



Specifying Controlled Impedance & Communicating Stackups

In the last few months I have been using a terrific new software tool for creating multilayer stackups and calculating the controlled impedances of these multilayers. The software is SB200 and SI8000 from Polar Instruments in the UK (www.polarinstruments.com).

Why Is This Important?

As more PCB manufacturing moves offshore, communicating a multilayer stackup, materials and the resultant impedance becomes more difficult. This stems from the differences in manufacturing processes and the availability of materials. Many of the laminates that Asia uses are less used or known in North America. These communication issues can lead to increased yield losses and a

resultant increase in costs, marginal thickness and impedance tolerances and delayed shipments. Polar has endeavored to solve this problem by creating an easy to use stackup generator based on a detailed materials library. To tie this stackup into the impedance simulation, they have linked it to the popular SI8000 v3.1.0 Impedance Solver. You can see this interaction in Figure 1, an eight (8) layer multilayer stackup with all the signal layers data and impedance calculations. This is the latest version of their numerical method field solver that started with the universally popular CITS25.

Improved Impedance Models

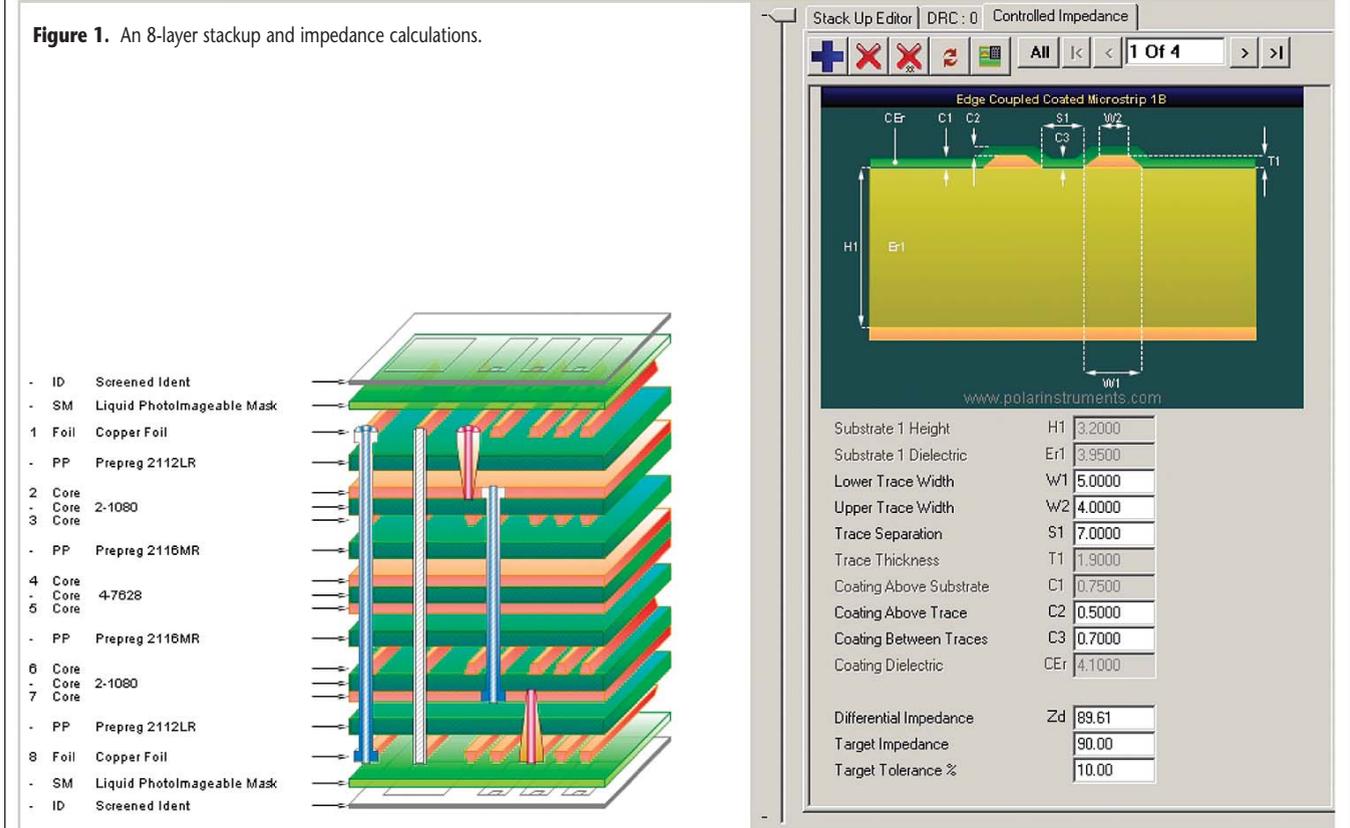
The expanded impedance models include 13 single-ended, 28 single-ended

