



HP ENTERPRISE/

MID-MARKET

DESKTOP PC POWER

SUPPLY ARCHITECTURE

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Introduction

The HP Compaq 6000/6005 Pro Series and HP Compaq 8000/8100 Elite Series desktop PC products introduced a new PC power supply architecture designed to improve power delivery and efficiency in the face of new and challenging Energy Star and other regulatory requirements. This document explains the new HP power supply architecture and compares it to other power supply architectures found in the industry today. The conclusion will summarize HP innovation and the value it can provide to our customers. It will also touch on the direction we believe the industry is moving in this area.

2009/2010 Power Supply Architecture

The following sections evaluate the various power supply architectures used by the PC industry in 2009/2010, including HP PC platforms. This will help define what is and is not considered a standard as the foundation for understanding the new HP Enterprise/Mid-market business PC power supply architecture.

Intel® ATX12V Standard

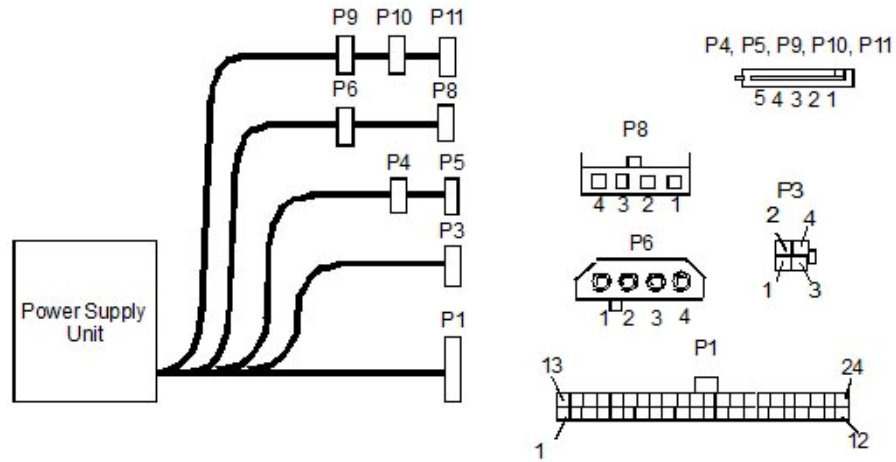
Most PC industry standards are centered on the Intel® ATX standard (http://www.formfactors.org/developer/specs/atx2_2.pdf) published in the 1990s and maintained by Intel. This standard defines common points of interconnect between power supplies, motherboards, and chassis that allows components from different suppliers to be interchangeable, increases component leverage, and shortens product development cycles.

The primary power supply standard, referred to as ATX12V, defined both the electrical interface between the power supply and motherboard and the mechanical dimensions and mounting interface between the power supply and chassis.

The ATX12V electrical power supply interface has been the primary industry standard for over a decade, but even this interface standard has gone through an incremental evolution to keep up with technology trends, such as the transition from PATA to SATA drives. The last major update to this standard was published in 2004 when the 20-pin connector was increased to 24-pins to accommodate the increased power requirements of the industry's new PCI Express standard.

The interface standard from the current ATX 2.2 specification is shown in [Figure 1](#) from the *Technical Reference Guide for the HP Compaq dc7900 Series*. The 24-pin Main Power Connector and 4-pin 12V Power Connector are the key interface between the power supply and the motherboard to supply +12V, +5V, +3.3V, +5VSB, and -12V, as well as some control signals to turn the power supply on and off. In addition to this primary interface, the standard also defines optional connectors to supply additional +5V and +3.3V power, if needed, but this connector is rarely used in current products. There is also an optional header for side-band signals to control the fan speeds. This connector is also rarely used.

Figure 1. Power Supply Cabling for the dc7900 CMT Systems



Conn	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Pin 10	Pin 11	Pin 12
P1	+3.3	+3.3	RTN	+5	RTN	+5	RTN	POK	5 ALUX	+12	+12	+3.3
P1 [1]	+3.3	-12	RTN	PSOn	RTN	RTN	RTN	PS Det	+5	+5	+5	RTN
P3	RTN	RTN	VccP	VccP								
P4, 5, 9, 10, 11	+3.3	RTN	+5.08	RTN	+12							
P4, 5, 7	+12	RTN	RTN	+5								
P11	+5	RTN	RTN	+12								

NOTES:
 Connectors not shown to scale.
 All + and - values are VDC.
 RTN = Return (signal ground)
 GND = Power ground
 RS = Remote sense
 POK = Power ok (power good)
 [1] This row represents pins 13–24 of connector P1.

