1394 TRADE ASSOCIATION
Power Specification
Part 1: Cable Power Distribution

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Energy Conservation Working Group
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Approved by the

1394 Trade Association

Abstract: This specification provides informative extensions and clarifications to IEEE 1394a-2000 power distribution rules to create a predictable environment for the use of cable power. The requirements for cable power distribution and consumption are intended to promote adequate, uniform and cost-effective power availability for 1394 devices.

Keywords: 1394, Power Consumer, Power Producer, Power Provider, Power Class

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Revision History

Date	Revision	Comment
October 6, 1998	0.94	• Changed Power Provider references to Primary Power Provider • Updated Table 1 • Changed unregulated voltage requirement to regulated or unregulated requirement • Removed ambiguity of whether alternate power provider needed to pass through power or to have diode isolation. Both are supported. • Added text to enforce that a bus reset occur anytime a node changes power states • Added text that prohibits the mixture of 4 pin and 6 pin connectors on the same platform
December 2, 1998	0.95	• Changed odd page header to properly reflect revision of document • Corrected 1394 Trade Association address
December 9, 1998	0.96	• Added this revision table • Changed foot note to correspond with other ECWG documents • Added IEC60950 (3rd edition) to reference section • Changed 1.4 1394.a references to 2.0 1394.a • Miscellaneous clean up of document
February 3, 1999	0.97	• Added specification number to document • Updated year references to 1999
April 28, 1999	0.98	• Added further clarification for note “a” for power class four
September 3, 1999	0.99	• Incorporated all Ballot Review Comments • Updated IEEE P1394a references to IEEE 1394a-2000
October 5, 1999	1.00	• Approved by the 1394 Trade Association Board of Directors

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1. Overview

Standard IEEE 1394-1995, High Performance Serial Bus, has been ratified as a standard via the IEEE balloting process. An examination of the IEEE 1394-1995 standard by members of the personal computer industry has concluded IEEE 1394-1995 does not provide adequate guidance for how power is to be provided, used, or managed. A supplement to IEEE 1394-1995 has been developed (Draft Revision 2.0 IEEE 1394a-2000) in which a more comprehensive definition of power distribution and management has been provided.

This document, "Power Specification, Part 1: Cable Power Distribution," is intended to provide further enhancement by providing specific implementation guidelines and more detailed clarification of the enhancements found in IEEE 1394a-2000 supplement.

This document (part 1 of a three part power specification) deals with distribution of power within a network of 1394 nodes. It defines the power and voltage levels expected from compliant power providers, places restrictions on the use of 1394 power and the quantity and type of 1394 connectors a node implementation may have.

Part 2 of this specification *Suspend/Resume Mechanisms* deals with the capabilities and implementation of low power bus states in IEEE 1394a-2000 compliant nodes (standby/resume/suspend).

Part 3 of this specification, *Power State Management* deals with the management of changing the various power states of the individual components which make up an IEEE 1394a-2000 node - specifically the controls and mechanisms to move between various power states, the selection of power providers and routing (distribution) of power.

Part 4 of this specification, *Power Distribution Management* deals with the management of delivering power to cable powered devices - specifically, how much power exists on the network, which nodes are consuming power and what is the power budget for newly connected devices that need power.

2. References

IEEE Std 1394-1995, Standard for a High Performance Serial Bus

IEEE 1394a-2000, Standard for a High Performance Serial Bus (Supplement)

IEC60950 (3rd edition)

3. Introduction

Implementations of nodes compliant with IEEE 1394a-2000 may be categorized into three node configuration groups: 1) those which provide cable power, 2) those that consume cable power, and 3) those that neither consume or provide cable power. Nodes which provide cable power are divided between two types: 1) *Primary Power Provider,* and 2) A*lternate Power Provider*.

A *Power Consumer* is an implementation of a node which consumes power from the cable.

A *Self Powered* node is an implementation which shall not consume power from the cable for any purpose other than [optionally] powering its PHY.

A *Power Provider* provides power to the cable through V_p and V_G as defined in its self-ID packet.

An *Alternate Power Provider* provides power to the cable through V_P and V_G at a capacity different than that of a *Power Provider* such that it cannot be accurately described in the self-ID packet. The capabilities of a *Alternate Power Provider* shall be defined in the node CSR entry.

Table 1 provides a correlation between a node's power configuration implementation and the POWER_CLASS reported in its self-ID packet.

