

Table of contents

Network planning assistance

- Ethernet
Network expansion HDX
 - Ethernet
Network expansion FDX
 - Fast Ethernet
Network expansion HDX
 - Fast Ethernet
Network expansion FDX

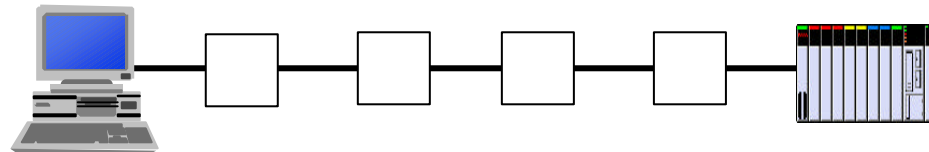
 - Specifications of the components
Rail products
 - Overview
10/100Mbit/s ETHERNET
 - Overview
1000Mbit/s ETHERNET
- ETHERNET
Example of cascading depth
 - ETHERNET
Example of network expansion
 - ETHERNET
Example of ring topology
 - Fast ETHERNET
Examples of network expansion

ETHERNET

Maximum network expansion - half duplex (HDX)

In theory: 5,120 m (51.2 μ s Slottime)

In practice: Model 1: 4 Repeater rule, 2,500 m



Model 2: complicated calculation of the propagation equivalence and path variability value between all components

Hirschmann: Calculation of the maximum network extension

$$4,520 \text{ m} - \sum \text{propagation equivalence} = \sum \text{cable distances}$$

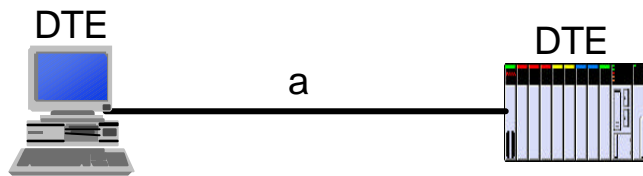
Calculation of the maximum cascading depth

$$40 \text{ BT} - \sum \text{path variability values} \geq 0$$

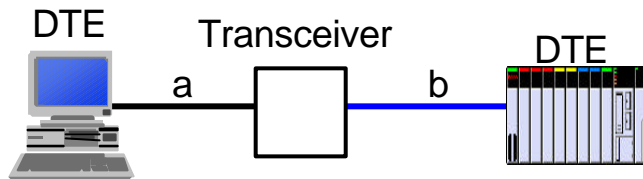
(Not necessary to calculate the Bit Times for end devices)

ETHERNET

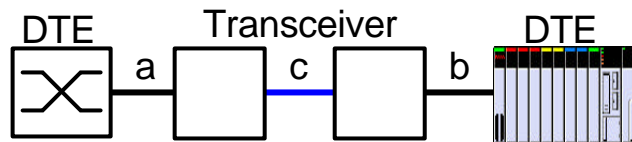
Maximum network expansion - full duplex (FDX)



Distance a:
 - TP: 100m
 - FO : max. 2000m*



Distance a + b:
 - TP/FO: max. 2100m* (TP distance ≤ 100m)



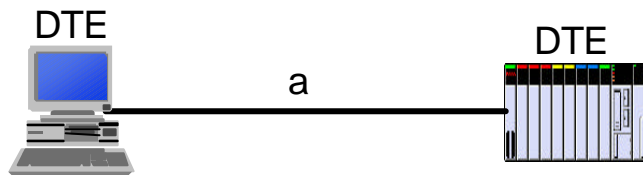
Distance a + b + c:
 - TP/FO: max. 2200m* (TP distance ≤ 2 x 100m)

$$* \text{ max. FO cable distance} = \frac{\text{link budget} - \text{system reserve}}{\text{fiber attenuation}}$$

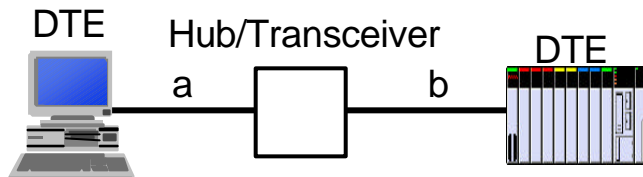
Fast ETHERNET

Maximum network expansion - half duplex (HDX)

