"Noisew" specifications

1. Objectives

"Noisew" is a program to calculate an impedance characteristic of power supply system of an electronic circuit for facility. A circuit characteristic of power supply system is decided on a characteristic of power supply wiring (plane) equal to a course supplying a power supply by a parasitism characteristic of an electronic device using an electric current. In "noisew", you can easily appoint these parameters. In addition, a graph can display an impedance characteristic in a frequency axis.

2. Backgrounds

With speedup of a recent electronic device, various problems due to an impedance characteristic of power supply system of an electronic circuit appear close. An interchange electric current used with an electronic device discharges an electromagnetic wave from power supply wiring and affects neighboring wireless units. In addition, a voltage descent occurs by a consumption electric current of an electronic device and affects it in a movement timing of a signal (jitter) and lets an electronic device malfunction.

As means to grasp an impedance characteristic of power supply system of such an electronic circuit quantitatively, Spice simulation is used. However, it is necessary for modeling to do power supply wiring and a characteristic of an electronic device with a basic element of an electronic circuit to perform Spice simulation. Technical knowledge is necessary for modeling, and results are different greatly when they perform wrong modeling.

It is the opportunity when what want to grasp an impedance characteristic of power supply system easily developed "noisew". I make many characteristics it temporarily to pursue simplicity. I leave grasp of an accurate characteristic to Spice simulation.

3. F matrix and impedance

"Noisew" performs an impedance calculation with F matrix. F matrix is a matrix to consist of an element of 2x2 and expresses an impedance characteristic of an electronic circuit as follows.

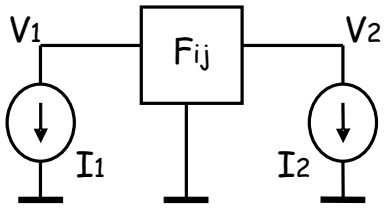

Fig.1

$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{pmatrix} \bullet \begin{pmatrix} V_2 \\ I_2 \end{pmatrix} \text{ Ex.1}$$

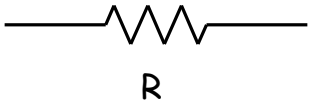

Fig.2 $= \begin{pmatrix} 1 & R \\ 0 & 1 \end{pmatrix}$ Ex.2

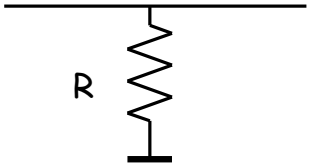

Fig.3 $= \begin{pmatrix} 1 & 0 \\ 1/R & 1 \end{pmatrix}$ Ex.3

"Noisew" does modeling of the following equivalent circuit with this F matrix. When V2 expresses the power supply voltage to supply in an electronic circuit and calculates an impedance characteristic of power supply system, I define it as zero [V] in convenience. A F matrix can define power supply wiring and a parasitism characteristic of an electronic device voluntarily (refer to list of nets specifications). I1 expresses a consumption electric current of an electronic device. And "noisew" calculates an impedance characteristic (Z) when V1 occurs by I1 as Z = V1 / I1.

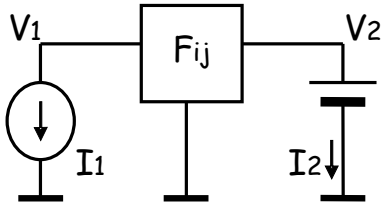

Fig.4

$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{pmatrix} \bullet \begin{pmatrix} 0 \\ I_2 \end{pmatrix} \text{ Ex.4}$$

$$V_1 = F_{12} \bullet I_2 = \frac{F_{12}}{F_{22}} \bullet I_1$$

4. Characteristic of a capacitor

A capacitor is an important part to select an impedance characteristic of power supply system of an electronic circuit as. As a bypass capacitor (Japanese popular name, PassCon), I am connected around an electronic device and usually use it. It is known that a capacitor has parasitism inductance (ESL) and parasitism resistance (ESR) for not only static capacitance but also interchange. An impedance characteristic strongly shows influence of this parasitism element, and there can be a thing behaving in a complicated way by a resonance characteristic with other electronic devices in particular. This resonance characteristic can influence that an electronic circuit can do unexpected behavior by a change of a capacitor.

"Noisew" appoints static capacitance of a capacitor and I calculate a parasitism parameter automatically and add it. Therefore, please use Spice simulation for accuracy because I am missing when I use an accurate value and design it. A parasitism parameter of a capacitor can obtain Murata Manugacturing or TDK from a homepage of a major part maker.

5. Microstrip lines

Power supply wiring is a bit big, and there can be a thing laying it out with wiring shape of constant width. In such a case it is suitable to do modeling as a microstrip line for grand plane. A microstrip line is decided to undergo a characteristic by a dielectric constant of an insulator other than wiring width and distance (height) with grand plane.

Because I fix a dielectric constant to 4.5, please appoint "noisew" with an equivalent circuit of LCR when I design it with a value except it. In addition, various homepages or books please refer to an approximation expression in search of a characteristic of a microstrip line because various things are shown.

