Measuring the Conducted EMI of a Switching Power Supply Using the SIMPLIS LISN Device

SIMPLIS Technical Webinar
July 3rd, 2025

Technical Webinar Series

Overview

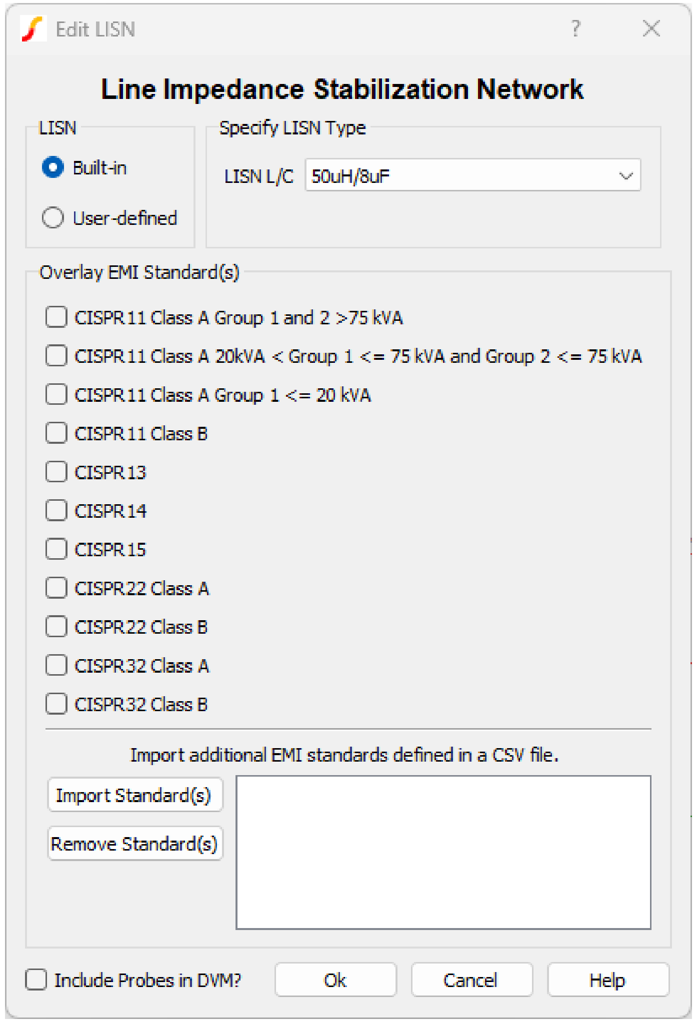
- Overview of SIMPLIS Line Impedance Stabilization Network (LISN)
  - Schematic
  - Usage
  - Features
  - Short Introductory Example

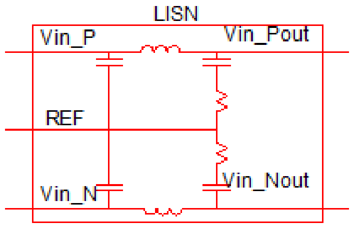
- Design Example using the LISN, the Design Verification Module (DVM), and the Optimiser: Designing a Differential Mode Filter for a PFC Rectifier
  - Works in **9.2b** OR **9.2d** and later (not 9.2c!)

