

IEEE802.3da draft 3.1 power calculations - appendix



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Goal of this appendix

- To present the calculations describing currents and voltages at each MPD of a mixing segment
- To calculate the worst-case input voltage at the last MPD (for 16 MPDs).
- To calculate the worst-case maximum current drawn from the MPSE (for 16 MPDs).
- To present calculation-matching simulations

The purpose of this presentation is to add calculations of voltage and current of each segment in a multidrop system, as an annex to the IEEE802.3da standard

System Description

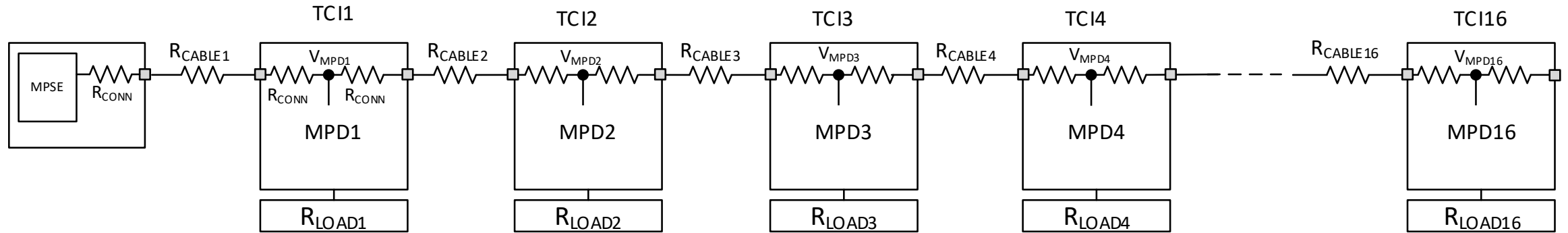


Fig 1 – MPoE system for power, voltages and currents calculations

Assumptions

- All MPDs consume the maximum power allowed for their type (1.1W for Type 0, 4W for Type 1)
- All MPD loads are Power loads – mandating a constant power
- Each MPD is comprised of 2 connectors, each of which has a maximum of 0.075Ω resistance
- Overall loop-resistance is 6.4Ω consisting of 4Ω Cable resistance and 2.4Ω TCI connector resistance.
- The power consumed by the load is part of the MPD – no additional power losses included.
- Worst-case system structure is assumed to contains 16 MPDs
- Worst-case power dissipation and voltage drop occurs when the cable length between MPSE and the first MPD is the longest , and the cable length between the rest of the MPDs is reasonably short (10cm).

MPoE System Power Calculations

For each MPD node, the following relations can be written:

$$(EQ.01) \quad V_{MPD}(n) = V_{MPD}(n+1) + i_{RCABLE}(n+1) \cdot (R_{CABLE}(n+1) + 2R_{CONN})$$

$$(EQ.02) \quad i_{MPD}(n) = \frac{P_{MPD}}{V_{MPD}(n)}$$

$$(EQ.03) \quad i_{RCABLE}(n) = i_{RCABLE}(n+1) + i_{MPD}(n)$$

- where:
- n : the index of MPD (1 to 16)
- $V_{MPD}(n)$: voltage on the n -th MPD load
- $i_{MPD}(n)$: current flowing into the n -th MPD load
- $R_{CABLE}(n)$: Cable resistance connecting between the $n-1$ and n -th MPD
- R_{CONN} : connection hardware resistance (connectors + wires) between input of MPoE cable and MPD load, or between MPD load and output connection to the MPoE system. $R_{CONN} = 0.075\Omega$
- $i_{RCABLE}(n)$: current through the cable connecting between the $n-1$ and n -th MPD.

