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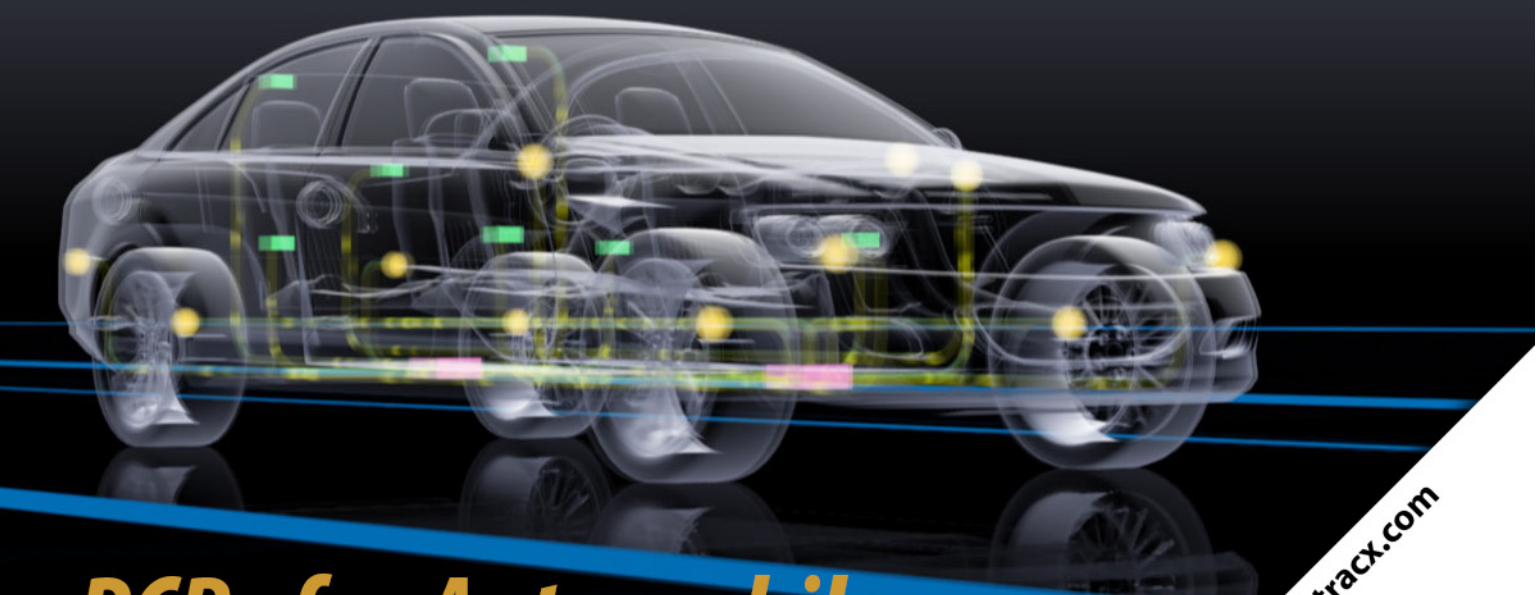

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Figure 2: Interior instrumentation panel of KITT. (Photo courtesy of Enterprise-dashboard.com)

PCBs for Automobiles: A Turbo Boost for Sales?

by Yash Sutariya
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Summary: With the projected trajectory of electronics content in vehicles, automotive PCBs are a global growth driver for our industry. And yet, the pressing question for any N.A. PCB manufacturer might be, do I even want to get in this race?

As I began to write this article, the first thing that popped into my head was the classic '80s series, Knight Rider, featuring an artificially-intelligent black Pontiac Trans Am named KITT, with a dashboard full of esoteric lights, displays and dials. KITT overwhelmed and fascinated my young mind. While today's vehicles don't have most of those features, they have come a long way in terms of electronics content. While some is mandated by the NHTSA (safety, collision avoidance—mainly things you don't see), the content that has the biggest marketing impact for an automobile manufacturer is the stuff you do see—displays, entertainment systems, interactive information systems, etc.