- Upcoming 9.3 features: peak, quasi-peak, and average EMI measurements

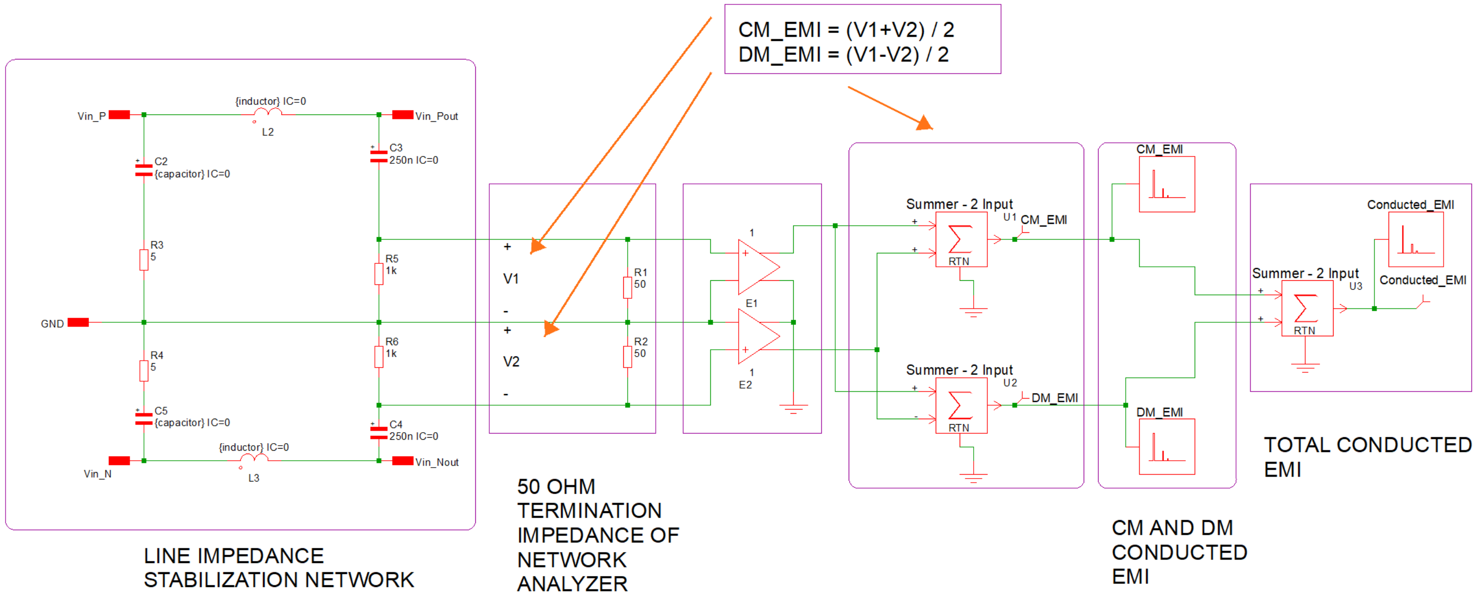
Line Impedance Stabilization Network

- From 9.2b, a Line Impedance Stabilization Network (LISN) device is available in SIMPLIS





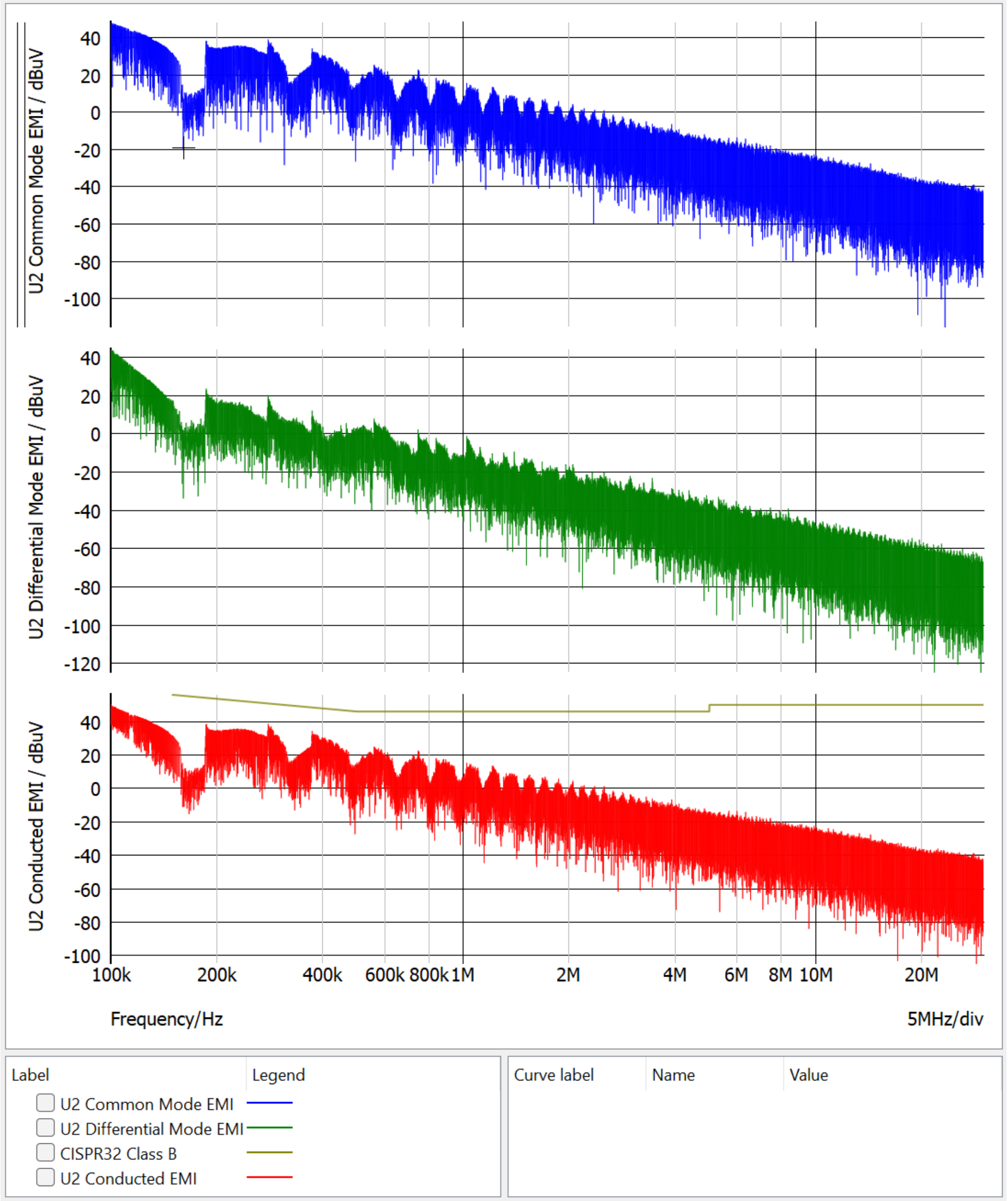
- The LISN provides a constant input impedance for a power supply, emulating a mains supply, and enables the measurement of conducted noise from the power supply into the mains



