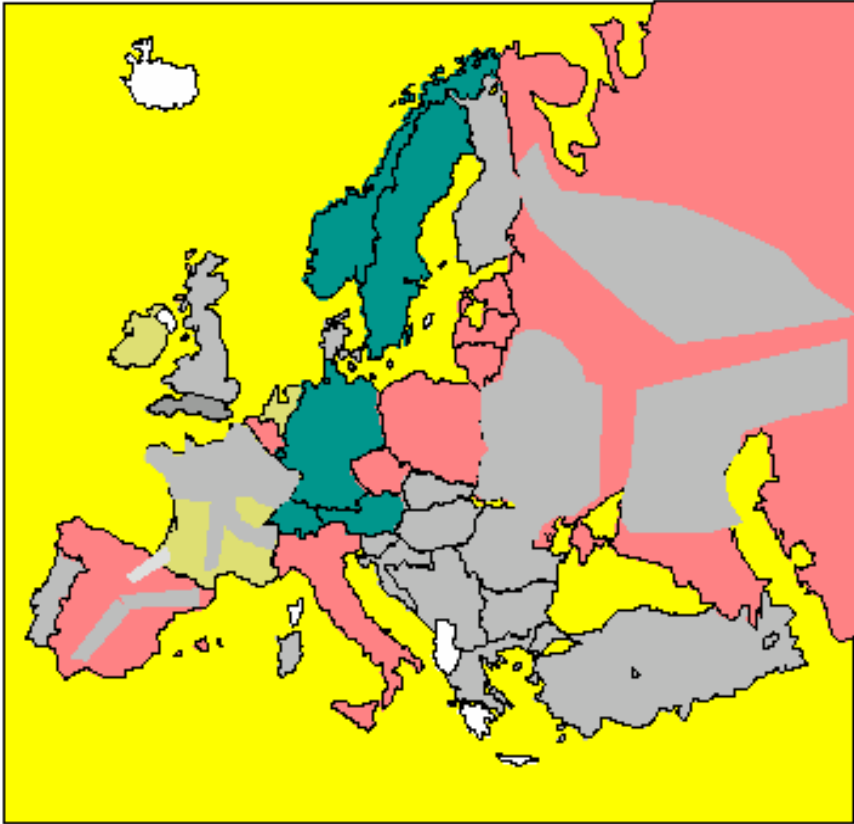


Standard voltages for Railway Power Supplies

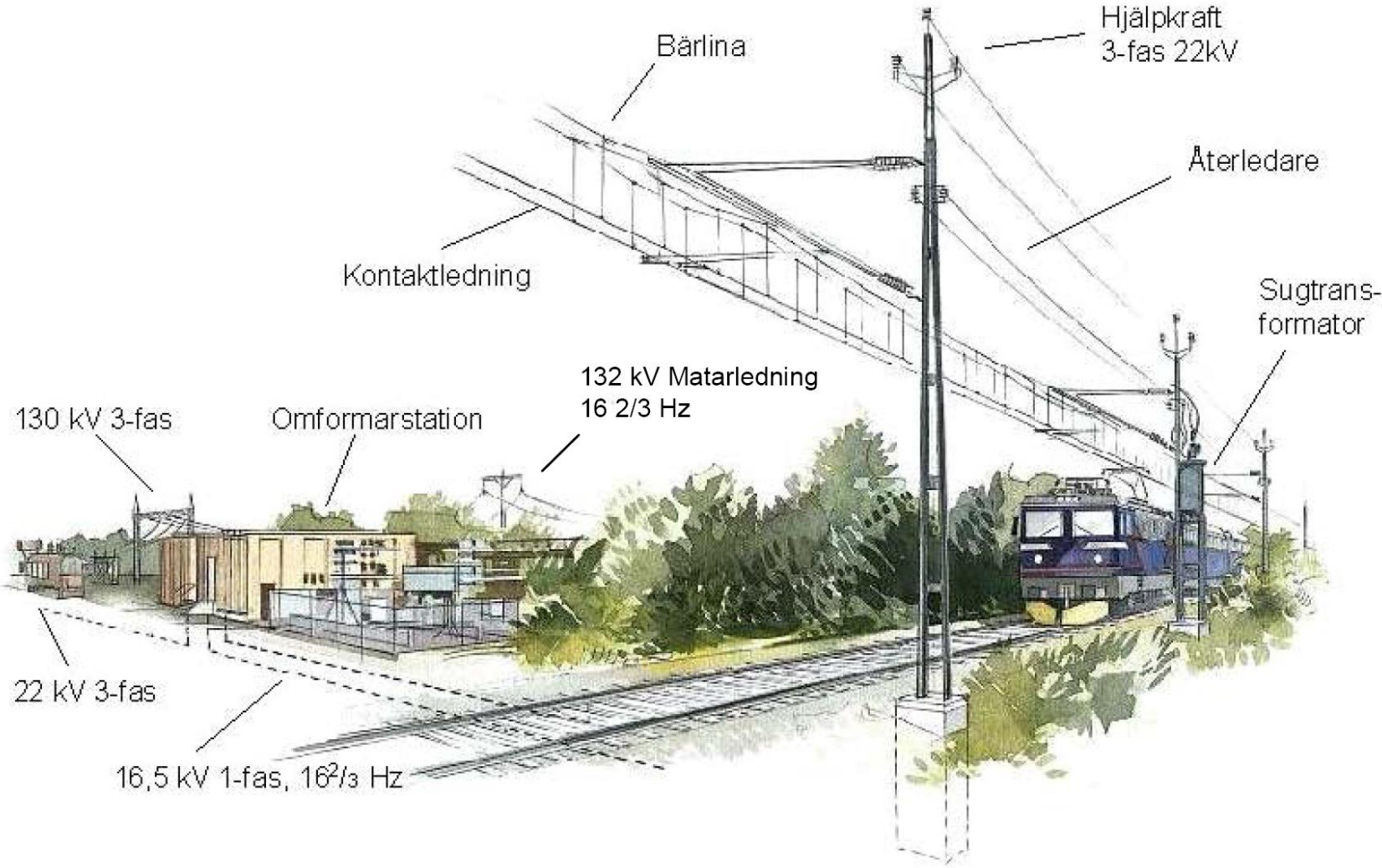
	Kortvarigt minimum (V)	Minimum (V)	Nominell spänning (V)	Maximum (V)	Frekvens (Hz)
Likspänning (DC)		450-500	650-750	770-900	-
		1000	1500	1800	-
		2000	3000	3600	-
Växelspänning (AC)	11 000	12 000	15 000	16 500	16 2/3
	17 500	19 000	25 000	27 500	50 eller 60
	35 000	38 000	50 000	55 000	50 eller 60

European Railway Power Supply Systems

- 15 kV AC $16\frac{2}{3}$ Hz
- 25 kV AC 50 Hz
- 3,0 kV DC
- 1,5 kV DC
- 1200 V DC



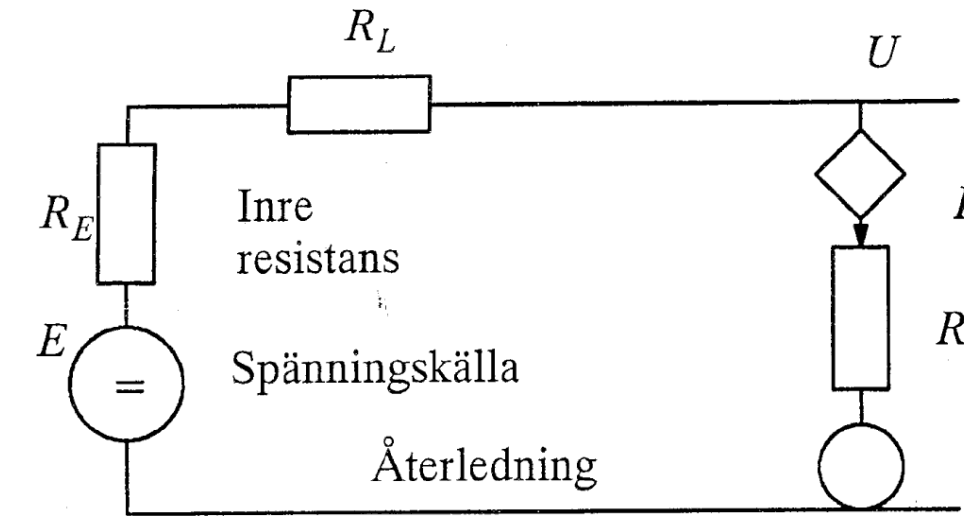
Railway Power Supply Systems



DC Railway Power Supply Systems

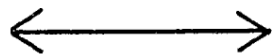
- The DC motor was initially the predominant traction motor
- Relatively low voltages
- High currents
- Difficulties at high power levels

