1394 TRADE ASSOCIATION
Power Specification
Part 1: Cable Power Distribution

Revision 0.93

February 13, 1998

Sponsor

Architecture Working Group
of the
1394 Trade Association

Approved by the

1394 Trade Association

Abstract: This specification provides informative extensions and clarifications to IEEE Std 1394-1995a 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

1394 Trade Association
West Braker Lane, Suite 425, Austin, TX, USA

1394 Trade Association Specifications are developed within Working Groups of the 1394 Trade Association. Participants on the committees serve voluntarily and without compensation. Most participants represent member organizations of the 1394 Trade Association, but the Working Groups are free to invite technical participation from anyone. The specifications developed within the Working Groups represent a consensus of the expertise represented by the participants.

Use of a 1394 Trade Association Specification is wholly voluntary. The existence of a 1394 Trade Association Specification does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the 1394 Trade Association Specification. Furthermore, the viewpoint expressed at the time a specification is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the specification. Users are cautioned to check to determine that they have the latest edition of any 1394 Trade Association Specification.

Comments for revision of 1394 Trade Association Specifications are welcome from any interested party, regardless of membership affiliation with the 1394 Trade Association. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise about the meaning of specifications in relationship to specific applications. When the need for interpretations is brought to the attention of the 1394 Trade Association, the association will initiate action to prepare appropriate responses.

Comments on specifications and requests for interpretations should be addressed to:

Editor, 1394 Trade Association
West Braker Lane, Suite 425
Austin, TX 78759
USA

1394 Trade Association Specifications are adopted by the 1394 Trade Association without regard to whether or not their adoption may involve patents on articles, materials or processes. Such adoption does not assume any liability to any patent owner nor does it assume any obligation whatever to the parties adopting the specification documents.

This document has been approved as "stable" by the 1394 Trade Association Architecture Working Group. It will be submitted to 1394 Trade Association for adoption when the Power State Management Specification has been approved as stable by the Architecture Working Group.

Table of contents

List of Figures

List of Tables

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 1.4 IEEE P1394a) in which a more concise 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 Draft Revision 1.4 IEEE P1394a 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 P1394a 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 P1394a node - specifically the controls and mechanisms to move between various power states, the selection of power providers and routing (distribution) of power.

2. References

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

IEEE P1394a, Standard for a High Performance Serial Bus (Supplement), Draft revision 1.5 as of this writing.

3. Introduction

Implementations of nodes compliant with IEEE P1394a 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) *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 3-1 provides a correlation between a node's power configuration implementation and the POWER_CLASS reported in its self-ID packet.

Table 3-1 Node Power Configuration versus POWER_CLASS Source

Node Power Configuration	Self-ID POWER_CLASS	
	Single-port	Multi-port
Power Provider	1, 2, 3	1, 2, 3
Alternate Power Provider	4	4
Power Consumer	4, 6, 7	N/A
Self-Powered	0	0,4

Table 3-2 defines all POWER_CLASS types for 1394 node implementations.

Table 3-2 Self-ID packet field for POWER_CLASS

Field	**Derived from**	**Comment**
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]

[a] The link is enabled by the LinkOn PHY packet (see clause 7.5.2 of IEEE Std 1394-1995a). This packet may also enable application layers.

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) *Power Provider*, and 2) *Alternate Power Provider*. The behavior and requirements for each are detailed in the sections which follow.

Current limit circuitry shall be implemented so as to comply with all appropriate regulatory agency specifications.

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 Power Provider

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

A *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 *Power Provider's* 6-pin connectors must originate from its own power source).

A *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 *Power Provider* 6-pin connector shall not pass through to any other *Power Provider* 6-pin connector).

While supplying cable power, a *Power Provider* shall deliver an unregulated voltage, under full load conditions, in the range 20 to 33 volts. The minimum power capacity provided by a *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 *Power Provider* should not power its PHY from the cable. A *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 *Power Provider* shall comply with all signal pass through requirements for single or multi-port self-powered node. When trickle powering its PHY, a *Power Provider* shall declare its POWER_CLASS to be 000_2.

