



Automated Board Thickness Measurement

Purpose

Manufacturing organizations routinely seek multiple vendors for each component to ensure reliable supply, and to control unit cost. Unfortunately, functionally equivalent printed circuit boards (PCB) frequently exhibit board-to-board variations, which include, but are not limited to, PCB thickness. The Automated Board Thickness Measurement capability of the Agilent 5DX can be implemented to accommodate these thickness variations on a board-by-board basis.

Implementation

(This section is intended to augment, not replace, the complete description residing in Chapter 7 of the 5DX Reference Guide.)

Each `.THICKNESS_PADS` command entered into the Board.ndf file will result in a thickness measurement as defined by the corresponding parameters. These commands are placed in the Board.ndf file for the side facing down.

`.THICKNESS_PADS: <delta-z> <fg Index> <margin> <fov> <technique> <component> <pin>`

Delta-Z

Because the highest contrast image will be found up, off the board surface, and into the joint where the solder mass is more appreciable, this offset is useful to adjust the final value to reflect the actual position of the board's bottom surface. Positive Delta-Z entries result in a thinner final board thickness.

FG Index

As with the actual inspection, the FG Index may require adjustment to accommodate local shading. Typically, the FG Index value used for the target component is the same value as that used in the Camera.ndf file.

Margin

This declares an Inter-Pad Distance applicable specifically to the thickness measurement. Although this parameter generally has only a small effect, it is recommended that a positive margin be used such that the rectangle captures the high contrast features associated with the specified joints along with a modest amount of background gray. The region should not include features other than the target joints. Typical values are on the order of the pad pitch. (Refer to the section COMPONENT and PIN for related information.)

FOV

In general, the selection of a smaller FOV will improve the repeatability of the thickness evaluation. This declaration is independent of the inspection FOV, but the user is constrained to one of the FOVs used for the inspection.

Technique

There are now four techniques, or algorithms, which can be used to evaluate the images for best focus. The fourth, SOBEL_GRADIENT, was added in the 7.0 software release along with some modest adjustments to the existing algorithms that improve both speed and accuracy. Good success on gullwing and fine-pitch gullwing joints can be obtained with SOBEL_GRADIENT or PROFILE_DERIV_VARIANCE. The repeatability of the measurements is slightly better for SOBEL_GRADIENT with a variation that is roughly double that provided by a laser surface map point. Each thickness measurement event adds 6 to 8 seconds to the end of the laser surface map evolution.

COMPONENT and PIN

A variety of combinations of components and pins may be incorporated here, but better success will be obtained if they are of the same type and if they all fall within the same view. Gullwing and fine-pitch gullwing joints provide good results, but surface traces are not recommended.

A good technique is to pick two or three gullwing joints in a row or column that provide a clear image. There is no advantage to using more than a few, and the additional calculation can cause delay. Again, the margin may be adjusted to capture only the desired area.

The physical dimensions, and relationship of the pins specified in the last parameters of the [.THICKNESS_PADS](#) command, will define the region of the image which is to be evaluated for contrast. That region is identified by a green box, which appears in the image window only during the X-ray board thickness measurement. (As an aside, the menu item Test/CheckCad feature can be used to verify the view for the package and pins of interest. Use the Go-to-Component option.)

One difficulty occurs if pins on opposite corners of a large package are selected such that they do not reside within the same view. In this case no evaluation box will appear, and the system will attempt a thickness measurement centered on the midpoint between the joints. This may be in the package center where no joints are visible.

Another pitfall can occur when joints on adjacent edges of the package are selected. In this instance, the evaluation box will include the pins, the package corner, and a region of area into the package. (Figure 1) In this instance, leads within the package may be erroneously captured by the algorithm rather than just the joints of interest.

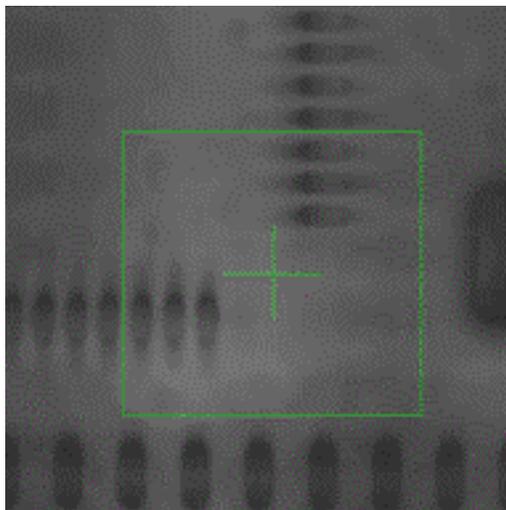


Figure 1: Not Recommended

Search Configuration

The user can alter the search sequence by editing the BrdThick.cfg file located in the CALIB directory. This file can contain up to three lines which define each of three possible searches. The first integer on each line is the number of steps that are to be evaluated, above and below the starting point. The second integer is the step size in mils. The default configuration described above, (Coarse 2,5, Fine 2,2) has been demonstrated to be both expedient and repeatable. Larger coarse steps can improve the search range, but the fine search should not span less than one coarse step. Reducing the fine search step below 2.0 mils does not improve repeatability and it may result in a time penalty. This does not imply that 2.0 mils is the limit of precision because the software creates a mathematical representation of the contrast and interpolates to the best Z position.

Theory of Operation

In many applications, the board thickness value declared in the Panel.ndf and Board.ndf files provides the 5DX with the needed offset to permit components on both the top and the bottom of the board to be properly focused during X-ray laminography. However, if the PCB thickness is varying either board-to-board, or across-board, then good focus is more difficult to achieve. During automated board thickness measurement, one or more sites on the board's bottom surface may be evaluated for vertical position relative to that measured by the laser top surface map operation. The difference at each site is of course the board thickness, and the average of these is then used in lieu of the Board.ndf entries when the Map_res.00n file is created in preparation for the inspection. One inherent limitation is that the technique will address board-to-board variation, but it cannot address across-board thickness changes.

As mentioned previously, the top reference for the thickness measurement is created by interpolating the Z positions for the three map points in the neighborhood of the thickness measurement site, as obtained during the laser surface map activity. For an accurate thickness measurement, it is imperative that repeatable laser map points be selected, and that the Delta-Z values assigned to these points result in good focus for the features right at the top surface of the board. The search for the bottom then begins with this average as adjusted by the board thickness from Board.ndf, and by the X-ray Delta-Z specified in the **.THICKNESS_PADS** command.

The X-ray search is a methodical sequence of Z-stage movements followed by image evaluation of the designated component. At each Z position, the image contrast is calculated by one of the four available algorithms that the user has selected. The image offering the highest contrast is taken to be the image offering best focus, and the corresponding Z-stage position is augmented by the X-ray Delta-Z value to calculate board thickness which is then incorporation into the Map_res.00n file.

In addition to algorithm selection, component selection, and Delta-Z, the programmer can also define the search model in BrdThick.cfg. As a default, the sequence consists of one coarse search followed by a fine search. This default can be altered to include an intermediate search with a modest time penalty. Each search is specified by a number of steps above and below the starting point, as well as the size for each step (i.e. +/- 2 steps at 5 mils/step). For example, the default coarse search begins with the Z-stage 2 steps, of 5 mils each, down from the estimated resulting from the laser map. It then progresses up until it is 2 steps above the estimate. (-10 mils to +10 mils). The result of the coarse search is provided as the starting point for the fine search which is also +/- 2 steps, but now the step size is reduced to 2 mils/step.

