Clause 169 Power System Parameter Adjustment

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Introduction

This presentation has 2 goals

1. Define a rule set to help judge trade-offs when adjusting the delivered power in Clause 169

    Start with a simple rule set for system builders

    Define interactions and limits on choices such as output power, node count, channel resistance

    Define limits of voltage regions in the state machine so the system can be implemented with lowest possible complexity

2. Recompute delivered power for Type 0 and Type 1 systems

    Market is asking for 24V +/- 10% Type 0 supply (currently 26V - 30V)

    Change channel resistance to achieve objectives with new supply

    Reallocate power on Type 1 system based on new channel resistance

Network Construction Rules

Network Construction Rules

How are unit load rules applied to network construction?

1. Power load on a mixing segment may not exceed 16 Units
2. Each unpowered node counts as 1U until the limit of 16U has been reached on the mixing segment.
3. After 16 units of load** been reached, no more powered nodes may be added. Unpowered nodes may be added, but the mixing segment length must be reduced by 1.5 meters per non-powered node*.

- *Based on tconn max of 0.1Ω @ 20C and 20AWG cable. See tables for derating with other AWG
- **Power is limited to 16U by power coupling inductance allocation

```
Length Derating for each data-
only node when mixing segment
unpowered load exceeds 16U*
------------------------------
awg18   :   2.39m / node
awg20   :   1.50m / node
awg22   :   0.85m / node
awg23   :   0.67m / node
awg24   :   0.53m / node
```

Max Power per Node Algorithm

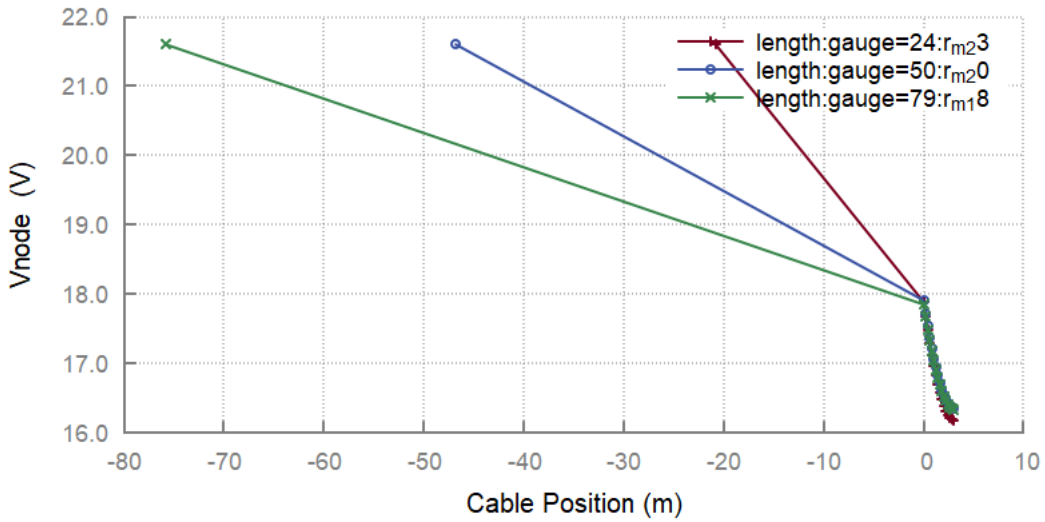
I. Given a mixing segment resistance
    I. e.g. 50meter 20gauge at 65C
II. Given a T-connector resistance
    I. e.g. 100mΩ between TC1 and TC2
III. Given a number of powered nodes
    I. e.g. 16
    II. Caped by mixing segment power coupling inductance allocation / droop spec
IV. Given a minimum MPD input voltage
    I. Type1 = 32V, Type0 = 16V
    II. Maintain voltage gap between operating regions: Type1 / Type0, Type0 / Discovery_Low
V. Pick a worst case network configuration
    I. Distance between nodes
        I. e.g. 20cm (~8")
VI. Place nodes at the end of the mixing segment with specified separation
    I. Last node is placed at 50 meter mark
VII. Maximize node power while keeping last node voltage above minimum MPD input voltage
VIII. PPSE should not be above 90W
    VIII. Allow inaccuracy in PPSE measurements between 90W and 100W
IX. Mixing segment rules should be the same for Type 0 and Type 1 to avoid market confusion