While providing cable power a *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 4-1). 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 power provider node.

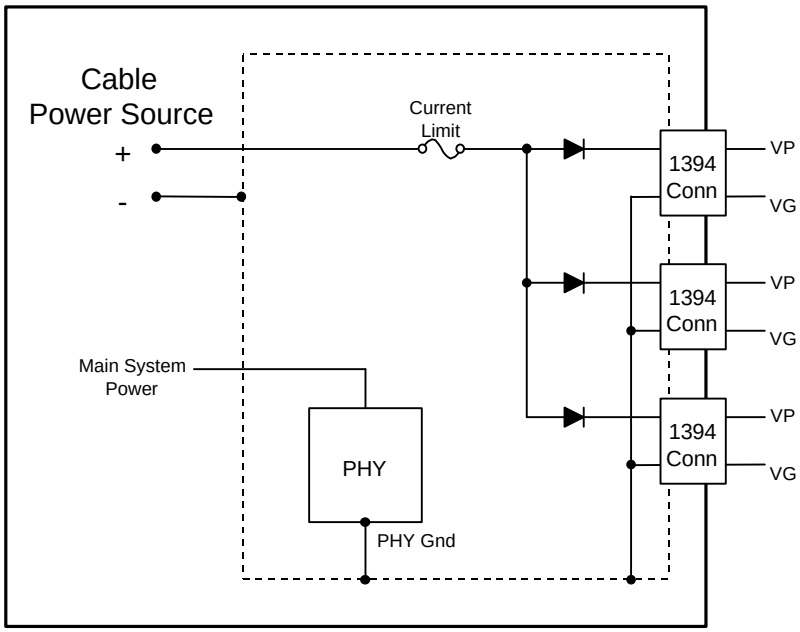

Figure 4-1 Diode Isolation and Current Limit for a *Power Provider* of class 001_2, 010_2, or 011_2

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.

> Note: 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 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 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 33 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 does not provide power to the cable shall alter the contents of its configuration space register (CSR) to report zero cable power capacity.

An *Alternate Power Provider* shall not preclude the functionality and operability of a *Power Provider* present on the cable.

An *Alternate Power Provider* which 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 that it provides to the cable.

Figure 4-2 is an electrical representation of the required behavior of an *Alternate Power Provider* which self powers its own PHY - actual circuit implementation may vary.

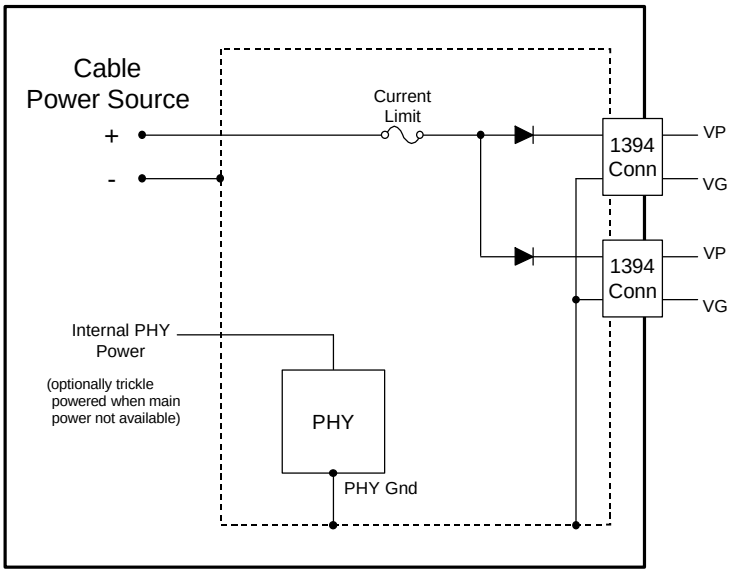

Figure 4-2 *Alternate Power Provider* - self-powered PHY

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

Note: 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 is unregulated, therefore, when an *Alternate Power Provider* consumes cable power for its own PHY, it must provide voltage regulation circuitry for its PHY.