Note

This illustration is Figure 7-3 of the *Technical Reference Guide for the HP Compaq dc7900 Series*.

The main ATX specification is also supported by supplemental specifications, such as MicroATX and BTX—similar standards that focus on the mechanical interfaces (large system vs. small system) rather than the electrical interfaces or power supply. The *Power Supply Design Guide for Desktop Platform Form Factors* (<http://www.formfactors.org/FFDetail.asp?FFID=13&CatID=2>) is a supplement to the ATX specification that specifically focuses on power supply standards to support the different form factor produced by the PC industry. While this design guide defines different standards for power levels and mechanical form factors, it continues to support the same ATX12V interface described above. These mechanical form factors include ATX12V, SFX12V, CFX12V, LFX12V, TFX12V, and FlexATX.

HP AC Adapter with Smart ID Technology

No standard governs external power adapters commonly used by notebook PCs and some smaller form factor desktop designs (i.e., the HP USDT form factor). For many reasons, the notebook PC industry has not centered on a common interface standard. External AC adapter power supplies are critical to this product segment, and because of the sensitive relationship between the power supply and the notebook itself, OEMs prefer to constrain the power supply to a proprietary design that is specifically qualified for use with their particular product. The connector design is also unique to prevent unqualified power supplies from being used.

The HP notebook product group has developed the HP standard interface for the single-output, external power adapters used across other product divisions including the HP Personal Systems Group (PSG) that produces consumer and business PC products. Several HP business PC platforms, including the Ultra Slim Desktop and All-in-One platforms use external power adapters designed by the business notebook development teams.

The HP external power adapter design enables special features, such as the Smart ID technology, that give HP the flexibility to deliver customer-valued innovation. While this is not an industry standard, it is an example of industry standards failing to meet the needs of HP and its customers.

The primary output voltage of external power adapters is approximately 19V and is always on. Operating voltages, +12V, +5V, +3.3V, and +5VSB, must be generated on the motherboard.

HP Mid-Level/Enterprise PC Power Supply Architectures

The following sections summarize the power supply architectures implemented on HP Mid-Level/Enterprise PC products prior to 2009 and our transition to the current architecture. Each form factor utilizing internal power supplies employs a power supply architecture specific to the needs of the particular system. It is important to note that HP business PC platforms have not followed the Intel ATX power supply standard for many years.

Convertible Mini-Tower (CMT)/Micro-Tower (MT)

The CMT and MT form factor power supplies have been based on the Intel ATX12V standard; however, these form factors stopped supporting the Intel ATX12V standard with the introduction of the dc7600 product family in 2005. Prior to the dc7600 product line, the HP tower chassis could support an ATX12V standard power supply with an adapter kit. With the introduction of the dc7600 line in 2005, the chassis could no longer support a standard ATX12V power supply.

The Intel ATX12V standard power supply did not meet the product quality and reliability goals HP set for its business PC products. The ATX12V power dimensions constrain the integrated fan to 80mm. HP found the 80mm fan failed to meet thermal and acoustic performance requirements set for its business PC platforms, so the power supply dimensions were increased to allow a 92mm fan. This action effectively broke away from the ATX12V standard.

The CMT and MT form factor power supply electrical interface prior to the introduction of the 2009 HP Compaq-branded business PC products did follow the ATX power supply electrical interface standard. There was no customer benefit to pursuing an alternate solution for this standard interface.

In summary, the CMT and MT power supplies follow the industry standard electrical interface, but have not supported a mechanical industry standard for many product generations.

Small Form Factor (SFF)

The HP Small Form Factor (SFF) power supplies are based on the CFX12V industry standard form factor defined by the ATX specification. The exact CFX12V power supply dimensions, however, are not compatible with the traditional HP SFF system dimensions; therefore HP must deviate from the specification. The HP chassis design includes an innovative serviceability feature that requires additional deviation from the CFX12V specification.

As with the CMT/MT, the CFX12V standard power supply did not meet the product quality and reliability goals for HP products. The CFX12V power dimensions constrain the integrated fan to 80mm. HP found the 80mm fan failed to meet thermal and acoustic performance requirements set for its business PC platforms, so the power supply dimensions were increased to allow a 92mm fan. This action effectively broke away from the ATX12V standard.

