Annex 189 A (informative)

Powered segments voltage and power calculations

189A.1 Overview

This annex presents a model to describe currents and voltages at each MPD of a segment when used for multidrop Clause 189 powering. It then presents an example of the "worst-case" calculation of the input voltage and current at the last MPD (for 16 MPDs), and calculates the "worst-case "maximum current drawn from the MPSE (for 16 MPDs).

189A.2 System Model

Figure 189A-1 presents a model of the MPoE system used for calculation of power voltages and currents.

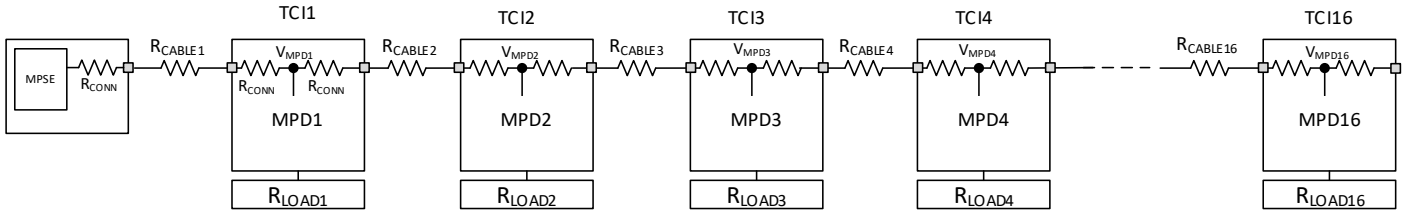

Figure 189A-1 MPOE system for power, voltages and current calculations

189A.3 Modeling assumptions

For the calculation of currents and voltages, the following assumptions are made:

a) All MPDs consume 1 Unit Load of poweraccording to their type (1.1W for Type 0, 4W for Type 1).
b) All MPD loads are consume a constant amount of power.
c) -Each MPD is comprised of 2 TC connectors, each of which has a maximum of 0.075Ω resistance to the trunk.
d) The overall powered segment loop resistance is the maximum amount specified at 6.4Ω consisting of 4Ω Cable resistance and 2.4Ω TCI connectors resistance.
e) The power consumed by the load is part of the MPD – no additional power losses included.
f) The worst-case system structure is contains 16, 1 Unit Load MPDs
g) The worst-case power dissipation and voltage drop occurs when the cable length between the MPSE and the first MPD is longest and the cable length between the rest of the MPDs is reasonably short (10cm or less from MPD to MPD).
h) The MPSE is at one end of the powered segment.

189A.4 Voltage and current at each MPD node

For each MPD node, Equation 145A-1 and Equation 145A-2 describe the voltage and current at the nth MPD node, respectively. Equation 145A-3 describes the voltage in the cable segment immediately prior to the MPD (relative to the MPSE).

$$V_{MPD}(n) = V_{MPD}(n+1) + i_{RCABLE}(n+1) \cdot (R_{CABLE}(n+1) + 2R_{CONN}) \quad \text{(145A-1)}$$

$$i_{MPD}(n) = \frac{P_{MPD}}{V_{MPD}(n)} \quad \text{(145A-2)}$$

$$i_{RCABLE}(n) = i_{RCABLE}(n+1) + i_{MPD}(n) \quad \text{(145A-3)}$$

where:

n is the index of MPD (1 to 16, with 1 being nearest the MPSE)

$V_{MPD}(n)$ is a voltage on the n-th MPD load

$i_{MPD}(n)$ is a current flowing into the n-th MPD load

$R_{CABLE}(n)$ is a cable resistance connecting between the n-1 and n-th MPD

R_{CONN} is a connection hardware resistance (connectors + wires) between input of MPoE cable and MPD load, or between MPD load and output connection to the MPoE system. $R_{CONN} = 0.075\Omega$

$i_{RCABLE}(n)$ is current through the cable connecting between the n-1 and n-th MPD.

For the last (n=16) MPD node, the current going to the next stage is 0 A , and Equation 145A-4 and 145A-5 describe the current into the last MPD.

$$i_{MPD}(16) = \frac{P_{MPD}}{V_{MPD}(16)} \quad \text{(145A-4)}$$

$$i_{RCABLE}(16) = i_{MPD}(16) \quad \text{(145A-5)}$$

Hence, the recursion can now be completed, as shown below:

For n=15 MPD:

$$i_{MPD}(15) = \frac{P_{MPD}}{V_{MPD}(15)} \quad \text{(145A-6)}$$

$$V_{MPD}(15) = V_{MPD}(16) + i_{RCABLE}(16) \cdot (R_{CABLE}(16) + 2R_{CONN}) \quad \text{(145A-7)}$$

Similarly, for n=1 MPD:

$$i_{MPD}(1) = \frac{P_{MPD}}{V_{MPD}(1)} \quad \text{(145A-8)}$$

$$V_{MPD}(1) = V_{MPD}(2) + i_{RCABLE}(2) \cdot (R_{CABLE}(2) + 2R_{CONN}) \quad \text{(145A-9)}$$

$$i_{RCABLE}(1) = i_{RCABLE}(2) + i_{MPD}(1) \quad \text{(145A-10)}$$

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

$$V_{MPSE} = V_{MPD}(1) + i_{RCABLE}(1) \cdot (R_{CABLE}(1) + 2R_{CONN}) \quad \text{(145A-11)}$$

$$i_{TOTAL} = i_{RCABLE}(1) \quad \text{(145A-12)}$$

189A.5 Example computations of the worst-case voltages at each node

An iterative numerical solver common in many spreadsheets may be used to find the numerical solutions for $V_{MPD}(n)$ by setting the voltage at the MPSE, $V_{MPSE,}$ as a constraint.

The iteration proceeds as follows:

1. Calculation starts by guessing $V_{MPD}(16)$
2. Iterative calculation starting from n=15 down to n=1 is used for $V_{MPD}(n)$ calculation
3. Using numerical solver to converge with MPSE voltage

An example is shown below:

Table 189A-1 summarizes the power parameters analyzed for a clause 189 powered segment:

Table 189A- 1 Clause 189 powered segment parameters

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

189A.5.1 Type 0 powered segment

Table 189A-2 summarizes the power parameters analyzed for a Type 0 Clause 189 powered segment.

Table 189A- 2: Type 0 example power parameters

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

Table 189A-3 shows the calculated voltages at each node for a powered segment of 16 MPD, 1 Unit Load per node MPD given an MPSE voltage of 21.6V:

Table 189A- 3: Calculated voltages at each node of a 16 MPD, 1 unit load per MPD type 0 clause 189 powered segment

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)		

189A.5.2 Type 1 powered segment

Similarly, a Type 1 Clause 189 powered segment may be analyzed. Table 189A-4 shows the calculated voltages at each node for a powered segment of 16 MPD, 1 Unit Load per node MPD given an MPSE voltage of 45V:

Results of calculation for Type 1:

Table 189A- 4: Calculated voltages at each node of a 16 MPD, 1 unit load per MPD type 1 clause 189 powered segment

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**		

189A.6 Conclusion

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