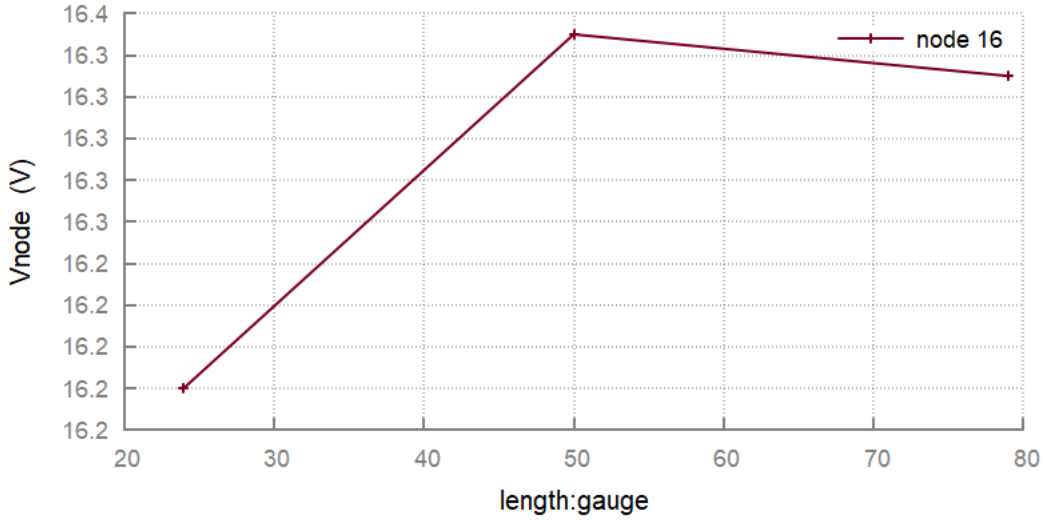
Recalculate System Power Delivery

Industrial Use Case : $V_{MPSE,min}$ = 21.6V w/ different gauge

```
Equivalent distance to 50m, 20g @ 65C
temp        : 65.00 40.00 25.00
------------------------------
18awg       : 79.67 87.04 92.16
20awg       : 50.00 54.63 57.84
22awg       : 28.22 30.83 32.65
23awg       : 22.38 24.45 25.89
24awf       : 17.75 19.39 20.53

Resistance of 50m cable @ temperature
temp        : 65.00 40.00 25.00
------------------------------
18awg       :  2.47  2.26  2.13
20awg       :  3.93  3.60  3.40
22awg       :  6.96  6.37  6.02
23awg       :  8.78  8.04  7.59
24awg       : 11.07 10.13  9.57
```