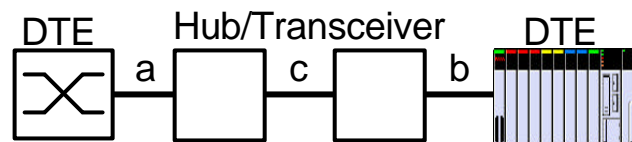
Only 1 Class-1 or 2 Class-2 repeaters per collision domain



Distance a:
 - TP: 100m
 - FO : 412m



Distance a + b:
 - TP: 200m (2 x 100m)
 - FO : 272m (Class-1 Repeater), 320m (Class-2 Repeater)
 - TP/FO: 260m (Class-1 Repeater), 308m (Class-2 Repeater)



Distance a + b + c:
 - TP: 205m (Class-2 Repeater) c: max. 5 m
 - FO : 228m (Class-2 Repeater)
 - TP/FO: 216m (Class-2 Repeater)

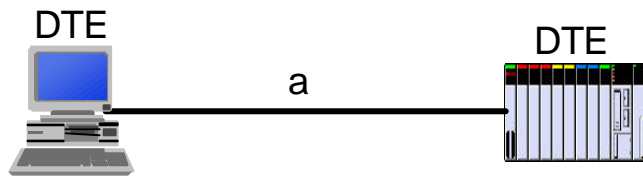
max. FO cable distance = $(412BT - \Sigma \text{repeater delays} - \Sigma \text{TP cable delays}) / 1,0BT/m$

(Terminal units (DTE) in 412 BT with 50BT each considered, repeater delay 92BT (Class-2)
 FO cable delay 1,0BT/m, TP cable delay 1,112BT/m, without system reserve (4BT))

Fast ETHERNET

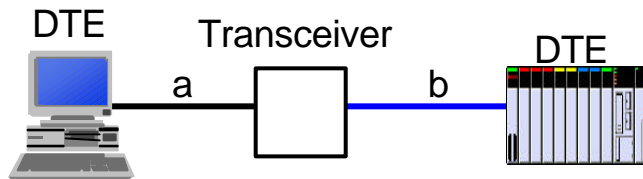
Maximum network expansion - full duplex (FDX)

Only 1 Class-1 or 2 Class-2 repeaters per collision domain



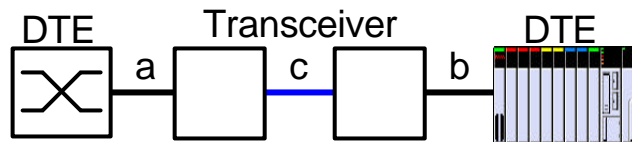
Distance a:

- TP: 100m
- FO : max. 2000m*



Distance a + b:

- TP/FO: max. 2100m* (TP distance ≤ 100m)



Distance a + b + c:

- TP/FO: max. 2200m* (TP distance ≤ 2 x 100m)

$$* \text{ max. FO cable distance} = \frac{\text{link budget} - \text{system reserve}}{\text{fiber attenuation}}$$