LISN

- The LISN L/C values can be configured
- The LISN device automatically provides waveforms of the common mode (CM), differential mode (DM), and total conducted electromagnetic interference (EMI), both as voltages and a frequency spectrum
- The frequency spectrum is derived by performing an FFT on the voltage waveforms
- The LISN device can also be configured to overlay EMI standard specification curves on the total conducted EMI frequency spectrum, to see if the power supply meets EMI requirements
- In addition to built-in EMI standards, the user can define additional standards in an external text file

EMI Measurements



- Taking an FFT of the noise voltages is **not** what a real EMI Test Receiver does
- EMI Test Receivers have three measurement modes: peak, quasi-peak, and average
- The average measurement typically is very close to the peaks of the FFT
- Therefore, the standards built-in to the LISN device are all **average** specifications: if the FFT is below the average specification curve, then it's likely that the device meets the specifications

Design Example

1. Simulate a PFC rectifier without a DM EMI input filter.
2. Use the LISN device to measure the conducted noise, and compare it to the CISPR 22 Class A standard, thereby calculating the required attenuation for a DM EMI filter.
3. Use the Optimiser to derive the component values of the EMI filter such that the attenuation requirements are met.
4. Simulate the PFC rectifier with the Optimiser-derived EMI filter to verify that the conducted noise is now within the allowed limits of the CISPR 22 Class A standard.

All of this will be automated using the Design Verification Module (DVM), and the results will be presented in a DVM Report.

Test 1

- Sets the input filter in PFC_LISN.sxsch to a default set of values and then disables it
- Sets an initial conditions file to initialize the simulation in steady-state
- Runs the PFC simulation without the input filter, LISN measures the noise
- Calls the post-processing script PFC_LISN_postprocess.sxscr:
  - Takes the difference between the CISPR 22 standard and the noise FFT, to determine the amount by which the noise exceeds the standard
  - From this, it calculates the attenuation the input filter needs to have

Test 2

- Does not do any simulation of PFC_LISN.sxsch
- Runs a post-processing script called PFC_LISN_calculate_input_filter_values.sxscr:
  - Opens up the Optimiser with schematic PFC_LISN_Filter_Calculator.sxsch, which contains only part of the LISN and the input filter
  - Runs the optimization to find L and C values for the input filter that fulfill the attenuation requirement calculated at the end of Test 1
  - Writes the result of the optimization – the L and C values for the filter – to the file PFC_LISN_with_InputFilter.txt

Test 3

- Reads the L and C values from PFC_LISN_with_InputFilter.txt and sets them to the input filter in PFC_LISN.sxsch and enables it