The electronics content of a vehicle is increasing every year as engineers are able to jam more technology and features into the same four-wheeled space. As a result, automotive electronics are expected to generate a compound

Figure 1: Knight Rider's KITT. (Photo courtesy of Deviantart.com)

annual growth rate in excess of 6% through the year 2020, at which point some estimate the global market to be north of $300 billion. To me that's an astounding figure as it pegs electronics to be approximately 10% of the total cost of a vehicle. Regardless, it's a huge market that translates to a lot of bare printed circuit boards to be made by our industry.

Further, with the projected trajectory of electronics content in vehicles, it will definitely be a global growth driver for our industry. The immediate questions that must occur to a North American PCB manufacturer probably include the following:

- When can I get started in this market?
- How do I get a piece of the pie?

In my opinion, however, the very first question should be this: Do I want to even bother targeting the automotive market?"

I have two career experiences that show why it looks like I have a chip on my shoulder for the automotive industry.

First, prior to being in the PCB industry, I worked for a consulting group that focused on bankruptcy/turnaround/crisis management. Based on the outskirts of Detroit (where I also grew up) we naturally had a lot of automotive-related business. A LOT! More often than not, our group's conclusion as to the root cause of a supplier's financial issues was pricing pressure from the OEMs (Note: it was the OEMs that hired us to investigate the supplier in the first place). Then, instead of having us fix the issue that they helped to create, the OEM who hired us found it to be a cheaper solution to shut the supplier down and move production elsewhere.

Needless to say, that job started to suck pretty bad after a few years, which led me to move into this industry in the banner year of 2001. That's where my second experience comes into play. My previous employer was also heavily into the automotive market, with automotive PCBs accounting for 90% of sales in 2000. In a further testament to the nature of the automotive industry, I saw more than half of our 2001 sales disappear within a three-week period—starting the week before Christmas—as customers moved their production to China. I worked the following 10 years to diversify as much as possible out of automotive markets and am happy to say that we were very successful in doing so.

OK, so now it's all on the table. There's very good reason for a fabricator to really ask himself if he even wants to bother targeting the automotive market. If the answer is yes, please read on, as your approach to this market will be critical. Approach it the wrong way, and you might be paid a visit by my former colleagues.

If the answer is no, you should also read on, as you can still benefit from implementing the systems and performance requirements of the automotive market. I believe that servicing the automotive market can be viewed as a boot camp to build a better company. This market forces you to maintain extremely high levels of quality, service, and performance, all while maintaining an extremely low cost basis. If you can make it in the automotive market, you will be a rock star to customers in other industries.

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TS16949 Quality Management System: What is it?

While a strong ISO-9000 quality management system will sometimes suffice, to be a true player in the automotive supplier base, being certified to TS16949 is a must. TS16949 came about as a way to merge all U.S., European, and Asian automotive standards into a single technical specification. Prior to this, an automotive supplier had to hold the individual certifications required by

each customer, making it very difficult to operate a single plant with multiple customers.

While many PCB fabricators hold an ISO-9000 certificate, only five PCB manufacturers in North America have achieved TS certification (we just passed our initial TS certification audit last month, making us the fifth). Now, before you call me a hypocrite, let's review the TS standard and compare it to the ISO-9000 standard.

The standard rule for ISO-9000 is do what you say, and say what you do, meaning as long as you are performing the task as you have documented that it should be performed, you are ISO-9000 compliant. I'll admit that this does oversimplify the standard; it is a fairly easy standard to pass. In contrast, the TS standard is much stricter as it is more process driven, dictates management involvement, and requires continuous improvement to be a documented part of the system. Below are the primary elements of TS16949:

0. Introduction
1. Scope
2. Normative reference
3. Terms and definitions
4. Quality management system
5. Management responsibility
6. Resource management
7. Product realization
8. Measurement, analysis and improvement

While the first three clauses do not contain QMS requirements, they do provide helpful background and summary information. Clauses 4–8 contain the guts of the standard and would really require an entire article dedicated to those alone to provide sufficient explanation. However, there are a host of helpful web resources should you wish to investigate further. Some of the sites I used include:

- www.askartsolutions.com
- thequalityportal.com
- 16949store.com

> ***"In our opinion, the difference between ISO-9001 and TS16949 is 75 additional paragraphs which reinforce the concept that "you cannot only meet specification; but, you can do so efficiently and without interruption to guarantee viability of the entire supply chain to the TS customer."***

From my perspective as a manager, regardless of which industry created the standard, it's really the right way to run your business. Focus on processes and systems to control product quality, involve management, and monitor customer satisfaction indices to verify effect.

