Net lists and automated wiring diagram generation

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1 Introduction

Wiring diagrams are a major component in the service documentation. Wiring diagrams give an overview on electrical systems and are crucial for diagnostics. But wiring diagrams are hard to assemble, labour intensive to produce and a mistake is easily made. This document focuses on the challenges of today for wiring diagram production and how to handle the wiring diagram production.

2 Complexity in documentation

2.1 Still increasing amount of data
Having many electronic systems in a car is resulting in a massive amount of wiring documentation for an average model. Not only the amount of systems but also the curve of system complexity is going up. For the near future the expectation is that even more additional systems will be built.

2.2 Variants and options
At this moment customers can almost tailor made their cars when they configure their required model. A customer can select systems, like for instance, seat heating, rain detection, different infotainment types, safety packages, adaptive lighting and so on. The list of configurations possibilities is almost infinitive. This results in a wiring system that is almost unique for each car that leaves the factory.
2.3 The downside

Eventually a car arrives in the workshop sooner or later for service and maintenance, and shall be accompanied with documentation. Creating a set of documentation manually for diagnostics and wiring diagrams is a daunting task. Not only because the amount of wiring but also all the variants and options need to be described and drawn. The production of the documentation is therefore very labour intensive and thus error prone.

When finally the hard task of processing the documentation is finished, the question is, does the end user appreciate the documentation. TTA has held clinics and interviews to see how effective repair documentation is. The experience during the clinic is that an average end user is intimidated when he user is confronted with hundreds of pages of wiring, for just one vehicle. The situation deteriorates, when the end user is not only confronted with complex diagrams but also with multiple parts in the diagram, being valid for one or more variants and options. The end user tends to ignore the documentation completely and starts finding the faults by trial and error.
3 Converting a net list to wiring diagrams

3.1 Net list
The better way of providing wiring diagrams is by generating the wiring diagrams based on net lists. A so called net list is a logical description of wires. A wire has a starting point and an ending point that is described as a goes ‘FROM’ and ends at a ‘TO’. This basic concept can be found in the sample below.

<table>
<thead>
<tr>
<th>From component</th>
<th>From terminal</th>
<th>Wire data</th>
<th>To component</th>
<th>To terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed sensor</td>
<td>1</td>
<td>Red 0.5mm</td>
<td>Engine ECU</td>
<td>90</td>
</tr>
<tr>
<td>Speed sensor</td>
<td>2</td>
<td>White 0.5mm</td>
<td>Engine ECU</td>
<td>91</td>
</tr>
</tbody>
</table>

There are multiple standards that describe the packaging of this data. Of course standards deviates and some standards cover more information than others, but basically they all are database types that describe the connectivity of wires.

3.2 Conversion to wiring diagram
For the net list conversion to a wiring diagram a diagram generator is required. This is a software tool that reads the net list and connects all the wires and electrical objects together in memory. Then the wiring diagram generator retrieves the symbol and formatting data from a library. With this data the wiring diagram ‘knows’ how to depict symbols like ECU's, Grounds, Splices and so on. The formatting settings determine the layout of the wiring diagram. That means for instance the number of wires which are allowed on one page, the logical flow from left to right, or top to bottom. It means also spacing between wires, keep-out areas, to allow crossings or not. All these formatting settings are important factors for layout.
3.3 Inter connecting to other data types

For proper documentation it makes sense to generate references from electrical components to 3D models and vice versa. This helps the end users to find where components are located. Also generating a reference to the connector end views with pin configurations are very helpful because the end user often wants to know what a signal is on a certain pin in a connector.

3.4 Translation

Usually the documentation is published for usage in foreign countries. End users appreciate if tooltips that appear in the wiring diagrams show up in their native language. Therefore it is required to let the auto rendering tool cooperate with a dictionary and translate each object in the appropriate language.

3.5 Publication

For publication the decision needs to be made if rendering is done on beforehand or on the fly.

When rendered on beforehand, the publication can be shipped without exposing the rendering software. The performance is fast but the drawback here is that in case of late changes a new publication needs to be shipped to the end users.

The other choice here is to render only if the end user requires data. This allows continuous amendments to the wiring data. It also allows rendering variant and option specific.
4 Does autorendering work out?

4.1 Cost savings
The most important aspect of autorendering that one can imagine is the saving of costs.
Auto rendering of wiring diagrams:
- Reduces manual labour costs because the rendering itself takes only seconds.
- Significantly reduces the lead time in a project which allows a shorter time to market time.

4.2 Advantages for the end user
Another important advantage of autorendering is the capability to offer the end user only the data required, and not bother him with unrequested data that makes the user loose courage. This works the best if data is rendered on the fly because only the data that is requested is depicted. Whereas data that is pre-rendered still may contain optional data that needs to be blanked out, so end users no longer have to deal with options and configurations that fog their view on the wiring diagrams that are full with options and variants.

4.3 Data quality
Where the manual process is very error prone, the autorendering is errorless. That is of course if data provided is correct. If the provided data is not correct the render tool declares the parsed data in-valid. The point is that not always all of the data that goes up-to-date. Non matching data are a common issue because often engineering data is reworked after documentation has been issued.

4.4 Late adjustments
Eventually if rendering on the fly is used, it is possible to repair or amend data in a very late stage. It is possible to even update after publication date.
4.5 Format independent

Above is an auto rendered wiring diagram depicted. For instance the output can be set to SVG, CGM4 or HTML5. If a different output format is required because of a strategic decision, this can be easily resolved by re-rendering all data in the newly required format. Of course the interactivity possibilities differ per format but one is no longer dependant on a fixed output format.

4.6 Conclusion

Using a tool to render wiring diagrams based on net lists definitely eases the documentation and distribution process. It is also a relative fast and efficient way to get better quality, interactive and tailor made wiring diagrams. If you have the availability of net lists you should consider the usage of a render tool.
5 About TTA

TTA International is a global player in training and engineering solutions focusing on the automotive industry. Wiring and wiring schematics software-tooling is one of the areas where TTA offers multiple specialized services.

For more information please check the company website: http://www.tta-international.com/

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