- Sets an initial conditions file to initialize the simulation in steady-state

- Runs the PFC simulation with the input filter, LISN measures the noise

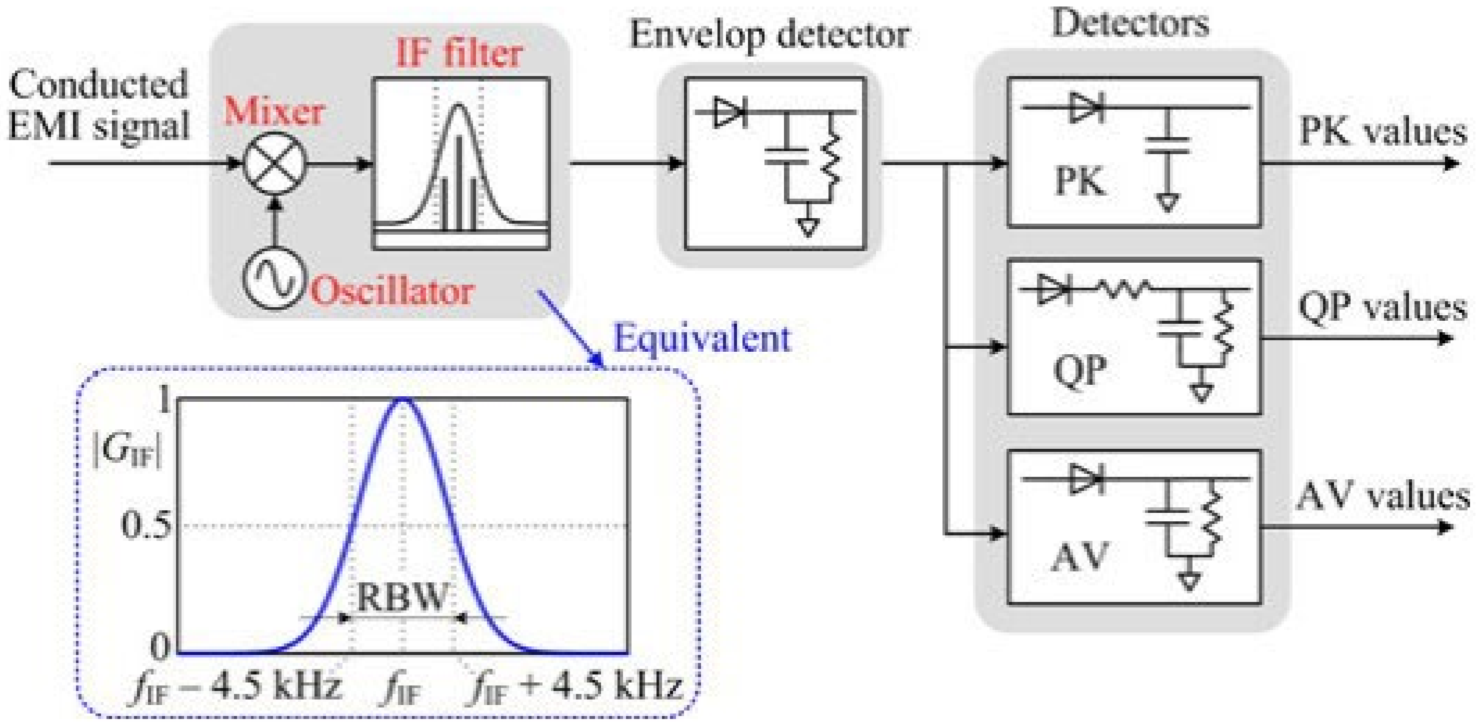
- Calls the post-processing script PFC_LISN_postprocess.sxscr:
  - Takes the difference between the CISPR 22 standard and the noise FFT, to determine whether the PFC with the input filter now meets the standard specifications

Test 4

- Resets PFC_LISN.sxsch to the initial state before Test 1 was run (no simulation)

EMI Detectors

- The CISPR16.1 standard defines the structure of EMI Test Receivers and the types of measurements:



Q. Ji, X. Ruan and Z. Ye, "The Worst Conducted EMI Spectrum of Critical Conduction Mode Boost PFC Converter," in *IEEE Transactions on Power Electronics*, vol. 30, no. 3, pp. 1230-1241, March 2015, doi: 10.1109/TPEL.2014.2317172.