Circuit at DC Power Supply



Dragfordon

$$\text{Effekt } P = U \cdot I = R \cdot I^2$$

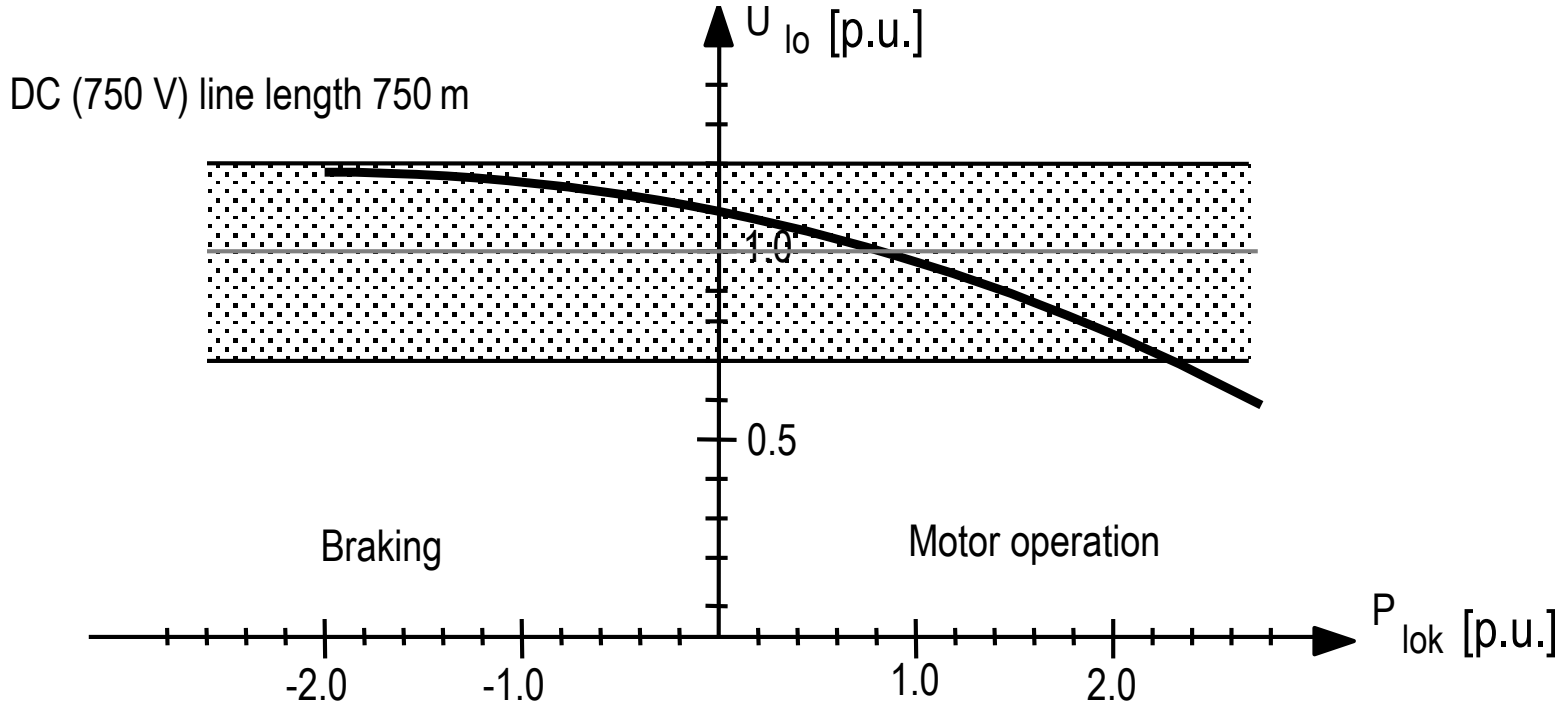


Matnings-
station

Total förlustresistans

$$R_F = R_E + R_L$$

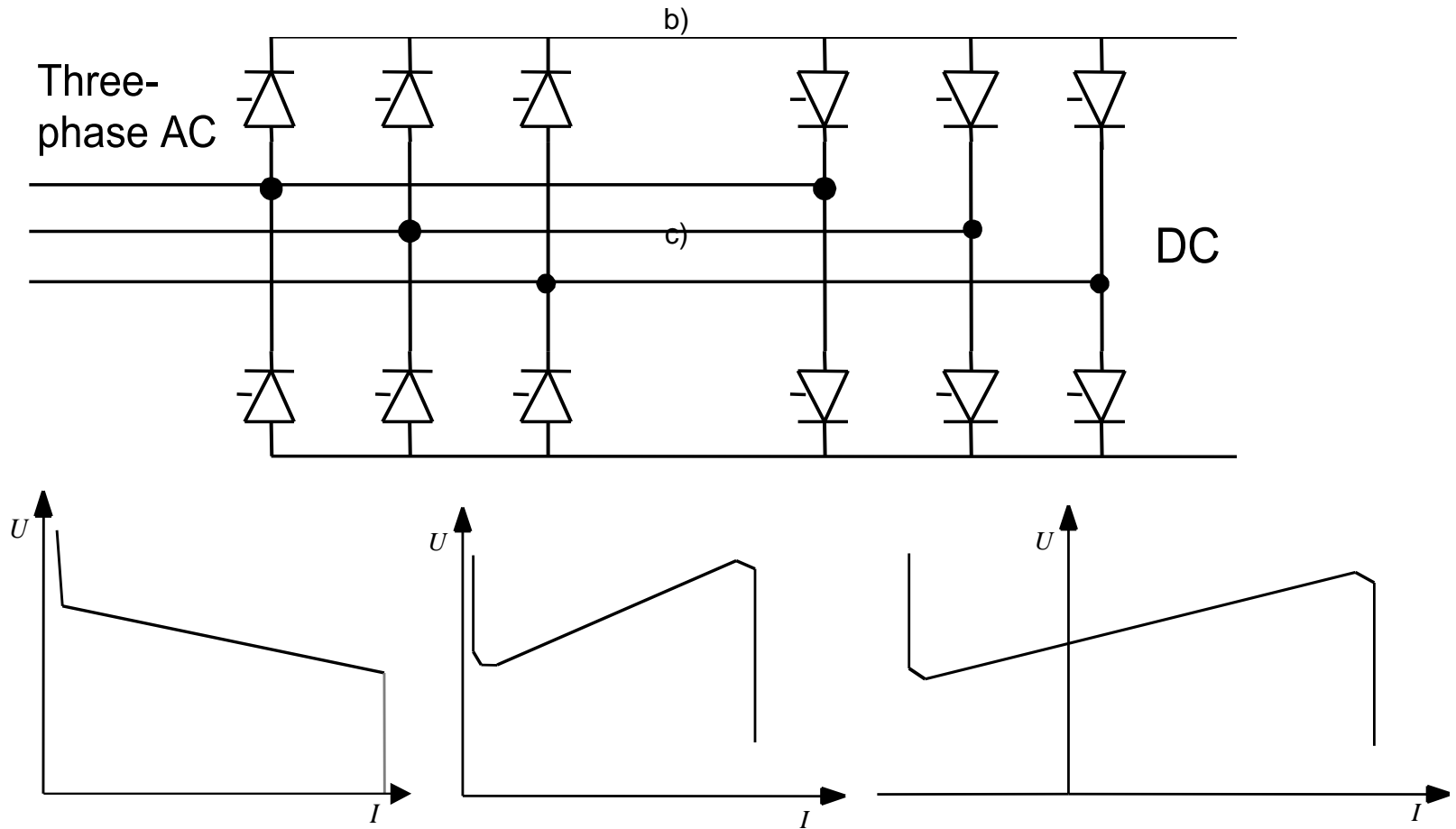
Voltage drop at given desired output power



a)