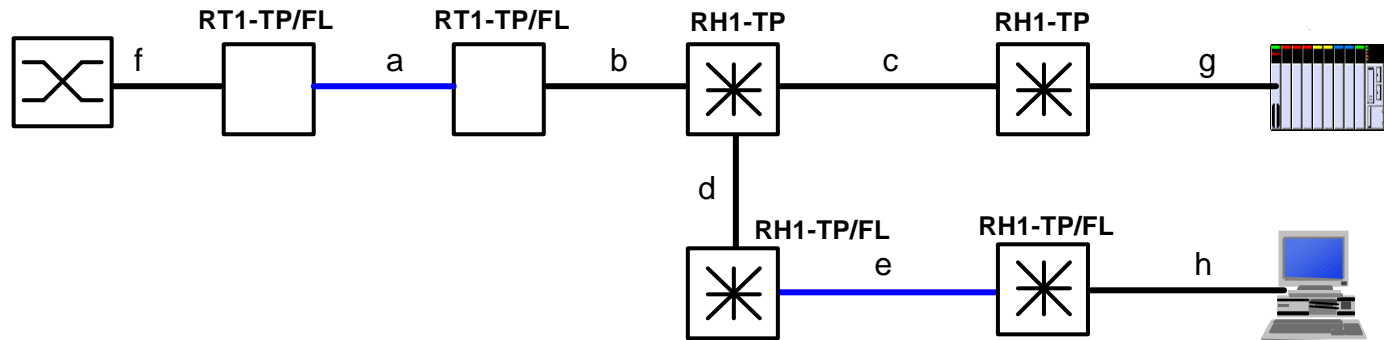
Specifications of the components

Operation time equivalent, path values and link budget

	Propagation Equivalence (Round trip collision delay)	Path Variability Value	Delay Value	Link Budget	
RT1-TP/FL - TP to FO	100 m (2x5 BT)	1 BT		≥ 11 dB MM 50/125 ≥ 14 dB MM 62,5/125	ETHERNET 1 BT = 100 ns
RH1-TP - TP to TP	190 m (2x9.5 BT)	4 BT			
RH1-TP/FL - TP to TP - LWL to FO - TP to FO	190 m (2x9.5 BT) 260 m (2x13 BT) 390 m (26 BT+13 BT)	3 BT 3 BT 6 BT		≥ 11 dB MM 50/125 ≥ 14 dB MM 62,5/125	
RT2-TX/FX - TP to FO	-		84 BT	≥ 8 dB MM 50/125 ≥ 11 dB MM 62.5/125 ≥ 11 dB SM 10/125	Fast ETHERNET 1 BT = 10 ns
RH2-TX - TP to TP	-		92 BT		

ETHERNET

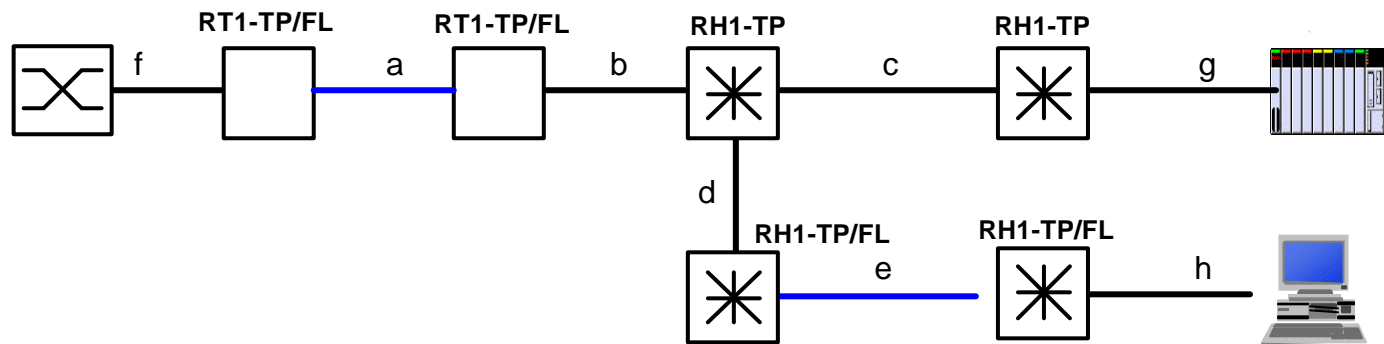
Example of cascading depth



PVV Distance f-g:	2 x RT1-TP/FL (FO / TP) 2 x RH1-TP (TP / TP)	2 x 1 BT + 2 x 4 BT = 10 BT < 40 BT
PVV Distance f-h:	2 x RT1-TP/FL (FO / TP) 1 x RH1-TP (TP / TP) 2 x RH1-TP/FL (FO / TP)	2 x 1 BT 1 x 4 BT 2 x 6 BT = 18 BT < 40 BT
PVV Distance g-h:	2 x RH1-TP (TP / TP) 2 x RH1-TP/FL (FO / TP)	2 x 4 BT + 2 x 6 BT = 20 BT < 40 BT