Figure 4-3 is an electrical representation of the required behavior of an *Alternate Power Provider* which consumes cable power for its PHY - actual circuit implementation may vary.

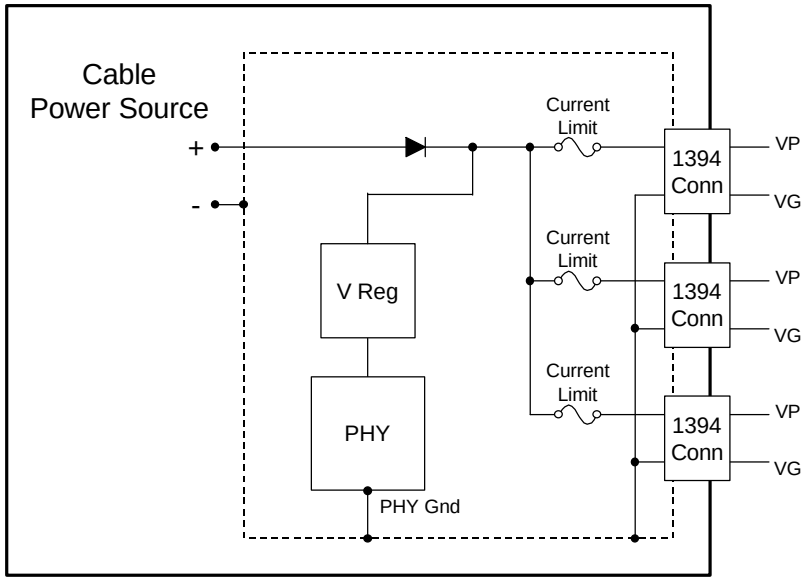

Figure 4-3 *Alternate Power Provider* - cable powered PHY

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

Note: 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 4-5 is an electrical representation of the required behavior of an *Alternate Power Provider* which self-powers its PHY and implements per port diode isolation.

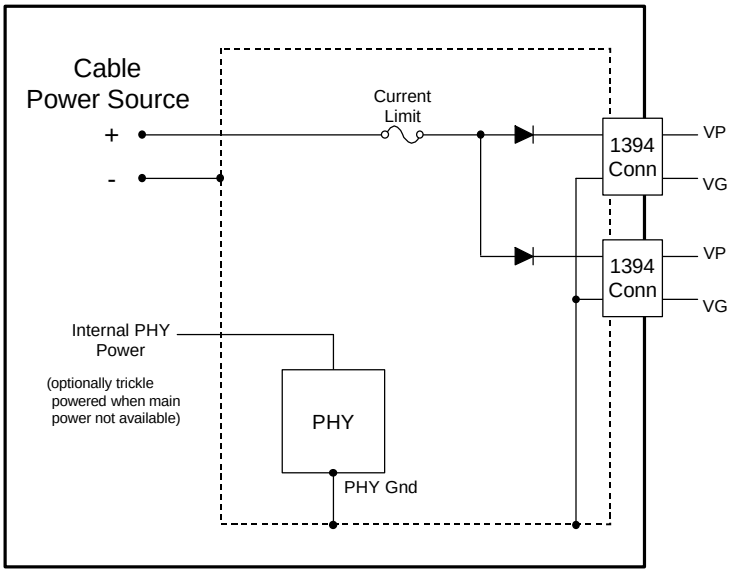

Figure 4-4 *Alternate Power Provider* - per port diode isolation & self-powered PHY

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 not providing cable power and, while powering its own PHY, shall 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 5-1 provides an electrical representation of the required behavior of a *Power Consumer* - actual circuit implementation may vary.

