Conducted Emission ICEM Model Compare to a Measure

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1 Substract

The purpose of this paper is to present emission prediction made with a microcontroler ICEM model, after what a comparison was made with measure of this emission, obtained in a automotive standard condition. We show that in a EMC prediction objective, the low frequency model allow to use and construct quite easy the ICEM model. For higher frequency, it would be uncontournable to measure precisely the device network impedance.

2 General approach.

The measurement of the current I flowing through the IC supply pin was performed using the 1 ohm method described in the IEC 61967 part 4 standard. From this information we can construct a table of the current amplitude for some frequency of interest. Here we present results for frequencies between 0.15 and 1 Megahertz. The microcontroler activity is define by the device manufacturer. For a futur use on real product it can be a source of dispersion and unaccuracy in the EMC prediction. But this dispersion margin can be took into account in the prediction. The supply impedance network wasn't known precisely, but using the default value proposed in the cookbook, the result was sufficiently good. This is due to the fact that for the frequency band of study, the device network impedance is without doubt not of first influence in the determination the current value transmitted to the wire of the harness. For the calculus of the field emitted, we need to construct a schematics including the supply wires, and the parasitic components link to the test geometry structure. Once the current extracted from this circuit, obtained from SPICE, we use them in a MathCad sheet that gives us the electric field at one meter from the center of the harness, as define in the standard.

3 ICEM model values.

From the IEC61967 part 4 measures made by the manufacturer, we have the following values of current:

frequency (Mhz)	**amplitude value (dBuV)**
0.2	45
0.4	43
0.6	34
1	26
2	31
4	36

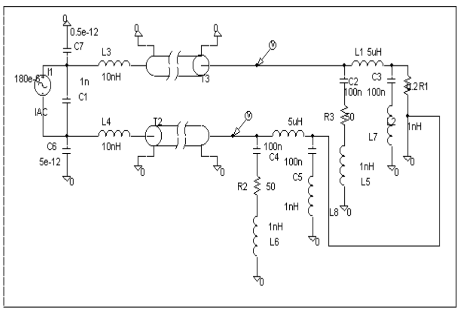
For the network we consider the following typicals values (see for reference the "ICEM cookbook, page 12):

Lpacks = 1nH
Cd = 50 nF

We neglicted in this first step the resistance value.

4 Standard configuration test modelization.

Once the model construct for the noise source, we must add the connexion to the 1.5 meter long harness, with the LISN network connected to the other side. The height of the wire upon the ground plane define the characteristic impedance of the line associated with. The T model in spice allow to simulate the current and charge values in both the two wires of the harness. Taking into account of the parasitic elements as inductance of the LISN network is important. The final schematic is this one:



For the frequency of 4Mhz, the value readable is 36 dBuV. This is the value reused to calculate the field at this frequency. And we retrieve the resonance around 1500 khz, seen in the measurement.

5 Calculation of the electric field.

In the frequency band of interest, the current and voltage still homogeneous all along the wire. To calculate the electric low frequency field we consider the charge distributed on the line. This charge is given by:

$$Q(f) = \frac{1}{c.Zc}.V(f)$$

From the value of Q once calculate the scalar potential at the observation point. The potential is given by:

$$\psi_f = 2\int_0^{l/2} \frac{Q(f)}{4\pi\epsilon\sqrt{z^2+x^2+y^2}}dx$$

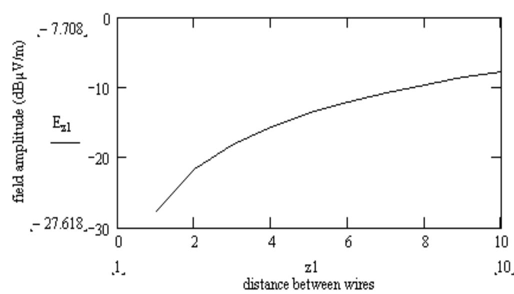
(l) is the lenght of the wires, (x) the wire direction, and (z)the one perpendicular to them, to t he antenna, (y) the third space dimension. Afterwhat the electric field is deduced from:

$$\overrightarrow{E_y} = \int_h -\overrightarrow{grad}(\psi_f(y))dy$$

Where (y) is the space direction following (h), the higher of the dipole antenna used in the standard measurement. To evaluate the total field, once must just add the four fields coming from the two wires and their image by the ground plane. The distance between one wire and the ground is of 5 cm, and the antenna center is 5 cm up to the wire plane.
It must be seen that the distance between wires is a important factor of the field amplitude. So, to evaluate the evolution of the result, it's interesting to view differents amplitudes linked to various wire distances.

6 results and comparisons

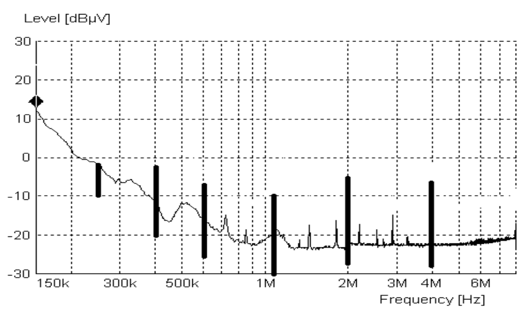
Calculus was made with MathCad. The curve of electric field values obtain for example at 600 khz for various distance, is:



The measure was include between -12 and -15 dBV/m

The results obtained are under hypothesis of full report of the device noise on the supply lines. this can be discussed, but in term of a prediction, the margin and uncertainty get up the problem. If we find, even with the bigger distance between wire that the levels are near of the standard limit objectives, it supposed in beginnning of a project to imagine filters solutions to make those levels one decade lower. In the case showed here, we see that even what can be the wire separate distance, we have such a margin of more than 20 dB compare to some automotive's

standard. If we remember that the level is obtained with a complete report of noise to the wire, it allow to consider the product as in compliance with the objectives.
Another effect is the influence of the global electronic equivalent schematics of the test configuration. Depending of the impedance used, resonances can appear. In this case, the errors made in the construction of this network can destroy the evaluation validity. At low frequency this is the first problem to resolve. But here too, a parametric study gives generally rapidly a group of values useable to evaluate the EMC risk, and the dispersion moves around 10 dB typicaly. One can construct a probabilistic EMC risk study which will give sufficiently information to conclude. We can see on the curve below that estimation including dispersion are around the measure:



7 Conclusion.

It's today sure that the ICEM model can allowed to predict EMC behavior of an IC in conducted emission, and radiative standard one by wires. Concerning low frequency coupling, it's true even if the impedance network is not well known. For higher frequency, it must be known, and the radiation performance by conducted noise on wires should be calculate from the vector potential, and from the wires and displacement currents. In the radio frequency band, this part of radiation is very important for automotive. But at lower frequencies, the low frequency field effect are major source of radiation.
We can hope for futur of an introduction of the ICEM IC device model in component data sheet. Some simple tools would gives EMC evaluation of radiation, waiting for more complex CAD software including the model.

8 References.

ICEM CookBook. IEC UTE 47A EMC Task document.