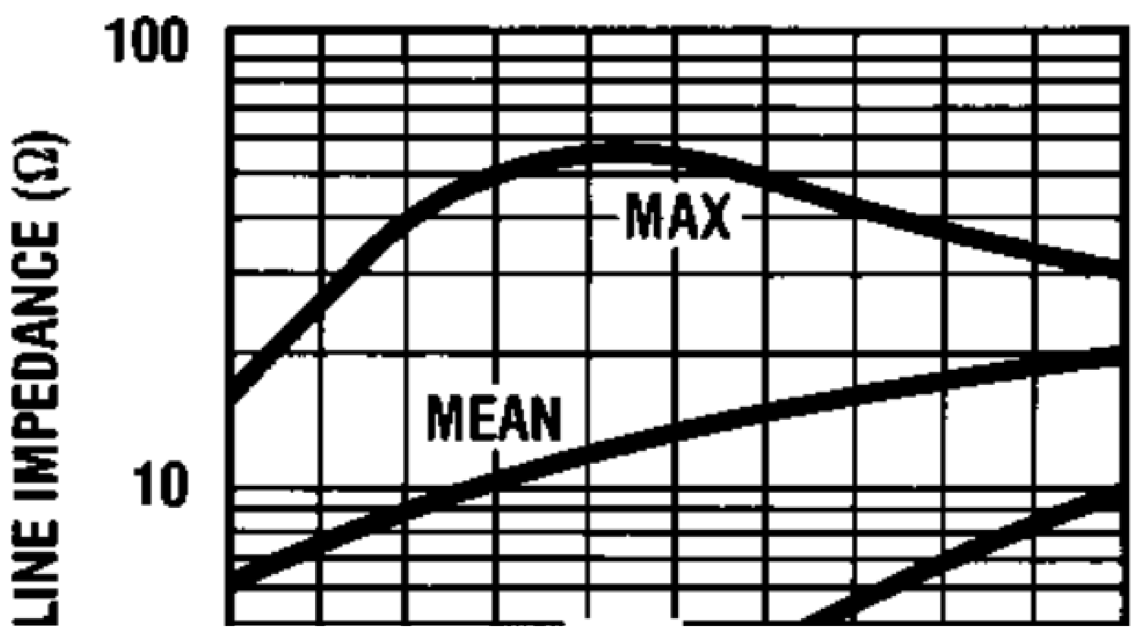
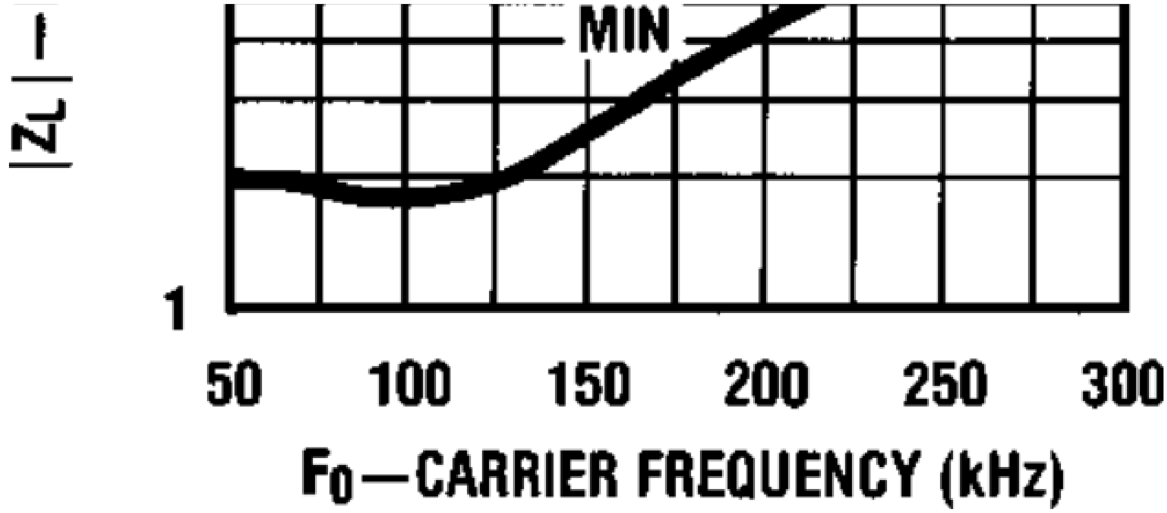
When you measure conducted perturbation, you want to know the amount of noise produced by the equipment or device under test (DUT) which flows back to the source. The source can be the mains or another ac or dc generator like a battery for instance. The idea is to isolate the noisy converter from the source via a filter so that its pollution does not perturb other systems sharing the same power source.