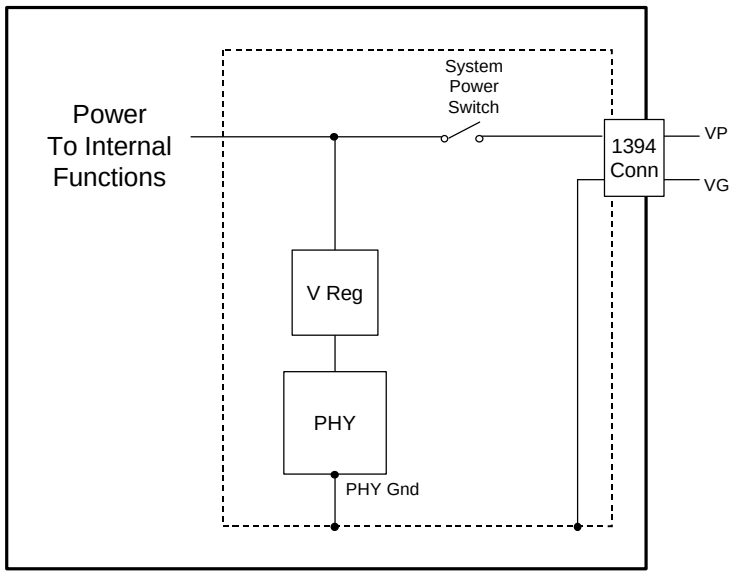

Figure 5-1 *Power Consumer* node implementation

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) for its PHY 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 connectors may be of the type 4-pin or 6-pin. Implementations of multiple connectors shall be of the same type - either all 4-pin or all 6-pin(a mixture of connectors shall not be on the same 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 the following electrical representation (actual circuit implementation may vary).

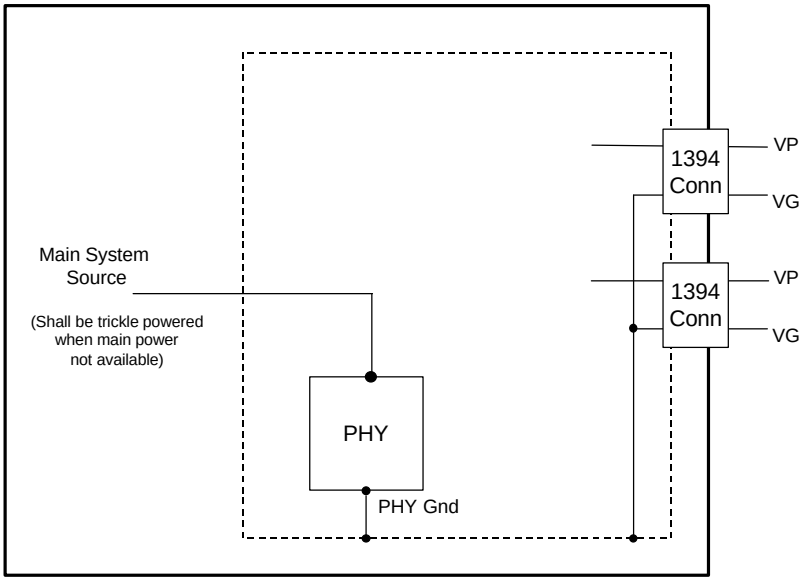

Figure 6-1 *Self-Powered* multi-port node implementation (POWER_CLASS 000_2)

Figure 6-2 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).