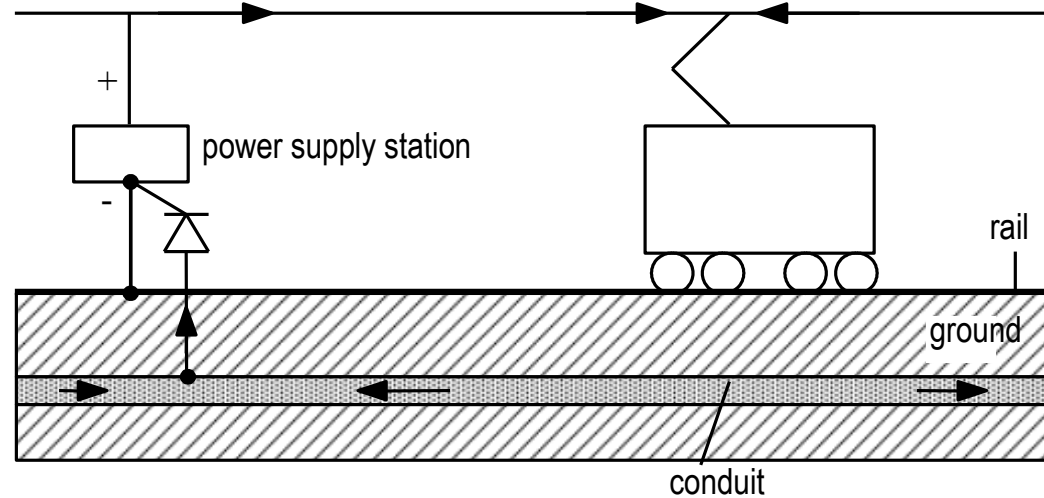
Converter Stations for DC Power Supply

- Diode or thyristor rectifier



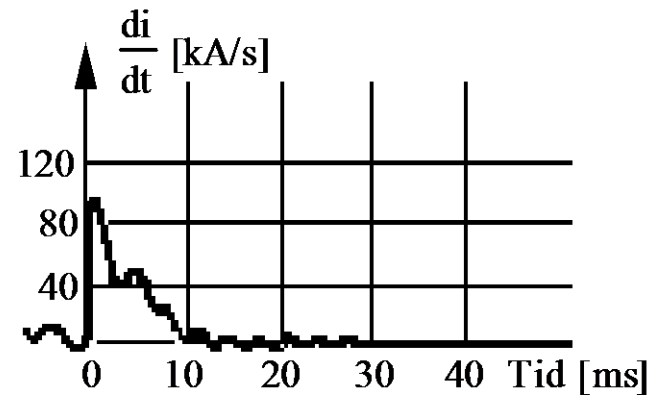
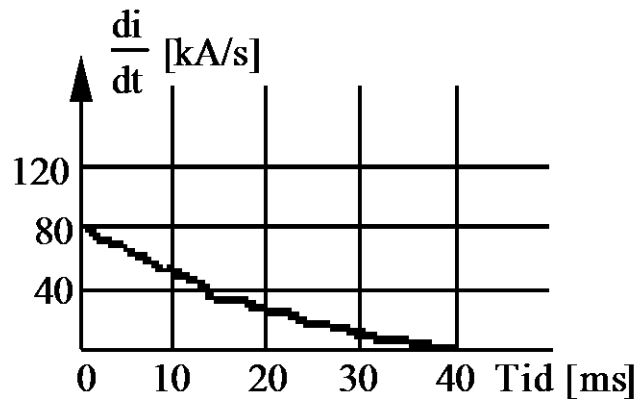
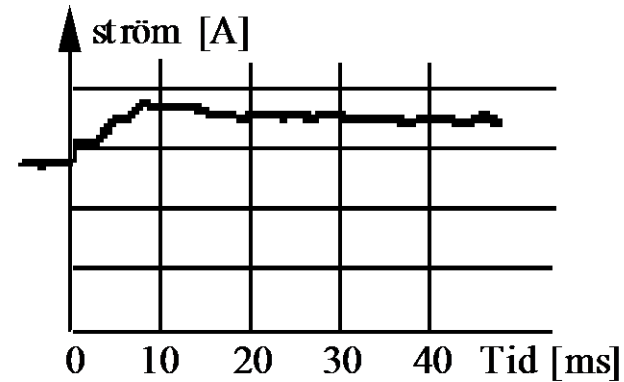
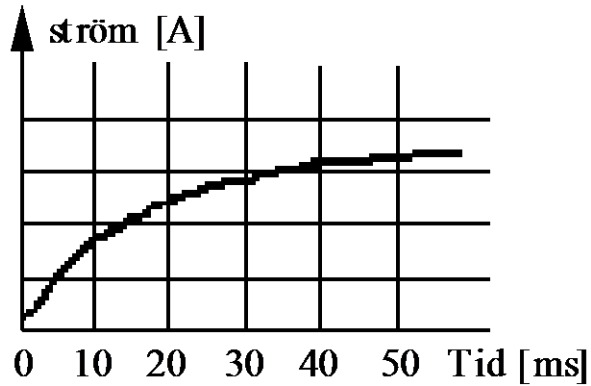
Return currents

- The return current in both rails
- Insulation of rails through sleepers and macadam



- LU has a special rail for current return

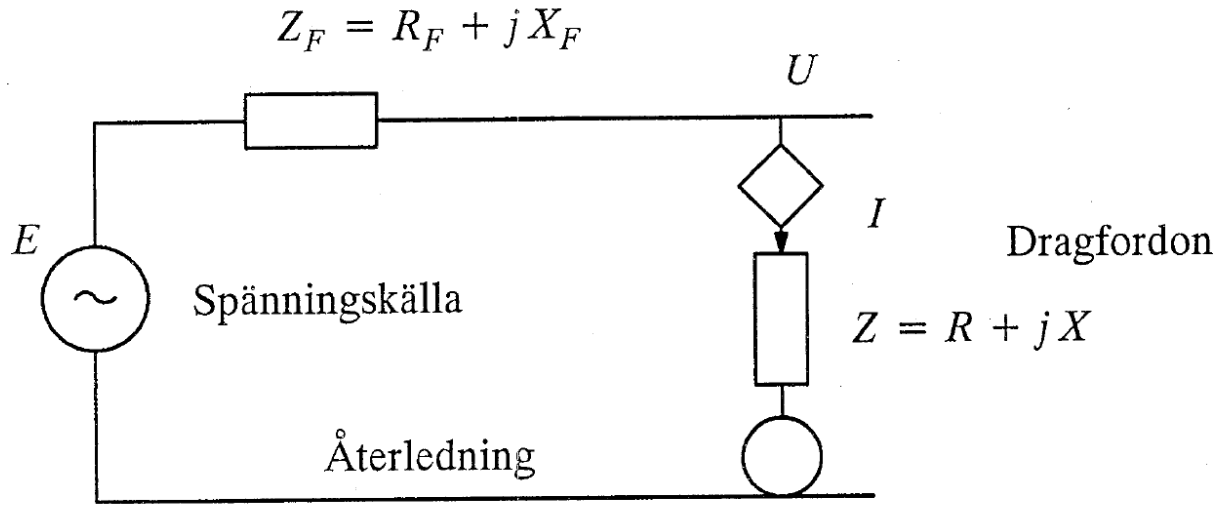
Detection of over-current by current derivative



AC Power Supply

- Higher voltages results in lower losses
- Longer distance between in-feed points
- Can easily be transformed