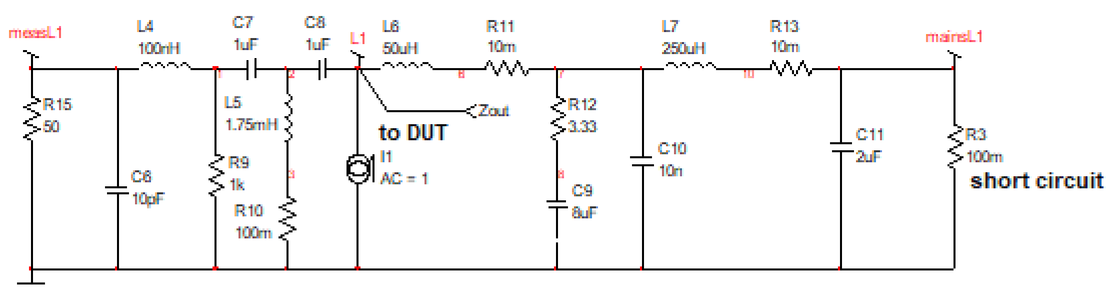
The amount of noise which flows back to the source depends on its impedance. Characterizing a source impedance can sometimes be a difficult exercise. If we take the mains for instance, whether you are in a residential area or in a commercial building, the mains impedance will not be the same. There are not many documents showing the impedance variations of the mains but I remember tinkering with the LM1893 many years ago and the below graph was proposed in the data-sheet, showing how the impedance may vary depending whether you measure it in residential or commercial buildings:



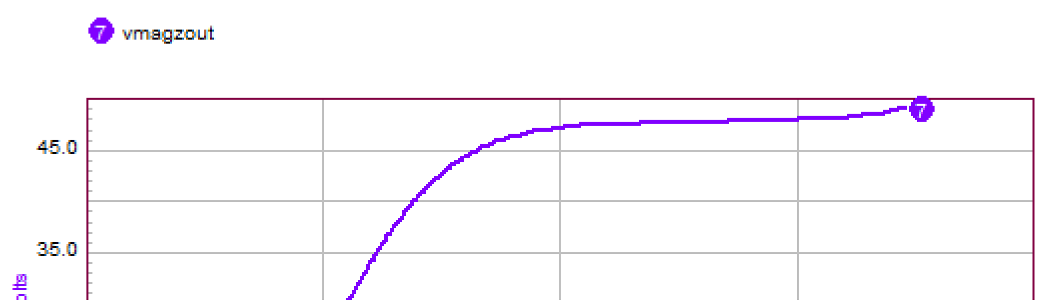


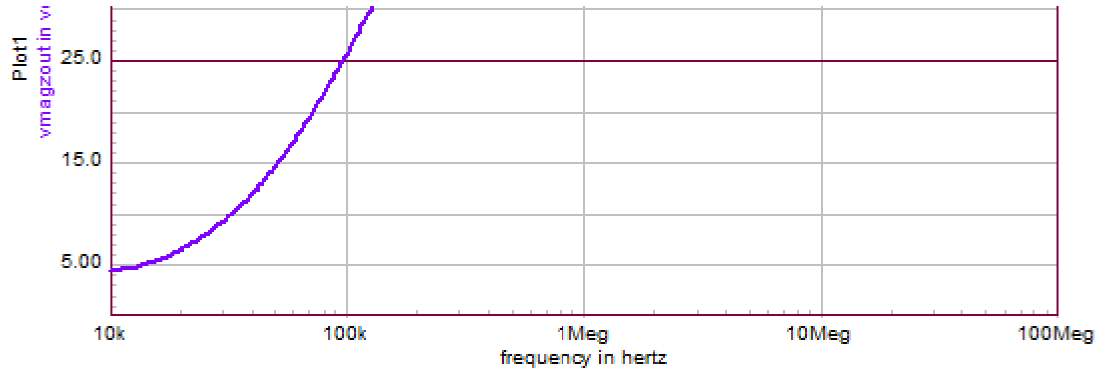
If you fix by a standard a certain level of noise your power supply is allowed to inject, you can see that if you perform the measurement in building A and then in building B in a different country, you may have a completely different signature for the same converter. To avoid this problem, the *comité international spécial des perturbations radioélectriques* (CISPR) - oui, it is French - has defined a specific network that you insert between the source - the mains or a dc generator - whose role is to maintain a specific and known impedance for the measurement. This way,

whether you run the measurement in the US or in Taiwan, you should collect the same amount of noise with the line impedance stabilization network or LISN. The schematic diagram of a LISN used to characterize offline switching converter appears below. It is coming from an old box manufactured by Rohde and Schwarz (you need two of these, one for L and another one for N):



