Power System Parameter Examples

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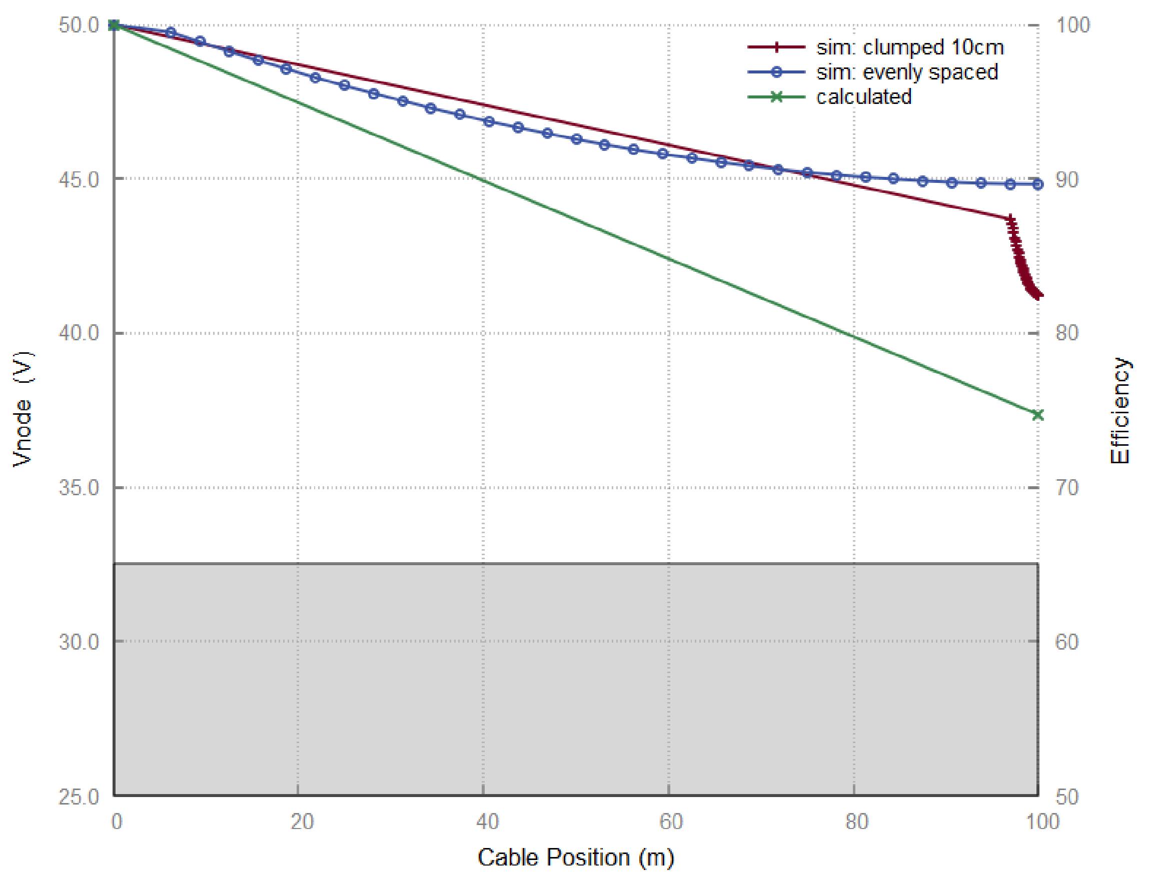
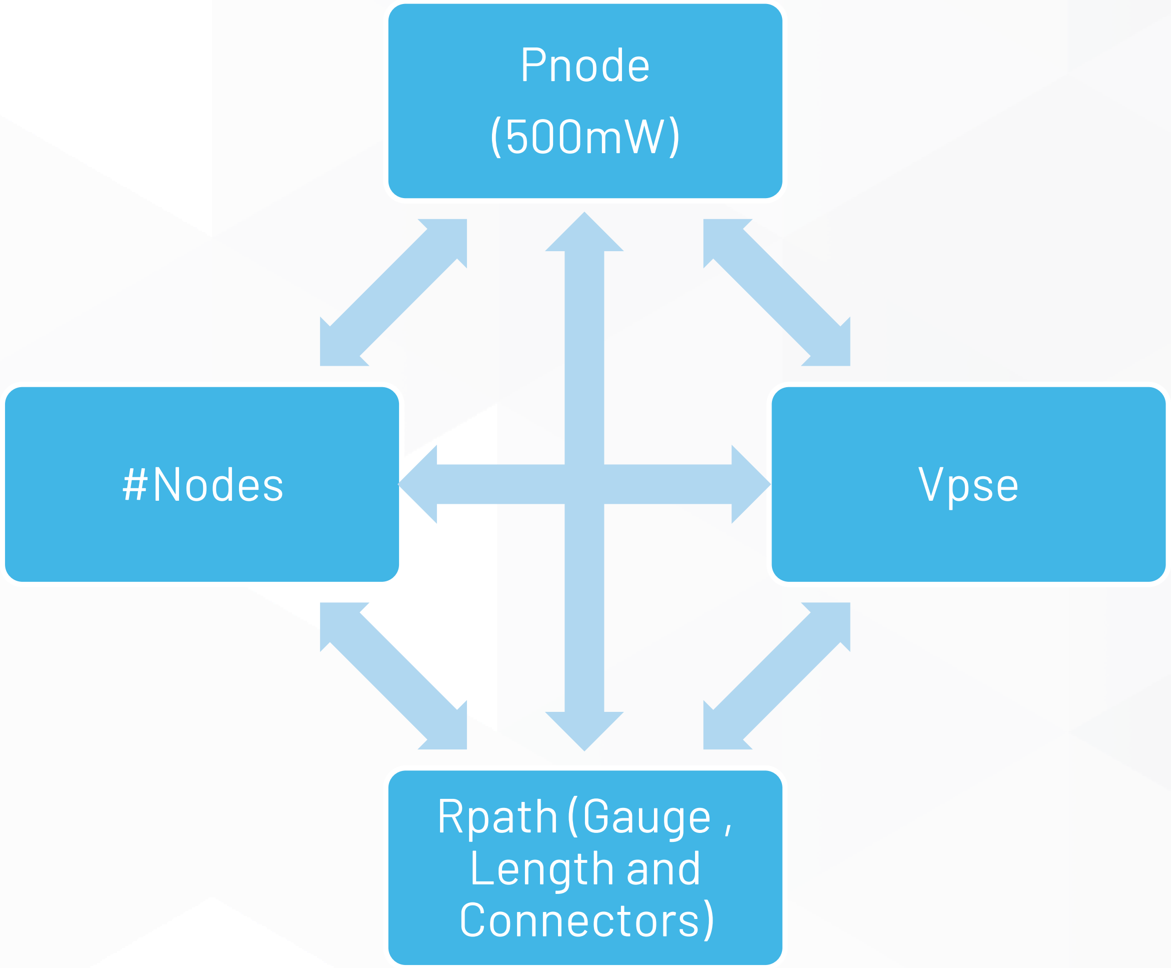
Calculated vs Simulated