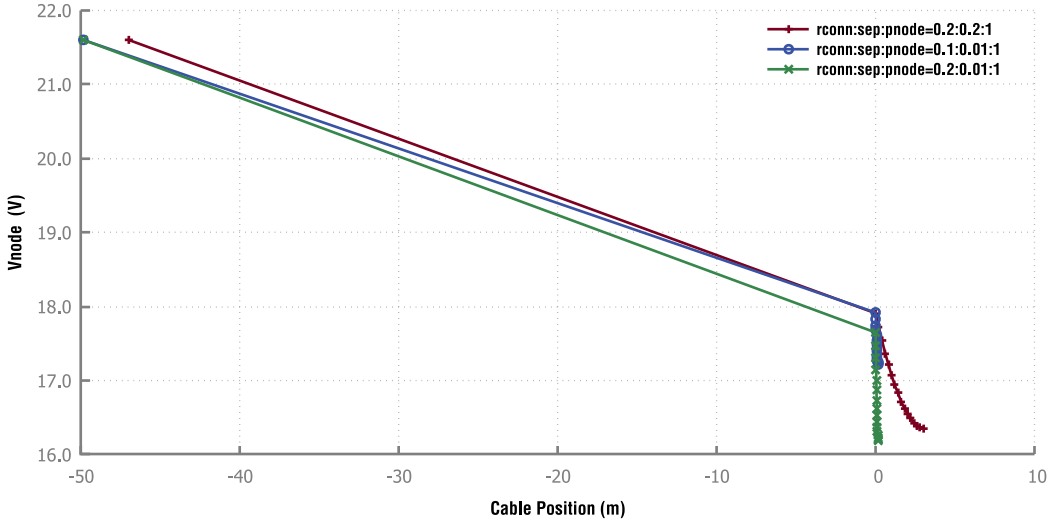


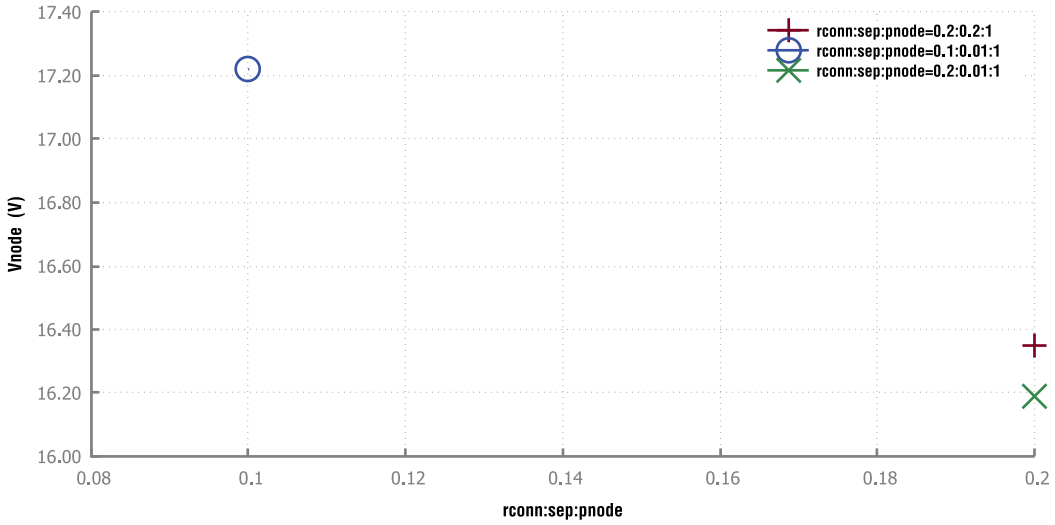
Type 0 Power Delivery

- Based around 24V (+/- 10%) supply
  - Vmpse_max = 26.4V
  - Vmpse_min = 21.6V
- Choose 20AWG Cable (50m @ 65C) ~4Ω
- Clump 16 nodes at the end of the mixing segment
- Last node must stay above 16V
- Deliver at least 1W per MPD

Option	Vpse	Ppse	Pmpd	Ploss	Ipse	Rchan	Vlast	rconn	sep	pnode
1	21.600	-20.456	16.000	-4.456	-0.947	7.129	16.354	0.2	0.20	1
2	21.600	-19.786	16.000	-3.786	-0.916	5.529	17.222	0.1	0.01	1
3	21.600	-20.698	16.000	-4.698	-0.958	7.129	16.188	0.2	0.01	1