If you want to sweep its output impedance, simply install a 1-A ac source across the connections where the DUT plugs and short the input which normally goes to the ac mains via an isolation transformer. If you now plot the voltage across the current source, the impedance is that voltage divided by 1 A: the displayed voltage curve is representative of the impedance you want:





For those interested by the complete SPICE model of the LISN, here it is:

.subckt LISN mainsN mainsL1 measN measL1 L1 N

*

L4 measL1 1 100nH

R9 1 0 1k

C7 1 2 1uF

L5 2 3 1.75mH

R10 3 0 100m

C8 2 L1 1uF

L6 L1 6 50uH

R11 6 7 10m

R12 7 8 3.33

C9 8 0 8uF

C10 7 0 10n

L7 7 10 250uH

R13 10 mainsL1 10m

C11 mainsL1 0 2uF

R3 mainsL1 0 100m

C4 measN 0 10pF

L2 measN 11 100nH

R5 11 0 1k

R5 11 0 1k

C5 11 12 1uF

L3 12 13 1.75mH

R6 13 0 100m

C12 12 N 1uF

L8 N 16 50uH

R7 16 17 10m

R8 17 18 3.33

C13 18 0 8uF

C14 17 0 10n

L9 17 20 250uH

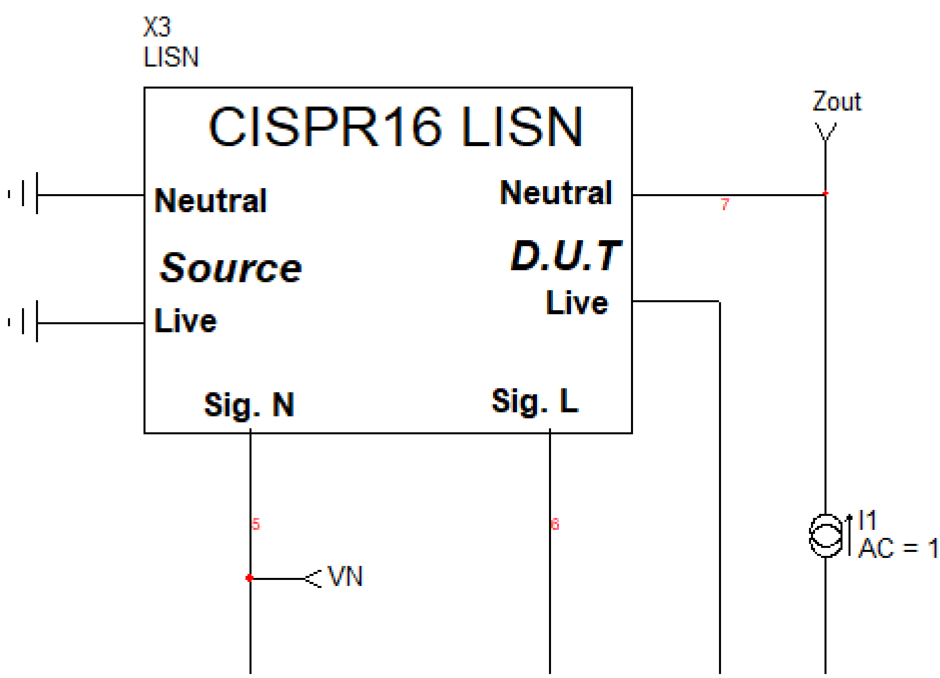
R14 20 mainsN 10m

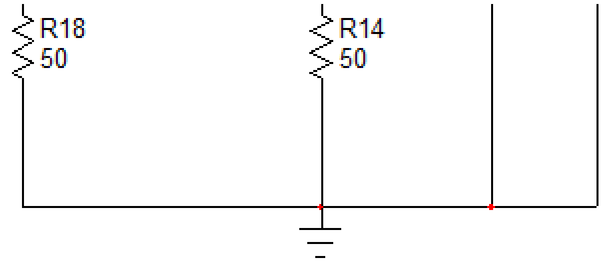
C15 mainsN 0 2uF

R17 mainsN 0 100m

.ENDS

and once encapsulated, it is wired the following way:





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edited Dec 22 '18 at 7:28

answered Dec 21 '18 at 21:53

Verbal Kint
11.1k 1 9 33

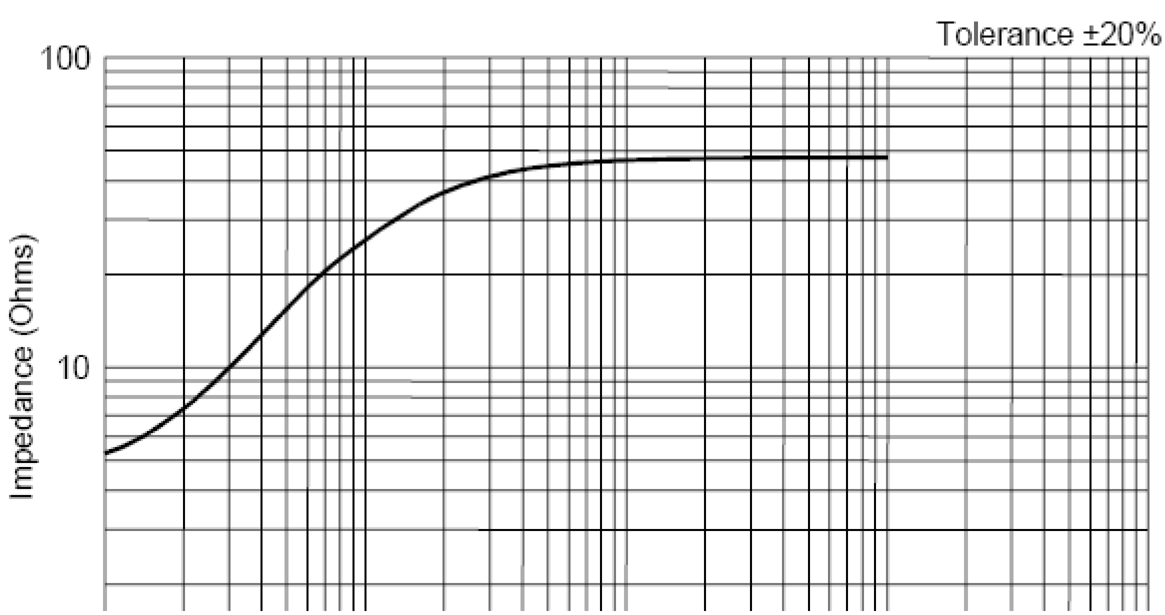
Thanks for the nice clear and very informative answer. I used 1A AC and performed the simulation and the plot is fine only if the terminals are shorted as you said. I stuck at a point. What is the logical reason for shorting the terminals in circuit theory perspective? Yes it works only if I short the source terminal but cannot explain myself why so. – cm64 Dec 22 '18 at 15:36

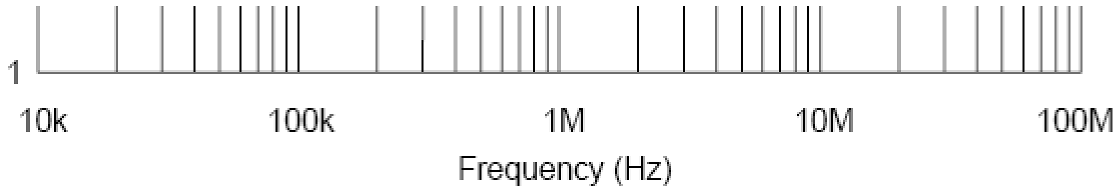
Glad if I could help. Actually, the source itself does not participate in the output impedance determination. Because the (perfect) source amplitude does not change as you ac-sweep the output, its ac value is 0 V during the analysis. A zeroed ac voltage source is a short circuit in ac analysis. If the source was not perfect and feature an output resistance or impedance, zeroing the source would leave the impedance or resistance in place. But if the line source is perfect, just short the input.Check if you leave the source and affect a dc bias to it: it won't change the ac analysis results. – Verbal Kint Dec 22 '18 at 15:55

I guess I understand what you mean; for AC analysis any voltage source(in this case it could be mains impedance) is actually a short circuit. I simulated for short and later for 50 Ohm termination there were almost no difference. So shorting is the best way since we don't know the source impedance. (Your empirical data does not exceed 50 Ohm so it is safe to assume grid/mains impedance as zero and to short the terminals) – cm64 Dec 22 '18 at 17:48

