Active Copper Cables (ACC)

Research Report

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Introduction

For the past ten years, almost all server connections to the Top-of-Rack (ToR) switch have been either Direct Attach Copper (DAC) or 10G Base-T. Bandwidth growth increased modestly with each server generation. This slow increase in server bandwidth is changing as customers increase server and NIC utilization, move to future PCIe bus speeds, and adopt new applications like AI/ML. Server connectivity speeds in 2023 are rapidly moving from 10/25G to 100G/400G, pushing the limit of what DAC can do. As the industry moves to the higher speeds of 100G/400G, DAC can no longer reach the whole rack, and customers are evaluating a mix of technologies with the express goal of not moving to a fiber-based architecture. ACC plays a vital role in the transition to these higher speeds.

PCIe Bus Generations Drive Higher Speed Connectivity

All servers use a bus to connect memory, accelerator cards, hard drives, and processors called Peripheral Component Interconnect Express (PCIe). The PCIe speed upgrade cycle is critical in how much bandwidth a server can push onto the network. The industry languished on PCIe Gen3 in the previous decade, with slower bandwidth growth. However, the newest Intel (Saphire Rapids) and AMD (Genoa) chipsets rapidly pushed the market to PCIe Gen5, a rapid 4X bus bandwidth increase. This is an essential dynamic in the market because it will not just be the high-end AI servers that can no longer use DAC, but a large and broad portion of the server market will rapidly move to higher speeds. In addition, PCIe generationally improvements and upcoming massive core count processors will change the rate at which server bandwidth increases for several server design cycles.

Table 1: Customer Type Examples

Customer Type	Example
Hyperscalers AI Clusters	ChatGPT, Meta AI Research SuperCluster
Hyperscalers Std. Compute	Alibaba, Amazon, Baidu, Google, Meta, Microsoft, Tencent
Rest of Cloud	Oracle, OVH, Salesforce, Twitter
Enterprise and SPs	AT&T, JP Morgan, Wal-Mart, Verizon

Accelerators, Smart NICs, and DPUs Increase Utilization

Driven by the largest Cloud customers, many servers now include Smart NICs, DPUs, and other offload accelerators to increase CPU utilization. By offloading a process like storage and security to the NIC, the server CPU cores can focus on workloads, not overhead. This is a key component to severs transitioning to higher speeds as well. A server with 16 cores vs. one approaching 100 cores increases networking bandwidth.

Server Speed Transitions

Server connectivity speeds vary based on the type of customer. Today, AI and Hypsercalers are moving towards 100G through 800G per server, depending on the workload. Table 1 provides examples of each type of customer. Concurrently, these customers also move towards 112G PAM4 SERDES as the standard building block. As we get to 112G PAM4 SERDES-based connections, DAC can no longer provide the reach needed, and the cable gauge becomes too thick to manage. 112G PAM4 SERDES will also be a building block of different network speeds for over a decade, becoming the most common and highest volume interface this decade. If we take the architecture changes to PCIe Gen5 and above, next-generation NICs, and processor improvements, server bandwidth should reach much higher speeds during the next three years (Table 2).

Table 2: Server Migration Speed by Customer Type

Customer Type	2020 and 2021	2022	2023	2024
Hyperscalers AI Clusters	100G	100G->400G	400G->800G	800G->1.6T
Hyperscalers Std. Compute	25/50G->50/100G	25/50G->50/100G	100G->400G	100G->400G
Rest of Cloud	10G->25G	10G->25G	25G->100G	25G->100G
Enterprise and SPs	10->25G	10->25G	10->25G	25G->100G

DAC Limitations

Customers loved DAC for its low cost and simple connectivity, but the time is approaching when it won't work for server access. As the server speed increases, the distance DAC can reach decreases, and the gauge increases. As the market transitions from 56G->112G PAM4

SERDES and from 25/50G ports to 100G/400G ports, DAC is no longer feasible as the cables can't bend nor reach every location in a rack. In some racks, the issue manifests as the cable's connectivity depth being almost the same depth as the rack. This is impractical from a space point-of-view and makes cooling and replacement impractical.

ACC and AEC options emerge

Industry consensus was that when DAC became obsolete, the industry would move to fiber and middle-of-row architectures. However, Active copper solutions emerged to keep those links copper and not rearchitect the data center. Active copper is an attractive solution as it handles multiple speed and SERDES transitions, allowing customers to stay with the technology for numerous server cycles. In addition, active copper uses a smaller gauge cable and provides enough distance for all rack connectivity. The technology is also backward compatible to support any legacy server connectivity.