32 nodes, Rconn = 300mΩ, Pnode=600mW, 22AWG Cable @ 65C, 100meters

- Relationship between T-connector resistance and Cable resistance is not intuitive
- Closed form equation for multi-drop power might not exist
  - Simplified calculations are very pessimistic
- Use spice to converge on solution
  - Spice will not converge if Barkhausen criterion is not met
- Need margin above Barkhausen criterion

Powering Trade-off

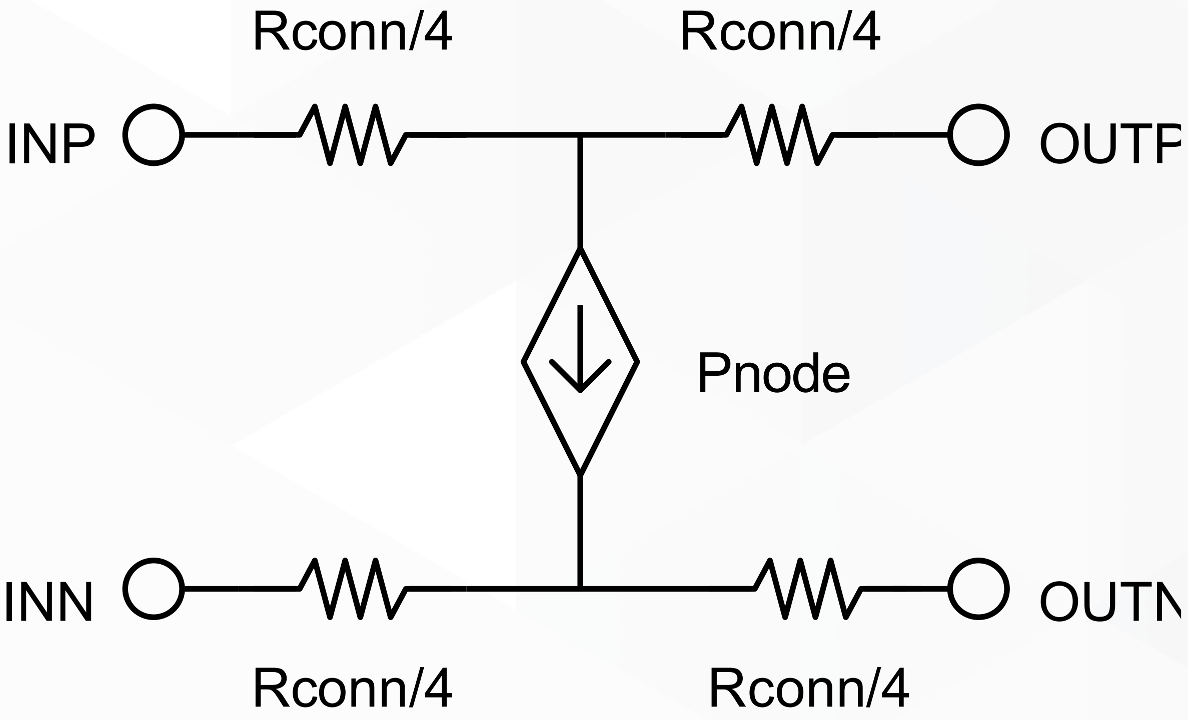


- $Icable = \frac{Vpse + \sqrt{Vpse^2 - 4*Rpath*Pnode*Nnodes}}{2*Rpath}$
- >500mW / node required
  - Need enough power to start comms + small extra for simple sensors
- Trade off
  - PSE Voltage | Rpath | Node Count