Node Power Configuration	Self ID Power Class Single-Port	Self ID Power Class Multi-Port
Primary Power Provider	1,2,3	1,2,3
Alternate Power Provider	4	4
Power Consumer	4,6,7	Not Allowed
Self-Powered	0	0,4

Table 1 Node Power Configuration versus POWER_CLASS Source

Table 2 defines all POWER_CLASS types for 1394 node implementations.

Field	Derived from	Comments	
pwr	POWER_CLASS	Power consumption and source characteristics:	
		000_2	Node does not need power and does not repeat power.
		001_2	Node is self-powered and provides a minimum of 15 W to the bus.
		010_2	Node is self-powered and provides a minimum of 30 W to the bus.
		011_2	Node is self-powered and provides a minimum of 45 W to the bus.
		100_2	Node may be powered from the bus and is using up to 3 W. No additional power is needed to enable the Link.[a]
		101_2	Reserved for future standardization.
		110_2	Node is powered from the bus and is using up to 3 W. An additional 3 W is needed to enable the Link.[a]
		111_2	Node is powered from the bus and is using up to 3 W. An additional 7 W is needed to enable the Link.[a]

Table 2 Self-ID packet field for POWER_CLASS

[a] The link is enabled by the Link-On packet (see clause 8.5.2 of IEEE Std 1394a-2000). This packet may also enable application layers. Once the link has been enabled, further information about the capability and features of the node may be discovered via a read of the Configuration Status Registers (CSR) for the node

A node may change its configuration such that specific power CSR entries reflect updated information or to provide different configuration information in its self-ID packet than initially represented. When a node changes its configuration in such a manner, it shall cause a bus reset.

4. Power Providers

A *Power Provider* is an implementation of node which shall source power to the cable through V_P and V_G at a capacity defined in its self-ID packet and/or node CSR.

Power to the cable may be provided by a node capable of doing so from its own power source - whether that power source be a connection to the AC wall socket ("Wall Powered") or batteries ("Battery Powered").

The point at which the power capacity of a node providing cable power is measured shall be the V_P pin of the 1394 receptacle on the circuit board side.

There are two types of nodes that may provide power to the cable: 1) *Primary Power Provider*, and 2) *Alternate Power Provider*. The behavior and requirements for each are detailed in the sections which follow.

Products which source power to the 1394 cable shall comply with the Limited Power Source requirements of IEC60950 (3rd edition) sub-clause 2.5. Examples are an impedance (such as Polymer PTC devices) which limits the output in compliance with table 2B of IEC60950 or an over current protection device (such as a "one-shot" fuse) to limit the output in compliance with table 2C of IEC60950.

If a short should occur on any V_P wire, current limit circuitry shall limit short circuit current such that a node providing power will not have its main system power source affected by the short circuit.

4.1 Primary Power Provider

A *Primary Power Provider*, while providing power to the cable, shall declare its POWER_CLASS to be 001_2, 010_2, or 011_2 in its self ID packet. A *Primary Power Provider* which no longer provides cable power and continues to power its own PHY shall declare is POWER_CLASS to be 000_2.

A *Primary Power Provider* shall have one or more 6-pin port connectors (three are recommended) and shall not have any 4-pin connectors.

A *Primary Power Provider* must be the only provider of power to each of its 6 pin connectors (i.e. power delivered to V_p on any of the *Primary Power Provider's* 6-pin connectors must originate from its own power source).

A *Primary Power Provider* shall not receive power into any 6-pin connector (i.e. power from another source present on the cable side of the V_p pin on any *Primary Power Provider* 6-pin connector shall not pass through to any other *Primary Power Provider* 6-pin connector).

While supplying cable power, a *Primary Power Provider* shall deliver a regulated or unregulated voltage, under full load conditions, in the range of 20 to 33 volts. The minimum power capacity provided by a *Primary Power Provider* is identified in the *POWER_CLASS* field of its self-ID packet (the minimum being 15 watts for *POWER_CLASS* 001_2). A more precise description for the amount of power capacity available may be obtained by reading the appropriate node configuration space register (CSR) as defined in Part 3 of this Power Specification.

A *Primary Power Provider*, when providing cable power, should not power its PHY from the cable. A *Primary Power Provider* may trickle power its PHY from a system provided power source when the system's primary source of power is lost. When trickle powering its PHY, a *Primary Power Provider* shall comply with all signal pass through requirements for single or multi-port self-powered node. When trickle powering its PHY, a *Primary Power Provider* shall reset the bus and declare its POWER_CLASS to be 000_2.