MPoE System Power Calculations

For the last (n=16) MPD, current going to the next stage is 0, hence:

$$(EQ. 04) \quad i_{MPD}(16) = \frac{P_{MPD}}{V_{MPD}(16)}$$

$$(EQ. 05) \quad i_{RCABLE}(16) = i_{MPD}(16)$$

For n=15 MPD:

$$(EQ. 06) \quad i_{MPD}(15) = \frac{P_{MPD}}{V_{MPD}(15)}$$

$$(EQ. 07) \quad V_{MPD}(15) = V_{MPD}(16) + i_{RCABLE}(16) \cdot (R_{CABLE}(16) + 2R_{CONN})$$

Similarly, For n=1 MPD:

$$(EQ. 08) \quad i_{MPD}(1) = \frac{P_{MPD}}{V_{MPD}(1)}$$

$$(EQ. 09) \quad V_{MPD}(1) = V_{MPD}(2) + i_{RCABLE}(2) \cdot (R_{CABLE}(2) + 2R_{CONN})$$

$$(EQ. 10) \quad i_{RCABLE}(1) = i_{RCABLE}(2) + i_{MPD}(1)$$

For the first MPD and MPSE, the following equations hold:

$$(EQ. 11) \quad V_{MPSE} = V_{MPD}(1) + i_{RCABLE}(1) \cdot (R_{CABLE}(1) + 2R_{CONN})$$

$$(EQ. 12) \quad i_{TOTAL} = i_{RCABLE}(1)$$

MPoE System Power Calculations

By using a numerical solver, setting the goal to the VMPSE required voltage, it is possible to find a numerical solution for Vmpd(n).

IEEE802.3da Parameter	min	typ	max	unit
Cable length			50	m
PMPD power Type 0			1.1	W
PMPD power Type 1			4	W
Vsupply Type 0	21.6		30	V
Vsupply Type 1	45		50	V
Cable loop resistance			4	Ω
MPI connector resistance			0.075	Ω
Number of nodes	1	16	16	-
Cable Resistance			0.08	Ω/m

Value used for Numerical Simulation	Value	Unit
Cable length of first segment	48.5	m
Cable length of other N-1 segment	0.1	m
MPD Type	0	-
MPD power	1.1	W
MPSE voltage	21.6	V

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	-	21.60 V					21.60 V		1.070 A
MPD	1		48.5 m	3.88 Ω	1.1 W	0.15 Ω	17.2881 V	0.06363 A	1.070 A
MPD	2		0.1 m	0.008 Ω	1.1 W	0.15 Ω	17.1291 V	0.06422 A	1.006 A
MPD	3		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.9803 V	0.06478 A	0.942 A
MPD	4		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.8417 V	0.06531 A	0.877 A
MPD	5		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.7134 V	0.06582 A	0.812 A
MPD	6		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.5955 V	0.06628 A	0.746 A
MPD	7		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.4880 V	0.06672 A	0.680 A
MPD	8		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3912 V	0.06711 A	0.613 A
MPD	9		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3049 V	0.06746 A	0.546 A
MPD	10		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.2293 V	0.06778 A	0.479 A
MPD	11		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1643 V	0.06805 A	0.411 A
MPD	12		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1102 V	0.06828 A	0.343 A
MPD	13		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0668 V	0.06846 A	0.275 A
MPD	14		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0343 V	0.06860 A	0.206 A
MPD	15		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0125 V	0.06870 A	0.137 A
MPD	16		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0017 V	0.06874 A	0.069 A
			50 m	4 Ω	17.6 W	2.4 Ω	16.002 V		
							Vmpd(final)		

MPoE System Power Calculations – Type 0

Add as Informative Annex

By using a numerical solver, setting the goal to the VMPSE voltage required, it is possible to find a numerical solution for Vmpd(n).

