Flex Circuit news

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Flex Circuit Design Co. Buys Minority Stake in CAD Design Software

(Warning: Shameless plug ahead)

Flex Circuit Design Company now owns a small part of CAD Design Software (CDS), the good folks who produce Electronics Packaging Designer (EPD).

I have used EPD for over twenty years now to design flex circuits - I find it to be a very useful CAD tool because it runs on top of AutoCAD making it perform PCB design functions and create gerber files. John Sovinsky, the founder of CDS, has always been supportive of my company.

Taking advantage of AutoCAD's powerful engine, CDS has software for leadframe design that can intelligently create and modify leadframe designs and wirebond patterns. They also have a darn good impedance calculator as well as modules for RF and microwave design.

In 2008 we obtained a site license to be able to access all of their high end tools, especially the interface between Cadence and EPD **(link)**: with it I can set up and

AutoCAD is the key!

How to Reverse Engineer Flex Circuits

Every now and then a call comes into the CAD cave that goes something like this: "I've got a broken flex circuit and I need to buy a replacement, but I don't have any drawings and I have no idea who made it." Time for reverse engineering!

Tom Woznicki

I love working on these projects - each is a mystery to be solved. As Hercule Poirot would say they exercise "the little grey cells". In this article I'll share the eight steps I use for reverse engineering a flex circuit.

I use AutoCAD, Electronics Packaging Designer (EPD), Photoshop, a flatbed scanner, an ohm meter, a good magnifier and two calipers - a digital one that measures in both inches and millimeters, the other a dial caliper that measures in inches.

Step one - use the flatbed scanner to capture front and back images of the flex circuit.

I scan at a 600 DPI and then use Photoshop to improve the images, increasing the contrast and adjusting the brightness so I can clearly see the features of the flex circuit.

preroute a flex circuit in Allegro, then export the BRD file into EPD for clean up and optimizing the trace layers for flex circuitry. Bring the trace layers in DXF format back into Allegro and *viola!* A beautiful flex circuit design in Allegro!

So after a long friendship between our two companies, we now own about a four percent share in CDS.

What can I say - I liked EPD so much I bought a part of the company! (Apologies to Victor Kiam).

CAD Design Software is in the heart of Silicon Valley. You can learn more at **www.cad-design.com** or call them at 408-436-1340.

Step two - import images into AutoCAD, rotate and scale the images.

AutoCAD is commonly used in the flex circuit world. One especially useful feature is it's ability to import JPG or other graphic images into the database.

After the top image is imported and placed on a reference layer I draw some reference lines and rotate the image until it's orthogonal (or as close as I can get it). Then using the magnifier and calipers (Figure 1) I measure the length and width of key areas and adjust the X and Y scaling of the image so it matches as closely as possible to the actual measurements of the circuit.

The process is then repeated for the bottom image, with the additional step of mirroring the image so it will overlap the top image properly. I place the bottom image on a separate reference layer so I can turn each image on or off as I need to.

At this point in the operation I try to figure out whether the circuit was designed in inches (mils) or millimeters and set up my database accordingly.

Figure 1. Carefully measuring features for scaling the images.

It makes it easier when drawing the traces and constructing vias, components and other features. For example, if there are non-plated holes that measure close to 78 mils I can safely assume they are 2 millimeter hole and circuit was designed in millimeters.

Next I pick a feature to use as my datum point. A non-plated hole is best, but if there is no such feature the intersection of two straight edges will do. Using the selected feature I move the images to the zero-zero point in the database.

Step 3 - draw the outline and circuitry.

Using the reference images I draw the outline features, trace widths, lands and vias on the appropriate layers in AutoCAD. Then I measure the actual circuit features for verification.

Step 4 - verify the finished trace layout with an ohm meter.

I check the circuit carefully for shorts and opens. Sometimes this involves some selective destruction of the circuit - usually scraping away some of the coverfilm to expose a trace or via. For example

- if there is are traces with a via between two pads that are obviously connected but show no connectivity when probed with the ohm meter it's likely that the via is defective. Scraping the coverfilm off can help determine where and what kind of defect it is - it may be the trace is cracked in a bending area, or the via is cracked. Knowing where the defect is will help improve the design.

Step 5 - carefully examine the circuit to determine materials, copper thickness and manufacturing processes.

By carefully measuring the circuit thickness in areas where there is copper and other areas where there is no copper I can figure out the copper weight and the thicknesses of the polyimide and adhesive. Sometimes this involves destruction of a small part of the circuit, pulling some of the coverfilm off to measure the thickness.

Careful examination can reveal other attributes of the materials and manufacturing. I look carefully and see if I can pick out any grain structure. In areas that are exposed by coverfilm openings I look and see if the base material is adhesive based or adhesiveless and I examine the vias to see if it was button plated. The thickness of any stiffeners is measured.

Step 6 - use EPD to build intelligence into the AutoCAD database and export a reference netlist.

EPD will create intelligent vias and components in AutoCAD. I export the reference netlist that I will use in the next step.