coplanar, 20 differential, and 24 coplanar-differential structures. Many of these come with two to four materials between signal and reference planes to handle cores and prepreg differences in thickness and dielectric constants. The specialized model allows you to compensate for the resin-rich area between differential-pairs. All of this makes for the most accurate, easy-to-use impedance analyzer you can buy. The Quick Solver allows you to seek the missing dimension if you know the other constraints, and that includes the dielectric constant.

Flexibility

What I really like about this new software, in addition to its accuracy, is my increased productivity. I can set up a

Figure 1. An 8-layer stackup and impedance calculations.



Happy Holden is manager of advanced technologies for Westwood Associates (West Haven, CT). He is responsible for next-generation printed circuit manufacturing technologies, advanced design tools, and design consulting. Prior to joining Westwood, he was a consultant with TechLead Corporation, and had been at Hewlett-Packard for over 27 years. Holden formally managed Hewlett Packard's application organizations in the Far East and holds degrees in Chemical Engineering and Computer Science. If you have questions, he can be contacted via e-mail at hth@westwd.com.

Type	Supplier	Supplier Description	Description	Stock Number	Dielectric Cons	Base Thick	Finished Thick	Resin Content	Tg
Prepreg	NanYa CCL	NP-170B	Prepreg 106	NP-170B	3.72	2.2	2.2	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1080LR	NP-170B	3.63	2.1	2.1	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1080	NP-170B	3.32	2.8	2.8	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1080MR	NP-170B	3.23	2.9	2.9	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1080HR	NP-170B	3.16	3	3	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2112LR	NP-170B	3.95	3.2	3.2	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2112	NP-170B	3.9	3.6	3.6	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2113	NP-170B	3.85	3.5	3.5	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2313	NP-170B	3.84	3.7	3.7	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2116	NP-170B	3.79	4.25	4.25	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2116MR	NP-170B	3.71	4.8	4.8	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 2116HR	NP-170B	3.63	5	5	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1506	NP-170B	3.98	6.4	6.4	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 1506MR	NP-170B	3.86	6.3	6.3	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 7628	NP-170B	4.13	7.2	7.2	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 7628MR	NP-170B	4.03	8	8	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 7628HR	NP-170B	4	8.5	8.5	0	170
Prepreg	NanYa CCL	NP-170B	Prepreg 7628LF	NP-170B	4.08	7.1	7.1	0	170

Type	Supplier	Supplier Desc	Description	Stock Num	Upper Cu Thick	Lower Cu	Dielectric Cons	Base Thick	Finished Thick	Resin Cont	Tg
FR4	NanYa CCL	NP-170	1080 Core	NP-170TL	0.6	0.6	3.5	3	3	62	170
FR4	NanYa CCL	NP-170	1080 Core	NP-170TL	1.3	1.3	3.5	3	3	62	170
FR4	NanYa CCL	NP-170	1080 Core	NP-170TL	2.7	2.7	3.5	3	3	62	170
FR4	NanYa CCL	NP-170	2-1080 Core	NP-170TL	0.6	0.6	3.9	4	4	47.1	170
FR4	NanYa CCL	NP-170	2-1080 Core	NP-170TL	1.3	1.3	3.9	4	4	47.1	170
FR4	NanYa CCL	NP-170	2-1080 Core	NP-170TL	2.7	2.7	3.9	4	4	47.1	170
FR4	NanYa CCL	NP-170	2116 Core	NP-170TL	0.6	0.6	4.27	4	4	43	170
FR4	NanYa CCL	NP-170	2116 Core	NP-170TL	1.3	1.3	4.27	4	4	43	170
FR4	NanYa CCL	NP-170	2116 Core	NP-170TL	2.7	2.7	4.27	4	4	43	170