IEEE802.3da Parameter	min	typ	max	unit
Cable length			50	m
PMPD power Type 0			1.1	W
PMPD power Type 1			4	W
Vsupply Type 0	21.6		30	V
Vsupply Type 1	45		50	V
Cable loop resistance			4	Ω
MPI connector resistance			0.075	Ω
Number of nodes	1	16	16	-
Cable Resistance			0.08	Ω/m

Value used for Numerical Simulation	Value	Unit
Cable length of first segment	48.5	m
Cable length of other N-1 segment	0.1	m
MPD Type	0	-
MPD power	1.1	W
MPSE voltage	21.6	V

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	-	21.60 V					21.60 V		1.070 A
MPD	1		48.5 m	3.88 Ω	1.1 W	0.15 Ω	17.2881 V	0.06363 A	1.070 A
MPD	2		0.1 m	0.008 Ω	1.1 W	0.15 Ω	17.1291 V	0.06422 A	1.006 A
MPD	3		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.9803 V	0.06478 A	0.942 A
MPD	4		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.8417 V	0.06531 A	0.877 A
MPD	5		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.7134 V	0.06582 A	0.812 A
MPD	6		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.5955 V	0.06628 A	0.746 A
MPD	7		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.4880 V	0.06672 A	0.680 A
MPD	8		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3912 V	0.06711 A	0.613 A
MPD	9		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3049 V	0.06746 A	0.546 A
MPD	10		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.2293 V	0.06778 A	0.479 A
MPD	11		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1643 V	0.06805 A	0.411 A
MPD	12		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1102 V	0.06828 A	0.343 A
MPD	13		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0668 V	0.06846 A	0.275 A
MPD	14		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0343 V	0.06860 A	0.206 A
MPD	15		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0125 V	0.06870 A	0.137 A
MPD	16		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0017 V	0.06874 A	0.069 A
			50 m	4 Ω	17.6 W	2.4 Ω	16.002 V		
							Vmpd(final)		

4. Using numerical solver to converge to MPSE voltage

1. Calculation starts by guessing $V_{MPD}(16)$

3. Target voltage at MPSE

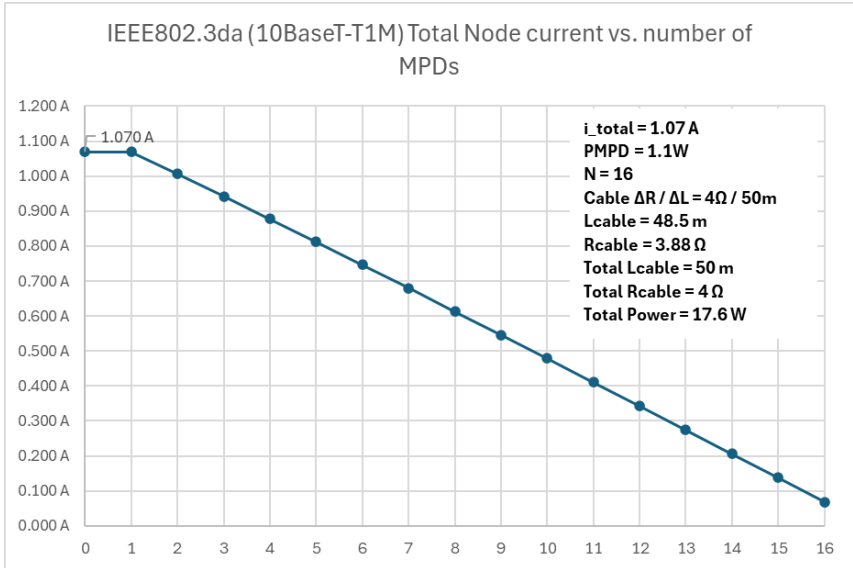
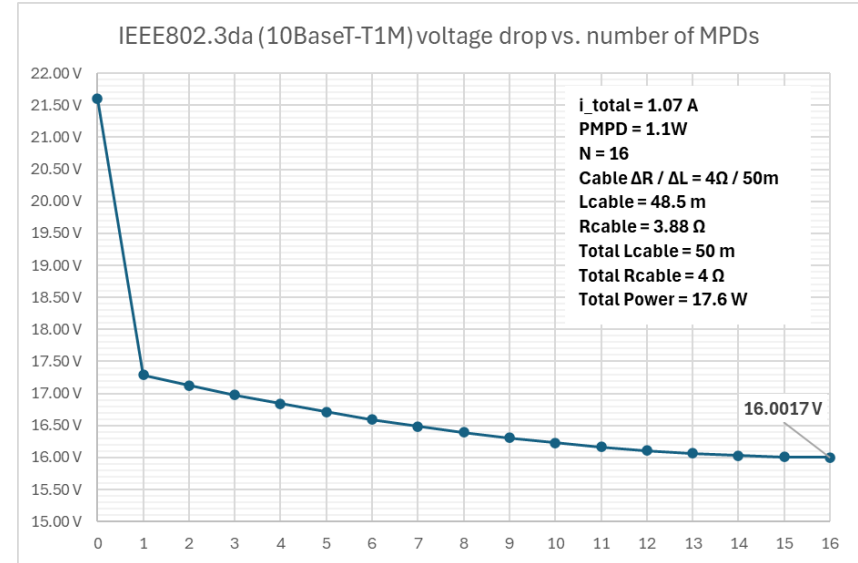
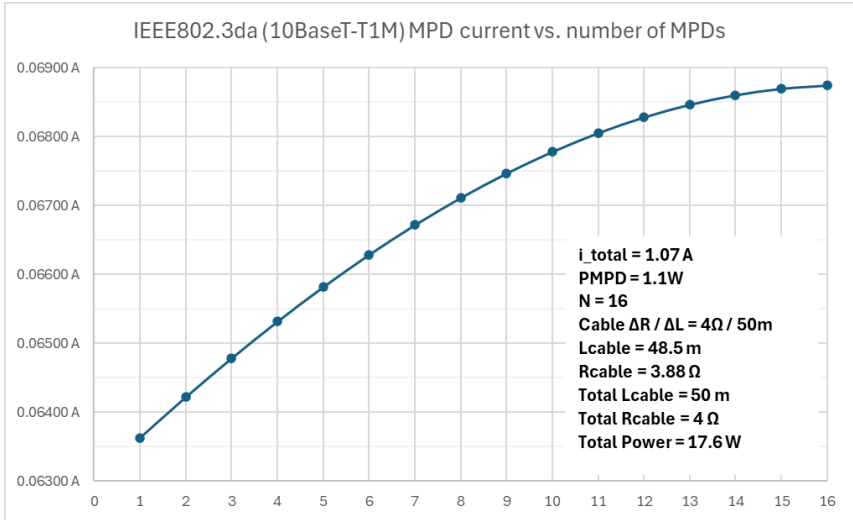
2. iterative calculation starting from n = 15 used for $V_{MPD}(n)$ calculation



