

## Precision Datum Construction for X-ray Measurements on Multilayer Panels

Special care is required for making measurements relative to datum on an x-ray system. Measurements that would be straightforward with conventional Optical video imaging systems require special techniques when attempted with X-ray video imaging systems. Due to the x-ray parallax effect, features that are not centered in the field of view will be measured with some error introduced.

Early usage of InnerVision x-ray systems was almost exclusively for inner layer scaling measurements. In that application the datum is used only to establish a panel reference for the measurement program to position the coupon dots for Video Edge Detection (VED). As long as the datum technique results in well-centered coupon measurements, parallax-induced measurement errors were so small they were not a problem. The coupon measurements for scaling are actually constructed distances between corresponding coupons. As such, any error in datum location has so far been insignificant.

However, in cases such as measuring for drill optimization, or checking x-ray drill accuracy where the purpose is to measure the location of imaged copper fiducials on inner layers relative to the punched slots or other tooling holes that are used to establish the datum, parallax can introduce significant error.

The following detailed method will assure that the features are measured at the center of the field of view. The technique described below has been enhanced to minimize errors due to slot roughness, so the procedure should also be reasonably tolerant of excess resin in slots.

- 1) Clear all features, and start a new session.
- 2) Check the datum menu to be sure that the system is at machine skew and zero.
- 3) On the VED menu, set the tool configuration for the buffer tool to 25 points.
- 4) Place the panel on the transport referenced to the tooling, and secure it. For this four-slot (Lenkeit) example, place the long axis of the panel from left to right, with the offset slot towards the back of the machine.
- 5) If you are working with thin materials, place a 6 mm. (approx.) sheet of polycarbonate (Cyrulon®, Lexan®, Tuffak®, or equivalent) on top as a weight to flatten the part.
- 6) Open a new program and begin recording.
- 7) Record the x-ray settings for measuring the slots, the teach setting, and the units.
- 8) Place the panel on the transport using the OPTEK Multilayer Tooling or some other means to reproducibly place panels. Fix the panel to the transport with the offset slot near the top-center of the panel.
- 9) **Position the transport so that the left edge of the top slot is centered on the monitor.**
- 10) Measure the vertical line with a wide, narrow buffer tool firing from dark to light. (Figure1-1)
- 11) Construct a point on the line.(Figure 1-2) Alternatively, a point can be generated automatically whenever a line is measured. This is accomplished through an entry in the QC4000.ini file. In the [QC4000] section add a line as follows: Pt From Line Result=1.

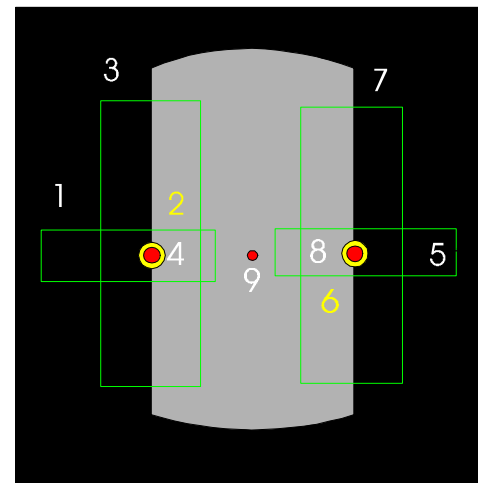


Figure 1 One of Two Vertical Slots

- 12) **Position the transport to measure the right edge of the slot**, constructing a point in the same manner. (Figure1-5)
- 13) Construct a point between the two points. This is similar to what we normally did in the past. But this time the usage is different. (Not Shown)
- 14) Zero on the midpoint. **Now we have a reasonably good X reference on the panel.** This is a temporary zero used only for X centering.(Figure1-9)

## Horizontal Slots

### Left Slot

- 15) Position the transport so that the top edge of the left slot is centered on the monitor.
- 16) Measure the horizontal line with a tall, fairly wide buffer tool firing from dark to light. **(The previous X centering allows the use of a wide tool, and thus minimizes the effect of roughness.)** (Figure 2-3)
- 17) Construct a point on the line. (Figure 2-4)
- 18) Zero on the point on the top line. (4)
- 19) On the CNC menu choose Go To and enter X=0, Y=0. the transport will center the top edge on the monitor.
- 20) Without moving the transport, measure the line again. This time the measurement is made with good X and Y centering, canceling parallax distortion. The error induced due to variations in part placement on the transport is eliminated.
- 21) Construct a point on the second line (8).
- 22) Repeat steps 15 to 21 for the bottom line, measuring the bottom line a second time as well, and construct a new point there also.

