A Method for Locating Short Circuits

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Introduction

This note describes a method for locating short circuit between two nets in a complicated wiring network using simple equipment. Although the example is for a printed circuit board, the concept is extendable to wiring harnesses and any situation for which a short circuit is difficult to visually locate.

The key in general to solving a lot of problems is to view the problem from a different perspective than the one in which it is difficult to approach. In the schematic perspective, all connections to a single node (a.k.a. net) are regarded literally – that is there is no impedance between the connections. Although practically true this is not exactly true. In the wiring perspective all connections to a single node have individual resistances, albeit very small, that can serve as measurement devices for tracing the path an applied current is taking. The method described here exploits that.

The Method

The instruments needed are:

1. A power supply that can output around 0.3 volts (no load) and which can operate as a regulated constant current of several hundred milliamperes. If an available power supply does not have current regulation then it can be operated at 0.3 volts output and a resistor of around 1 to 2 ohms can be placed in series. The purpose of the low voltage is to avoid damaging existing electronics. Higher voltages and currents can be used as practical. Because resistances of printed circuit traces are low it takes a significant current to make measureable voltage drops. A tiny 10 mil printed circuit board trace can easily survive a test current of a few hundred milliamperes.

2. A digital volt-meter (DVM) that can be operated on a low voltage scale so that it can resolve tenths of a millivolt.

The method is best described using an example as shown in Figure 1. This figure is drawn to illustrate the paths of two separate nets on a printed circuit board and each net has many connections and that somewhere in the maze is a short between them. Although drawn on separate sides of the figure for clarity of illustration the two nets would likely interweave with many chances for shorts. Finding the short with direct ohm-meter measurements is impractical because of the low resistances involved.

1. The power supply is applied as shown. It makes no difference where on each net the power supply is connected. The optimum place for connection is wherever it

is most convenient. The short current is set to around 300 mA or less with either the regulated current control on the supply or an external resistor as shown.

2. The negative lead of the DVM is attached to a point as close as practical to the negative connection of the power supply with the important consideration that it not share the connection with the power supply as the DVM is used to make Kelvin style measurements that must exclude the connection resistance of the power supply.

3. The positive lead of the DVM is used to probe the circuit for small voltage drops along the path of the applied current.