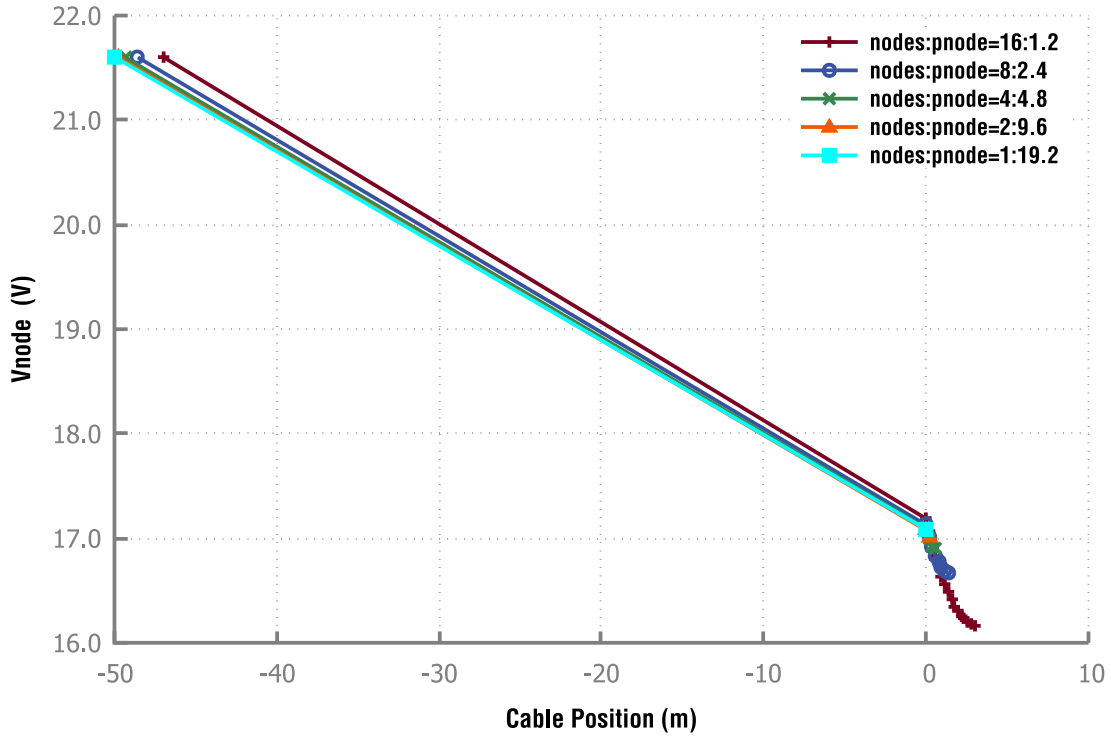
- All options work well
- We can deliver 16 MPDs 1W each @ 50 meters