MPoE System Power Calculations – Type 0 results

Type 0 MPDs (1.1W)

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	0	21.60 V					21.60 V		1.070 A
MPD	1		48.5 m	3.88 Ω	1.1 W	0.15 Ω	17.2881 V	0.06363 A	1.070 A
MPD	2		0.1 m	0.008 Ω	1.1 W	0.15 Ω	17.1291 V	0.06422 A	1.006 A
MPD	3		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.9803 V	0.06478 A	0.942 A
MPD	4		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.8417 V	0.06531 A	0.877 A
MPD	5		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.7134 V	0.06582 A	0.812 A
MPD	6		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.5955 V	0.06628 A	0.746 A
MPD	7		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.4880 V	0.06672 A	0.680 A
MPD	8		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3912 V	0.06711 A	0.613 A
MPD	9		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.3049 V	0.06746 A	0.546 A
MPD	10		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.2293 V	0.06778 A	0.479 A
MPD	11		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1643 V	0.06805 A	0.411 A
MPD	12		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.1102 V	0.06828 A	0.343 A
MPD	13		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0668 V	0.06846 A	0.275 A
MPD	14		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0343 V	0.06860 A	0.206 A
MPD	15		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0125 V	0.06870 A	0.137 A
MPD	16		0.1 m	0.008 Ω	1.1 W	0.15 Ω	16.0017 V	0.06874 A	0.069 A
			50 m	4 Ω	17.6 W	2.4 Ω	16.002 V		



MPoE System Power Calculations – Type 1

Add as Informative Annex

By using a numerical solver, setting the goal to the VMPSE voltage required (e.g. 21.6V for Type 0, 45V for Type 1), it is possible to find a numerical solution for Vmpd(n).