6. Ferrite beads

The ferrite beads are used by a power supply electric current to restrain electromagnetic radiation to occur. The ferrite beads change impedance of the power supply system greatly to have big inductance and capacitance inside. There is the thing that attention is necessary for a resonance characteristic depending on a case.

In "noisew", I appoint impedance and the frequency of the peak of the cover characteristic and I generate an equivalent circuit of LCR for facility and add it. Therefore, I am different from the characteristic of the real device. In addition, the precise equivalent circuit is available from TDK homepage of the major part maker.

7. Netlist specifications

"Noisew" reads structure of power supply system of an electronic circuit from a list of nets. As for the list of nets, the power supply side of an electronic circuit, bottom become the current source side of an electronic device the upper part. A power supply and a current source are modeling possibility by one each. Please use Spice simulation for a design of more complicated power supply system.

* Structure of a list of nets
Electronic device #1
Electronic device #2
:
Electronic device #n

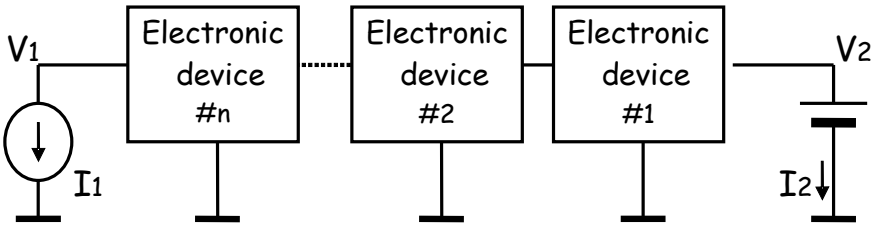

Fig.5

I explain a usable electronic device in "noisew" as follows. I can use a unit for each property value. Please describe the next unit without putting a blank following a number.

* An available unit: a f p n u m k meg g t

(1) Coil (Inductance) <<Series>>

Format:: L <Inductance value[H]>

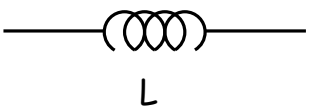

Fig.6

(2) Resistance (Register)

<<Series>>
Format:: R <Resistance value[ohm]>

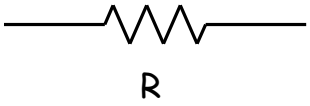

Fig.7

<<Parallel>>
Format:: RP <Resistance value[ohm]>

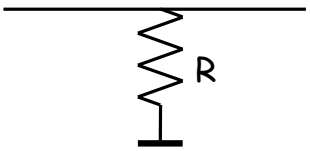

Fig.8

(3) Capacitance (Capacitor) <<Parallel>>

Format:: C <Capacitance value[F]>

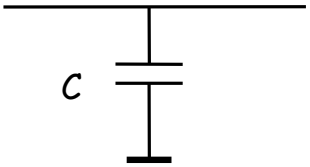

Fig.9

(4) Bypass capacitor (PassCon) <<Parallel>>

Format:: PC <Capacitance value[F]> [Number [ESL [ESR]]]

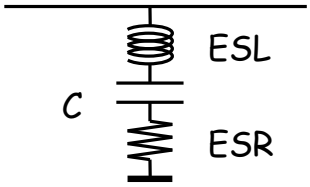

Fig.10

$$ESL = (0.003 \cdot \log(C) + 0.5) \cdot 10^{-9}$$
$$ESR = e^{0.018 \cdot \log^2(c) + 0.12 \cdot \log(C) - 6.4}$$

Ex.5, Ex.6

Reference) Murata Chip S-Parameter & Impedance Library(1005/1608/3216/3225)

(5) Ferrite beads <<Series>>

Format:: FB <Impedance value[ohm]> <Frequency value[Hz]>

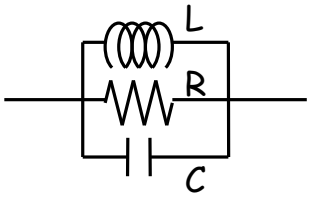

Fig.11

$$R = Z$$

$$L = \frac{2Z}{2\pi f}$$

$$C = \frac{1}{2\pi f \cdot 2Z}$$

Ex.7, Ex.8, Ex.9

(6) Microstrip line <<Series>>

Format:: US <Conductor width[m]> <The amount of insulator[m]> <Mayor of line[m]> [εr]

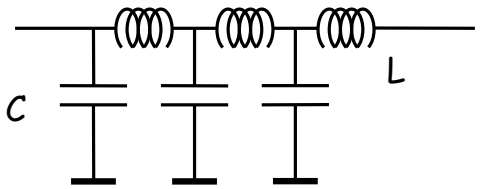

Fig.12

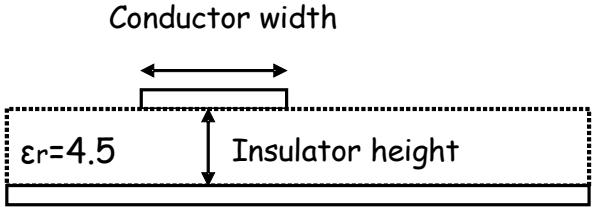

Fig.13

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \cdot \left\{ \left(1 + \frac{12 \cdot h}{W} \right)^{-\frac{1}{2}} + 0.04 \cdot \left(1 - \frac{W}{h} \right)^2 \right\} : \frac{W}{h} \le 1$$