While providing cable power a *Primary Power Provider* (whether wall or battery powered) shall implement an isolation diode in V_p for each port it provides power to (as shown in Figure 1). The figure presents a behavioral representation of the requirement - actual circuit implementation may vary. Note: this requirement is compliant with section 4.2.2.7 of 1394-1995 but more restrictive as it does not allow power to flow into a Primary Power Provider node.

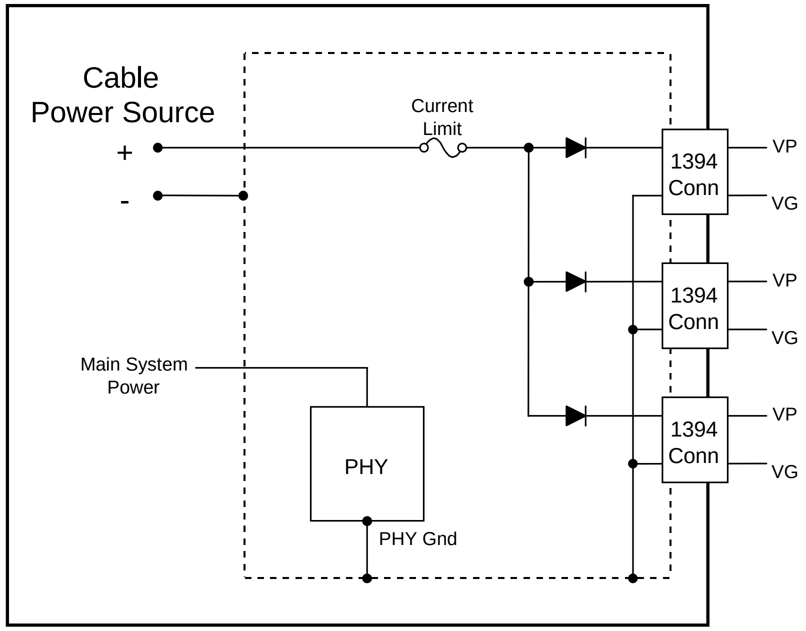

Figure 1 Diode Isolation and Current Limit for a *Primary Power Provider* of class 001_2, 010_2, or 011_2

Diode isolation provides a simple means of creating power domains - establishing a low cost means for adding incremental power to the cable (better power distribution management).

Current limit circuitry shall be implemented so as to comply with all appropriate regulatory agency specifications. Current drawn through any single port shall not exceed 1.5 amperes.

The maximum DC resistance of the current limit circuitry and circuit board trace connecting power to the V_P pin on the 1394 receptacle shall be ≤ 0.27 Ω for the rated capacity of the Primary Power Provider.

4.2 Alternate Power Provider

An *Alternate Power Provider* shall declare its POWER_CLASS as 100_2 in its self-ID packet. The power capacity of an *Alternate Power Provider* shall be specified in a node configuration space register (CSR) as defined in part 3 of this Power Specification.

An *Alternate Power Provider* shall have one or more 6-pin 1394 connectors (two are recommended) and shall have no 4-pin connectors.

An *Alternate Power Provider* shall implement diode isolation to prevent power from a higher voltage power source on the cable from flowing into the power source of the *Alternate Power Provider*.

The minimum launch voltage for an *Alternate Power Provider* shall be a regulated or unregulated 8 volts. Note: The voltage drop through a cable which connects any one port on a node to any other port on a separate node shall be ≤ 0.5 Volts. The maximum voltage drop through the current limit circuitry and the interconnecting circuit board trace shall be ≤ 0.75 Volts. Therefore, while allowed, a launch voltage of 8 volts has limited value. A minimum launch voltage of 9.25 volts is recommended for those implementations expecting to support a *Power Consumer* through at least a single cable connection.

The maximum launch voltage for an *Alternate Power Provider* shall be a regulated or unregulated 30 volts. An *Alternate Power Provider* providing cable power at a launch voltage of 20 volts or greater shall implement per port isolation diodes (as described previously for a *Power Provider*) so as to provide a simple means of creating power domains - establishing a low cost means for adding incremental power to the cable. An *Alternate Power Provider* with a launch voltage less than 20 volts but greater than 8 volts may implement per port isolation diodes.

An *Alternate Power Provider* may discontinue providing power to the cable. An *Alternate Power Provider* which ceases to provide power to the cable shall alter the contents of its configuration space register (CSR) to report zero cable power capacity and reset the bus.

An *Alternate Power Provider* that does not implement per port diode isolation shall not preclude the functionality and operability of a *Power Provider* present on the cable.