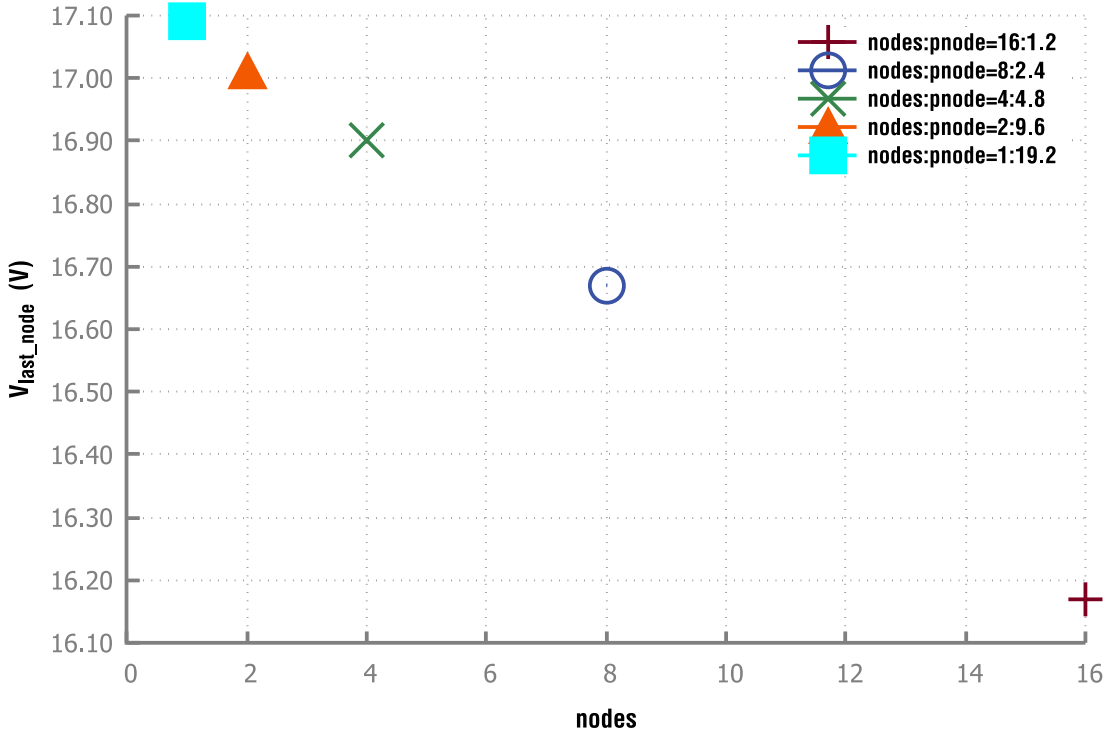




Type 0 Unit loads – Maximize Power

Nodes x Load	Vpse	Ppse	Pmpd	Ploss	Ipse	Rchan	Vlast	Ilast	nodes	pnode
16 x 1u	21.600	-25.089	19.200	-5.889	-1.162	5.529	16.174	0.074	16	1.2
8 x 2u	21.600	-24.627	19.200	-5.427	-1.140	4.729	16.667	0.144	8	2.4
4 x 4u	21.600	-24.420	19.200	-5.220	-1.131	4.329	16.901	0.284	4	4.8
2 x 8u	21.600	-24.329	19.200	-5.129	-1.126	4.129	17.014	0.564	2	9.6
1 x 16u	21.600	-24.265	19.200	-5.065	-1.123	4.014	17.091	1.123	1	19.2





Optimizing Type 1 Power Delivery

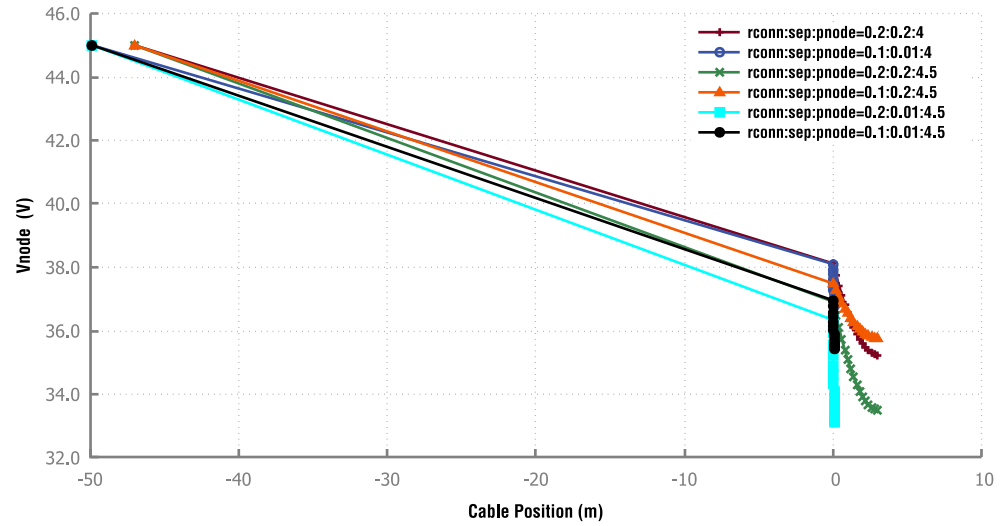
Option	Vpse	Ppse	Pmpd	Ploss	Ipse	Rchan	Vlast	rconn	sep	pnode
1	45.000	-79.491	64.000	-15.491	-1.766	7.129	35.221	0.2	0.20	4
2	45.000	-77.317	64.000	-13.317	-1.718	5.529	36.790	0.1	0.01	4
3	45.000	-93.422	72.000	-21.422	-2.076	7.129	33.496	0.2	0.20	4.5
4	45.000	-89.104	72.000	-17.104	-1.980	5.529	35.754	0.1	0.20	4.5
5	45.000	-94.639	72.000	-22.639	-2.103	7.129	33.118	0.2	0.01	4.5
6	45.000	-90.082	72.000	-18.082	-2.002	5.529	35.432	0.1	0.01	4.5