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \cdot \left\{ \left(1 + \frac{12 \cdot h}{W} \right)^{-\frac{1}{2}} \right\} : \frac{W}{h} \ge 1$$

$$Z_0 = \frac{60}{\sqrt{\varepsilon_{re}}} \cdot \log\left(\frac{8 \cdot h}{W} + 0.25 \cdot \frac{W}{h} \right) : \frac{W}{h} \le 1$$

$$Z_0 = \frac{120 \cdot \pi}{\sqrt{\varepsilon_{re}}} \cdot \left\{ \frac{W}{h} + 1.393 + 0.667 \cdot \log\left(\frac{W}{h} + 1.444 \right) \right\}^{-1} : \frac{W}{h} \ge 1$$

$$T_d = \frac{\sqrt{\varepsilon_r}}{C}$$

$$L_{UNIT} = Z_0 \cdot T_d$$

$$C_{UNIT} = \frac{T_d}{Z_0}$$

Ex.10, Ex.11, Ex.12, Ex.13, Ex.14, Ex.15, Ex.16

Source) MWAVE-LABORATORY(http://www.mwave-lab.jp/mline.htm)

(7) Multi-frequency current source

It is a current source of an electronic device to appoint when I calculate the noise voltage in "noisew". I calculate the electric current spectrum which assumed a general logical circuit when I appoint clock frequency and an average electric current. I convert the electric current spectrum which I calculated into the noise voltage with an impedance characteristic of power supply system mentioned in a list of nets and display histogram.

Format:: CLK <Frequency[Hz]> <An average electric current[A]>

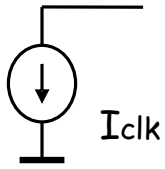

Fig.14

* The electric current spectrum which I use (Frequency does a normalization)

Frequency [UNIT]	0.1	0.11	0.12	0.14	0.17	0.20	0.25	0.33	0.5
Electric current [A]	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.2

Frequency [UNIT]	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Electric current [A]	0.48	0.28	0.22	0.18	0.15	0.12	0.10	0.09	0.08	0.07

Table 1

(8) Signature wave pattern current source

It is a current source of the single frequency. An above-mentioned multi-frequency current source and the combination are possible, too.

8. A definition of the impedance

The graph displayed impedance shows whether it is it in several times of the electric current which the voltage to occur between two terminals when I impressed an electric current between two terminals of the closed circuit impresses in "noisew". In addition, I show whether it is it in several times of the electric current which the arbitrary voltage to occur between two points impresses of the closed circuit when I impressed an electric current between two terminals of the closed circuit with the transfer impedance equally. For example, in figure 15, as for the impedance, as for V_0/I_0, the transfer impedance, it is V_1/I_0, V_2/I_0, … V_n/I_0.

In "noisew", there is a function to display the transfer impedance of the bypass capacitor in the position that is the nearest to a power supply automatically.

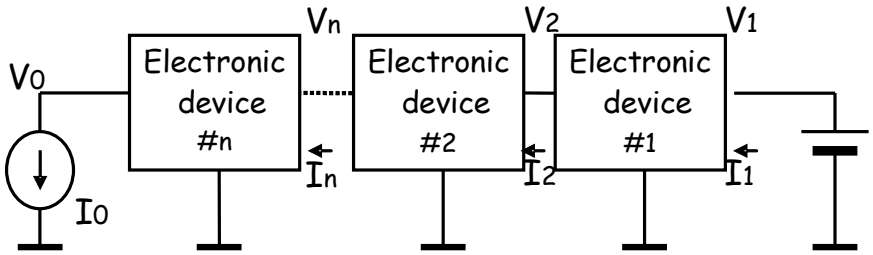

Fig.15

9. The definition of the current gain

When I impressed an electric current between two terminals of the closed circuit, the graph displayed the current gain shows whether it is it in several times of the electric current which the electric current which I leave for the power supply, and drift to the arbitrary point impresses of the closed circuit in "noisew". For example, in figure 15, the current gain is I_1/I_0, I_2/I_0, ... I_n/I_0.

In "noisew", there is a function to display the current gain of the bypass capacitor in the position that is the nearest to a power supply automatically.

10. The calculation of the noise waveform

The noise voltage calculates it by impedance and the product of the electric current to impress. In addition, the noise wave pattern converts the noise voltage into a sin wave pattern and I put it on top of one another every frequency and calculate it.

In addition, I calculate a noise wave pattern and the current waveform of the bypass capacitor in the position that is the nearest to a power supply. These wave patterns multiply an electric current to impress on transfer impedance and a current gain each and demand it.

11. Addresses

If there are questions about this program, please feel free to contact me. In addition, please forgive that there is the case that cannot reply by circumstances of diversity beforehand.

Akimoto Tetsuya (kappa.v.v.v@nifty.com)