Figure 2. New materials library of prepregs and cores.

multilayer stackup and impedances about ten times faster than my old manual spreadsheet way. This is possible because of a “tool” called the “Stackup Wizard.” This “automation tool” sets up boards from 2 to 64 layers, the build type, materials, planes, and drilling. All that is required after this is detailing the prepregs, cores, line widths and copper thicknesses. The automatic tie in to the SI8000 Quick Solver moves thicknesses and dielectric constants over automatically, where they can solve for a particular impedance and bring back line widths or spacings.

The Materials Library is a major contribution to PCB fabrication communications. All too often, the fabrication blueprint has only the most minimum amount of information about what the designer intended for the stackup. Most cases, the B/P calls out an “ideal” stackup in nice “round” numbers for thickness, with the FR4 having a “normal” Er of 4.5.

In reality, the Er of FR4 changes with resin content, thickness, frequency, temperature and humidity. Equally, the “pressed” thickness of a prepreg will depend on construction, lamination pressure, heat input rate, copper fill opposite the prepreg and border damming. SB200 captures many of these material characteristics in the Library. Anyone can view these material characteristics because Polar has a free Viewer for SB200 that can be downloaded from their Web Site. As you can see in Figure 2, eight different materials are cataloged in the library: Foils, RCC, Pre-Preg, Cores, Solder Masks, Identity Inks (Legend), Peelable Masks, and Coverlays.

Within a category, 10-12 different properties are supplied: Type, Supplier, Suppliers Description, Description, Stock Number, Dielectric Constant, Base Thickness, Finished Thickness, Resin Content, Tg, and if appropriate, copper thicknesses and color.

New Features

Built into the new stackup generator is a Design Rule Checker (DRC). While you are building your stackups, this checker will look for eight common errors in the stackup and flag them in RED. These eight are a useful check on: Two adjacent copper layers, Resin coated copper on internal layer, External prepreg, Internal solder mask, Internal legend, Internal Peelable mask, Symmetry, Different material types, and Copper not balanced.

The initial offerings for outputs are pretty complete. In addition to the stackup diagram, there is a complete report as shown in Figure 3a. Also available is the outputs in Gerber 274X, DFX and PDF as seen in Figure 3b. These should go a long way in standardizing the “look and feel” for fabrication drawings and creating a common communication vehicle.

Spreadsheet Macro Calls

Introduced with the SI6000 Impedance Solver and continued with the SI8000 is the ability to do Excel Macros. In addition to the impedances (Z_0), you can calculate delay (T_{pd}), inductance per unit and capacitance per unit. When working with differential pairs, in addition to the