ETHERNET

Example of network expansion



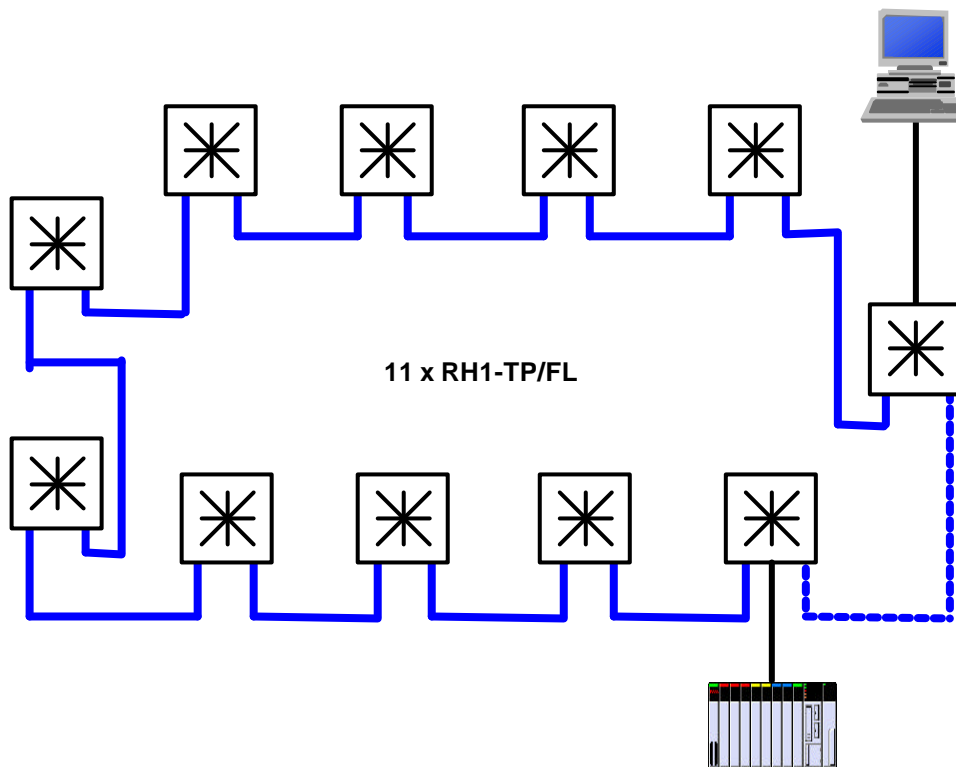
Propagation Equivalence distance f-g: $2 \times 140\text{m (DTE}^{\text{TP}}) + 2 \times 100\text{m (RT1-TP/FL (FO / TP))} + 2 \times 190\text{m (RH1-TP)} = 860\text{m}$
 max. distance f-g: $4520\text{m} - 860\text{m} = 3660\text{m}$

Propagation Equivalence distance f-h: $2 \times 140\text{m (DTE}^{\text{TP}}) + 2 \times 100\text{m (RT1-TP/FL)} + 1 \times 190\text{m (RH1-TP)} + 2 \times 390\text{m (RH1-TP/FL (FO / TP))} = 1450\text{m}$
 max. distance f-h: $4520\text{m} - 1450\text{m} = 3070\text{m}$

Propagation Equivalence distance g-h: $2 \times 140\text{m (DTE}^{\text{TP}}) + 2 \times 190\text{m (RH1-TP)} + 2 \times 390\text{m (RH1-TP/FL (FO / TP))} = 1440\text{m}$
 max. distance g-h: $4520\text{m} - 1440\text{m} = 3080\text{m}$