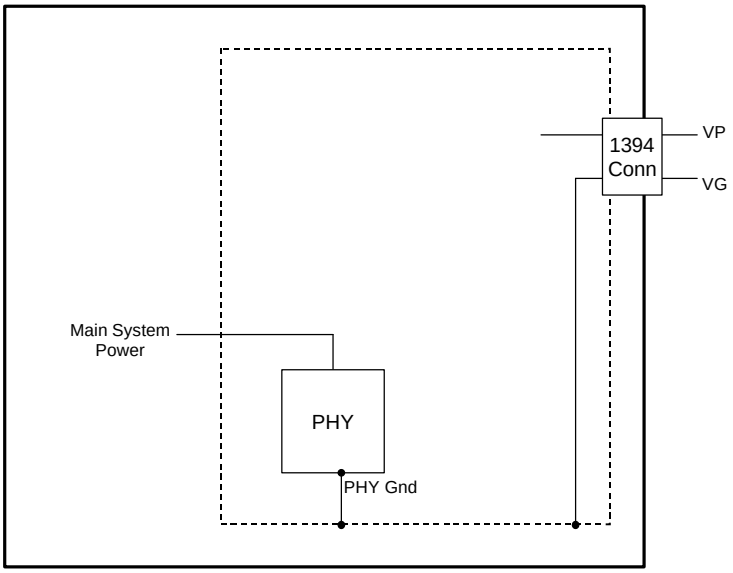

Figure 6-2 *Self-Powered* node implementation (POWER_CLASS 000_2)

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* which implements two or more ports shall maintain power to its PHY.

A POWER_CLASS 100_2 *Self Powered* node may consume power from the 1394 cable to power its PHY or it may power its PHY from the main system power or from a trickle source of power from the system when the main system power is not available.

All POWER_CLASS 100_2 *Self-Powered* nodes which have only two 6-pin connectors shall electrically connect the V_G and V_P pins as shown in Figure 6-3 (e.g. power is connected as pass-through). The figure illustrates an electrical representation of the required behavior for a node which does not consume cable power - actual circuit implementation may vary.

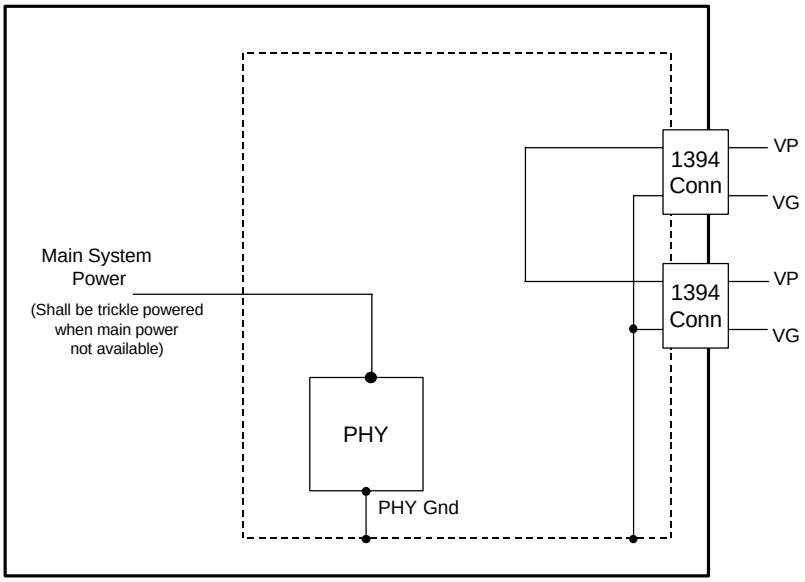

Figure 6-3 *Self Powered* two-port, non-cable powered PHY

When a POWER_CLASS 100_2 *Self-Powered* node has three or more 6-pin connectors, V_P from each connector shall be connected through current limit circuitry to a common internal node as shown in figure 6-4 below. The figure illustrates an electrical representation of the required behavior for a node which does not consume cable power - actual circuit implementation may vary.