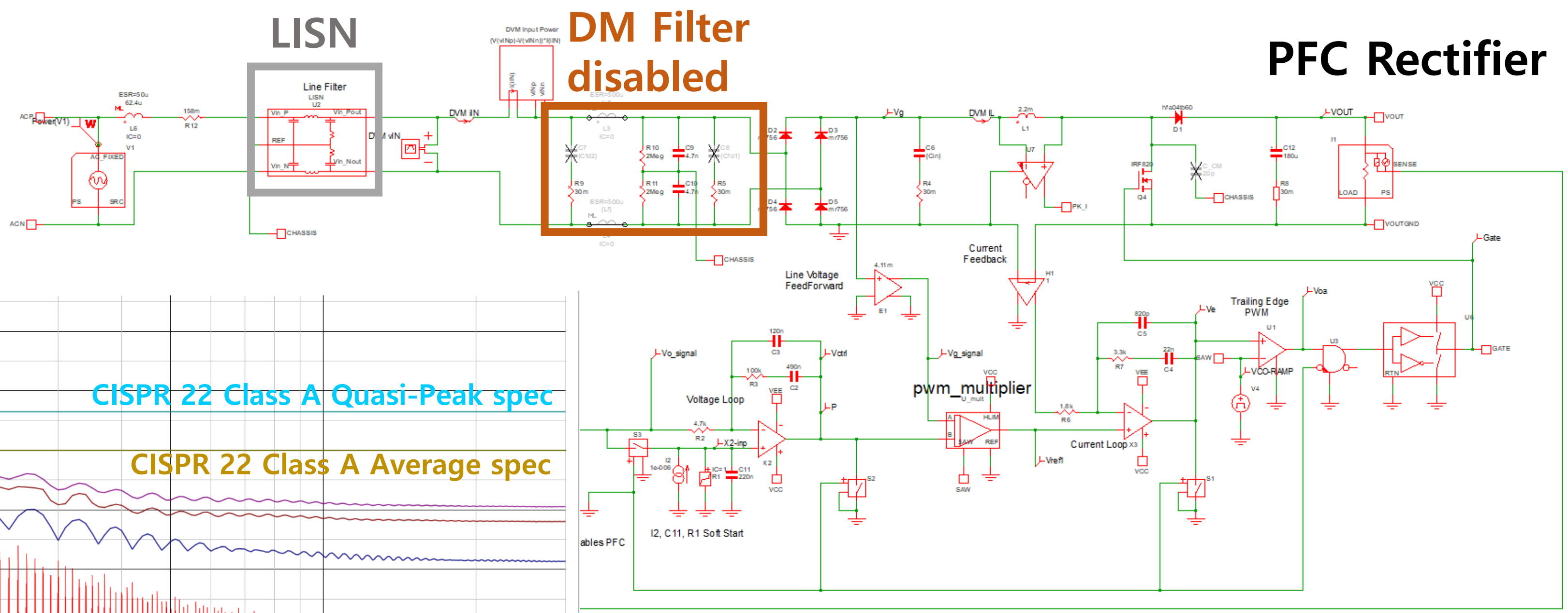
Quasi-Peak Detection

- Represents the weighted average of EMI over a unit of time, applying a specific weighting factor based on amplitude and repetition rate

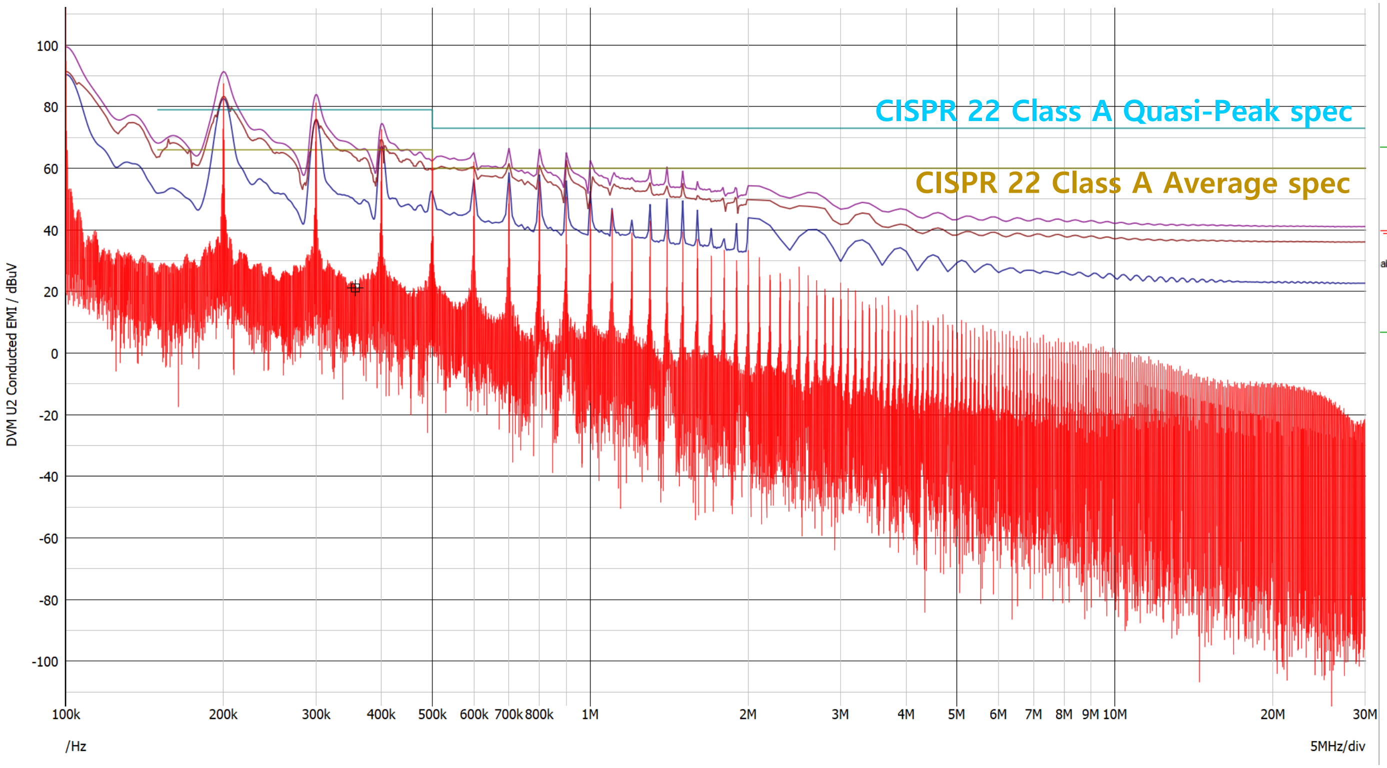
- Quasi-peak detection applied to most conducted emissions measurements (Band B, 0.15 – 30 MHz):
  - IF bandwith of 9 kHz
  - Attack (charging) time of 1 ms
  - Discharging time of 160 ms