An *Alternate Power Provider* that does not implement per port diode isolation and delivers cable power at a launch voltage less than 20 volts should discontinue providing power to the cable when detecting a cable voltage greater than it provides to the cable.

Figure 2 is an electrical representation of the required behavior of an *Alternate Power Provider* that does not implement per port diode isolation and self powers its own PHY - actual circuit implementation may vary.

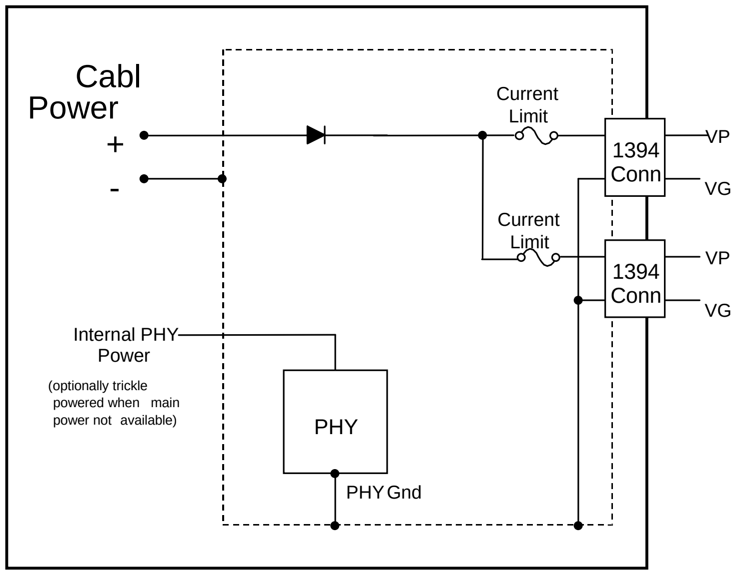

Figure 2 *Alternate Power Provider* - self-powered PHY

An *Alternate Power Provider* may consume power from the 1394 cable to power its own PHY.

> If an *Alternate Power Provider* consumes power from the cable to power its own PHY, the cable power it consumes may, in fact, be provided by the *Alternate Power Provider* itself. Note: Voltage delivered to the cable may be unregulated, therefore, when an *Alternate Power Provider* consumes cable power for its own PHY, it must provide voltage regulation circuitry for its PHY.

Figure 3 is an electrical representation of the required behavior of an *Alternate Power Provider* that does not implement per port diode isolation and consumes cable power for its PHY – actual circuit implementation may vary.

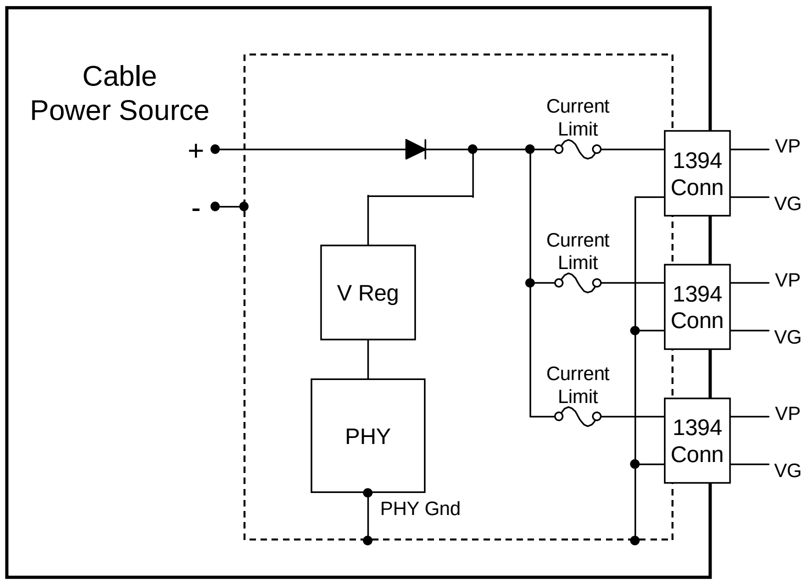

Figure 3 *Alternate Power Provider* – cable powered phy

An *Alternate Power Provider* with two or more 6-pin connectors may pass power through from connector to connector.

> The maximum DC resistance of the current limit circuitry and circuit board trace interconnecting two ports in a node shall be ≤ 0.5 Ω for a rated capacity of 1.5 amperes.

Figure 4 is an electrical representation of the required behavior of an *Alternate Power Provider* that self-powers its PHY and implements per port diode isolation.