The basic design of the CFX12V power supply form factor causes it to partially overhang the motherboard. This creates an additional height constraint on the motherboard components. In the HP SFF, the large 24-pin power connector must be placed in or near the motherboard region constrained by the overhanging power supply.

There have been several solutions to this issue in recent products. The dc7700 and dc7800 SFF products used a smaller micro-fit connector instead of the larger, industry-standard, mini-fit connector. The dc7900 and dc5800 SFF products were able to return to the industry-standard mini-fit connector, but there were still challenges to that solution.

When the dc7900 and dc5800 SFF returned to the industry-standard connector, the system still needed a fan control interface. This function had been integrated in

the smaller micro-fit connector design of the dc7700 and dc7800 SFF products. Instead of using the optional 6-pin connector defined by the ATX standard for the fan control signals, HP simply used a common fan connector used by other fans in the system. The primary reason for using this style of connector was that the dc5800 motherboard was shared between the SFF and MT chassis, and the MT required a rear chassis fan connection instead of the power supply fan connection. The fan connector was the solution shared by the SFF power supply fan and the MT rear chassis fan.

In summary, the SFF power supply has not been fully compliant with the CFX12V industry standard, either electrically or mechanically, for many product generations.

Ultra-Slim Desktop (USDT)

The USDT form factor has evolved significantly since the dc7700 product. The small size of the dc7700 chassis did not allow the power supply to follow any industry standard mechanical form factor. The dc7700 USDT product did share the same non-standard, micro-fit power supply connector design as the dc7600 SFF described above. Earlier USDT products also had unique power supply designs.

The dc7800 USDT product marked the introduction of the smaller USDT form factor, and it transitioned to the external power adapter solution following the HP notebook standard design described above.

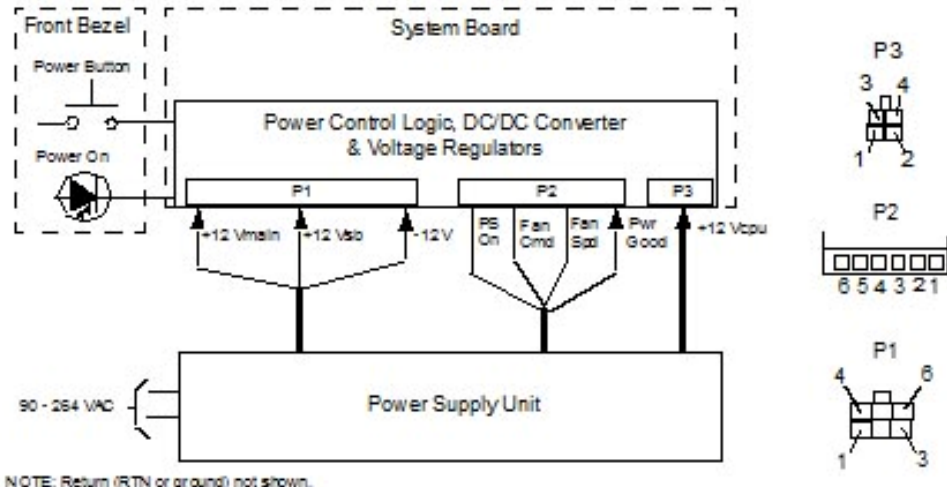
In summary, the USDT power supply has never followed any industry standard design.

New HP +12V Power Supply Architecture

Beginning with the 2009 introduction of the HP Compaq 6000/6005 Pro Series of business PCs, HP rolled out a new internal power supply architecture to replace the existing ATX power supply electrical interface standard for all future business PC products targeted to the enterprise and mid-market customer segments. The 2009 power supply mechanical form factors are very similar to the 2008 generation platforms.

This new electrical interface (shown in [Figure 2](#)) consists of a 6-pin main power connector (replacing the 24-pin ATX connector), 4-pin 12V power connector (same as ATX), and a 6-pin control connector (different from optional ATX 6-pin connector). The operational voltages supplied by this interface are +12V, +12VSB, and -12V. The +5V, +3.3V, and +5VSB voltages defined by the ATX standard are generated on the motherboard. The motherboard then provides the +12V and +5V peripheral power that is traditionally provided directly by the power supply. Additional details can be found in the [Technical Reference Guide for the HP Compaq 8000/8000f Elite Series](#).