Stack-Up Report - C:\Program Files\Polar\SB200\Samples\NanYa_8Layer.mil.stk



Layer	ID	Supplier	Supplier Desc	Description	Stock No	Usage	Base	Finish	Er	Color	Filename	
Ident		Polar Samples	0.001	Screened Ident	800-001	Ident	2.000			White	Top ID ger	
SM		Saiyo	LPI-4000	Liquid Photoimageable Mask	4000-001	Mask	0.750		4.100	Green	Top SM ger	
Foil		NanYa CCL	FOIL601	Copper Foil		H or	Copper	0.800	0.800		L1 ger	
PP		NanYa CCL	NP-1709	Prepreg 2112LR	NP-1709	Dielectric	3.200	3.200	3.950			
2		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Copper	0.600	0.600		L2 ger	
3		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Dielectric	5.000	5.000	3.990		
4		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Copper	0.600	0.600		L3 ger	
PP		NanYa CCL	NP-1709	Prepreg 2116MR	NP-1709	Dielectric	4.800	4.800	3.710			
4		Core	NanYa CCL	NP-170	4-7628	NP-170TL	Copper	0.600	0.600		L4 ger	
5		Core	NanYa CCL	NP-170	4-7628	NP-170TL	Dielectric	21.000	21.000	4.300		
6		Core	NanYa CCL	NP-170	4-7628	NP-170TL	Copper	0.600	0.600		L5 ger	
PP		NanYa CCL	NP-1709	Prepreg 2116MR	NP-1709	Dielectric	4.800	4.800	3.710			
8		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Copper	0.600	0.600		L6 ger	
9		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Dielectric	5.000	5.000	3.990		
7		Core	NanYa CCL	NP-170	2-1080	NP-170TL	Copper	0.600	0.600		L7 ger	
PP		NanYa CCL	NP-1709	Prepreg 2112LR	NP-1709	Dielectric	3.200	3.200	3.950			
Foil		NanYa CCL	FOIL601	Copper Foil		H or	Copper	0.800	0.800		L8 ger	
SM		Saiyo	LPI-4000	Liquid Photoimageable Mask	4000-001	Mask	0.750		4.100	Green	Bottom SM ger	
Ident		Polar Samples	0.001	Screened Ident	800-001	Ident	2.000			White	Bottom ID ger	

1st E. Layer	2nd E. Layer	Drill Type	PTH	Hole Count	Diff Hole Size	Minimum Size	Filename
1	8	Mechanical	True	2000	7	72	PTH.drt
1	8	Mechanical	False	25	2	100	NPTH.drt
1	2	Laser	True	1000	1	0.025	
2	7	Mechanical	True	2300	2	0.01	
8	7	Laser	True	600	1	0.008	

Structure Name	YL 1	YL 2	PL 1	PL 2	W1	W2	S1	G1	G2	G3	Imp.	T-imp.	Tol. %
Edge Coupled Coated Microstrip 1B	1	0	2	0	5.0000	4.0000	7.0000	0.0000	0.0000	0.0000	59.61	90	10
Edge Coupled Coated Microstrip 1B	8	0	7	0	5.0000	4.0000	7.0000	0.0000	0.0000	0.0000	59.61	90	10
Offset Stripline 1B1A	3	0	2	4	4.2500	1.4500	9.0000	0.0000	0.0000	0.0000	50.21	90	5
Offset Stripline 1B1A	6	0	5	7	4.2500	0.8500	9.0000	0.0000	0.0000	0.0000	49.45	90	5