There are two leading technologies in active copper. The first is Active Copper Cables (ACC) which uses an analog approach to recover the attenuated signals in the cable. Analog tends to be lower power and cost. Spectra7 pioneered this technology and was the first to deploy it at a major hyperscaler (Tencent in China). The second technology is Active Electrical Cables (AEC) which uses a digital system via a DSP to recover the cables' signals. Both approaches allow for longer reach over smaller gauge cables.

Current ACC and AEC Vendors

Several vendors provide semiconductors (Table 3). In addition, there is a mix between startups and incumbent companies. We expect each company to leverage its strengths in technology and market relationships to expand.

Table 3: ACC and AEC Vendors

ACC Vendors	AEC Vendors
MACOM	Astera Labs
Semtech	Broadcom
Spectra7	Credo
	Marvell
	MaxLinear
	Point2

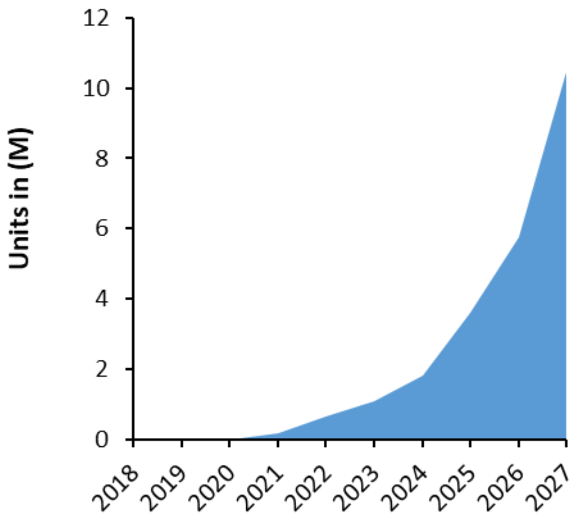
Two Routes to Market and Two Routes to the Cloud

There are currently two distinct routes to market. The first and most common is to partner with cable manufacturers that produce the cables and sell them to the end customer. Most vendors listed above chose this path. The second is to build the cable directly. Both approaches are viable and trade-off volume/scale with quality/control.

Getting to the end customer is a combination of partnerships and qualifications. For the Hyperscalers, this is direct engagement and working through validation and qualification. For the rest of the market, it is engagement via the server and switch OEMs. In addition, traditional DAC cable manufacturers will likely partner with semiconductor vendors to increase their addressable market and provide a better margin profile than basic DAC cables.

Size of the Market

Figure 1: Active Copper Cable Market



The Active Copper market will comprise the majority of 100G and above server links and have additional opportunities in disaggregated chassis and Telco SP markets. Hyperscalers, such as AWS, Microsoft, Google, and Meta, will be the initial adopters and most prominent users of Active Copper for AI clusters and general networking. Over the next few years, all data centers using 100G server links will likely migrate to Active Copper for reach, cost, and power reasons. Switch makers like Arista, Cisco, Juniper, and Nvidia will also adopt Active Copper as part of their offerings. The semiconductor content will exceed $100M in 2023 and $1B in 2027, growing at a CAGR of over 70%. The cable market will experience a similar CAGR and exceed $3B by 2027. Cable units should exceed 10M annually by 2027 (Figure 1). AI/ML workloads will have a higher percentage of Active Copper use, with most AI/ML servers moving away from DAC entirely. Given a new need is forming around the replacement of DAC, this is a robust opportunity for an ecosystem of semiconductor and cable companies to blossom and thrive.

Alternative Optical Technologies

There are two alterntive technologies. Active Optical Cables (AOCs) and traditional fiber pluggable modules solve the technical issues around connectivity but come at an unattractive or unfeasible price for widespread adoption. At the server layer, newer technologies like silicon photonics are still several generations away. Given that Active Copper can allow customers to keep the existing architectures, it plays a logical role for several generations of server and networking designs without the need to rearchitect or overspend on fiber solutions.

Vendors Future Action

There are many next-generation server designs currently going through testing by AI and cloud providers. As new 112G 5nm switch and NIC silicon come to market later this year, cloud providers will migrate rapidly away from DAC solutions. Semiconductor companies work closely with these customers and cable manufacturers to ensure quality and volume. It is essential to note the cloud volume quickly ramps to over 1M units per hyperscaler, so vendors need to spend time in their supply chain to provide a robust volume production plan to their customers.

Conclusion

ACC cables will play an essential role in AI and Cloud hyperscaler connectivity with the 100/400G server port and 112G PAM4 SERDES generation designs that will ramp up in the second half of 2023. As those systems ramp, the market will rapidly grow and become a billion-dollar semiconductor opportunity.

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