

To: T10 Membership
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Subject: Termination Power Requirements
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The requirements at each terminator for voltage and current are:

I_{min} @ V_{min} 0.65A (SE/LVD)
 I_{min}@V_{min} 0.5A (LVD)
 V_{min}@I_{min} 3.0V

The supply voltages are:

5V (+/-5%): 4.75V to 5.25V
 3.3V (+/-5%): 3.15V to 3.45V

Isolation is required for devices supplying termpower to the bus, and a fuse is recommended. If a diode and a fuse are used then an example voltage drop is:

Schottky backflow diode, 1N52820 is approximately 0.3V @ 1.3A.

Fuse smd200 (50mohms) is approximately 65mV @ 1.3A.

The total drop is 0.365V. There are also integrated circuit breakers available that have a maximum drop of 0.5V (@1.5A) and 0.33V (@1A). The drop with the 5V supply and the backflow diode and fuse is then,

5V is 4.64V at 1.3A

4.75V is 4.4V at 1.3A

For the 3.3V supply with a fuse and a diode is then,

3.3V is 2.94V at 1.3A

3.15V is 2.79V at 1.3A

These are the voltages that would appear at the connector with this load.

Cable

The cable lengths allowed for LVD are:

25 meters point to point

12 meters for multipoint

If the distance is greater than 12 meters than AWG28 minimum is required, if the distance is less than 12 meters then AWG32 can be used. The typical resistance's for these cables are:

AWG28(solid) 0.071 ohm/ft

AWG28(stranded) 0.065 ohm/ft

AWG32(solid) 0.174 ohm/ft

AWG32(stranded) 0.164 ohm/ft

The inductance per unit length is needed for calculating the minimum termpower bypass requirement.

Capacitance	40pF/m	65pF/m	90pF/m	115pF/m	140pF/m
L(Hi Z 100ohm)	400nH/m	650nH/m	900nH/m	1150nH/m	1400nH/m
L(Lo Z 70 ohm)	196nH/m	319nH/m	441nH/m	564nH/m	686nH/m

The A cable has two line supplying termination power and the P cable has four lines supply termination power. The minimum bypass capacitor required is 2.2uF, the maximum is 10uF. To calculate the minimum bypass capacitor size required for the different cases the common path impedance should be calculated based on the starting voltage the minimum voltage at the terminator and the minimum current at the terminator.

For the normal 5V supply, $Z_{5N} = (4.64V - 3V) / 0.65A = 2.52$ ohms

For the 4.75V supply, $Z_{5L} = (4.4V - 3V) / 0.65A = 2.15$ ohms

Since the 3.3V supplies are already below 3V, use the 3.3V nominal and a 2.7V terminator.

$Z_{3.3N} = (2.94 - 2.7) / 0.65A = 0.37$ ohms.

The common path impedance and the total cable inductance is then used to calculate the cutoff frequency.

12 meters A cable

L(Hi Z) uH	2.4	3.9	5.4	6.9	8.4
L(Lo Z) uH	1.18	1.91	2.65	3.38	4.12
F(5N, Hi Z) Hz	167112	102838	74272	58126	47746
F(5N, Lo Z) Hz	339890	209984	151347	118659	97347
F(5L, Hi Z) Hz	142576	87739	63367	49591	40736
F(5L, Lo Z) Hz	289985	179153	129125	101237	83054
F(3.3N, Hi Z) Hz	24536	15099	10905	8534	7010
F(3.3N, Lo Z) Hz	49904	30831	22221	17422	14293

12 meters P cable

L(Hi Z) uH	1.2	1.95	2.7	3.45	4.2
L(Lo Z) uH	0.59	0.955	1.33	1.69	2.06
F(5N, Hi Z) Hz	334000	206000	149000	116000	95500
F(5N, Lo Z) Hz	680000	420000	302000	237000	195000
F(5L, Hi Z) Hz	285000	175000	127000	99200	81500
F(5L, Lo Z) Hz	580000	358000	257000	202000	166000
F(3.3N, Hi Z) Hz	49100	30200	21800	17100	14000
F(3.3N, Lo Z) Hz	99800	61700	44300	34800	28600

25 meter A cable

L(Hi Z) uH	5	8.12	11.25	14.4	17.5
L(Lo Z) uH	2.45	4	5.5	7.05	8.6
F(5N, Hi Z) Hz	80200	49300	35700	27900	22900
F(5N, Lo Z) Hz	164000	100000	72900	56900	46600
F(5L, Hi Z) Hz	68400	42100	30400	23800	19600
F(5L, Lo Z) Hz	140000	85000	62200	48500	39800
F(3.3N, Hi Z) Hz	11800	7240	5230	4090	3360
F(3.3N, Lo Z) Hz	24000	14700	10700	8350	6850

25 meter P cable

L(Hi Z) uH	2.5	4.07	5.625	7.2	8.75
L(Lo Z) uH	1.23	2.0	2.75	3.5	4.3
F(5N, Hi Z) Hz	160000	98500	71300	55700	45800
F(5N, Lo Z) Hz	326000	201000	146000	115000	93300
F(5L, Hi Z) Hz	137000	84100	60800	47500	39100
F(5L, Lo Z) Hz	278000	171000	124000	97800	79600
F(3.3N, Hi Z) Hz	23600	14500	10500	8180	6730
F(3.3N, Lo Z) Hz	47900	29400	21400	16800	13700

The minimum bypass capacitor required is then calculated from the common path impedance and the cutoff frequency.