Equivalent circuit at AC Power Supply



Matningsstation

Förlustresistans

$$R_F = R_E + R_L$$

Matningsreaktans

$$X_F = X_E + X_L$$

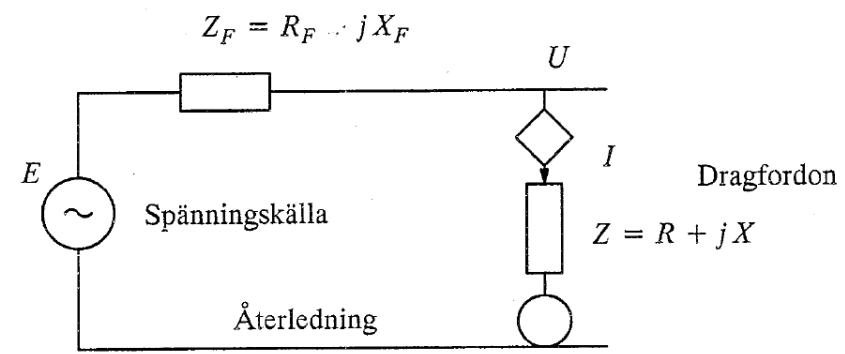
Matningsimpedans

$$Z_F = R_F + jX_F$$

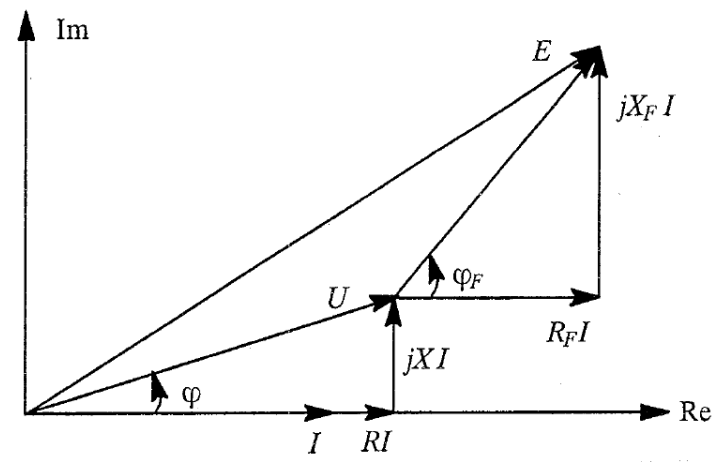
där index E avser matningsstationen och index L avser ledningar mellan matningsstationer och fordon.

$$j^2 = -1$$

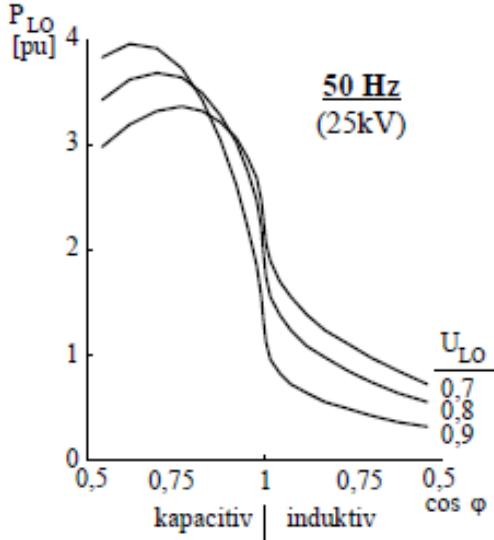
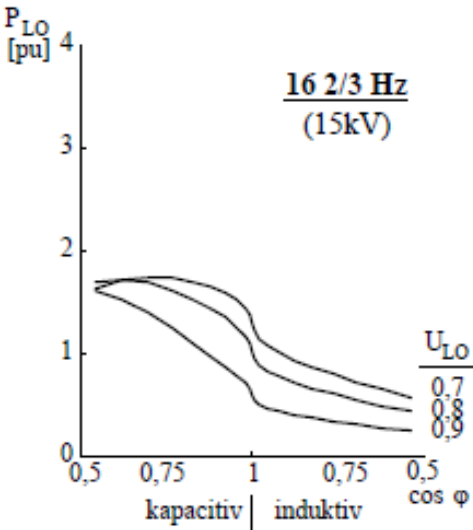
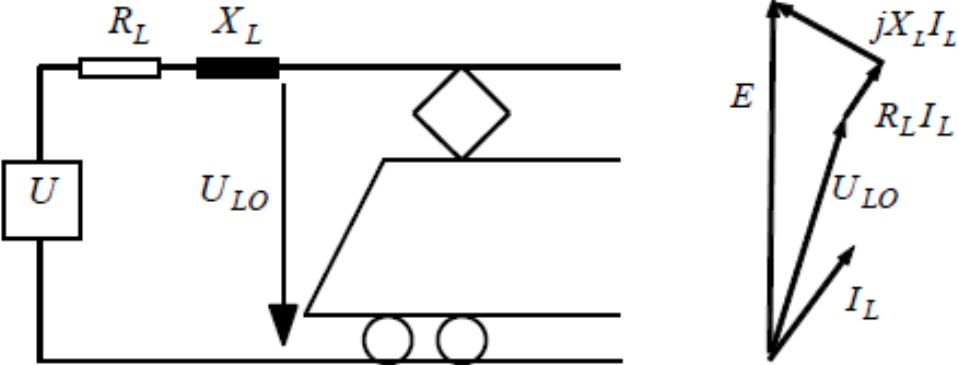
Voltage drop at AC Power Supply



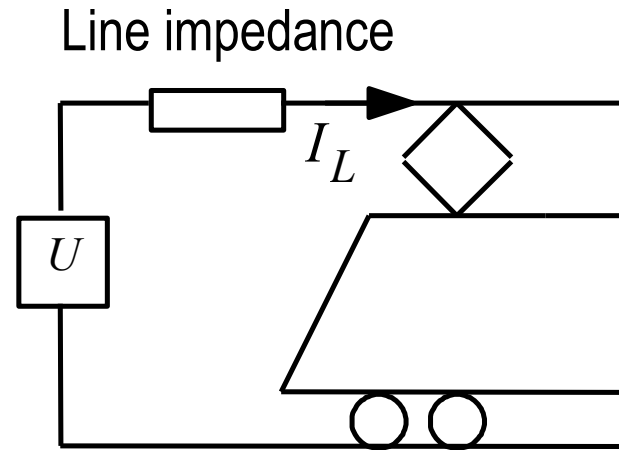
↔			
Matningsstation	Förlustresistans	Matningsreaktans	Matningsimpedans
	$R_F = R_E + R_L$	$X_F = X_E + X_L$	$Z_F = R_F + jX_F$



Power transfer capability in an AC system as function of the phase factor, $\cos\phi$