Parameter Priorities

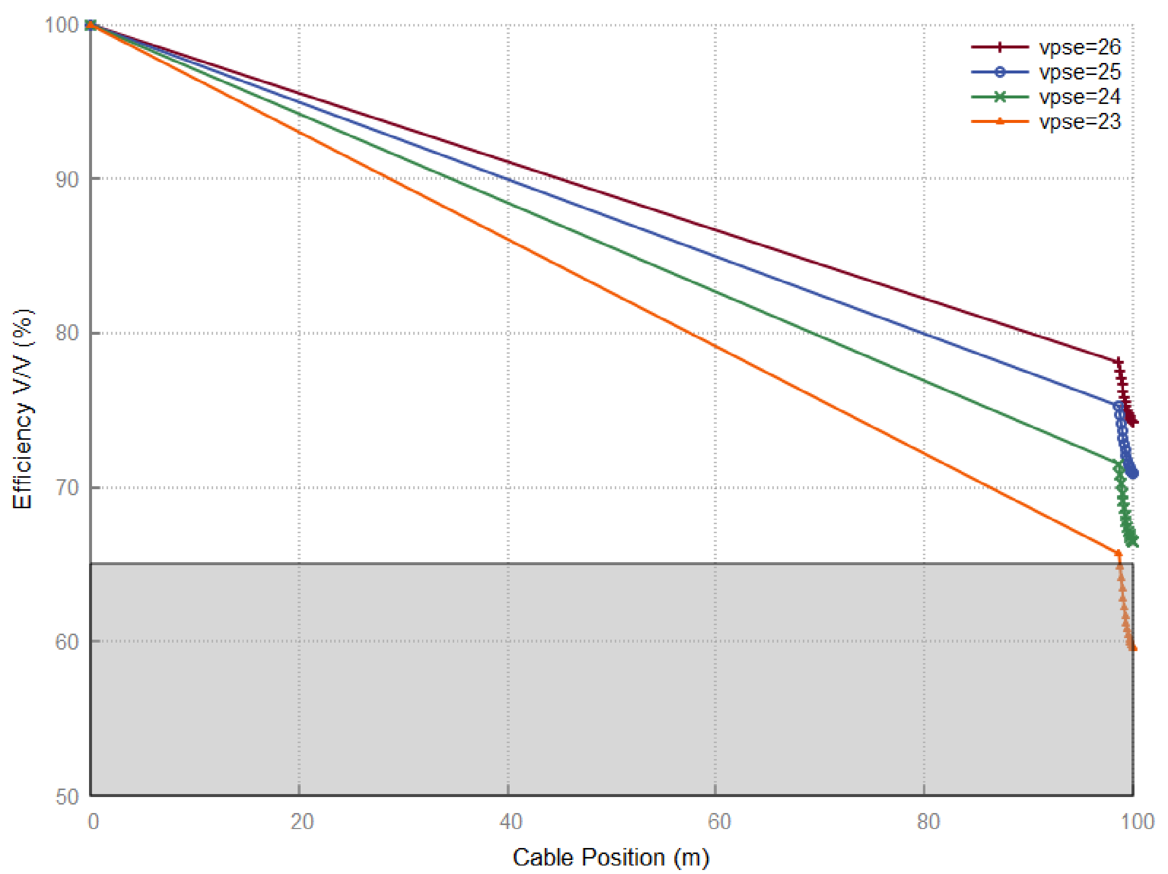
- Priorities for the following examples
  - 100m cables
    - Decent node counts w/ AWG22
    - Match traditional Ethernet for consistency
  - Smallest possible diameter (e.g. AWG22)
  - Maximize Node Count
  - >500mW Node
  - System Efficiency > 65%

Node Model



- Rconn is divided by 4 in each node
  - Represents contact resistance
  - Compensator Resistance
  - Etc.
- Rconn=300mΩ
  - <75mΩ per contact
- Need connector expert to validate this assumption