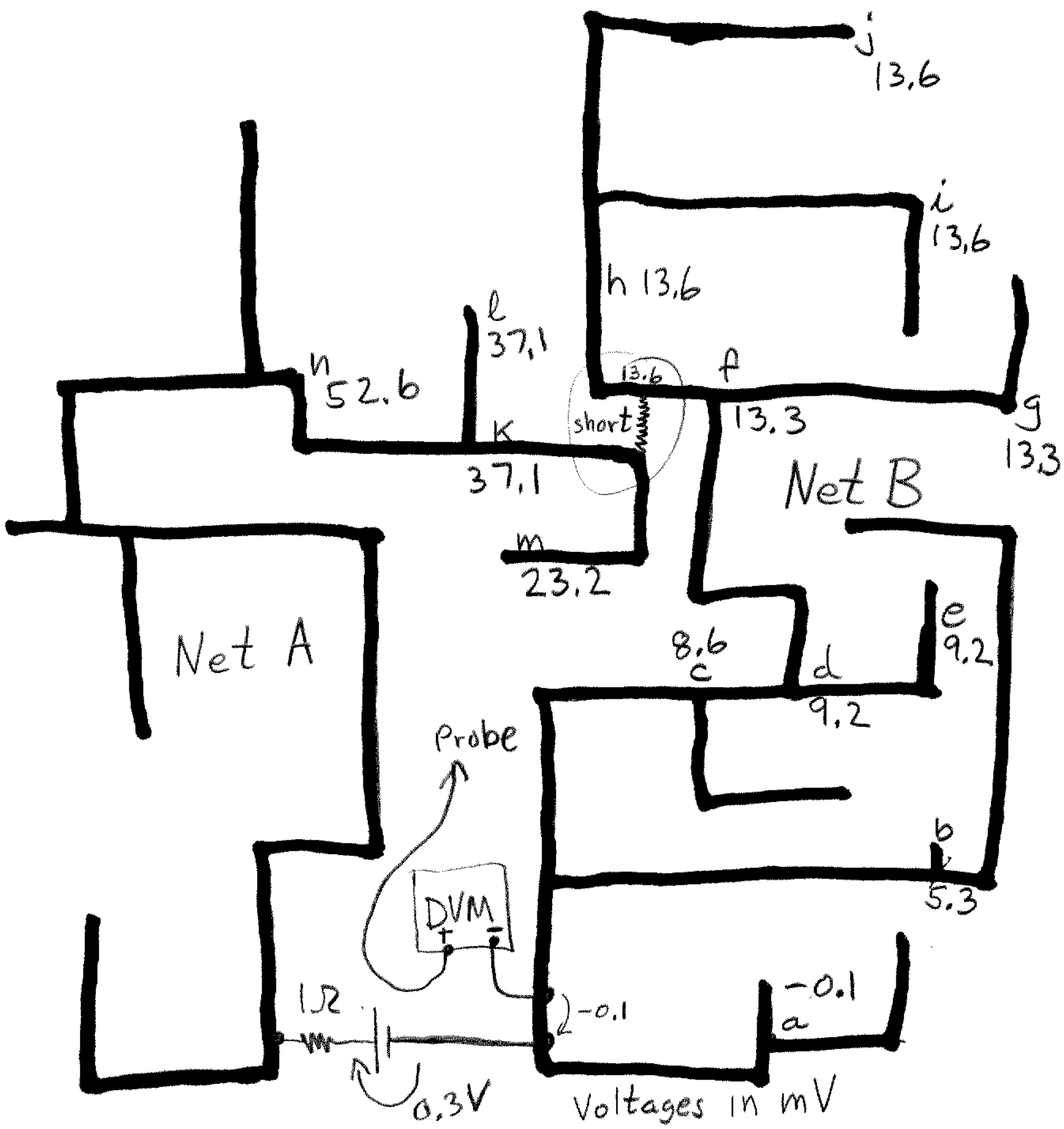

Figure 1: Example of a complicated Printed Circuit board net

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Voltage measurements ‘a’ through ‘n’ are discussed below concerning Net ‘B’. Although the location of the short is clearly visible in the figure, in reality that point is not known in advance – otherwise this procedure is not needed. The following describes the hunt for it. The starting point should be near the power supply connection but exploring each of all circuit paths to establish the path conducting current. The goal is to follow the current. It will lead to the short.

a. The voltage is slightly negative because of where the negative lead of the DVM is connected relative to the negative lead of the power supply. The significance of this is that point ‘a’ is not part of the short circuit current. Pursue another path.

b, c. The voltage here is small positive indicating that point ‘b’ is upstream voltage wise and may be part of the path. But the voltage at point ‘c’ is higher thus indicating that that is the path to pursue. Any other measurements on the trace near point ‘b’ would show the identical voltage thus proving that that path is open.

d, e. With a higher voltage than at point ‘c’ clearly, point ‘d’ is on the path from point ‘c’ but point ‘e’ is not. Thus pursue the path on ‘d’.

f, g. With a higher voltage than at point ‘d’ clearly, point ‘f’ is on the path from point ‘d’ but point ‘g’ is not. Pursue the path on ‘f’.

h, i, j. Going to point ‘h’ appears to be right since the voltage is increasing. But points ‘i’ and ‘j’ have the identical voltage thus they are not part of the path. It is not presently known if point ‘h’ before or after the short. More probing on either side of point ‘h’ is needed. More probing reveals that no higher voltage than 13.6 mV can be found between points ‘f’ and ‘h’. **The highest voltage and where it stops increasing is the location of the short.** Thus, the short is somewhere in-between. It might be visible or it might be hidden. Visibility is often enhanced if you know the narrow zone to focus on.

If the short is hidden (perhaps under an IC) then perhaps probing on Net ‘A’ may help with localization if points on it near the short are more accessible. Ordinarily there would be no point in searching on Net ‘A’. In this case the objective would be to locate the minimum voltage most nearly corresponding to the maximum voltage found on Net ‘B’. A short might have higher resistance than the printed circuit board traces and thus a higher voltage drop as shown in the figure.

The objective of all of this is to consider the real resistance (however small) of every conductive path and think about how to measure a small voltage drop to determine the path a test current is taking. Following the path will lead you to the short. This concept is extendable to any system, even those that have parallel or multiple current paths.