ETHERNET

Example of ring topology



Path Variability Value of the longest path:

$$2 \times 6 \text{ BT (FO/TP)} = 12 \text{ BT}$$

$$9 \times 3 \text{ BT (FO/FO)} = 27 \text{ BT}$$

$$\text{Total} = 39 \text{ BT} < 40 \text{ BT}$$

Propagation Equivalence of the longest path:

$$2 \times 140\text{m} = 280 \text{ m}$$

$$2 \times 390\text{m} = 780 \text{ m}$$

$$9 \times 260\text{m} = 2340 \text{ m}$$

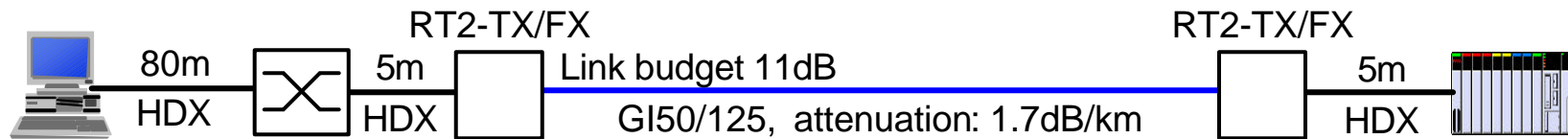
$$\text{Total PE} = 3400 \text{ m}$$

$$4520 \text{ m} - 3400 \text{ m} = 1120 \text{ m}$$

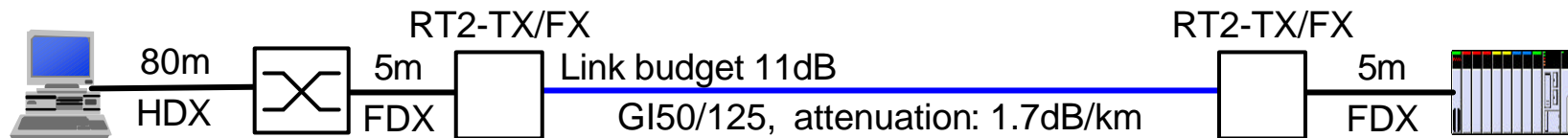
Maximum cable length = 1120 m

Fast ETHERNET

Examples of network expansion



max. FO cable length = (412BT - Σ repeater delays - Σ TP- cable delays - system reserve) / 1.0BT/m
 max. FO cable length = (412BT- 2 x 84BT - 10m x 1.112BT/m - 4BT) / 1BT/m = 228m



max. FO cable length = (Link budget - system reserve) / fiber attenuation
 max. FO cable length = (8dB - 3dB) / 1.7 dB/km = 2940 m

Overview

10/100Mbit/s ETHERNET



	Standard	Medium		Distance	Connection
Ethernet	IEEE802.3	AUI		50 m	
		10BASE-2	Coax	185 m	BNC
		10BASE-5	Coax	500 m	N
		10BASE-T	TP Category 5	100m	RJ45
		10BASE-FL	62.5µm, 50 µm, MM, 850nm, HDX	>2000 m	BFOC/ST
			62.5µm, 50 µm, MM, 850nm, FDX	>2000 m	BFOC/ST
Fast	IEEE802.3u	100BASE-TX	TP Category 5	100 m	RJ45
Ethernet		100BASE-FX	62.5µm, 50 µm, MM, 1300nm, HDX	412 m	Duplex SC
			62.5µm, 50 µm, MM, 1300nm, FDX	>2000 m	Duplex SC
			10µm, SM, 1300nm, FDX	>2000 m	Duplex SC

Overview

1000Mbit/s ETHERNET

	Standard	Medium		Distance	Connection
Gigabit Ethernet	IEEE802.3ab	1000BASE-TX	TP Category 5 (100Ω)	100 m	RJ45
	IEEE802.3z	1000BASE-CX	TP Category 5 (150Ω)	25 m	
		1000BASE-SX	62.5μm, MM, 850nm, FDX	260 m	SC
			50μm, MM, 850nm, FDX	550 m	SC
		1000BASE-LX	62.5μm, MM, 1300nm, FDX	440 m	SC
			50μm, MM, 1300nm, FDX	550 m	SC
			9μm, SM, 1300nm, FDX	>5000 m	SC