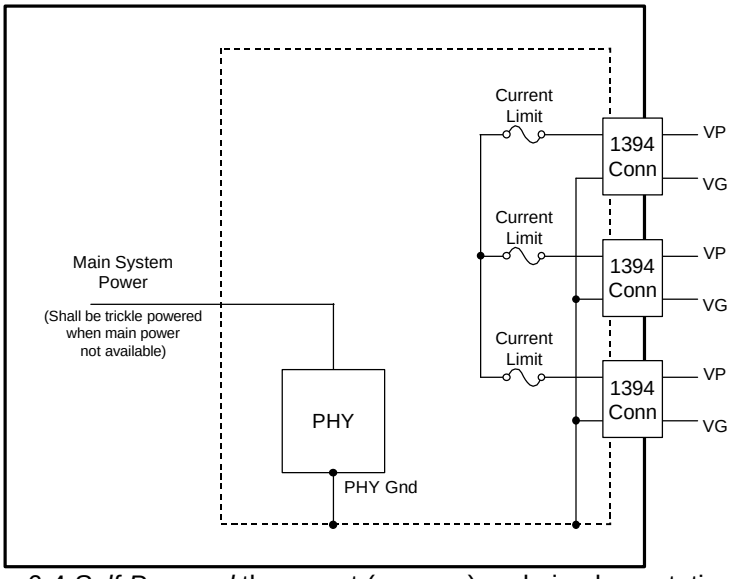

Figure 6-4 *Self-Powered* three-port (or more) node implementation

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 6-5. The figure illustrates an electrical representation of a POWER_CLASS 100_2 node which implements two or more ports - actual circuit implementation may vary.

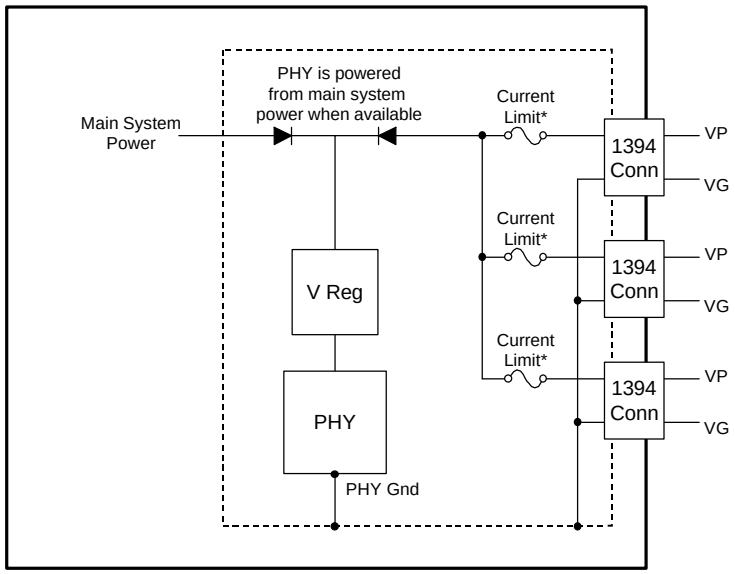

Figure 6-5 *Self-Powered* node (2 or more ports - cable or system powered PHY)

Figure 6-5 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.

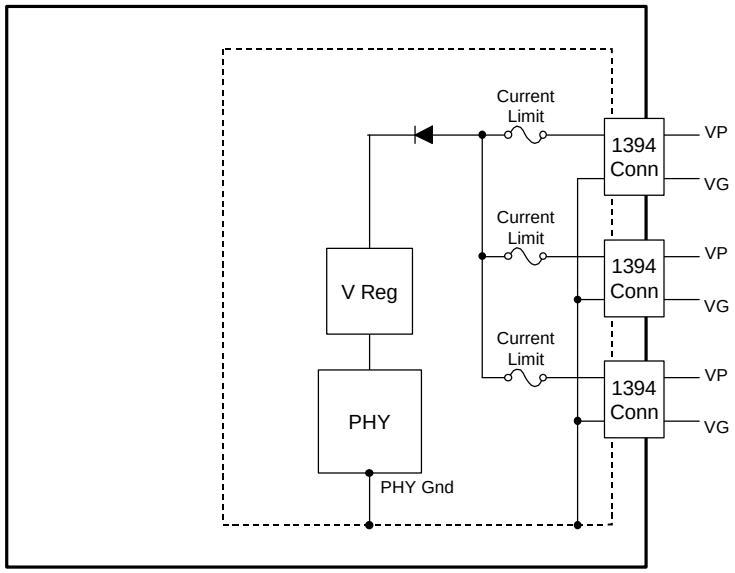

Figure 6-6 *Self-Powered* node (2 or more ports - cable powered PHY)

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.