Net Classification Algorithm

Purpose of Algorithm

To derive information about the signals on a printed circuit board based on information stored in the component library and the board layout files.

Description of Algorithm

Radiated emission cannot be calculated or even estimated without having some information about the signals propagating on the printed circuit board. Generally, this information is not stored in board layout files, schematics or any database readily available to the expert system. Therefore, this information must either be manually entered by the user or derived from the component and board layout files using expert system techniques.

Table 1. The parameters to characterize the nets on the board.

Type of nets	Attributes	Value	Description
Power/ground net	Voltage	V_{cc} or *0*	Voltage of the net.
Signal net	io_type	'I/O' or 'non_I/O'	Specify if the net is connected to input or output port.
	clockfreq	*frequency*	The frequency that the signal on the net is clocked at, if applicable.
	lowfreq, highfreq	*Low frequency, high frequency*	Frequency range of the signal on the net. lowfreq = highfreq for sinusoidal or narrow band signal.
	util	'HIGH', 'MEDIUM' or 'LOW'	Utilization of the net. For example, 'HIGH' for clock net, 'MEDIUM' for data line, and 'LOW' for reset signal.
	transtime	*Transition time*	Transition time of the signal.
	noise_margin	*Noise margin*	Noise margin of the net.
	Vmax, Vmin, Imax	V_{max}, V_{min}, I_{max}	Maximum voltage, minimum voltage and maximum current on the net.
	dig_analog	'digital', 'analog' or 'mixed'	Specify the type of the signal.
	V_supply	V_{supply}	The supply voltage to which the signal on the net is referenced.
	rad	'R1', 'R2' or 'R3'	Radiation classification. 'R3' for high potential radiation net. 'R1' and 'R2' for low and medium potential nets, respectively.
	susc	'S1', 'S2' or 'S3'	Susceptibility classification. 'S3' for the most vulnerable net to external noise. 'S1' for the strongest net.
	sig_ret_net	*Signal return net name*	The net intended to be the return path of the net.
	return_type[ ],	*'segment' or 'plane'*	Type of return path for a segment of the net.
	return_name[ ],	*name of return path*	The name of return path for a segment of the net.
	return_distance[ ]	*distance between segment and return path*	Distance between a segment of the net and the return path associated with it.

The Net classification algorithm assigns signal properties to each net on a board based on the properties of the components it connects and the properties of other nets connected to these components. The parameters assigned to each net are listed in Table 1. This algorithm is one of the most critical parts of the expert system since the "sources" in all the evaluation algorithms are signals whose electrical properties were determined by net classification.

The Net Classification algorithm classifies each net as either a "power/ground" net or a "signal" net. A net is classified as a *power/ground* net if any of the pins connected to it are Vcc or ground pins. Otherwise, it is classified as a *signal* net. The attributes for a signal net are derived from the properties of the pins connected to it as defined in the component library.

Since the board layout files for a printed circuit board do not have any electrical information, the Net Classification algorithm relies on having a relatively complete component library.

The Net Classification algorithm uses the following routines to assign appropriate attributes to the signal nets:

dig_analog() – classifies each net as digital or analog

clockfreq() – determines the frequency at which each digital net is clocked

net_type_I() – classifies each net as "I/O" or "non-I/O"

noise_margin() – determines the noise margin for each net

rad_susc() - determines radiation and susceptibility classifications for each net

freqrange() determines the range of signal frequencies that may exist on each net

V_supply() – determines the supply voltage for each net

signal_return_net() – determines the intended signal return net for each signal net

identify_return() – identifies the return current path for the signal for each net

u*tilization()* – determines the utilization (HIGH, MEDIUM or LOW) for each net

V_I() – determines the max. and min. voltages and max. current on each net

trans_time() – determines the transition time for signals on each digital net

Information on the operation of these routines is contained in their corresponding summaries.

Implementation details

The algorithm reviews each net on the board twice. A preliminary run-through creates lists of the active and passive devices connected to the net. Passive components attached to each net are also identified and that information is stored. If a component does not have a corresponding model in the component library, it is listed as an unknown component and assigned default parameters. Nets are classified as *power/ground* or *signal* nets and connectivity information is collected.

The second run-through assigns all the parameters associated with signal nets and stores this information in memory. The user is allowed to view and manually edit the results after the second run-through. Any editing by the user triggers a third run-through, since editing the properties of one net may affect the properties of many other nets.

When net classification is complete, the expert system is ready to evaluate the board.

References

[1] Navin Kashyap, *An Expert Systems Application in Electromagnetic Compatibility*, M. S. Thesis, University of Missouri-Rolla, 1997.