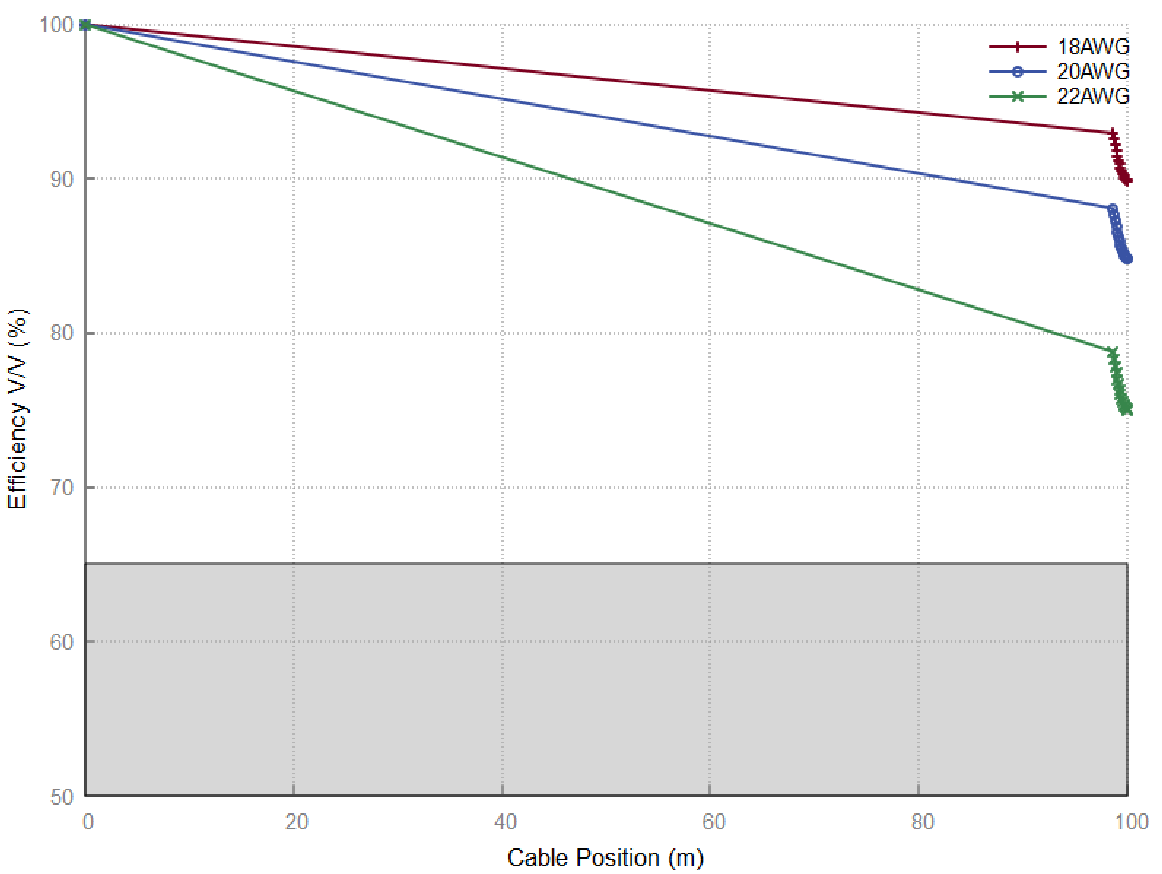
Searching for Min Vpse (24V system)



16 nodes, Rconn = 300mΩ, Pnode=600mW,
22AWG Cable @ 65C, 100meters

- Stepping Vpse from 26V to 20V by 1V
- System stops converging at 22V
- 23V system is getting too close to instability