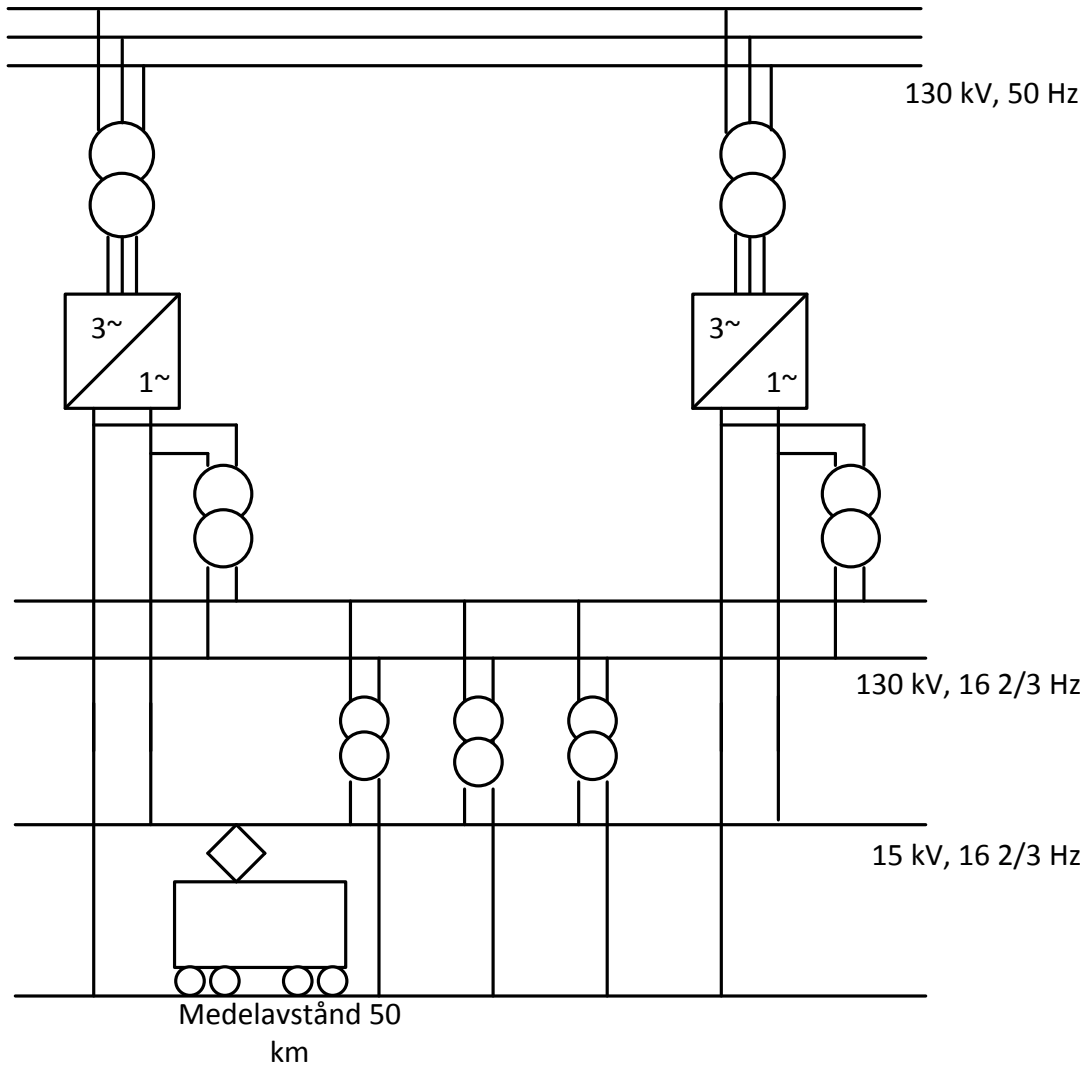
Power Supply Capacity



- Transmission
 - Stability

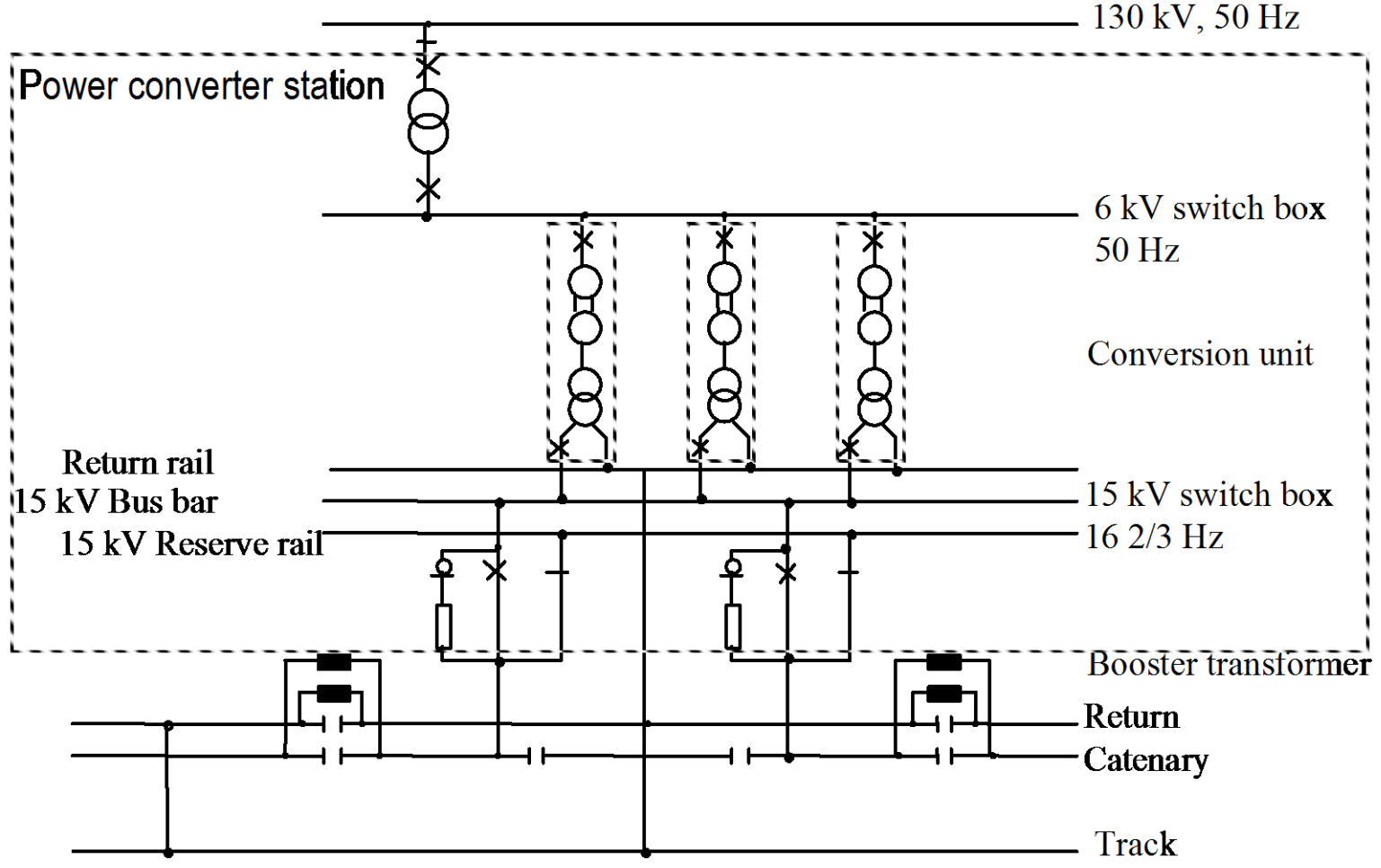
- Traction
 - Voltage tolerances
 - Thermal limitations
 - Instantaneous values