4. Using numerical solver to converge to MPSE voltage

IEEE802.3da Parameter	min	typ	max	unit
Cable length			50	m
PMPD power Type 0			1.1	W
PMPD power Type 1			4	W
Vsupply Type 0	21.6		30	V
Vsupply Type 1	45		50	V
Cable loop resistance			4	Ω
MPI connector resistance			0.075	Ω
Number of nodes	1	16	16	-
Cable Resistance			0.08	Ω/m

Value used for Numerical Simulation	Value	Unit
Cable length of first segment	48.5	m
Cable length of other N-1 segment	0.1	m
MPD Type	1	-
MPD power	4	W
MPSE voltage	45	V

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	0	45.00 V					45.00 V		1.749 A
MPD	1		48.5 m	3.88 Ω	4 W	0.15 Ω	37.9508 V	0.10540 A	1.749 A
MPD	2		0.1 m	0.008 Ω	4 W	0.15 Ω	37.6910 V	0.10613 A	1.644 A
MPD	3		0.1 m	0.008 Ω	4 W	0.15 Ω	37.4481 V	0.10681 A	1.538 A
MPD	4		0.1 m	0.008 Ω	4 W	0.15 Ω	37.2220 V	0.10746 A	1.431 A
MPD	5		0.1 m	0.008 Ω	4 W	0.15 Ω	37.0129 V	0.10807 A	1.323 A
MPD	6		0.1 m	0.008 Ω	4 W	0.15 Ω	36.8209 V	0.10863 A	1.215 A
MPD	7		0.1 m	0.008 Ω	4 W	0.15 Ω	36.6460 V	0.10915 A	1.107 A
MPD	8		0.1 m	0.008 Ω	4 W	0.15 Ω	36.4884 V	0.10962 A	0.998 A
MPD	9		0.1 m	0.008 Ω	4 W	0.15 Ω	36.3481 V	0.11005 A	0.888 A
MPD	10		0.1 m	0.008 Ω	4 W	0.15 Ω	36.2252 V	0.11042 A	0.778 A
MPD	11		0.1 m	0.008 Ω	4 W	0.15 Ω	36.1198 V	0.11074 A	0.667 A
MPD	12		0.1 m	0.008 Ω	4 W	0.15 Ω	36.0318 V	0.11101 A	0.557 A
MPD	13		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9614 V	0.11123 A	0.446 A
MPD	14		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9086 V	0.11139 A	0.334 A
MPD	15		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8733 V	0.11150 A	0.223 A
MPD	16		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8557 V	0.11156 A	0.112 A
			50 m	4 Ω	64 W	2.4 Ω	35.856 V		