Figure 2. Power Distribution and Cabling, Block Diagram



Conn	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 8
P1	RTN	RTN	-12 V	+12 Vmain	+12 Vmain	+12 Vsb
P2	FANcntl	Fan Speed	PS On	Pwr Good	Reserved	Reserved
P3	RTN	RTN	+12 Vcpu	+12 Vcpu		

NOTES:
 Connectors not shown to scale.
 All + and - values are VDC.
 RTN = Return (signal ground)

Note

This illustration is Figure 7-2 of the [Technical Reference Guide for the HP Compaq 8000/8000f Elite Series](#).

Why Change the Power Supply Architecture?

Two primary reasons were driving the decision to develop a new power supply for HP business PC products. First, the increasing regulatory focus on power consumption is forcing the industry to explore innovative solutions to meet increasingly strict product requirements. Second, there is an increasing emphasis on smaller form factor PC products, and the size and bulk of the current industry interface is a major obstacle to optimizing smaller form factors.

Regulatory Requirements

The global regulatory environment has changed significantly over the last 10 years. There is a very strong legal and industry emphasis on power consumption and power efficiency. The two leading efforts are the U.S. ENERGY STAR program and the European Union Energy using Products (EuP) Directive.

The ENERGY STAR program was initiated 1992 by the U.S. EPA and is now a partnership with the U.S. Department of Energy. The ENERGY STAR program is voluntary labeling program that promotes standards for efficiency designed to inform consumers about the energy efficiency characteristics of the products they purchase. In 2005, Gold/Silver/Bronze classifications were extended to power supplies in computers. In 2008, these classifications were extended to full computer system power consumption ratings, not just power supplies. These standards define specific power efficiency and consumption targets for both the power supply and computer in different operation states, such as suspend, off, and idle.

The EuP Directive is a legal requirement within the European Union. Products which do not meet the defined requirements may not be sold within the European Union. The EuP Directive Lot 6 Tier 1 requirements took effect in January 2009 and required all PCs to meet a 1W S5 off power limit. HP products currently meet this requirement.

The EuP Directive Lot 6 Tier 2 requirements will take effect in January 2013 and will require all PCs to meet 0.5W S5 off power limit. HP is currently working on innovative solutions to meet this requirement.

HP is committed to meeting these regulatory guidelines, not just because they may be legal requirements, but because they add value to our products and customers matching the HP commitment to the environment. HP and rest of the industry must focus on innovative solutions to meet these challenging requirements, including power supply architecture and its interface to the rest of the system. This new power supply architecture is designed to meet these requirements and position HP to respond new challenges in the future.

Product Optimization

Common MT and CMT Power Supply

In the 2008 HP business PC product lineup, the CMT used a different power supply, as did the MT. To improve product leverage and efficiency, the 2009/2010 generation CMT and MT platforms share a common power supply.

One obstacle to leveraging power supplies between multiple chassis is the quantity and location of the expansion optical and hard drive bays. The drive power cable is typically provided directly by the power supply. The length of the cable, quantity of connectors, style of connectors (right-angle vs. straight), and spacing between connectors is unique to each form factor. Form factors are unlikely to be capable of sharing a power supply unless the drive power cables can be detached from the power supply. By moving the drive cables from the power supply to the motherboard in the new power supply architecture, each chassis is allowed to implement its own drive power cable to meet its needs and then share the power supply.

SFF Cable Routing

The SFF power supply rotates back to allow access to the primary hard drive and overhangs the motherboard, which creates height constraints on connectors placed under or near the power supply, such as the power supply connectors.

The dynamic positioning of the rotating power supply feature requires flexible cabling between the power supply and the motherboard power connector. If the cable bundle is stiff or taut, it will interfere with the movement of the power supply and stress the connectors and cable routing within the system. The flexibility of the power supply cables is a function of the quantity of wires going to the connectors and the length of the cable. More wires create a less flexible cable. Shorter wires in smaller form factors also create a less flexible cable. The previous SFF products suffered from both of these issues.

The new power supply architecture removes +5V and +3.3V voltages and control signals from the primary high power connector, reduces that connector from 24-pins to 6-pins, and relocates the peripheral cables to the motherboard. As a result, the cable density and flexibility of the cable assembly is significantly improved.