We implemented TS16949 at our company not because we wanted to be a full-blown automotive supplier, but rather, we wanted to build a solid company using TS16949 as a foundation for quality and business management. As such, if the answer to the question that started this whole article (Do I want to even bother targeting the automotive market?) was no, automotive standards still may find a home in your business.

TS16949 Quality Management System—How do I get it?

Achieving TS certification involves a process similar to that required to achieve ISO-9000 certification, but work requirements are much more robust. Most registrars that support ISO-9000 also support TS16949 so a registrar change may not be required. However, plan on spending a lot of which most of us don't have—time!

In our opinion, the difference between ISO-9001 and TS16949 is 75 additional paragraphs which reinforce the concept that "you cannot only meet specification; but, you can do so efficiently and without interruption to guarantee viability of the entire supply chain to the TS customer." That means control of your suppliers, regulatory compliance, contingency plans, and a stable work force. The 75 additional paragraphs also expect improvement in both quality consistency and efficiency. All of this requires

documented proof.

Here is pretty neat checklist if you are converting from an ISO-9000 to a TS16949 system.

www.woodbridgegroup.com

It's important to have one person dedicated person to control of the program from an administrative standpoint, because there are a lot of moving parts. For our implementation, we approached the process by tackling the following primary areas:

1. Preventive maintenance
2. Work verification

We included the calibration, procedures, and document control from the existing ISO-9000, but beefed them up a bit.

There's no magic here—just hard work to create and implement production procedures for each major process step, a true calibration and preventive maintenance system, and an audit plan.

From a timing and cost perspective, if you currently have little automotive experience but a very qualified quality control manager, I would estimate an existing ISO-9000 system can be converted over to a TS system within 8–12 months with the full support of 1.5–2 employees.

Performance Requirements: Huh?

The Tests

When selling to the commercial market, the vast majority of performance requirements center on IPC standards such as IPC-6012 and IPC-A-600. While these standards are definitely helpful, they focus on acceptance criteria that are mostly visual. As you encounter automotive suppliers that you want to sell to, you will become exposed to performance and reliability requirements that make military requirements look easy. Global Tier 1 suppliers like Delphi and Continental even have their own PCB qualification specifications complete with test vehicle Gerbers, test methods, etc., striated, based on the end application of the PCB. For example, one such supplier's PCB certification breaks PCB requirements into five primary categories by application (Figure 3).

Automotive PCB Categories	
Class A	Interior Components
Class B	Under-Hood
Class C	On-Engine
Class D	In-Transmission
Class E	In-Engine

Figure 3: Automotive PCB categories.

The primary differentiating characteristic between meeting each of these specifications are the thermal cycling requirements (which I have used as a test method within past articles regarding PCB laminate quality).

- Standard cycle is room to minimum temperature within five minutes
- 25 minutes at minimum temperature
- Five minutes from minimum temperature to peak temperature
- 25 minutes at peak temperature
- Five minutes to lowest temperature

The PCB must pass through 1000 cycles with less than a 10% change in resistance as measured across a standardized daisy chain pattern. Figure 4 is a table that shows the changes in peak temperature between these classes of PCBs.

In comparison, the military requirements only call for 100 cycles between - 65°C and + 125°C. While the lowest temperature is lower than that used by automotive, the reduced number of cycles works in the fabricator's favor. In the last five years of testing I've rarely seen failures in even the first 336 cycles of the automotive thermal cycling tests we've performed. As such, if you can pass these requirements it will surely add to your rock star status.

What do I need to do to pass them?

Don't let the above performance requirements scare you. It is not absolutely necessary

Class	Min Temp	Peak Temp
A	- 40°C	+ 85°C
B	- 40°C	+ 125°C
C	- 40°C	+ 145°C
D	- 40°C	+ 155°C
E	- 40°C	+ 165°C

Figure 4: Changes in peak temperature between the five classes of automotive PCBs.

for you to meet them in order to build for the automotive market. There are plenty of lower risk and lower thermal exposure applications, but they typically involve lower technology and more commodity-like PCBs. Needless to say, there's plenty of competition in those segments of the market so it's going to be tough to earn a decent rate of return on the investment required to pursue the automotive market. There's a heck of a lot less competition in the high-performance segments of the market whose products include under-hood and on-engine applications.