Full disclosure - Flex Circuit Design Company is a minority owner of CAD Design Software. See story on page 1.

That said, there other ways to proceed without EPD, but it is harder. Heck - you don't even need AutoCAD! The key is if your mechanical CAD program will import images. AutoCAD LT, the scaled-down version of AutoCAD, will do it. SolidWorks will also import images for reference - I suspect others do as well. Draw the outline and trace lay-

ers and export them as DXF files.

All PCB design programs I know of can import DXF files. Set up your PCB database with the same units as your mechanical CAD database (inches or millimeters). Create vias and components, then import the DXF files for the trace layers and outline. Note - the higher end CAD tools, such as Cadence Allegro or Mentor Expedition, require a schematic and netlist first. So you'd have to create the components to establish pin numbers and draw the schematic based on the recreated trace layout.

Step 7 - improve the design.

In addition to fixing whatever made the circuit fail, as long as I have the design open I clean up any flex design rule violations. These circuits often have no stiffeners under solder joints, vias in bending areas, no pad capture, no teardrops or fillets, etc. Having the reference netlist makes sure I have everything hooked up properly when I'm done.

Step 8 - create fabrication and assembly drawings.

In the documentation I specify the info gleaned from step 5, changing only those things that will improve the design.

Case study

Thermal Conductive Bonding is a company here in Silicon Valley that provides bonding solutions for hi-tech companies with a specialty for joining materials with both elastomer and Indium bonding systems. A customer of theirs, a Gen 10 LCD manufacturer, asked if they could refurbish an electrostatic chuck used to hold the glass during the manufacturing process. These chucks have a very large flex circuit bonded to a thick aluminum plate with an gelpad elastomer. These chucks have to be replaced every so often because the flex circuits get damaged when a sheet of glass breaks. These replacements are very expensive to purchase from the OEM and they asked Thermal Conductive Bonding (TCB) if they could refurbish the chuck by bonding a new flex circuit onto it. TCB was confi-

dent that if they could get the flex circuit designed and built they could strip off the old flex circuit and elastomer from the plate and bond the new flex circuit in place for a much lower price than the customer was paying for replacements from the OEM.

Right from the start this circuit was a challenge. The metal plate was about 29 inches square and the flex circuit covered the entire surface. The flex also had a narrow tail about 9 inches long that wrapped around the plate. I didn't want to remove the flex from the plate - felt it would stretch and distort it, making it harder to measure features accurately. With the flex attached to the plate it wouldn't fit on my flatbed scanner, even in sections, and I couldn't find any artwork, blueprint or graphics company that had a scanner that was big enough! Fortunately, I found a commercial photographer who took digital pictures of eight different sections and pieced the eight pictures together with Photoshop to give us a full image of the circuit (Figure 2). Other parts were easy - the pattern is actually only two conductors, so there was no need to create a reference netlist or probe the circuit with the ohm meter.

I mentioned earlier in step 2 that it's a good to determine if the design was done in millimeters or mils - sure helped with this circuit. After taking several measurements it was pretty clear that the design was done in millimeters and there were re-
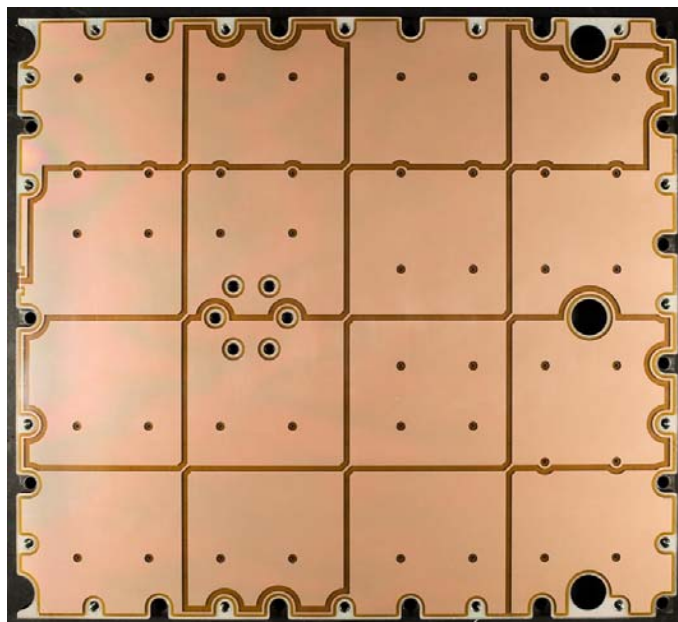

Figure 2 Top image of the flex circuit, created by combining eight different digital pictures.

peating patterns. I drew the patterns in AutoCAD and dimensioned the circuit outline, trace layout and hole locations I created. Then I measured the circuit itself and verified the dimensions - it matched almost perfectly (Figure 3).

