

Solutions to Sneak Circuit Analysis (SCA) of Very Large Equipment/System Designs

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Performing a Sneak Circuit Analysis on a large or complex system has traditionally been a labor intensive task. Because of the sheer cost of the huge amount of time that it typically takes to complete this kind of analysis, this process is often overlooked or de-prioritized in order to meet schedule and budgetary constraints. When it is viewed in relation to high cost, high risk, or safety critical applications, this is a process that can help to avoid serious errors that are not a malfunction per se, but rather are undiscovered/unintentional design flaws that may execute an undesired function or inhibit execution of a desired function. These undesired effects can lead to loss of life/limb, property, or mission failure.

A typical Sneak Circuit analysis would involve a large team of engineers that are intimately familiar with all of the circuitry elements and the design of the whole system. As more components are added to a design, the labor required to perform the analysis goes up exponentially, as there are more potential unintentional effects with each new circuit pathway added.

After performing many such analyses for our customers with mission and/or safety critical systems, The Omnicon Group developed a unique approach to dealing with this overwhelming task. Using a combination of fourth generation computer languages, databases, simulation and modeling tools, and graphical displays, this daunting man-power extensive undertaking can now be cut down to size. The techniques that we have developed are summarized in the body of this document.

The process begins by performing an initial analysis of the design. In this phase a list of all of the unique component types is compiled, placing them into one of three major categories: switch, relay or diode. In reality, there are generally far more component types in any given design, but The Omnicon Group has found that these components are the one's responsible for Sneak conditions more than 99% of the time. Other components may contribute to failed designs, but these effects are generally limited to failure of the components themselves. As such these cases are generally handled by a standard failure modes analysis (FMEA/FTA), which we view as a companion to the SCA.

The next step involves writing a software module to simulate the behavior of each specific component type (i.e., single pole/single throw switch, double pole/double throw relay, etc.). This software is not application specific, and may be reused over and over again on many different efforts. The main consideration in creating the simulation is how the device operates (normally), along with the circuit connection potential (e.g., single pole/single throw switch, single pole/double throw switch, double pole/single throw switch, etc.). Relays are basically modeled as switches that are automatically activated (no manual interaction), and may be either latching or non-latching (return to "default state") after voltage has been removed.

At this point in the process all of the components are imported into a database that is tailored for streamlining the circuit simulations and analysis. The database is created from a standard parts netlist. A series of tools is then used to manually apply circuit designations (such as function, for

example “firing circuit lockout” or “door safety switch”), and to link each instance of a component to a specific software simulation for that component. The main software application has a set of built in rules that it applies to all simulations in order to identify potential hazard situations. A Boolean expression generator (custom written to interface to our database format) is then used to specify any custom criteria from the components and states within the database. This allows for easy checking of these hazards during the main part of the simulation. An example of such a custom condition could be: door command open relay energized while door safety switch is engaged. These Boolean expressions are then stored in the database.

The heart of this process is a simulation. The simulation works in the following manner:

- Reads all circuit components from the master database (every SCA has its own database, unique to the design being studied)
- Builds an internal graphical representation consisting of all of the circuit components, their ports (interconnections), as well as paths to power and ground.
- Identifies which components are manual (switches) versus automatic (relays).
- Identifies circuit paths that are unidirectional (have a diode limiting current flow to one direction).
- Using the library of component simulation modules, links the simulations to specific instances of each circuit node. This state becomes the simulation default, and is returned to after each iteration.
- Manipulates all combinations of manual actions (switch activations). The simulation then recursively walks all of the nodes, applying power and/or grounding conditions to the rest of the components (as dictated by the states of the manual switches). When the simulation encounters a relay that is activated as the result of its coil having a complete path from power to ground, it manipulates the state of the relay. This propagation continues until all components reflect the current state of the system. Using its built in rules, the simulation then checks for potential problems. It also checks every node for states and/or conditions specified by the Boolean expression generator. Any problem areas found cause a textual report to be printed out, as well as a graphical representation (picture) of the circuit components/ports/paths.

Following completion of the simulation, analysts use the error reports and graphical representations of the hazards to perform a manual verification, and determine the criticality of the sneak identified by the tool. Since each error report/graph is unique, the analysts can divide up the investigation as time and staff permits without any potential for overlap. The graphical representations of the circuit focus the analysts’ attention directly on the problem area. Using this approach, The Omnicon Group has found that the level of effort required to perform a SCA has been reduced 75% as compared to performing one via more traditional methods.