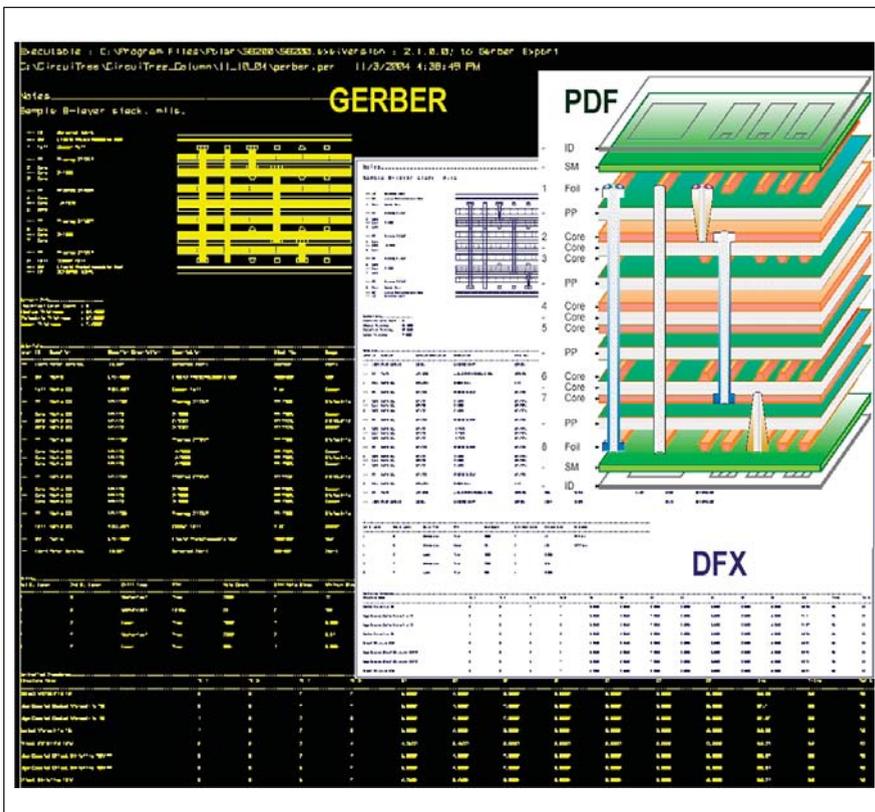


Figure 3a and 3b. Outputs available are a) Drawing and technical data or b) Gerber, DFX and PDF.

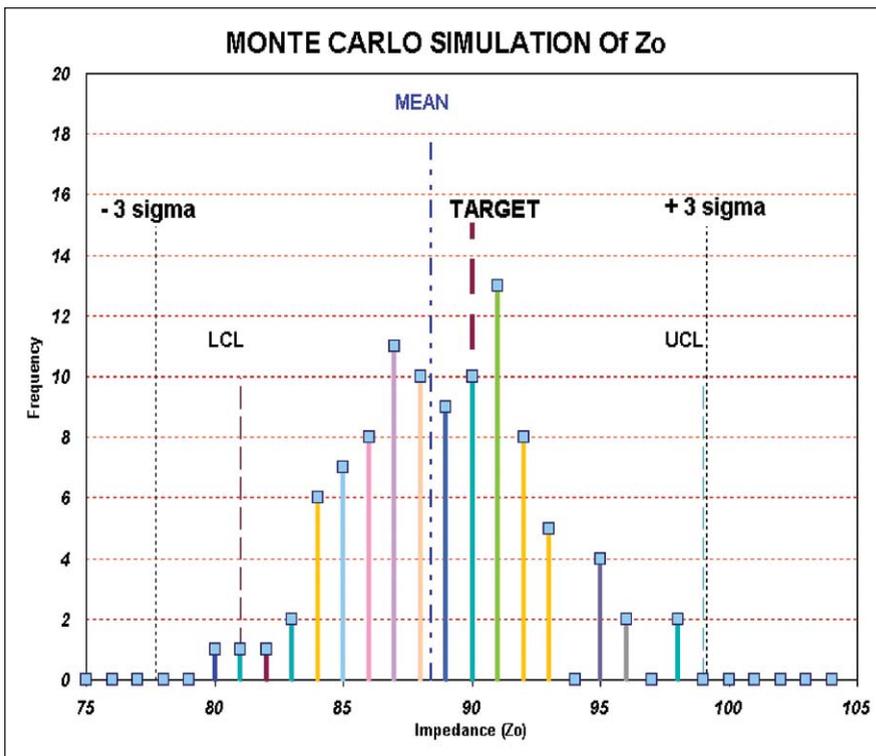


Figure 4. Monte Carlo simulation from an Excel spreadsheet of production outputs based on manufacturing characteristics.

differential impedance (Z_{diff}), you can calculate the odd (Z_{odd}), even (Z_{even}) and common mode impedances (Z_{common}). This allows you to set up Spreadsheets like the one below, Figure 4, to calculate a Monte Carlo Simulation of Production Output. I have others that calculate Backward Crosstalk, Critical Timing and Tolerance Sensitivity.

I believe so much that this new functionality can improve productivity, communications and yields that I am going to add our Materials Library (Westwood-NanYa.mlb) to our Web Site so that our customers can easily download it. I hope that all you fabricators will do the same and encourage the laminate, solder mask, foil suppliers to make theirs available on the Web. Together we can eliminate this one problem for good. **CT**