Passing these testing requirements could really make you the Bon Jovi of the PCB world, as it requires discipline and process knowledge throughout the organization. I've written articles for *The PCB Magazine* that touch on these topics:

- Materials for High Reliability Applications (June 2011)

- Built Board Tough—Backbones of PCB Reliability (July 2012)

- Built Board Tough: Budget DC Copper Plating for High Reliability and Increased Capabilities (January 2013)

These articles go into the details surrounding key processes and materials so I'll just briefly summarize each here.

Raw Materials: The most critical component towards building a high reliability PCB, in my opinion, is the copper clad laminate. Unfortunately, since this is often the single largest cost component of a PCB, many fabricators treat it like a commodity and purchase from the cheapest source. As I detailed in Latest on Lead Free Capable Materials (February 2012), materials do perform differently than one another even when having the same data sheet characteristics. It's important to test out each resin system as it behaves with your processing parameters.

Multilayer Lamination: Continuing with the materials selection, it's important to thermally profile the lamination parameters with each resin system. You're not just looking to achieve cure, but also optimize resin flow, remove voids, and achieve flatness. Putting the extra process engineering time in at initial recipe setup along with continual monitoring is paramount to achieving optimal results.

Drilling: Here's another area that scares me at many shops. I've seen and heard of fabricators using multiple brands and geometries pretty much willy-nilly, based on price and sometimes even auction scores. My belief is that each brand and geometry has its own set of optimal drilling parameters (feed, speed, retract, number of hits, etc.) that should be dialed in for your process. Since via failures are the most common root cause for a PCB failure in a high-stress environment, it's critical to have smooth hole walls that allow for optimal copper plating to occur.

Plating: One of my favorite topics—copper plating for through-holes and vias. The key to achieving plating for high reliability applications is to reduce variation as much as possible, making sample thickness measurements more reliable. Other characteristics such as tensile strength and elongation are determined by both chemistry selection and plating line setup. As I described in January's article, it doesn't have to cost you an arm and a leg to convert a standard copper plating setup to an optimal one.

What's in it for ME?

The bulk of the $1–$2 billion PCB market is currently being supplied by overseas sources. Trying to compete head-on is likely a prescription for bankruptcy, and may not even be necessary since most fabricators remaining in North America likely don't have the throughput necessary to run a true automotive production program. However, there are programs I can think of off the top of my heard that remain ideal for North American suppliers.

Prototypes: Here's a given: Almost across the board, volume automotive suppliers hate doing low-volume projects. Since automotive protos are often used for more than just design validation (life cycle testing, performance testing, etc.), it's often critical that they be built to production standards. As such, they need production-qualified suppliers that are willing and eager to supply quick-turn prototypes.

Optional Equipment/Low Volume Programs: While overall volumes for a given car or truck line often exceed 200,000 units annually, many of the higher-end options are picked up on only a fraction of the total vehicles sold. Also, automakers remain keen on having trophy vehicles that are not expected to sell well just to bring attention to the rest of the product lineup (e.g., Chevy Volt, Dodge Viper, Ford GT). These programs would require production quality units at much lower than standard volume as well (~10k–30k units annually). Coupled with volatile market demand, these types of programs are perfect to be supplied by a North American supplier.

Service Parts: Federal law requires OEMs to make available to the market all parts required to service any given product for a set number of years after the end of life of the program. These volumes typically only run up to a few

thousand units a year, have extremely volatile demand, and sometimes require a quick turnaround. Again, a perfect fit for a North American supplier.

Conclusion

While PCBs for automotive electronics represent a huge market, it's important not to get wrapped up in targeting it for the wrong reasons. Revising your systems and processes to become a qualified automotive supplier is a great way to improve the overall quality of your products and business as a whole; accordingly, you can become a rock star supplier to other industry segments and not just for automotive customers. Should you choose to end up having a focus on automotive work, there's still a lot of work out there that you can turn a profit on—it just isn't the super sexy 750,000 units for the F-150 program. The gold may just lie in the 5,000 units per year seat massage option on a Ford Taurus. The main idea here is to target the work that's right for your business. Do so, and you'll run circles around your competition, or at least a few burnouts and donuts in the parking lot. **PCB**

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