2

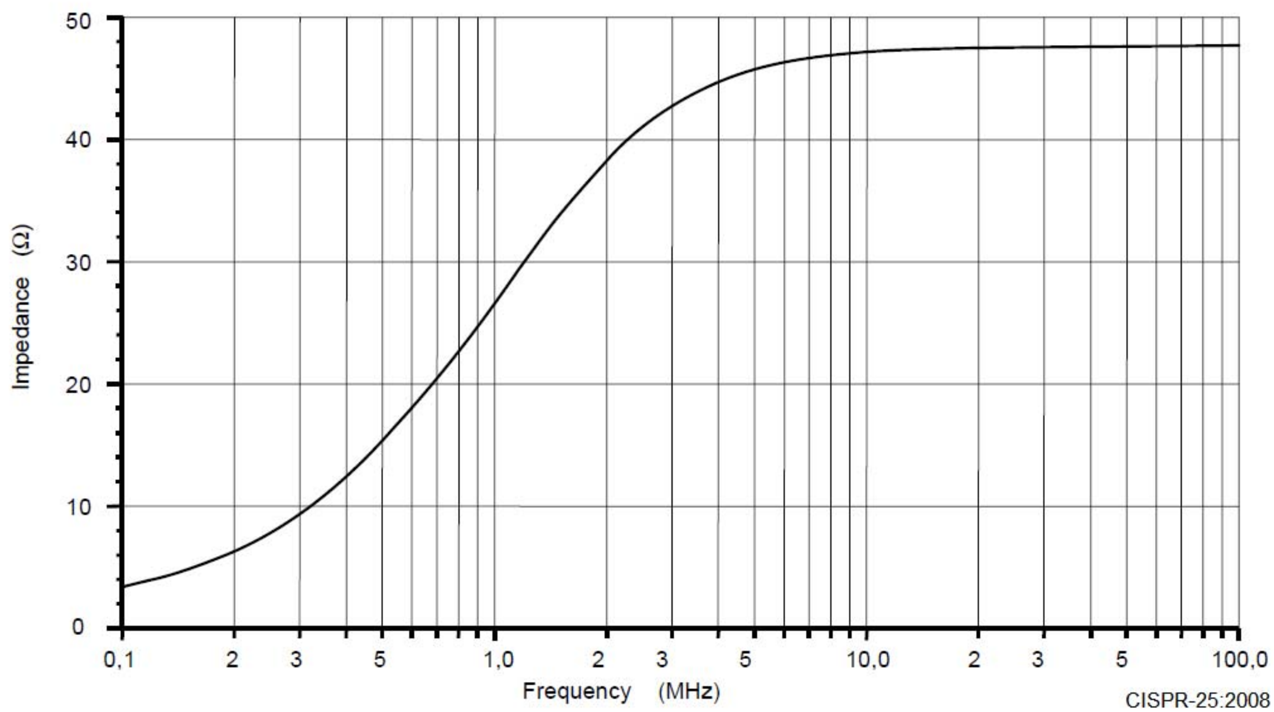
The simulation's impedance curve (to me) looks very similar to a [published MIL-STD-461E impedance curve](https://electronics.stackexchange.com):





This curve approaches but does not reach 50 ohms, much like your result. I think your simulation is trustworthy.

The [CISPR-25 curve] has a similar characteristic:



The idea of the LISN is to present a consistent impedance to the unit under test so that you get consistent results. Consistent doesn't mean flat, as you can see - consider AC line frequency at 50 - 400Hz. The LISN should be invisible to this LF signal so that you don't affect the unit operation and also so that you don't swamp the input of your analyzer with LF which will be orders or magniture higher in energy than the EMI you are trying to measure.

Share Cite Improve this answer Follow answered Dec 21 '18 at 16:25

Adam Lawrence
31.7k 2 54 104

0

The purpose is to stabilize variations in line impedance using L1 which raises the impedance to above 50 Ohms above 150kHz for conducted emissions between 150kHz and 30MHz. This L1 is equivalent to a short power line of 25m from a low Z distribution transformer to the DUT. The cct. also attenuates line noise with a current limited R1 + shunt cap, C1.

This is usually an air coil to avoid potential saturation effects from DUT surge currents. The cct is usually duplicated for dual line L1,L2 inputs.

R2 serves to limit the line impedance to the DUT to 1k to prevent unstable resonant operation before the 50 ohm Rx is connected.

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answered Dec 22 '18 at 0:52
Tony Stewart EE75
112k 3 41 149