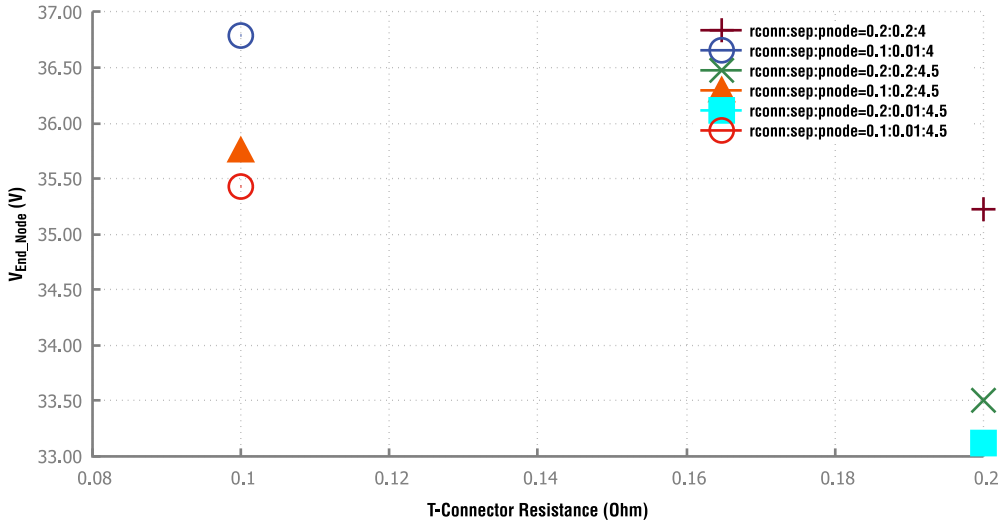
☒ Options 1 and 2 are only delivering 64W total

☒ Options 3 and 5 deliver 72W, nominal PSE output is > 90W

✓Options 4 and 6 deliver 72W with PSE output <= 90W

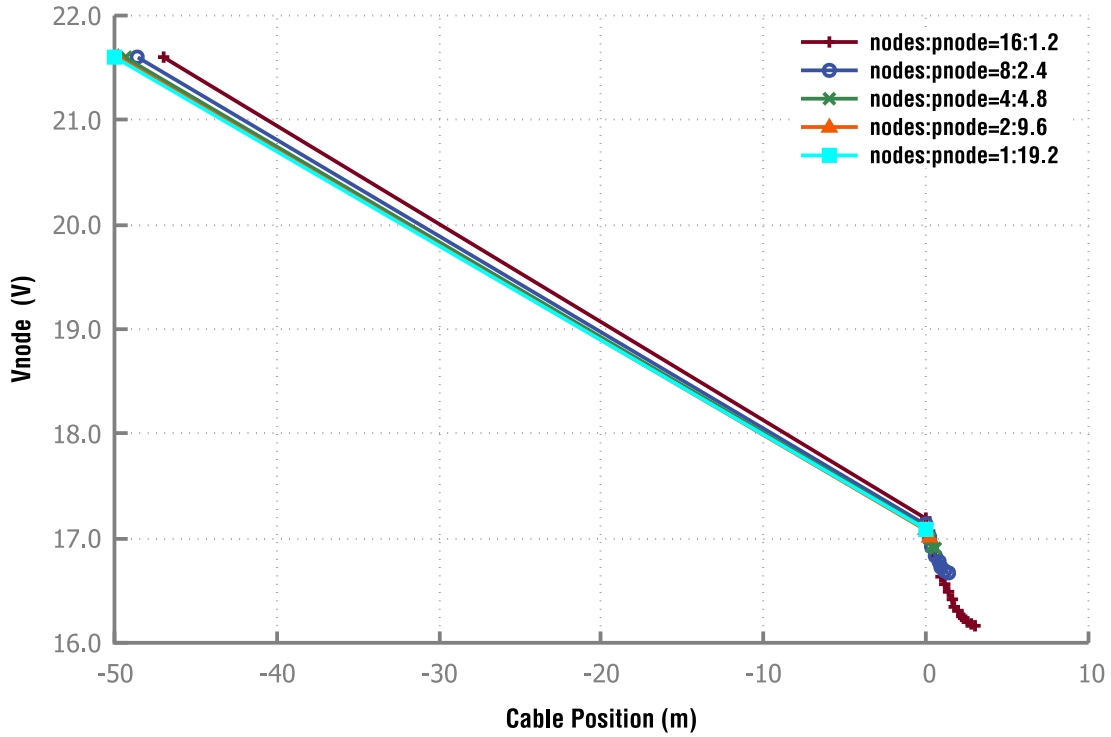
Requires <= 100mΩ connector resistance per node