Minimum bypass capacitor 12 meter A cable

C(5N, Hi Z) uF	0.38	0.61	0.85	1.09	1.32
C(5N, Lo Z) uF	0.19	0.3	0.42	0.53	0.65
C(5L, Hi Z) uF	0.52	0.84	1.17	1.49	1.82
C(5L, Lo Z) uF	0.26	0.41	0.57	0.73	0.89
C(3.3N, Hi Z) uF	17.5	28.5	39.4	50.4	61.4
C(3.3N, Lo Z) uF	8.6	14.0	19.4	24.7	30.1

The 2.2uF minimum bypass capacitor is fine in all cases where a 5V supply is used.

Minimum bypass capacitor 12 meter P cable

C(5N, Hi Z) uF	0.19	0.31	0.42	0.54	0.66
C(5N, Lo Z) uF	0.09	0.15	0.21	0.27	0.32
C(5L, Hi Z) uF	0.26	0.42	0.58	0.75	0.91
C(5L, Lo Z) uF	0.13	0.21	0.29	0.37	0.45
C(3.3N, Hi Z) uF	8.76	14.2	19.7	25.2	30.7
C(3.3N, Lo Z) uF	4.3	7	9.7	12.4	15

For the 12 meter P cable a 1uF minimum bypass would probably be sufficient. For the 3.3V supply 30uF minimum would be sufficient.

Minimum bypass capacitor 25 meter A cable

C(5N, Hi Z) uF	0.79	1.28	1.77	2.26	2.76
C(5N, Lo Z) uF	0.39	0.63	0.87	1.1	1.36
C(5L, Hi Z) uF	0.92	1.5	2.08	2.65	3.22
C(5L, Lo Z) uF	0.45	0.74	1.02	1.3	1.59
C(3.3N, Hi Z) uF	36.5	59.4	82.2	105.2	128
C(3.3N, Lo Z) uF	17.9	29.3	40.2	51.5	62.8

For the 25 meter A cable the minimum bypass capacitor should be 3.3uF.

Minimum bypass capacitor 25 meter P cable

C(5N, Hi Z) uF	0.39	0.64	0.89	1.13	1.38
C(5N, Lo Z) uF	0.19	0.31	0.43	0.55	0.68
C(5L, Hi Z) uF	0.46	0.75	1.04	1.32	1.61
C(5L, Lo Z) uF	0.22	0.37	0.51	0.65	0.79
C(3.3N, Hi Z) uF	18.23	29.7	41	52.6	63.9
C(3.3N, Lo Z) uF	8.99	14.6	20.1	25.6	31.4

For the 25 meter P cable the minimum bypass capacitor should be 1.6uF. The minimum bypass capacitors for a 5V supply are:

12 meter A cable 1.82uF
 12 meter P cable 0.91uF
 25 meter A cable 3.3uF
 25 meter P cable 1.6uF

The other factor is IR drop in the cable. This includes cable and connectors. The cable resistance used in the calculation is:

AWG28 (solid)	0.23 ohm/m
AWG28 (stranded)	0.21 ohm/m
AWG32 (solid)	0.57 ohm/m
AWG32 (stranded)	0.53 ohm/m

The connectors are 50 milliohms per connector for the calculation.

A Cable

Gauge (AWG)	Length (M)	Resistance (ohms)	Connector (ohms)	I(A)	Voltage drop (V)
28	25	2.9	0.1	0.65	1.95
28	12	1.4	0.1	0.65	0.98
28	6	0.69	0.1	0.65	0.5
32	12	3.4	0.1	0.65	2.3
32	6	1.71	0.1	0.65	1.2

P Cable

Gauge (AWG)	Length (M)	Resistance (ohms)	Connector (ohms)	I(A)	Voltage drop (V)
28	25	1.45	0.1	0.65	1.0
28	12	0.7	0.1	0.65	0.5
28	6	0.35	0.1	0.65	0.3
32	12	1.7	0.1	0.65	1.17
32	6	0.85	0.1	0.65	0.62

The minimum voltage of 3V at the terminator is required for 5V supplies. A 3.3V supply is not useable. If a 3.3V supply was used I would recommend the following conditions:

Maximum current at the terminator 0.5A.

Minimum output voltage at connector 3.0V.

Minimum voltage at terminator 2.5V (LVD only).

Minimum bypass capacitor 4.2uF.

Maximum cable lengths.

A cable

6 meters AWG28

P cable

12 meters AWG28

6 meters AWG32.