

Distributed Power Architecture Demand Characteristics

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Abstract—A demand characteristics survey was used to determine the implications of system design trends on distributed power architectures. The largest number of respondents came from the Communications segment (28.6%), with Military having the second-largest number of respondents (20.0%). Selected results from the survey indicate that within five years, engineers overall expect today's centralized power architectures will be replaced with distributed power architectures, spot power architectures and intermediate bus architectures (IBAs). But only a small percentage of respondents believe IBAs will be the "most often used" power system architecture in the future. The end-use segment expecting to use IBAs the most is the Military segment.

I. INTRODUCTION

Since their development in the Communications segment, distributed power architectures (DPAs) have grown in sophistication and complexity, with variants such as spot powering and the IBA gaining prominence alongside traditional DPAs. Traditional DPAs take an unusable bulk voltage, such as 48Vdc, and use isolated converters to supply a usable voltage. Spot powering, on the other hand, takes a usable voltage (e.g., 5Vdc) rather than a bulk voltage and converts it for a "spot" where a different voltage is needed. In an IBA, a "bus converter" (typically 12Vdc output) is employed to provide isolation from the 48Vdc power distribution bus. It reduces the 48V bus to a level where non-isolated Point-of-Load (POL) converters can operate with reasonable duty cycle without the need for a transformer. Non-isolated converters then generate load voltages needed from this intermediate bus. The IBA was introduced in order to address cost issues. In some systems, the savings from the use of the IBA could come to over 20% below the traditional DPA solution. Finally, along with Traditional, Spot and IBA power architectures, "hybrid" architectures exist that combine these three in different ways.

In addition to unit and dollar sales forecasts, it is useful to understand underlying product dynamics, and how product specifications are expected to change (if at all) during the forecast period. This paper looks at some of the implications of system design trends on DPA designs. DPAs power a base technology that is highly homogeneous, with a core IC technology that needs to be powered in a certain way. As a result, IC technology trends drive many of the system trends, and engineers must develop power architectures within the parameters of these systems. A demand characteristics survey

was used to determine the implications of system design trends on distributed power architectures [1].

II. METHODOLOGY

Approximately 50 companies were chosen that design products for the end-use segments identified in the survey. These companies were sent surveys. In addition, the survey was posted on Darnell Group's website for wider response. Of the companies chosen, 36 provided responses that were complete and deemed valid. The respondents do not represent a "normal" population; they represent companies from a small industry group. Therefore, the results are specific to the systems and power designs in the survey. These responses are believed to be accurate, partly based on the high percentage of individuals providing consistent data [2]. The sample represents the largest system makers, with about 95% of the respondents answering consistently. This produced a confidence interval of 95-99%.

III. STRUCTURE OF THE SURVEY

A questionnaire was developed, which was based on a previous questionnaire, to gather data on trends in power distribution. Prior to distribution, the questionnaire was sent to a number of companies who manufacture dc-dc converters and ac-dc front ends to get their feedback on the questions and their structure. The final survey consisted of 32 questions that (1) determined the background of the respondent; (2) asked specific questions about centralized power systems, traditional DPAs, spot power systems, and the intermediate bus architecture; and (3) asked questions specific to dc-dc converters, ac-dc front ends, back-up time and standards. Diagrams were presented to illustrate the various systems involved. Most questions were structured for "yes" and "no" answers, rankings of features, or multiple choice. A few qualitative ("open-ended") questions were included.

IV. SELECTED RESULTS

The largest number of respondents (about 28.6%) came from the Communications segment, with Military second (20.0%). The remaining respondents came from Industrial (17.1%), Electronic Data Processing/Computing (11.4%), Commercial (11.4%) and Consumer (5.7%). The remaining 5.7% ("Other")

represented the building infrastructure, automobile and automatic testing equipment sectors (see Table I).

There was a wide variety of responses to the open-ended question, "What type of specific application do you design?" A partial list includes "aerospace," "industrial automation," "test and measurement," "fuel cell installation," "ac-dc and dc-dc power supplies for computer systems," "ac-dc power supplies for PABX," "dc telecom power," "on-board dc-dc converters," "radio base station," and "UPS backup products."