- Original justification: it was considered to more appropriately indicate the subjective annoyance level experienced by a listener hearing interference to an AM radio station

Step 1



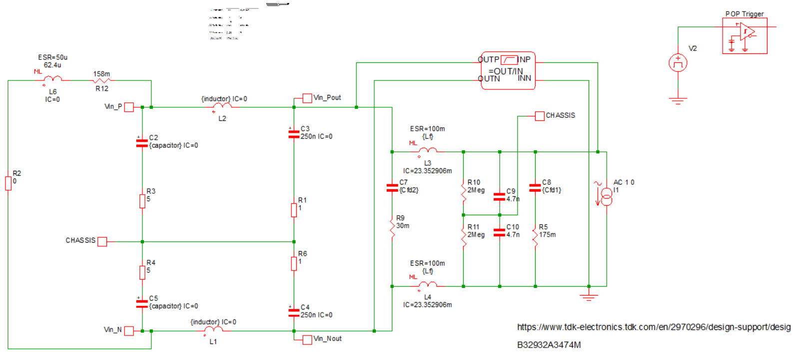
EMI Measurements



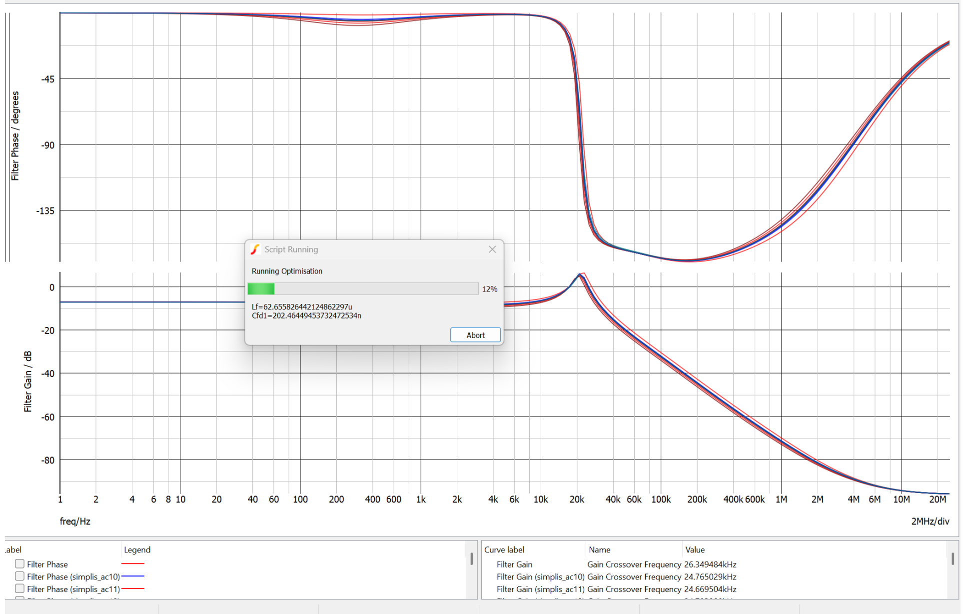
- Conducted EMI in the 150 kHz – 1 MHz range significantly exceeds the minimum defined by the CISPR 22 Class A standard

Step 2

Filter schematic



Optimiser finding correct attenuation



Parameters

Parameter name	Initial value	Minimum value	Maximum value
Lf	50u	25u	75u
Cfd1	200n	150n	850n