Railway Power Supply System with a single-phase 16 2/3 Hz, 130 kV feeder line

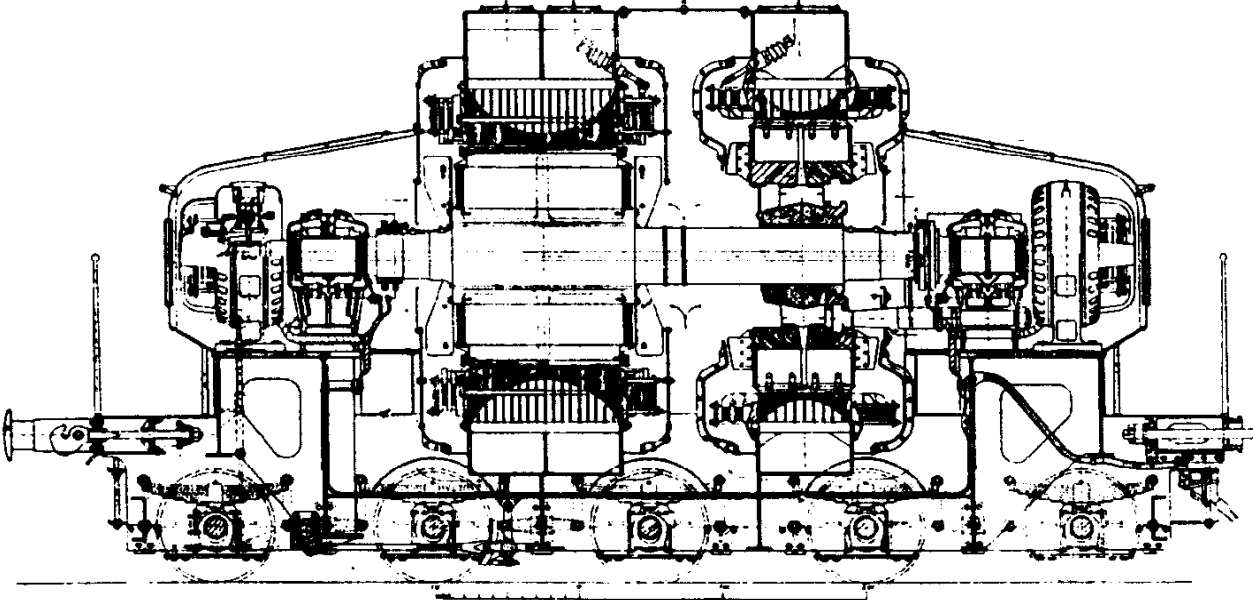


April 28, 2011

Typical design of a Swedish railway power supply station

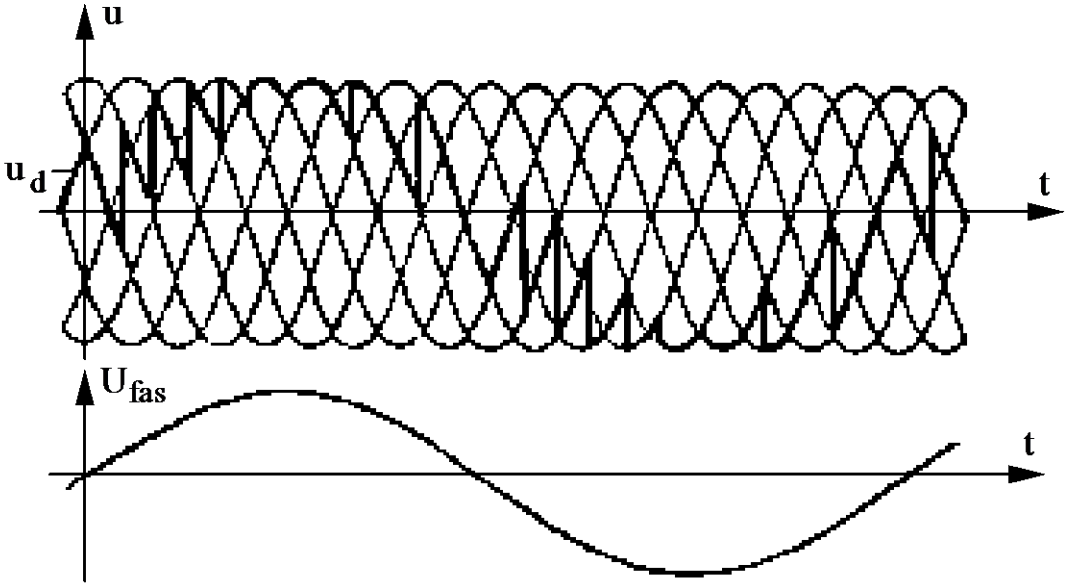
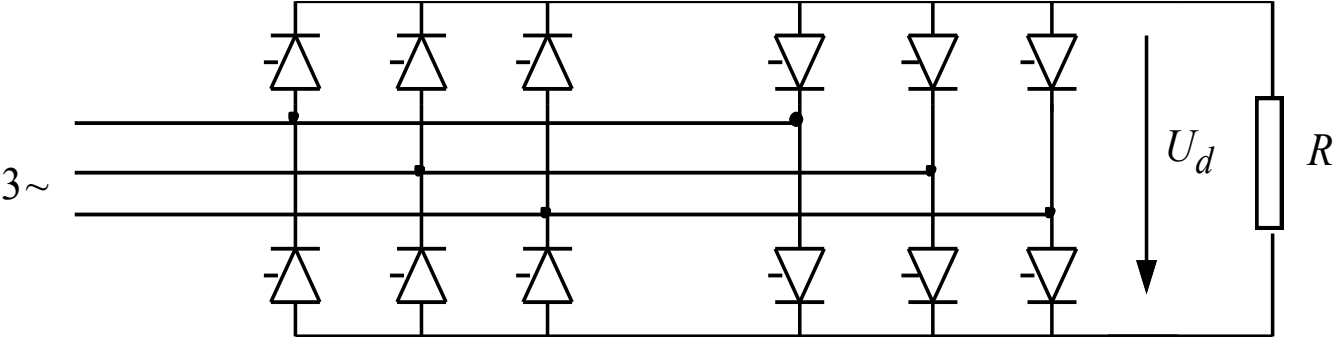