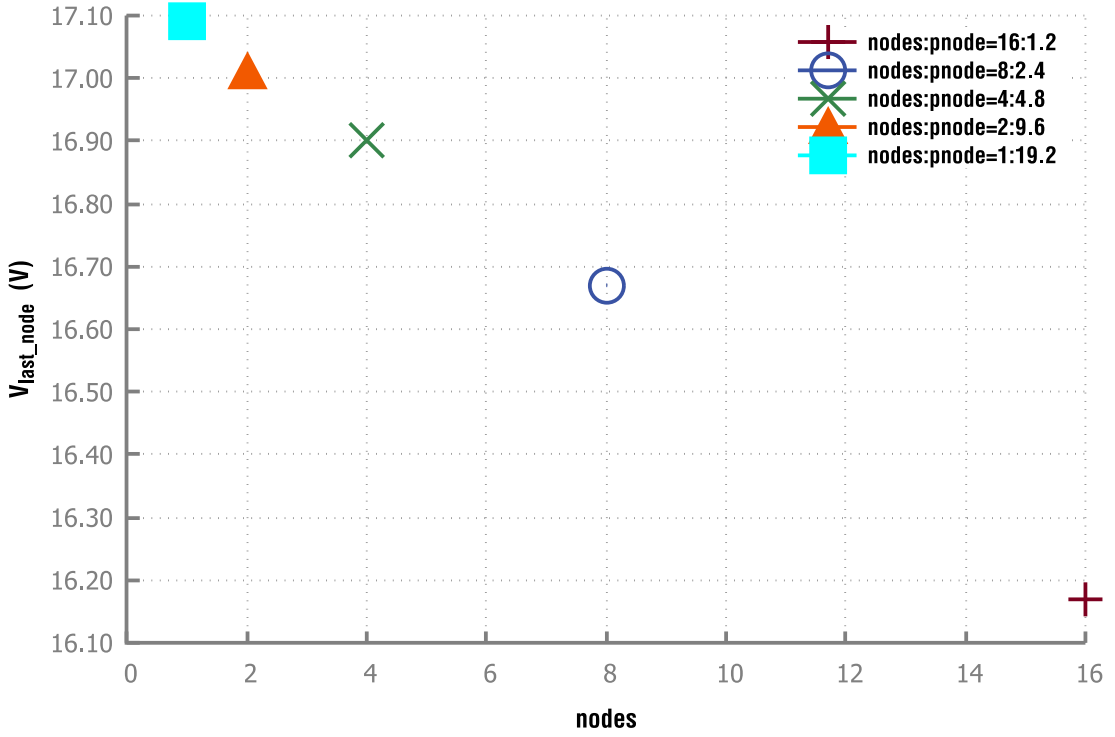




Type 1 Unit loads – Maximize Power

Nodes x Load	Vpse	Ppse	Pmpd	Ploss	Ipse	Rchan	Vlast	Ilast	nodes	pnode
16 x 1u	45.000	-89.104	72.000	-17.104	-1.980	5.529	35.754	0.126	16	4.5
8 x 2u	45.000	-87.944	72.000	-15.944	-1.954	4.729	36.545	0.246	8	9.0
4 x 4u	45.000	-87.409	72.000	-15.409	-1.942	4.329	36.927	0.487	4	18
2 x 8u	45.000	-87.170	72.000	-15.170	-1.937	4.129	37.113	0.970	2	36
1 x 16u	45.000	-87.003	72.000	-15.003	-1.933	4.014	37.240	1.933	1	72