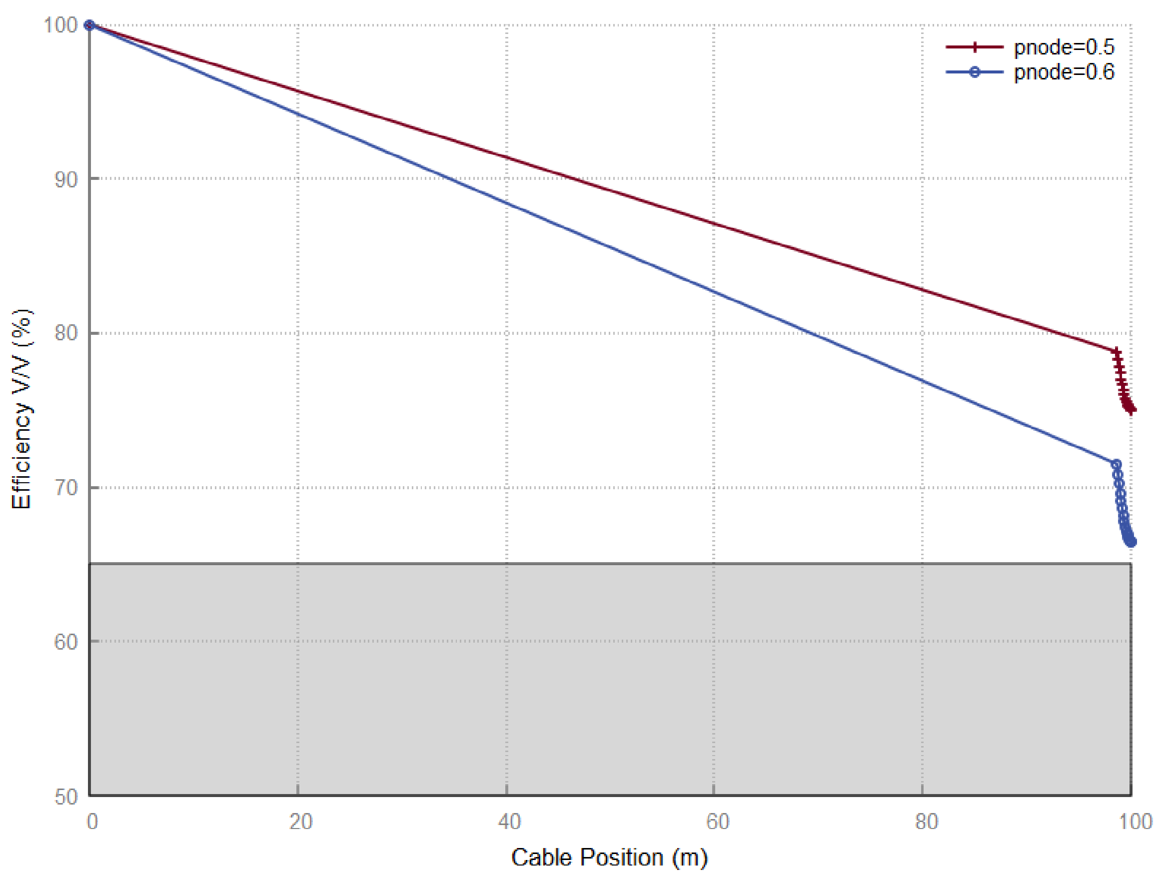
Searching For Gauge



16 nodes, Rconn = 300mΩ, Pnode=500mW, 100meters

- Set Vpse,min = 24V
- Searching AWG 18, 20, 22, and 24
- AWG 24 did not converge