Measurements

Analysis	Label	Type	Expression
.pop + TRIG_GATE={TRIG_GATE} + TRIG_COND=0_TO_1 + MAX_PERIOD=1u + CONVERGENCE=1p + CYCLES_BEFORE_LAUNCH=5 + TD_RUN_AFTER_POP_FAILS=-1	pop_0.0		
.ac DEC 25 1 25Meg	Objective	minimise	abs(YFromX(db(:25/:26),200000,1) +44.67)

Results

Iteration History

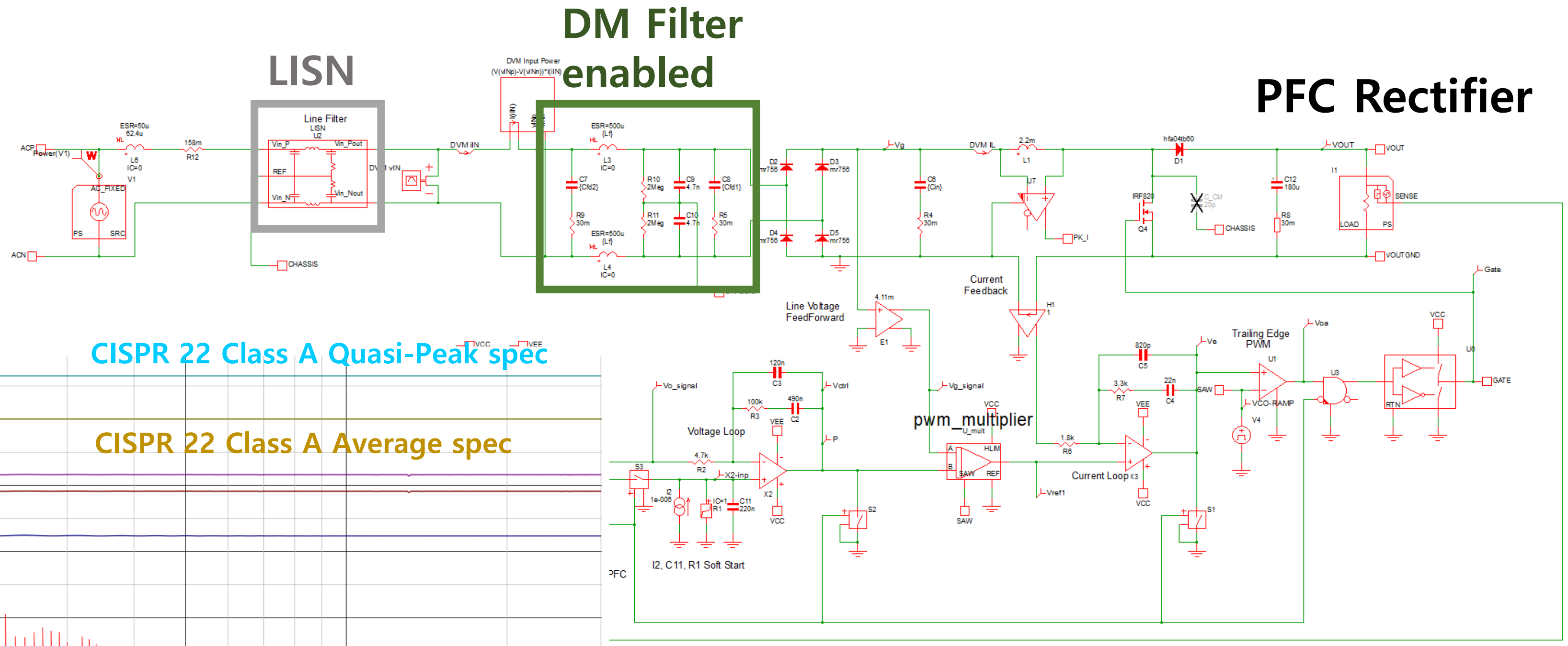
Iter.#	Parameters		Measurements
	Lf	Cfd1	Objective
1	50u	200n	1.916025
2	62.5u	200n	23.946802m
3	62.5u	237.5n	355.96496m
4	74.81188u	193.51861n	1.64502304
5	68.65594u	196.7593n	870.27179m
66	62.457795u	201.82251n	2.057206n
67	62.457795u	201.82251n	14.8571n
68	62.457795u	201.82251n	1.0955432n
69	62.457795u	201.82251n	11.528634n
70	62.457795u	201.82251n	7.7494491n
71	62.457795u	201.82251n	4.2466226n
72	62.457795u	201.82251n	2.220645n
73	62.457795u	201.82251n	2.4842635n
74	62.457795u	201.82251n	1.8818014n