+5V and +3.3V Operational Voltages

The importance and use of +5V and +3.3V have changed significantly since the ATX specification was first introduced. These voltages are primarily used by legacy and I/O devices, but are only used sparingly, if at all, by newer technologies, chipsets, processors, and internal communication protocols.

Electronic component and silicon technology, as well as power management techniques, have advanced beyond the need for +5V and +3.3V as the primary voltages. The majority of power consumed by a motherboard comes from operating voltages below +3.3V and more voltage levels are reduced nearly every year. As an example, the memory operating voltage has fallen from +2.5V (DDR) to +1.8V

(DDR2) to +1.5V (DDR3). This trend will continue as legacy standards, such as PCI, are replaced by newer standards, such as PCI Express.

The most common voltage requirements on the PCA that consume a majority of system power are $\leq +1.5V$. Any available voltage +3.3V or greater can be used to generate these lower voltages. The new HP power supply architecture utilizes +12V to generate lower voltages.

While +5V and +3.3V will be needed for a long time to come, they are no longer used as a high-powered source that justified their place in the ATX power supply interface standard. Notebooks, already single voltage systems, regulate +5V and +3.3V on the motherboard. Other server and blade products have also removed +5V and +3.3V from the power supply output. PCs are trailing in this transition, but the USDT and All-in-One form factors with external power supplies have already moved in this direction. Removing +5V and +3.3V from the new HP power supply architecture improves the overall efficiency of the power supply, thus allowing HP to deliver more innovative solutions to our customers.

+5V Standby vs. +3.3V Standby

The traditional standby voltage from the power supply is +5VSB. However, +5VSB does not directly provide power for any function on the motherboard in the S5 off system state, except for possibly a few microamps. The +5VSB provided by the power supply is only used to generate +3.3VSB and other lower voltages with very low efficiency. This is another technology change that has occurred since the introduction of the ATX standard.

The continued use of +5VSB in the power supply to generate +3.3VSB on the motherboard is very inefficient and is an obstacle to meeting the required low power off-state requirements defined by the EuP Directive.

The primary off and sleep-state voltage of +3.3VSB can be generated from any higher voltage, including +12VSB. The primary use for +5VSB is for USB and PS2 S3 sleep-state wake events, also with very light loading.

Most, if not all loads, are typically switched to the main +5V and +3.3V power sources, which support higher load currents, leaving +5VSB unused and unnecessary when the power supply is on. If all loading on +5VSB can be transferred to other sources, the +5VSB output of the power supply can be turned off, thus increasing overall power efficiency.

The new HP power architecture changes the standby voltage to a voltage above +5V and allows the motherboard to generate the standby voltages it needs. This is similar to the single-output external power supplies that produce a single voltage that is always on and the motherboard regulates down to what it needs. The innovative solution creates more opportunities to increase power efficiency and overall power consumption in the sleep and off states to meet the regulatory requirements.

Summary of HP Power Supply Standard Compatibility

As shown in the discussion above, HP Enterprise/Mid-market business PC products have not supported a formal power supply design standard for many product cycles. The mechanical standards were abandoned long ago, and the few remaining products that followed the industry's electrical standard have now been replaced by a new HP power supply architecture beginning with the 2009 business PC platforms. This new architecture will continue forward for future products.

Future Opportunities

There is currently no effort by the industry to define a new power supply standard. It is common for the industry to go through technology cycles in which standards are created and then fade away when those standards no longer meet industry needs. The start of the ENERGY STAR and EuP regulatory efforts signals the beginning of the end for the current ATX power supply interface standard. Notebook products have never followed this standard, and server products require more power than the ATX standard can support. The desktop industry is the only product group that still leverages the ATX standard, but the ATX power supply standard has fallen behind.

Eventually, a new generic industry standard will be developed to cover the new requirements that did not exist when the original ATX specification was created and to allow more flexibility and innovation to support new technologies that are sure to come. At the moment, the regulatory requirements are still evolving and are unstable, which means that a new industry standard cannot focus and consolidate around a specific target. In the meantime, the industry is left to its own resources to create solutions until the time is right for a new industry standard to emerge. The new HP power supply architecture is simply a first step in that direction, and it enables HP to provide new and innovative features and products to best serve the needs of our customers.



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