Searching for Max Delivered Power



16 nodes, Rconn = 300mΩ, 22AWG Cable @ 65C, 100meters, Vpse=24V

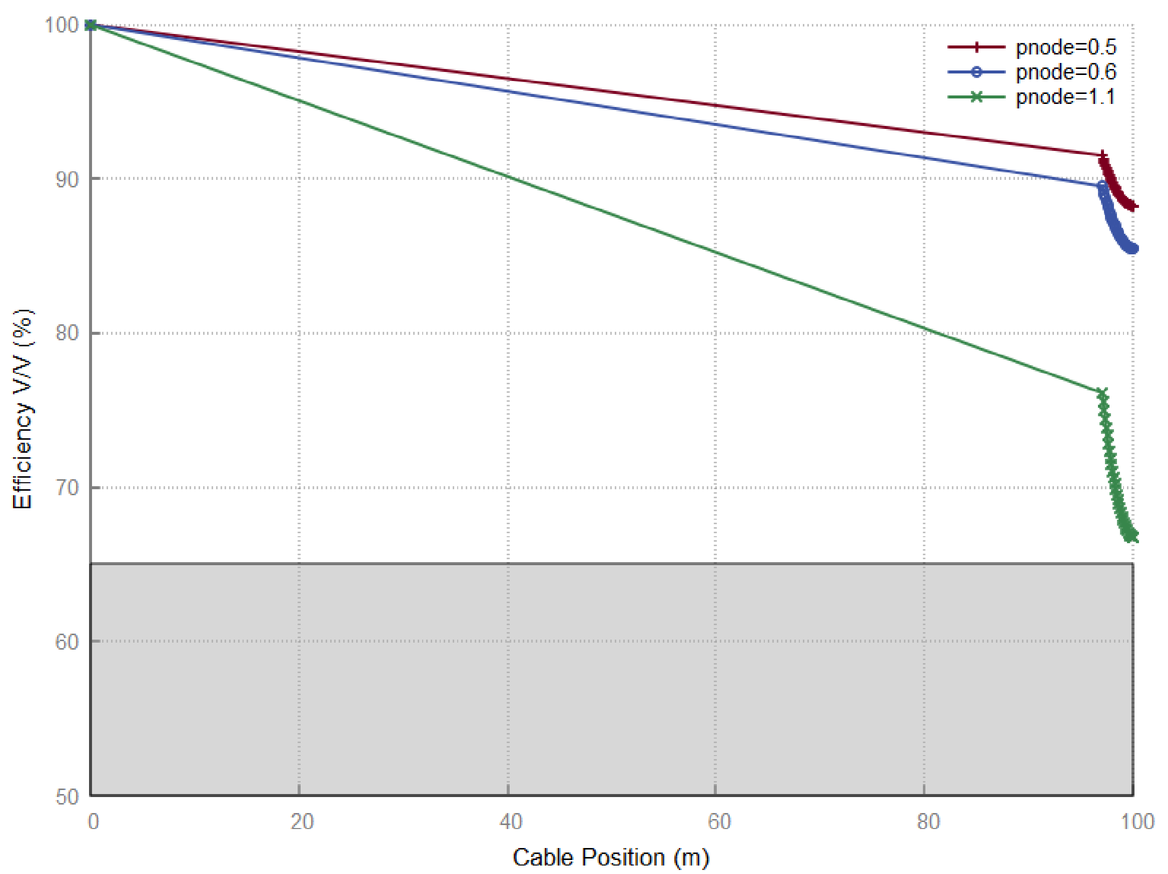
- Choose AWG 22 from last slide
- Search for power delivery > 500mW per node
- Can deliver 600mW @ 100m from 24V while meeting stability

Example 24V Setups

Parameter	Setup 1	Setup 2	Setup 3	Setup 4	units
Vpse,min	24	**22**	**21**	**20**	V
#Nodes	16	16	16	16	Nodes
Power / Node	600	**500**	500	600	mW
Cable Gauge	22	**22**	22	**20**	AWG
Connector Resistance	0.3	0.3	**0.15**	**0.3**	Ω
Length	100	100	100	100	m
Efficiency	66.5%	66.9%	65.4%	67.7%	V/V

Bold text shows differences from previous setups

50V System Example



32 nodes, Rconn = 300mΩ, 22AWG Cable @ 65C, 100meters, Vpse=50V

- Start with 24V system “Setup1”
- Change to Vpse_min = 50V
- Changed #Nodes to 32
  - 1 PSE, 31 PDs
- Can deliver up to 1.1W / Node
  - Ampacity of AWG 22 not high enough?
- Most conservative solution is to match 600mW solution from the 24V system

Example 50V Setup

Parameter	Setup 5	Setup6	Units
Vpse,min	50	50	V
#Nodes	32	32	Nodes
Power / Node	600	600	mW
Cable Gauge	22	**24**	AWG
Connector Resistance	0.3	0.3	Ω
Length	100	100m	m
Efficiency	85.4%	**74%**	V/V

Bold text shows differences from previous setups

Proposed Power Systems

Parameter	24V System	50V System	Units
Vpse,max	30	**60**	V
Vpse,min	24	**50**	V
Ipse	550mA	**428mA**	V
Ilimit	*Ipse * 1.2*	*Ipse * 1.2*	V
#Nodes	16	**32**	Nodes
Power / Node	*600*	*600*	mW
Cable Gauge	*22*	*22*	AWG
Connector Resistance	*0.3*	*0.3*	Ω
Length	*100m*	*100m*	m
Efficiency	66.5%	**85.4**%	V/V

Bold text shows differences between the two systems

Conclusion

- Power System has several degrees of freedom that are interrelated
- 802.3da needs to narrow the limits to progress in power design
- Two Voltage classes are proposed for 802.3da powered systems
- Is connector resistance estimation reasonable?