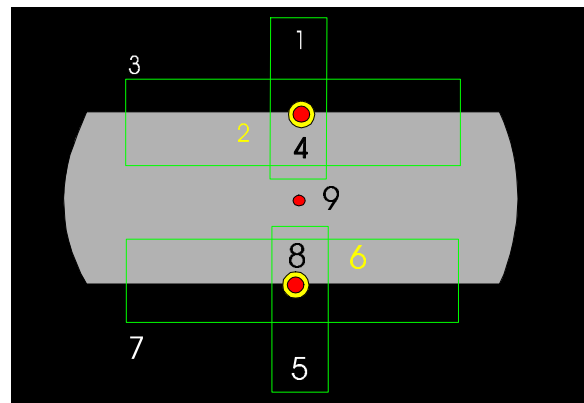
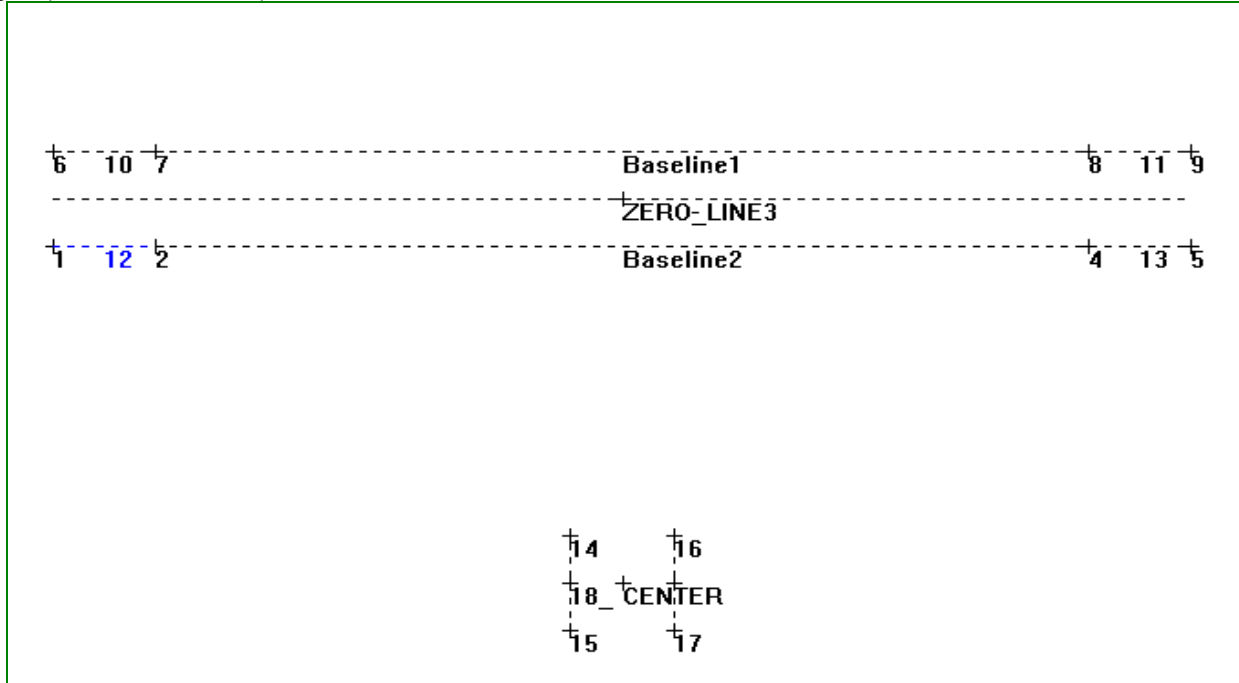


Figure 2 One of Two Horizontal Slots

## Right Slot

- 23) Now measure the right slot using the same method repeating steps 15 to 21.
- 24) Then construct a line all the way across the panel between the second points of the two top slot edges.(10-11: Baseline 1)



**Figure 3 From a Three Hole Datum Session Not to Scale**

- 25) Then construct a line between the second points of the two bottom slot edges.(12-13:Baseline 2)
- 26) Then construct a line from the two lines. This line will be a bisector between the other two, across the horizontal center of the panel. (Line3)
- 27) Skew on the bisector line. Now we have a really good skew and Y zero. But the X still needs a bit of work.

## Vertical Slots Bottom & Top

Note: Some panels have only three slots. Four slot panels have one slot offset horizontally.

Please determine from the blueprint whether it is the top or bottom which is offset, and by how much.

- 28) Measure the center slot at the **bottom** of the panel and construct a final center point in the same way as the left and right slots were measured.
- 29) Measure the offset slot at the **top** of the panel and construct a final center point in the same way as the left and right slots were measured.
- 30) Zero on the center of the offset slot. Note that at this time, the skew is still across the horizontal center of the panel.
- 31) Construct a point at Y=0, X=Offset, to put the point directly above the center of the bottom center slot.
- 32) Construct a line between the points from steps 28 and 31.
- 33) Zero on the intersection of the skew line and the line from Step 32.
- 34) At last, a datum free from parallax error is established.

35) One additional thing: delete all of the Go To steps used in creating the program so far. During automatic execution of the program, they will trick the VED tools, causing them to fire prematurely. They are also no longer necessary for stage positioning because the measurement steps accomplish this themselves.

This is a lot of steps, but they are necessary to assure that the inescapable parallax distortion is nullified. When possible to measure with conventional video, you should do so. Dealing with the physical characteristics of X-ray imaging makes a simple task complicated. But I expect that punch fiducial measurements taken after such careful referencing should be quite reproducible. I believe that your scaling measurements are fine, because in the end they are not referenced to datum. For accuracy, the only requirement is that the coupons are measured on center.

If you have to change any steps while programming or debugging, be sure to start a new session, and run the program to the step just prior to your correction. Then when you record a new step, the datum context will be current. This is essential; otherwise the VED locations may be recorded relative to an incorrect reference.

Some time can be saved if tooling consists of circular holes rather than slots.

## Circle Method

The left hole is imaged to find the location. A zero is set.  
Goto this location and fire the tool again to zero again, more precisely this time.  
Repeat this for a circle in the right.  
Skew on the centered measurements then zero on the left circle.  
End the program and delete the "GOTO" steps.

There are many variations of this method.  
The essence of these exercises is to go to the finder location and re-measure the tooling from a good frame of reference. Remember to delete the "GOTO" steps.

Best of luck,

Jim Dermody

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