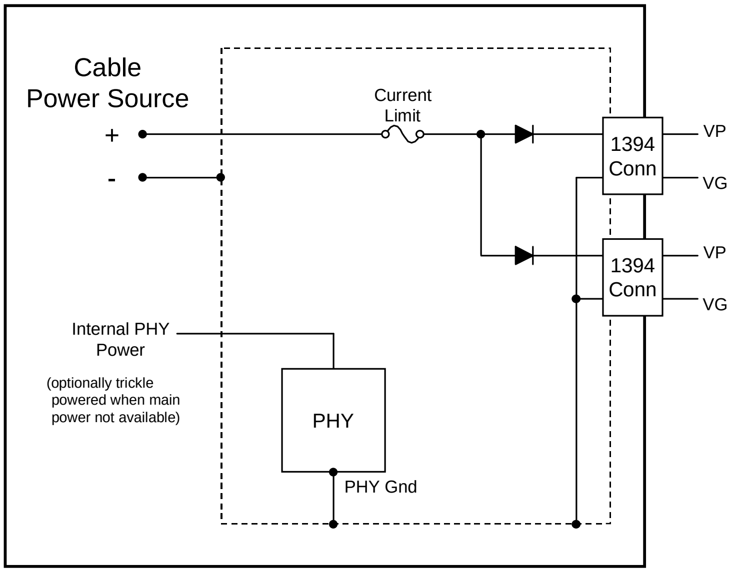

Figure 4 *Alternate Power Provider* - per port diode isolation & self-powered PHY

An *Alternate Power Provider* implementing per port diode isolation may trickle power its PHY when main system power is not available. Such an implementation of an *Alternate Power Provide*, when ceasing to provide cable power and, while powering its own PHY, shall reset the bus and declare its POWER_CLASS to be 000_2 in its self-ID packet.

5. Power Consumer

A *Power Consumer* shall declare its POWER_CLASS to be 100_2, 110_2, or 111_2 in its self-ID packet. A node configured as a *Power Consumer* may have only one 6-pin 1394 connector and shall have no 4-pin connectors.

Figure 5 provides an electrical representation of the required behavior of a *Power Consumer* - actual circuit implementation may vary.

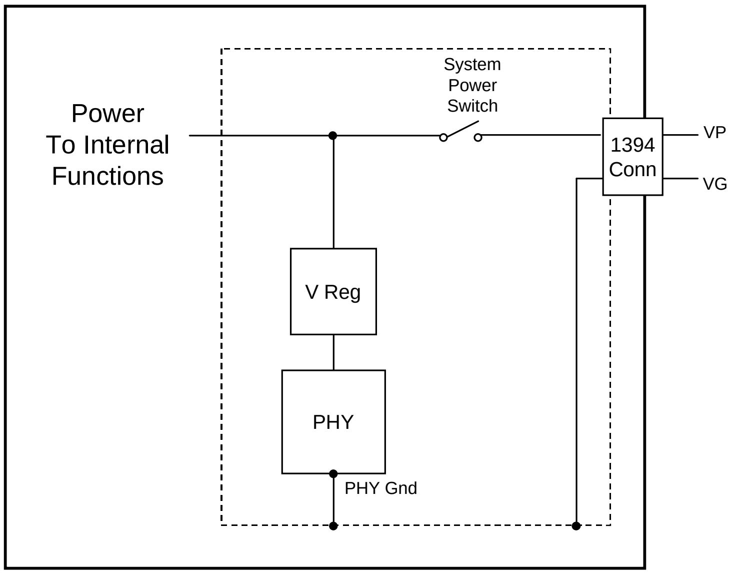

Figure 5 *Power Consumer* node implementation

Power Consumers may consume up to 10 Watts when completely functional (POWER_CLASS 111_2). Upon power-on reset a *Power Consumer* shall not draw more than 3 Watts (as measured at the 1394 cable connection) prior to receiving a LinkOn. Upon receipt of a LinkOn, the *Power Consumer* may consume an additional amount of power - up to the amount specified in its self-ID packet.

A *Power Consumer* shall be capable of being enumerated with a cable supply voltage as low as 7.5 Volts (as measured at the nodes voltage regulator input). If full functionality of the device requires a higher voltage, the required operating voltage level may be reported in a CSR register as defined in Part 3 of this specification.

6. Self-Powered Devices

A *Self-Powered* node shall declare its POWER_CLASS to be either 000_2 or 100_2 in its self-ID packet. Upon power-on reset a POWER_CLASS 100_2 *Self-Powered* node may consume power for its PHY. A POWER_CLASS 000_2 *Self-Powered* node shall not consume power from the cable.