3. Target voltage at MPSE

2. iterative calculation starting from n = 15 used for V_{MPD}(n) calculation

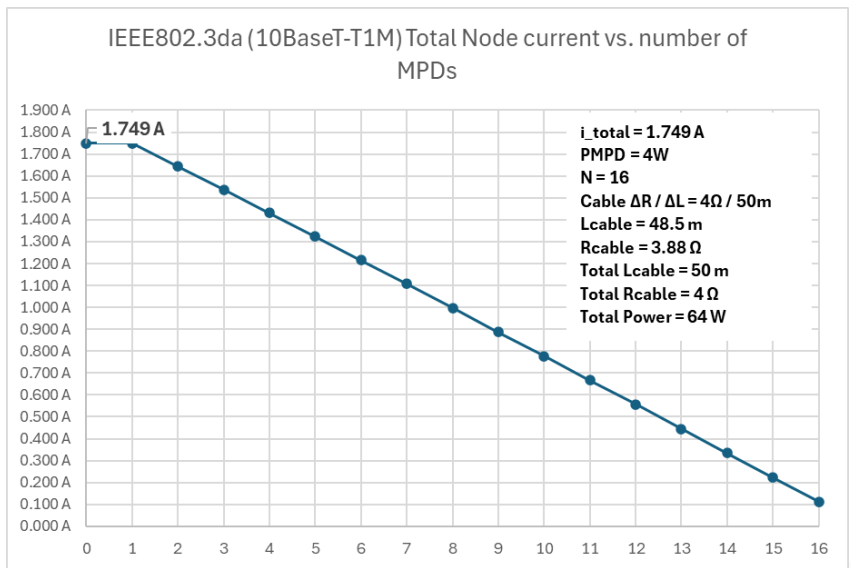
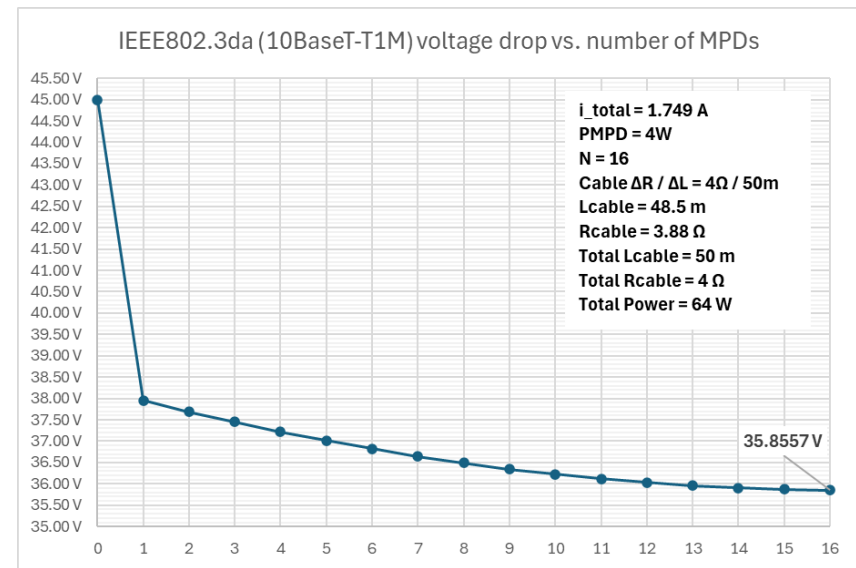
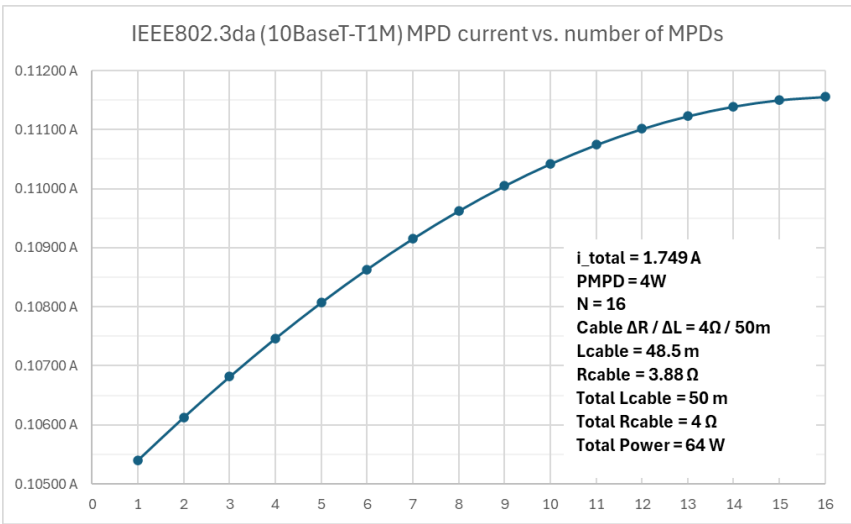
1. Calculation starts by guessing V_{MPD}(16)



MPoE System Power Calculations – Type 1 results

Type 1 MPDs (4W)