The average time-to-market is 10-12 months, with Consumer products having the shortest time-to-market (about 7.0 months) and Military products having the longest time (about 14.8 months). The average time-to-market for Communications products is 8.5 months. The typical product life cycle varies by application, with Consumer having the shortest time (15 months), and Military and Communications having the longest time (97 months and 90 months, respectively). Compared with the survey Darnell did in 1997, the average product life cycle has shortened from 120 months to between 60 and 120 months today.

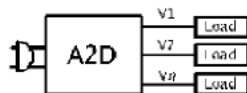
The respondents, who represent the end-user segments shown in Table I, were asked what type of power system architecture they use currently most often, and to project what type of system they are likely to use in two years and in five years. The power system configurations they chose from are illustrated in Figure 1. The results are given in Table 2.

TABLE I: EQUIPMENT END-USE MARKET (PERCENTAGE OF RESPONDENTS)

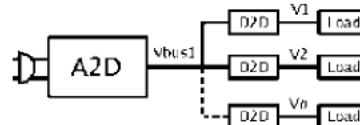
End-Use Market	Percent
Commercial	11.4
Communications	28.6
Consumer	5.7
EDP/Computing	11.4
Industrial	17.1
Military	20.0
Other	5.7
TOTAL	100.0

FIGURE I: POWER SYSTEM ARCHITECTURES

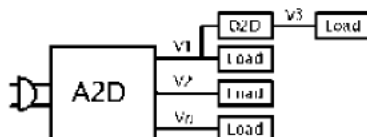
(A) Centralized Power System



(B) Traditional Distributed Power System



(C) Spot Power System



(D) Intermediate Bus Architecture

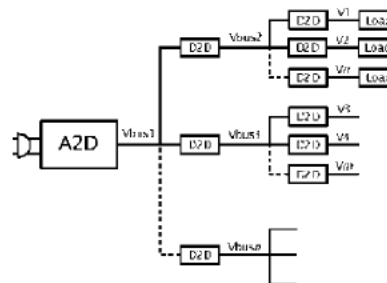


TABLE II: ARCHITECTURE EXPECTED TO BE USED MOST OFTEN

	Today	In 2 Years	In 5 Years
Centralized	44.4	8.6	0.0
Traditional	44.4	48.6	43.8
Spot	8.3	25.7	25.0
IBA	2.8	17.1	28.1
None	0.0	0.0	3.1
TOTAL	100.0	100.0	100.0

The results indicate that within five years, engineers overall expect today's centralized power architectures will be replaced with distributed power architectures, spot power architectures and intermediate bus architectures. This is more likely to happen as the cost of dc-dc converters has been reduced and the reliability of ac-dc power supplies has increased.

The survey results also suggest that the power supply market today is equally dominated by centralized and traditional distributed power systems. Fully 44.4% of the respondents selected either Centralized or Distributed power systems as their power system architecture. Additionally, 8.3% of the respondents selected Spot power systems, followed by IBAs, which have just started to penetrate the market. But in two years, the respondents expected traditional Distributed power systems to dominate the power supply market. Centralized power systems are expected to fall into last place, even behind Spot power systems and IBAs, with only 8.6% market share. Within the next five years, respondents expected Centralized power systems to disappear altogether. The power supply market will continue to be dominated by traditional Distributed power systems (43.8%), followed by IBAs (28.1%) and Spot power systems (25.0%). While we do not believe Centralized systems will disappear in five years, the survey results do point to some fundamental changes going on in the power supply industry.

"Spot power" is not, technically, part of a distributed power architecture; instead, it is usually part of a centralized power system. How "centralized" and "distributed" are defined is important when interpreting the survey results. Most growth in Spot powering will occur in the Computer segment, which already has the largest portion of this architecture.

An interesting finding of the survey is the small percentage of respondents who believe that IBAs will be the "most often used" power system architecture in the future. IBAs are an "emerging" architecture, so the 2.8% who report using them "most often" today is not surprising. But in two years, only 17.1% of end users indicate they are likely to be using IBAs, and that percentage will only increase to 28.1% in five years.

Broken down by end-use, the Communications segment has the highest percentage of respondents (48.3%) who selected the Traditional power architecture, followed by Military (47.6%) and Commercial (45.5%). On the other hand, Military has the highest percentage of respondents who selected the Centralized power architecture – about 28.6% versus 20.7% for Communications and 20.0% for Industrial. The Spot power architecture is most popular among the respondents of three groups: EDP/Computing, Communications, and Industrial. About 25.0% of the EDP/Computing respondents selected Spot powering, compared to 24.1% for Communications and 20.0% for Industrial.