While powered-on and active, a wall powered POWER_CLASS 100_2 *Self-Powered* node should not consume cable power.

A *Self-Powered* node is not required to be a *Power Provider* - regardless of whether it is wall or battery powered.

When a *Self-Powered* node changes configuration from not consuming to consuming cable power, it shall modify its CSR to indicate the change in its cable power consumption status and shall generate a bus reset.

A POWER_CLASS 000_2 *Self-Powered* node shall have one or more 1394 connectors. The connector sockets may be any IEEE 1394 defined socket type. Implementations of multiple connectors shall be of the same type, for example either all 4-pin or all 6-pin (there shall not be a mixture of connector types on the connector panel of the platform). When implementing two or more 6-pin connectors, the V_P pin of any one connector shall not be connected to a V_P pin of any other connector as illustrated in Figure 6 (actual circuit implementation may vary).

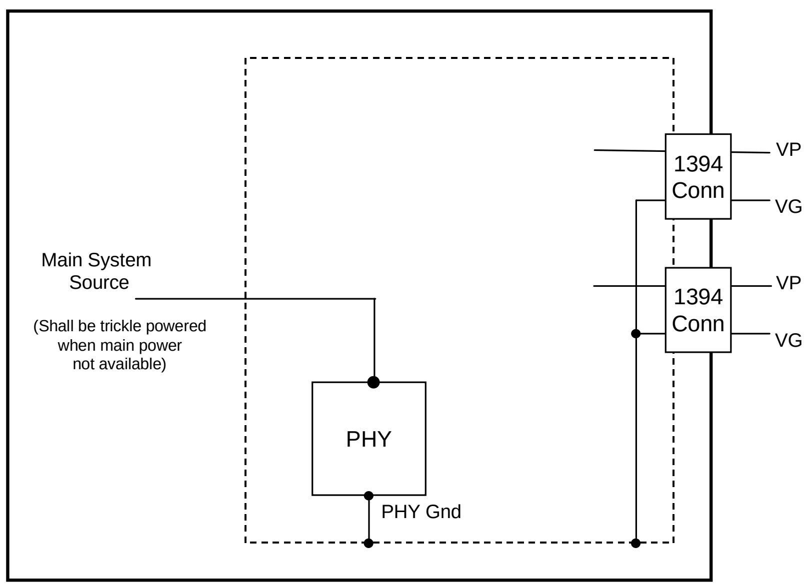

Figure 6 *Self-Powered* multi-port node implementation (POWER_CLASS 000_2)

Figure 7 illustrates an electrical representation of the required behavior of a single-port *Self-Powered* node of POWER_CLASS 000_2 (actual circuit implementation may vary).

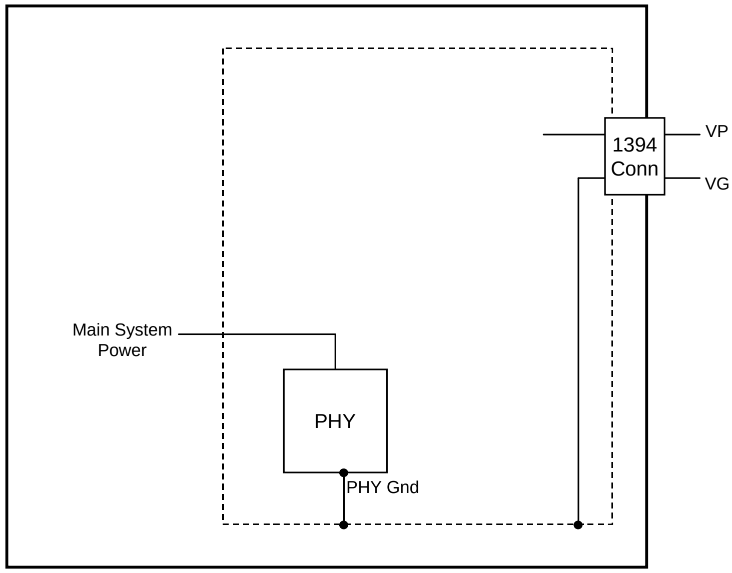

Figure 7 *Self-Powered* node implementation (POWER_CLASS 000_2)

A POWER_CLASS 000_2 *Self-Powered* node shall not power its PHY from the cable. A single-port POWER_CLASS 000_2 node is not required to maintain power to its own PHY when the main system power is not available.