Q24 rotary converter

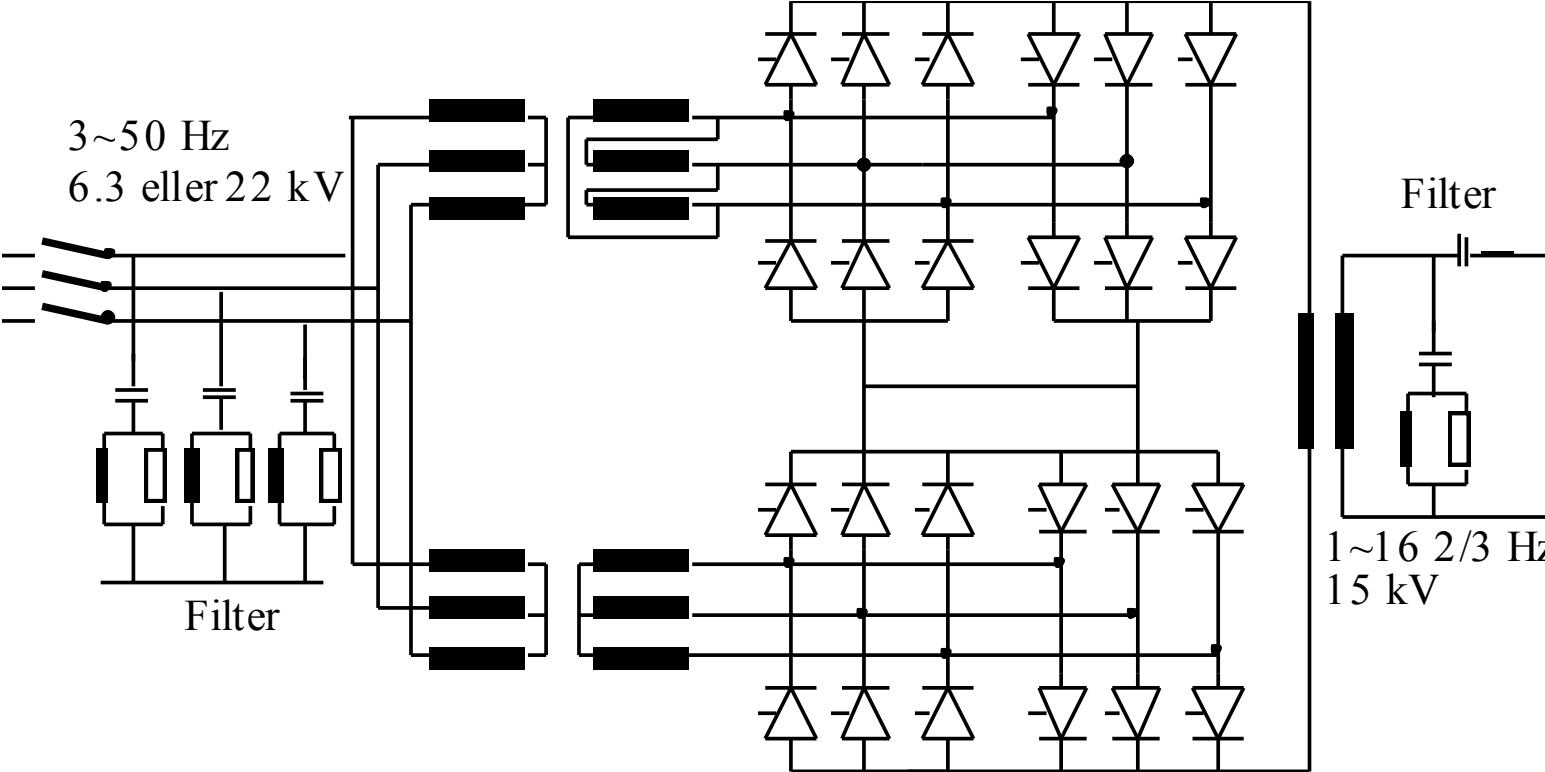


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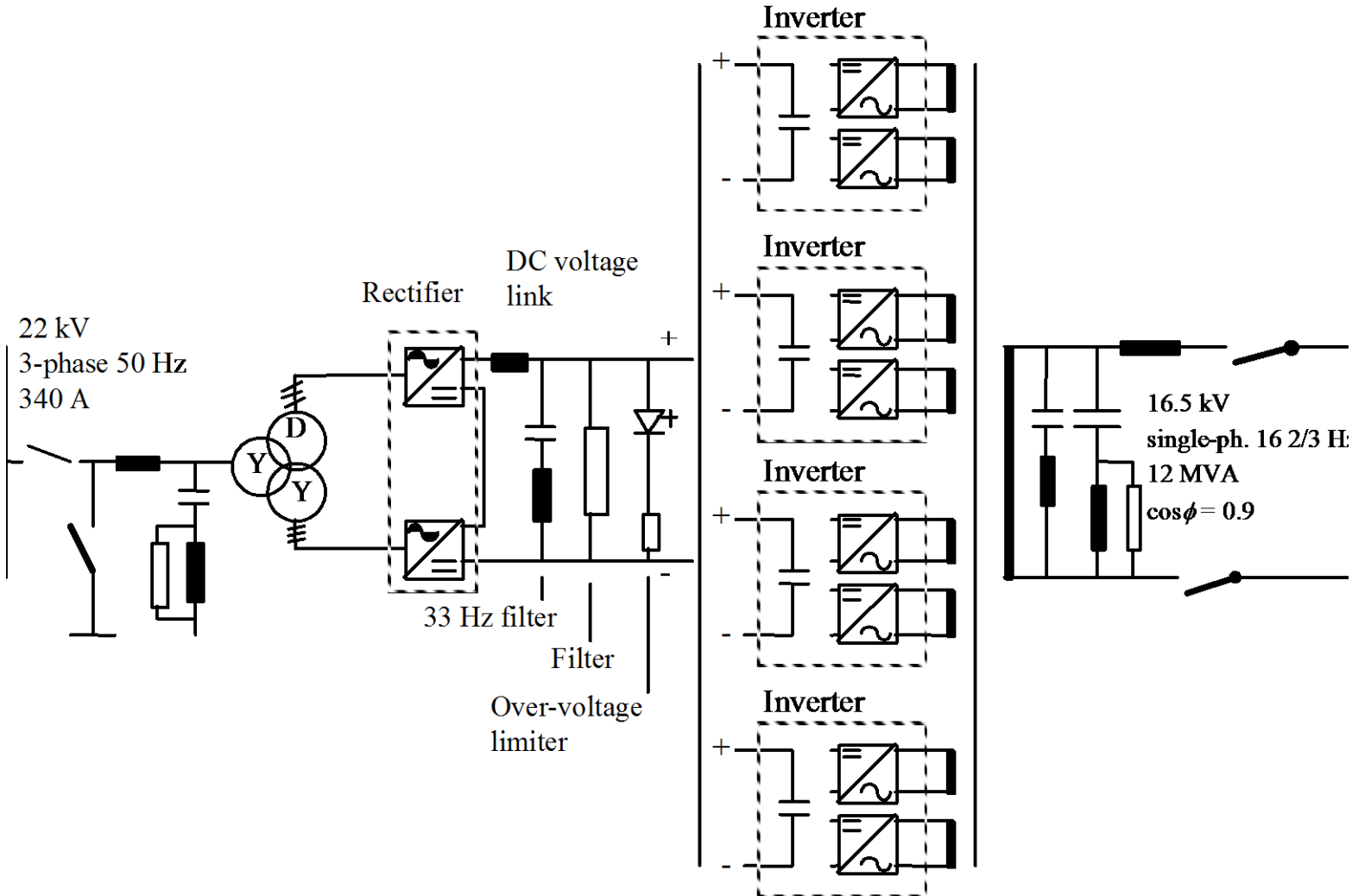
Direct conversion



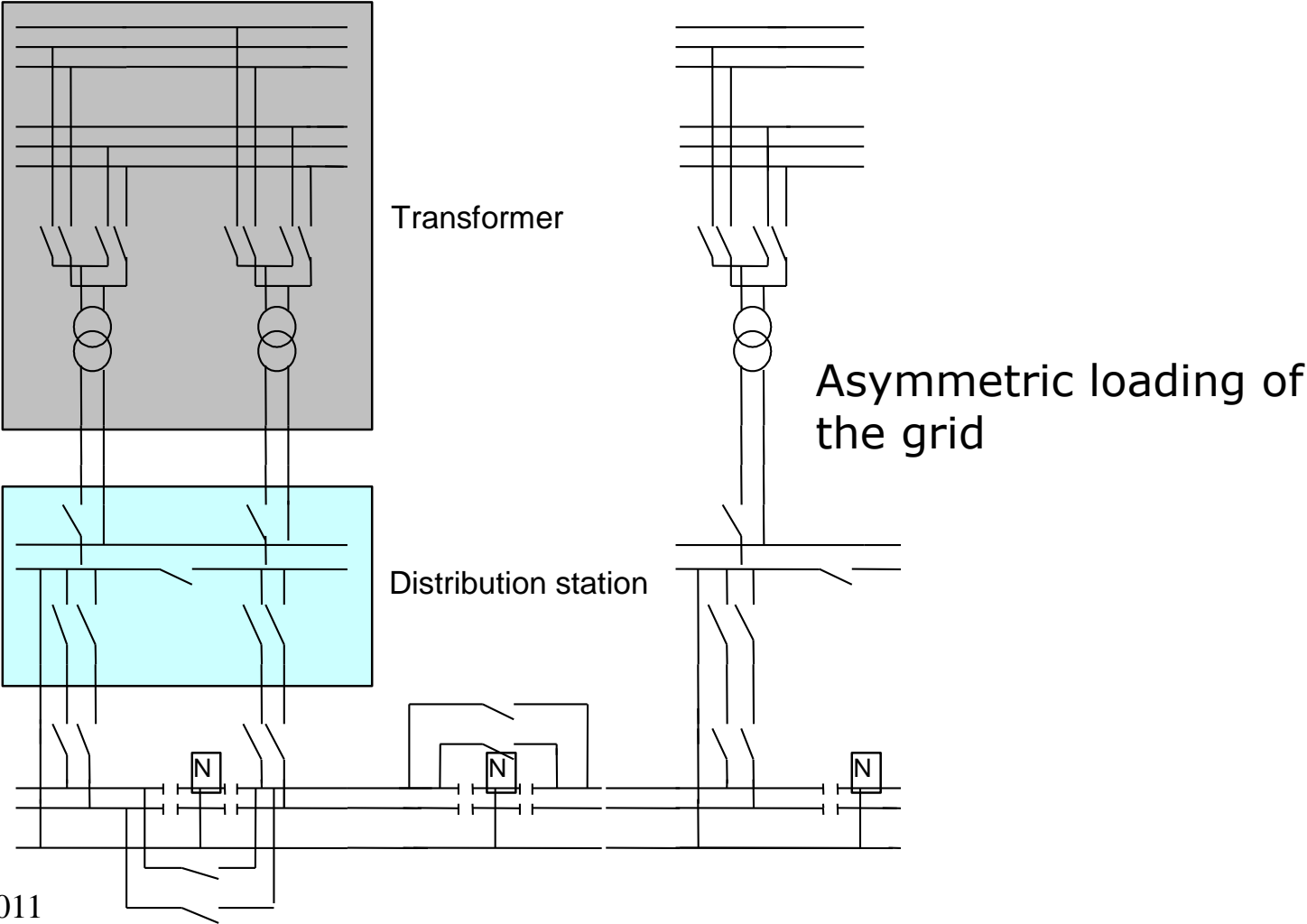
Converter station with direct converters (cyclo-converter)