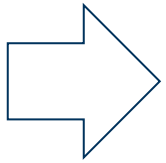


Maximized Power - Effect on Power Coupling Magnetics

Type 0 (24V)

Previously suggested magnetic sizes

Unit Size	Power (W)	IMPD (mA)	Size
1	1	63	3.2x2.5x2.5
2	2	125	3.2x2.5x2.5
4	4	250	3.2x2.5x2.5
8	8	500	4.5x3.2x2.5
16	16	1000	7x6x3.5
MPSE	23	1000	12x12x10.5



New magnetic size estimates

Unit Size	Power (W)	IMPD (mA)	Size
1	1.2	74	3.2x2.5x2.5
2	2.4	144	3.2x2.5x2.5
4	4.8	284	3.2x2.5x2.5
8	9.6	564	4.5x3.2x2.5
16	19.2	1123	7x6x3.5
MPSE	25.9	1200	12x12x10.5

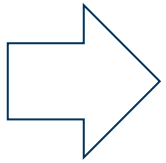
No Change in Type 0 Magnetic Sizes

Maximized Power - Effect on Power Coupling Magnetics

Type 1 (48V)

Previously suggested magnetic sizes

Unit Size	Power (W)	IMPD (mA)	Size
1	2	59	3.2x2.5x2.5
2	4	118	3.2x2.5x2.5
4	8	235	3.2x2.5x2.5
8	16	471	3.2x2.5x2.5
16	32	941	7x6x3.5
MPSE	45	1000	12x12x10.5



New magnetic size estimates

Unit Size	Power (W)	IMPD (mA)	Size
1	4.5	126	3.2x2.5x2.5
2	9.0	246	3.2x2.5x2.5
4	18	487	4.5x3.2x2.5
8	36	970	7x7x7
16	72	1933	7x7x7
MPSE	90	2000	15x15x15

Large Changes in Type 1 Magnetic Sizes

Potential System Type Power Modification

Adjust these headline numbers, ripple changes through Clause 169
This summarizes full extent of possible changes
Need to consider power coupling magnetics and maximum T-connector resistance before adoption

Table 169–1—System power types

	24V Nom. ~~30V Max~~ MPSE	48V Nom. ~~50V Max~~ MPSE	Units
System type	0	1	
$V_{MPSE(max)}$	~~30~~ 26.4	50	V
$V_{MPSE(min)}$	~~26~~ 21.6	45	V
$V_{MPD(min)}$	16	34	V
$I_{MPSE(min)}$	~~1000~~ 1200	~~1000~~ 2000	mA
$P_{MPSE(min)}$	~~26~~ 25.9	~~45~~ 90	W
$P_{MPD\_1U(max)}$	~~1~~ 1.2	~~2~~ 4.5	W

Proposed System Type Power Modification Comment 107

Adjust these headline numbers, ripple changes through Clause 169
This summarizes changes that can me made right now, along with text that changes the channel resistance

Table 169–1—System power types

	24V Nom. ~~30V Max~~ MPSE	48V Nom. ~~50V Max~~ MPSE	Units
System type	0	1	
$V_{MPSE(max)}$	~~30~~ 26.4	50	V
$V_{MPSE(min)}$	~~26~~ 21.6	45	V
$V_{MPD(min)}$	16	34	V
$I_{MPSE(min)}$	1000	1000	mA
$P_{MPSE(min)}$	~~26~~ 21.6	45	W
$P_{MPD\_1U(max)}$	1	2	W

Changes to 169.2 – Comment 106

Old Text:

169.2 Mixing segment

The dc loop resistance of the mixing segment shall be 12Ω or less, measured from edge termination to edge termination

New Proposal:

169.2 Mixing segment

The mixing segment consists of cable, nodes (TCIs), and terminations (see Figure 169-1).

100Ω terminations are connected at the ends of the mixing segment and must be AC coupled. The maximum dc loop resistance of the mixing segment cable, not including nodes, shall be 4Ω.

The mixing segment supports up to 17 in-line nodes, consisting of 1 MPSE and up to 16 MPDs or DTEs.

Each node may add a maximum of 200mΩ to the mixing segment loop resistance.