A POWER_CLASS 100_2 *Self-Powered node* that implements two or more ports shall maintain power to its PHY. It may consume power from the 1394 cable to power its PHY or it may power its PHY from a trickle source of power in the system otherwise it must power its PHY from the main system power source. During instances when it is impossible for the PHY to be powered (as when the AC plug becomes inadvertently detached from the wall plate) the design must be such that power shall be inhibited from passing from any one port to any other port.

All POWER_CLASS 100_2 *Self-Powered* nodes which have only two 6-pin connectors shall provide for the pass through of power as depicted by an electrical connection of the V_G and V_P pins shown in Figure 8. The figure illustrates an electrical representation of the required behavior for a node that does not consume cable power - actual circuit implementation may vary.

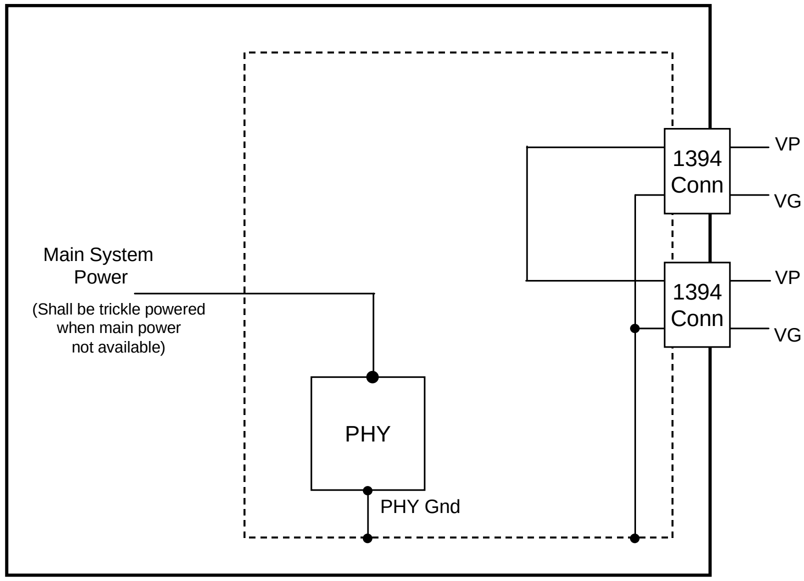

Figure 8 *Self Powered* two-port, non-cable powered PHY

When a POWER_CLASS 100_2 *Self-Powered* node has three or more 6-pin connectors, V_P from each connector shall pass power through current limit circuitry to a common internal node as depicted in the electrical representation shown in Figure 9 below. The figure illustrates required behavior for a node which does not consume cable power - actual circuit implementation may vary.

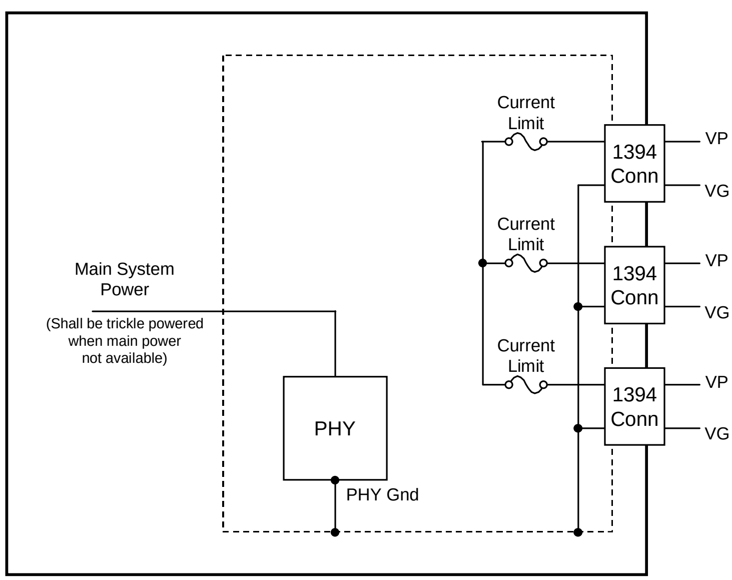

Figure 9 *Self-Powered* three-port (or more) node implementation

Current limit devices shall be implemented so as to comply with all appropriate regulatory agency specifications. Current drawn through any one connector shall be ≤ 1.5 amperes.

Note: The maximum DC resistance of current limit circuitry and printed circuit board trace interconnecting two ports in a node shall be ≤ 0.5 Ω for a rated capacity of 1.5 amperes.