Even more surprising is the end-use segment expecting to use IBAs the most: Military. Of all Military respondents, 14% report using IBAs as the "most" today; 14% expect to be using them the most in two years; and 43% expect to be using them in five years. The Industrial segment is the next largest user of IBAs, with 33% of Industrial respondents indicating they are likely to use them within two years. Communications and Commercial respondents report the lowest levels of IBA usage. Only 6.9% of the Communications respondents believed that IBAs will dominate the industry's power distribution architectures in the future.

It is worth keeping in mind that power architectures evolve slowly, especially if extra cost is involved. The shift from centralized to distributed power systems is a case in point. The survey of system makers from the 1997 "Trends in Power Distribution" report included questions on the actual use of centralized versus distributed power architectures, along with projected future use. Back then, DPAs were not as common as they are now, but they were getting hyped just as much. What happened? The move toward DPAs did, indeed, occur but not as quickly or completely as power supply companies hoped. In 1997, traditional centralized architectures were used by about 47% of the respondents. The latter projected that use of traditional centralized systems would decline to 15% by 2002. But in our 2003 survey, 44% of the respondents are still using traditional centralized architectures. The percentage has, indeed, gone down, but not as quickly as everyone thought.

IBAs could follow a similar pattern, although they are already a niche of the DPA market, making their adoption even less certain. Only 2.8% of the respondents to the 2003 survey indicated they currently use IBAs. They project this usage to increase to about 28% in five years. This is hardly an aggressive progression, especially if you assume it is influenced by the "push" surrounding IBA adoption. One power supply company confirmed that their customers were less than enthusiastic about IBAs, with few asking about products for this architecture. Darnell Group expects most IBA growth will be found in the Computer segment, with some growth occurring in the data communications and CPE

portions of the Communications segment. The Military and Industrial respondents indicate higher levels of IBA use, as well, although these will remain small markets compared with Computers and Communications. Additionally, IBA use currently seems to be a North America trend, with fewer customers in Asia and Europe showing interest in the architecture. Regional changes will be worth noting over the next five years.

This implies a “niche” market for IBAs in the future. Sayani and Wanes [3] determined that, “An intermediate bus approach with a wide-range input, regulated bus converter involve[d] a premium in cost, space and power dissipation” in 48V systems. And White [4] noted that, “there is a movement towards the use of intermediate bus voltages of 7-8V” when efficiency is “very important.” Obviously, IBAs are a good choice in certain kinds of systems but not in others.

V. COMPARISON WITH THE 1997 SURVEY

Since the survey done in 1997 [5], a number of things have changed regarding trends in power distribution. As noted above, the percentage of respondents using centralized power architectures in 1997 was slightly higher than it is today, about 47%. That usage was projected to decrease to 15% by 2002, which it did not. We think this represents the belief end-users have that power system architectures are moving in a particular direction, and they will need to change. But the cost of changing to a new architecture often keeps companies with their old (centralized) systems longer than expected. As a result, the use of centralized power architectures will probably decrease much more slowly than designers expect. On the other hand, the use of traditional DPAs was much lower in 1997, about 15%. That was projected to increase to 43% by 2002. Considering 44% of respondents in 2003 are using traditional DPAs, that projection was remarkably accurate.

The 1997 survey underlines the evolution taking place in distributed power architectures. Systems are very different

now from what they were back then. In 1997, the question on power system architecture usage identified four types of systems: centralized, per shelf, per function and per card, with the latter three being on-board designs. The report suggested that, “It is possible that these results represent a ‘migration’ of users toward more complex forms of power distribution, with today’s central power system designers employing either in-shelf or per-function in the future, while today’s in-shelf and per-function designers are more likely to become tomorrow’s on-board converter users.”

In fact, more and more functions are being shrunk and integrated onto the board, leading to new power system configurations to facilitate those requirements. Architectures have evolved since 1997, and they will no doubt continue to evolve over the next five years. “Spot power” and “IBAs” will most likely not even exist in their current form by 2008. Highly integrated, in-board solutions will probably alter, yet again, the definition of the term, “distributed power architecture.”

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