X. Dealing with Signature Differences

One of the most often asked questions that Tracker users ask is "when is a different signature considered a fault?". Simply put, "what makes a bad signature?". To answer these questions, we must explore what causes signatures to be different.

First, the definition of a different signature when referring to Trackers is any signature that appears different from the signature we are using for comparison (e.g. A channel versus B channel signature comparison). In the case of computer-controlled Trackers, the comparison signature is the "Stored" signature saved on the computer's hard drive. When the "test" signature deviates from the "Stored" signature by a user set amount (tolerance), the program flags that particular pin as being different. The key word here is "different" since "different" does not necessarily mean "bad". Different signatures can be caused by anything that affects the physical makeup of the circuit. Variations in the manufacturing process by IC makers, noisy and oscillating signatures, capacitors charging, board revision levels, board mounted potentiometers, jumpers, and switches, problems during PCB manufacturing, and faulty components can all cause a Tracker system to flag a signature as different. The question arises when trying to interpret which of these causes is generating the "different" signature. Interpreting signatures comes with practice, but we will make some suggestions here to assist the user with deciding what makes a signature "bad" rather than just "different".

Manufacturing **D**ifferences

There are many different electronic component manufacturers around the world and it can be assumed that they develop many of the same types of ICs. However, it can also be assumed that they probably all take a different road to get to the same point. For example, both Motorola and National Semiconductor make a 74LS04 and even though the two components are logically the same, the design and manufacturing process may vary greatly between the two companies. It is these design and manufacturing processes that cause the physical differences that show as a signature difference on a Tracker. Typically, manufacturing differences show as a variance in the width (voltage segment) of the signature. Both of these ICs should be functional and their truth tables the same but because of the variances in manufacturing, the pin for pin signatures may differ by a significant amount. When compared to commercial grade, military specification components have been found to have their signatures match to a much closer degree among different component manufacturers. However, the cost of "mil-spec" parts usually makes their general use in non-military applications prohibitive.

So what is the best way to deal with these signature differences among manufacturers? These suggestions may help:

- When creating software driven Tracker tests include the manufacturer name in the Component Type field, e.g. 74LS74 TI. This makes you aware of which company made the component you stored on the computer's hard drive.

- Merge the signatures of different manufacturers ICs together when storing signatures for computer-controlled Tracker tests. However, be careful not to merge signatures that are too different as this could cause you to miss important "subtle" differences during your tests. What is "too different" can be hard to explain but as a general rule we typically will not merge signatures that have more than one graticule segment difference.

- Look for consistent patterns among similar pins. For example, all of the output pins on a Motorola 74LS04 will appear to have the same signature when compared with each other. The output pins on a National Instruments 74LS04 should also have similar signatures although they may be different than the outputs on the Motorola device. We can, at this point, probably disregard these variances as manufacturing differences.

- Some Huntron users will create separate component serial number sets for different manufacturers of components on a particular board. These users may have two or three different "U1" signature sets based on the serial number name - one for each manufacturer that may have been used on the boards they test. Then they just choose the appropriate manufacturer serial number for the component they are testing. Though this method is more time consuming and will create a larger database, many computer-controlled Tracker users prefer to take the extra time initially to decrease the number of differences that will appear on the Troublesheet after running a board test.

- Choose ranges that minimize the effect of manufacturer variances. The LOW range, though best for checking for shorts on the board, will tend to exaggerate these manufacturing differences since it has the lowest voltage/impedance scale. Be careful not to sacrifice test quality for minimizing the number of differences by choosing ranges that do not give you the information you need.

- The optimum way to eliminate problems caused by manufacturing differences is to learn board signatures by it's unique serial number. To do this, the user must learn the signatures for every board they think they may have to troubleshoot someday and then save that test (by board serial number) as a unique test for that board *only*. This gives the user the ability to refer to the very same signatures of the board when it was in a working state. The disadvantages to this method are that it creates a large number of board tests (one for every board you might ever troubleshoot), and getting your hands on every board could take a very long time. However, having a "snapshot" of every board that may fail gives you the unique opportunity to troubleshoot a faulty board against itself when it did work. If board serial numbers are not present on the board, use a permanent marker to serialize the boards as you go through them. This solution is not for everybody but the success rate for repairs will be very

high.