Statistics

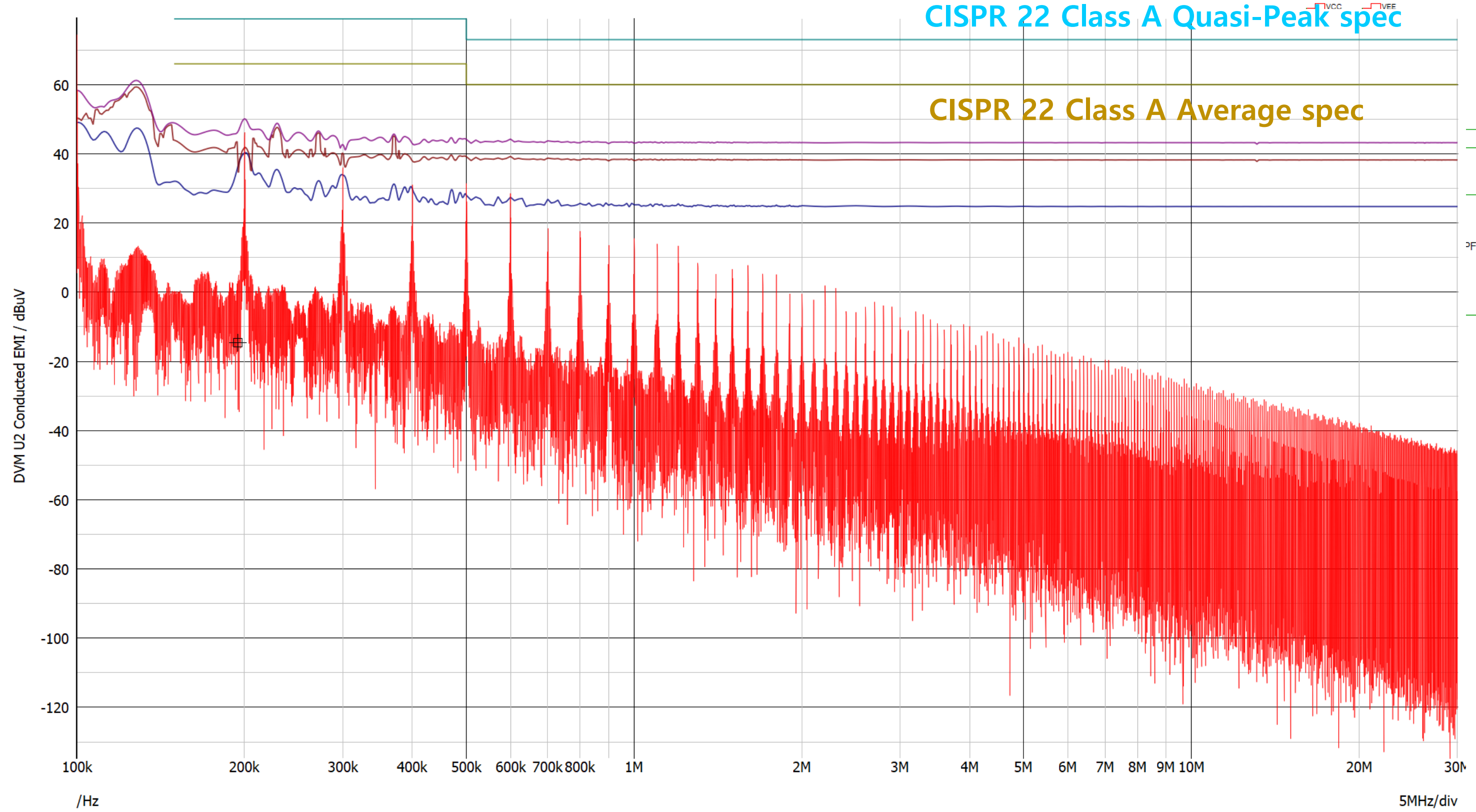
Start:	2025-03-16 8:47 PM
Finish:	2025-03-16 8:49 PM
Number of iterations:	74

- After 74 iterations, the Optimiser finds the L and C values for the filter that best achieve the required attenuation

Step 3



EMI Measurements



- After enabling the filter and setting the L and C values determined by the Optimiser, both the average and quasi-peak specifications of the CISPR 22 Class A standard are met

SIMPLIS TECHNOLOGIES

Conclusions

- The new LISN device can be used to characterize EMI performance of power supplies in SIMPLIS simulation
- Using DVM, the search for L and C values of an EMI input filter that provide the desired attenuation can be automated, and it can be verified that the power supply meets EMI standards
- In version 9.3, peak, quasi-peak, and average EMI measurements will also be available through the LISN
  - Download will be updated after 9.3 is released