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	0	45.00 V					45.00 V		1.749 A
MPD	1		48.5 m	3.88 Ω	4 W	0.15 Ω	37.9508 V	0.10540 A	1.749 A
MPD	2		0.1 m	0.008 Ω	4 W	0.15 Ω	37.6910 V	0.10613 A	1.644 A
MPD	3		0.1 m	0.008 Ω	4 W	0.15 Ω	37.4481 V	0.10681 A	1.538 A
MPD	4		0.1 m	0.008 Ω	4 W	0.15 Ω	37.2220 V	0.10746 A	1.431 A
MPD	5		0.1 m	0.008 Ω	4 W	0.15 Ω	37.0129 V	0.10807 A	1.323 A
MPD	6		0.1 m	0.008 Ω	4 W	0.15 Ω	36.8209 V	0.10863 A	1.215 A
MPD	7		0.1 m	0.008 Ω	4 W	0.15 Ω	36.6460 V	0.10915 A	1.107 A
MPD	8		0.1 m	0.008 Ω	4 W	0.15 Ω	36.4884 V	0.10962 A	0.998 A
MPD	9		0.1 m	0.008 Ω	4 W	0.15 Ω	36.3481 V	0.11005 A	0.888 A
MPD	10		0.1 m	0.008 Ω	4 W	0.15 Ω	36.2252 V	0.11042 A	0.778 A
MPD	11		0.1 m	0.008 Ω	4 W	0.15 Ω	36.1198 V	0.11074 A	0.667 A
MPD	12		0.1 m	0.008 Ω	4 W	0.15 Ω	36.0318 V	0.11101 A	0.557 A
MPD	13		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9614 V	0.11123 A	0.446 A
MPD	14		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9086 V	0.11139 A	0.334 A
MPD	15		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8733 V	0.11150 A	0.223 A
MPD	16		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8557 V	0.11156 A	0.112 A
			50 m	4 Ω	64 W	2.4 Ω	35.856 V		



MPoE System Power Calculations – simulation results

System	system #	Vsupply	cable length	Rcable	PMPD	2 x RCONN	Vmpd(n)	i(n)	iR(n)
MPSE	0	45.00 V					45.00 V		1.749 A
MPD	1		48.5 m	3.88 Ω	4 W	0.15 Ω	37.9508 V	0.10540 A	1.749 A
MPD	2		0.1 m	0.008 Ω	4 W	0.15 Ω	37.6910 V	0.10613 A	1.644 A
MPD	3		0.1 m	0.008 Ω	4 W	0.15 Ω	37.4481 V	0.10681 A	1.538 A
MPD	4		0.1 m	0.008 Ω	4 W	0.15 Ω	37.2220 V	0.10746 A	1.431 A
MPD	5		0.1 m	0.008 Ω	4 W	0.15 Ω	37.0129 V	0.10807 A	1.323 A
MPD	6		0.1 m	0.008 Ω	4 W	0.15 Ω	36.8209 V	0.10863 A	1.215 A
MPD	7		0.1 m	0.008 Ω	4 W	0.15 Ω	36.6460 V	0.10915 A	1.107 A
MPD	8		0.1 m	0.008 Ω	4 W	0.15 Ω	36.4884 V	0.10962 A	0.998 A
MPD	9		0.1 m	0.008 Ω	4 W	0.15 Ω	36.3481 V	0.11005 A	0.888 A
MPD	10		0.1 m	0.008 Ω	4 W	0.15 Ω	36.2252 V	0.11042 A	0.778 A
MPD	11		0.1 m	0.008 Ω	4 W	0.15 Ω	36.1198 V	0.11074 A	0.667 A
MPD	12		0.1 m	0.008 Ω	4 W	0.15 Ω	36.0318 V	0.11101 A	0.557 A
MPD	13		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9614 V	0.11123 A	0.446 A
MPD	14		0.1 m	0.008 Ω	4 W	0.15 Ω	35.9086 V	0.11139 A	0.334 A
MPD	15		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8733 V	0.11150 A	0.223 A
MPD	16		0.1 m	0.008 Ω	4 W	0.15 Ω	35.8557 V	0.11156 A	0.112 A
			50 m	4 Ω	64 W	2.4 Ω	35.856 V		

Type 1 MPDs (4W)