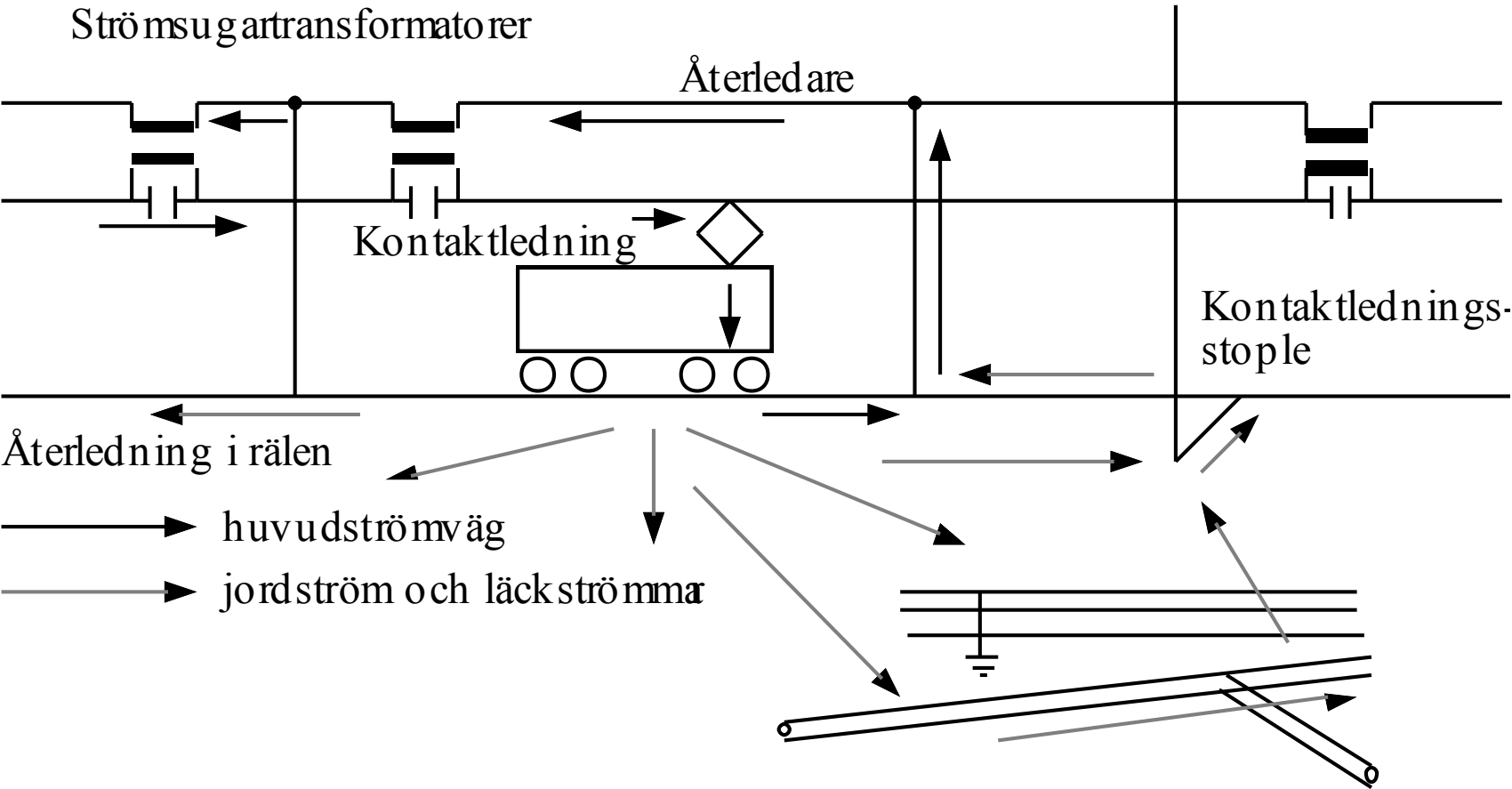
Power supply station with self-commutating inverters



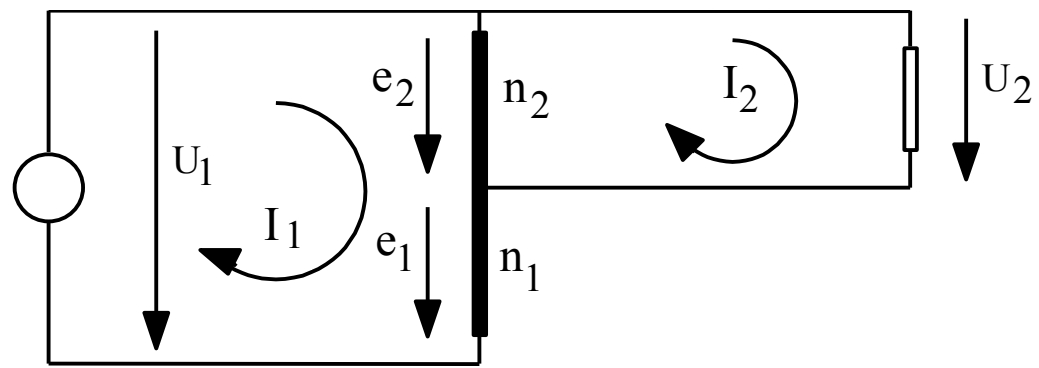
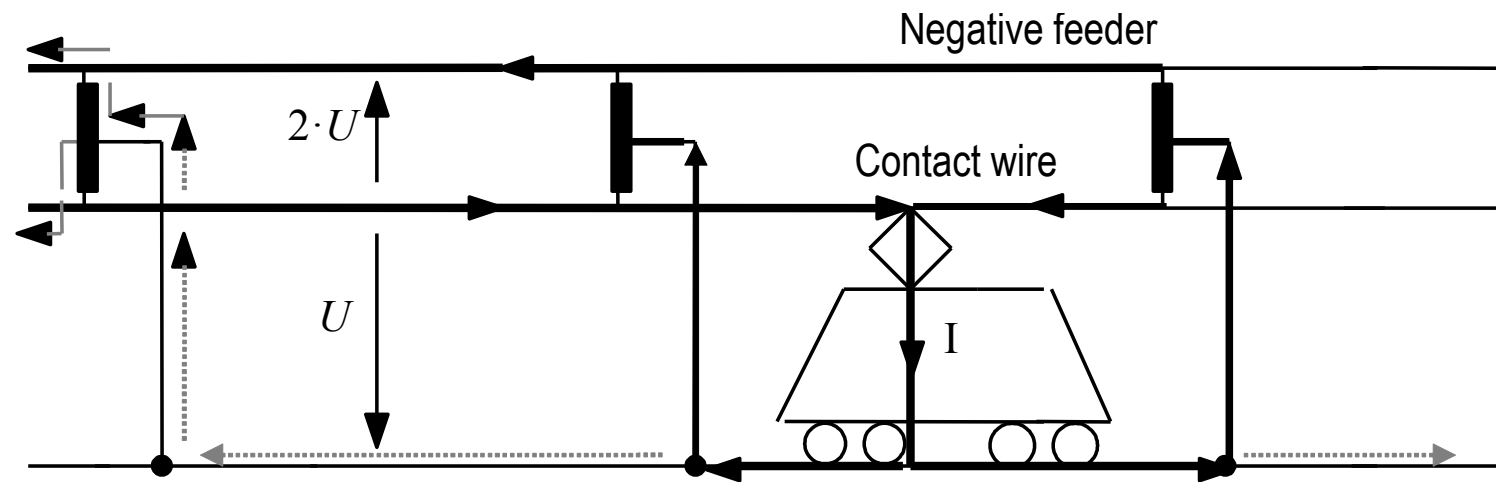
Power supply arrangement for a 50 Hz catenary system



Booster Transformer (BT)



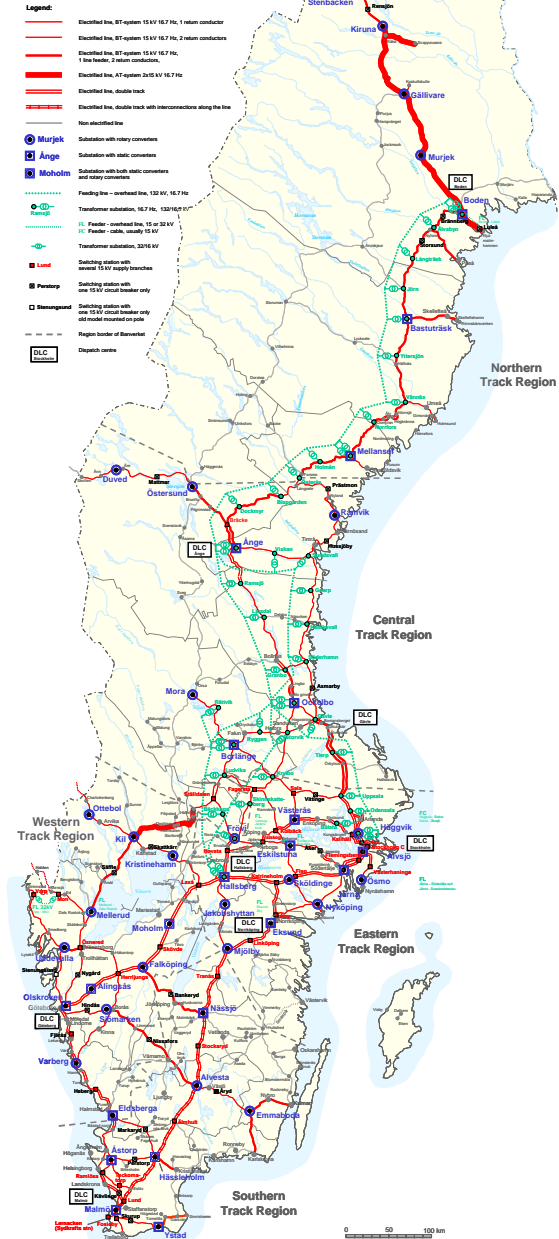
Autotransformer System (AT)



Swedish Railway Power Supply System

Railway network of Sweden
with power supply facilities

2005-11-12



April 28, 2011