Signatures **T**hat **C**hange **D**uring **S**ampling

Some components will exhibit signatures that appear noisy or oscillate. Referred to as "flagging", these signatures will tend to oscillate on the positive current (vertical) portion of the signature.
Generally, "flagging" is not considered a problem but a common occurrence among CMOS devices. However, if you are used to testing certain components without experiencing any oscillations and suddenly come across one that does then that particular component could have a problem. Here are some suggestions for dealing with oscillating signatures:
- Using benchtop Trackers on these types of components is not normally a problem since you are viewing the signatures at "real-time" on the Tracker's CRT.
- When using Trackers with signature storage, digital "snapshots" are taken of the signatures at only one particular moment in time. This can cause signatures to compare as "different" since the "snapshots" may have not been captured at the same instant. These differences are usually very minor but they can still clutter up your Troublesheet. To help eliminate these small differences, try merging signatures several times using the same good board. We have merged signatures of the same board up to five times to help eliminate differences caused by oscillating signatures. You are essentially trying to capture the signature in as many different states of "flagging" as possible and merging them together.
- Adding resistance between voltage and ground will sometimes help stabilize oscillating signatures. Our experience indicates that resistances between 1K ohms and 10K ohms tend to be the most effective. 1K ohms and 10K ohms jumper leads are supplied with computer-controlled Tracker equipment.
- If possible, limit your Test ranges to those that exhibit the least amount of oscillation but try to use at least two ranges when testing.
- Increasing the maximum number of samples, set at the Section level of the Huntron software, will not help with oscillating signatures but simply increase the test time.

Another cause of signatures changing during sampling is capacitors charging on the board as the Tracker signal is applied. These differences typically show up as a change in the horizontal (voltage) portion of the signature and only present a problem with Trackers using signature storage. The charging effect can sometimes be seen when viewing the signature in real time on the Tracker CRT. To deal with differences caused by the charging effect of capacitors, try the following:
- Increase the maximum number of samples set at the Section level of the Huntron software. This will allow the capacitive circuit to stabilize before the signatures are captured.

- Add parallel resistance to the capacitive circuits on the board. This will slow the charging effect giving the Tracker a better chance of capturing a stable signature.
- Shorting out the capacitive circuit will eliminate the charging effect but could cause you to miss important signature differences. This method should be used only as a last resort.

Board Revision Differences, Pots, Switches, and Jumpers

Revision level differences between boards can cause significant signature differences. It is important to note the revision level of the good board for future reference otherwise you could waste time isolating a signature difference that is caused by an engineering change and not a problem. Most of the time these revision differences are quite minor so for computer-controlled Tracker users it is much easier to create a duplicate of your initial test and make the necessary changes to the duplicate. Once those changes are made, it is a simple matter of relearning the signatures for the new revision.

To duplicate a board test, enter the Backup mode of the Huntron software and backup the board test you wish to duplicate. Once the back up is complete, enter into the Restore mode and restore the board you just backed up. The software will prompt you with a duplicate board name window at which time you can choose a new name for the test. Rename the test and the software will restore the test to your hard drive under a new name. This new test is an exact duplicate of the your original board test. Now you can make the changes needed to make the new test match a different board revision level. Once the changes are made, learn the signatures of the of the appropriate revision of board. This procedure saves you the time of having to retype all of the board, section, and component information.

Besides making note of board revision levels, it is equally important to make note of all potentiometer, switch, and jumper settings on the board. It is best to write down this information somewhere or include it in the instruction sections of the Huntron software. If switch and jumper settings change from board to board, decide on a default to set these to when you run tests on these boards. Potentiometer settings will vary from board to board, so it is best to adjust them to their maximum setting before learning or testing. Setting potentiometers to their minimum (shorted) setting could cause you to miss a problem with that potentiometer or surrounding components.

Signature Differences from Production Environment

There are essentially two types of "real" differences that will appear on a

circuit board. One is manufacturing (production) faults, or faults that are a result of the manufacturing process such as solder bridges, cold solder joints, or open or shorted traces. The other is "field faults", or problems that occur on boards that have been working (e.g. in the field) for a period of time.

Testing for manufacturing faults will mean setting up your test procedures to specifically look for the type of faults that occur during a manufacturing process. The types of tests to develop will check for continuity, open lines, pins, or pads, colder solder joints, wrong components, and component polarity. In general, these types of tests will require testing more points thus making the test time longer. On the bright side, manufacturing problems are usually easy to spot because of the nature of the failures (opens, shorts, backward components, etc.). Based on our own experience when looking for manufacturing problems with Trackers, we will start with probing any connectors on the board, than move to multiple pin components (ICs, transistors, etc.), and finish with the small discrete components (diodes, caps, resistors, etc.). The objective here is to test as many points as reasonably possible and therefore check not only the components but the interconnections between them.

Signatures Differences from the Field Environment

Field faults are faults that occur on boards that have worked at one point before they failed. These are the typical nature of boards that most technicians are used to seeing. Field faults are mostly caused by component failures and test procedures should be designed to look for faults of this type. Nodal testing is the most efficient way to test for component faults since there are many interconnections between components on most boards. Nodal testing is probing only the unique points (nodes) on a board. Such an example would be building the test to check the 5 volt line only once or each of the address lines on a processor only once even though these lines run throughout the board. Nodal tests are more time consuming to build but take significantly less time to perform. On more complex boards, schematics are usually necessary to find all of the unique points. If nodal testing is too time consuming to build or you do not have the documentation necessary to find all of the nodal points, then probing the connectors and ICs will usually cover most of the nodes on the board.