When the main system power is off on a POWER_CLASS 100_2 *Self-Powered* node, the node PHY may be powered from available cable power as represented in Figure 10. The figure illustrates an electrical representation of a POWER_CLASS 100_2 node which implements two or more ports - actual circuit implementation may vary.

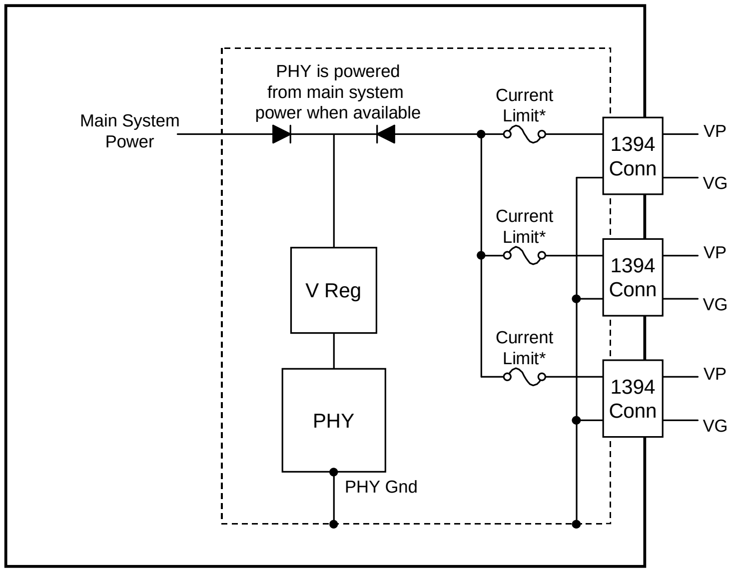

Figure 10 *Self-Powered* node (2 or more ports - cable or system powered PHY)

Figure 10 illustrates that a POWER_CLASS 100_2 node shall always maintain power to its PHY - even when main system power is not available.

A POWER_CLASS 100_2 *Self-Powered* node which always powers its PHY from available cable power is illustrated by the following electrical representation - actual circuit implementation may vary.

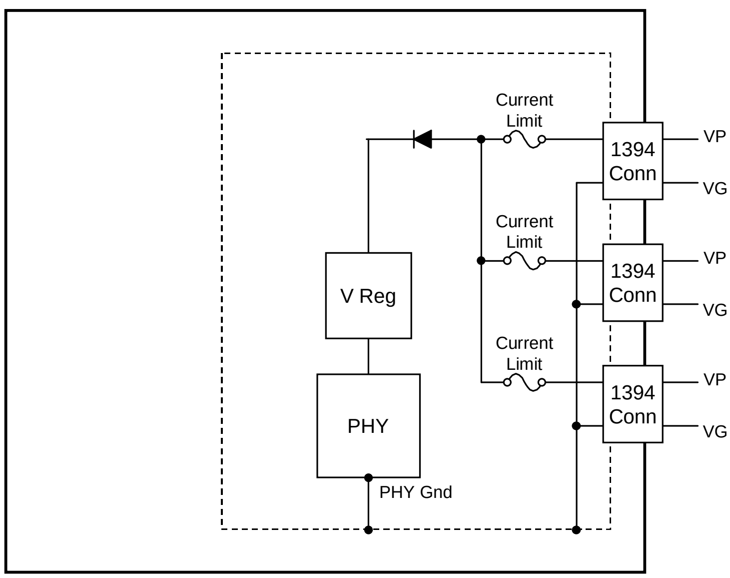

Figure 11 *Self-Powered* node (2 or more ports - cable powered PHY)

7. Power Down Behavior

When the main system power of a *Self-Powered*, *Power Provider*, or an *Alternate Power Provider* node with two or more ports is no longer available, the node shall:

1) Continue to power its own PHY, maintaining bus topology and insuring that nodes which receive and pass through power, or provide power can be properly enumerated by the Power Manager (preferred and recommended implementation); or,

2) Power it's PHY from cable power - maintaining bus topology as in (1) above (second best solution); or,

3) Prevent cable power from passing through any of its ports to any of its other ports and discontinue providing power to it's own PHY. Disabling power pass through is required when the PHY is powered off. A PHY with no power shall fragment the bus (transaction packets cannot pass through a powered off PHY). Power consumed through connections to a powered-off multi-port PHY can not be accounted for by a Power Manager and, therefore, subsequent LinkOn commands may prevent the bus from functioning properly.