This circuit also had an additional twist: if you look closely at Figure 2 it appears to be made of polyimide material but the color of the copper appears natural, not tinted orange as it would be if polyimide coverfilm was applied. Using a hobby knife I
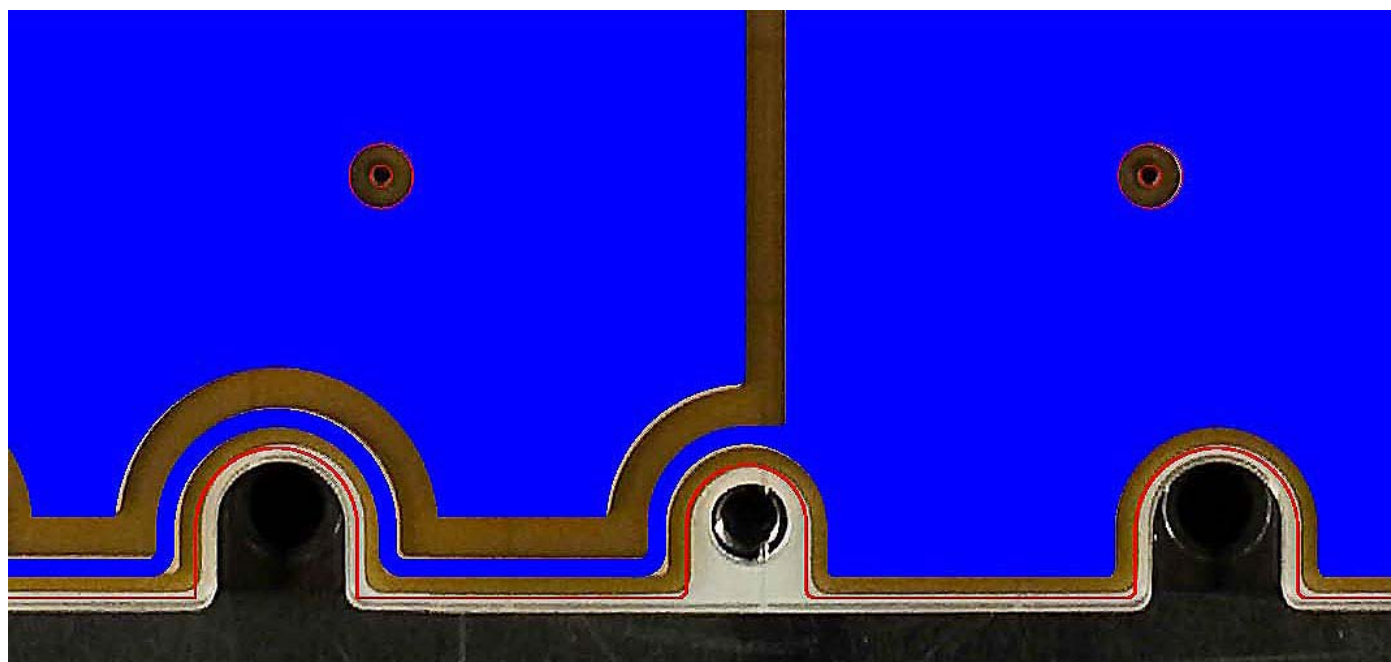

Figure 3. Traces (blue), holes and outline (red) drawn over the image.

peeled away the coverfilm in one corner and found it was made with polyimide basefilm and polyester coverfilm - an unusual combination, but understandable given the large size of the circuit. Polyimide is much more expensive than polyester, and if a polyester coverfilm will do the job it reduces the cost of the finished circuit.

Figure 4 shows the newly created flex circuits and the plate it will be bonded to.

Big, big thanks to Wayne Simpson and Angus McFadden at Thermoconductive Bonding for their help with this article! Learn more about them at **www.tcbonding.com** or call the at 408-920-0255.

Closing thoughts: these techniques obviously work best with two layer flex circuits and two layer PCBs. I suppose it could be used with three or four layer flex circuits if you can see clearly through them. Could it work on a rigid-flex circuit? I suppose it could, if you had access to equipment that could carefully remove layers once they've been scanned.

If you try it and succeed let me know!

Figure 4 Wayne Simpson, President of TCB, with the reverse engineered flex circuit.

Altium Designer

As best we can we try to meet the needs of our current customers and potential new ones. Sometimes that involves providing the final design in a particular PCB CAD program.

Last year we noticed an increase in number of folks asking for designs in Altium Designer, so just before the new year we decided to purchase a seat. I'll give you a review in an upcoming issue on how well it works for flex circuits.

On a personal note...

Beers To You, Old Amiga

Long time readers of The Flex Circuit News will remember Hobbs, my beer-drinkin' cat (November 2000 issue - **link**). She went off to kitty cat heaven near the end of last year due to skin cancer. She'd been the family cat for over sixteen years and often my companion in the CAD cave.

She got along fine for a time but gradually slowed down and we could tell she was suffering. I held her as the vet put her to sleep: now she's resting forever in the backyard.

Beers to you, Hobbs - thanks for sixteen great years!

Bye old friend - thanks for all the good times.