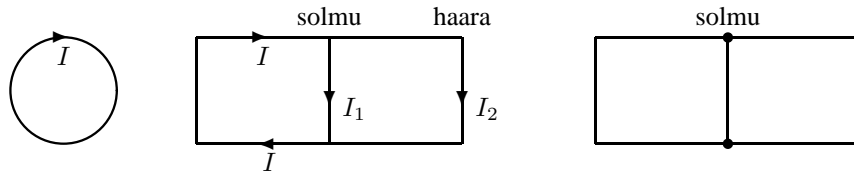


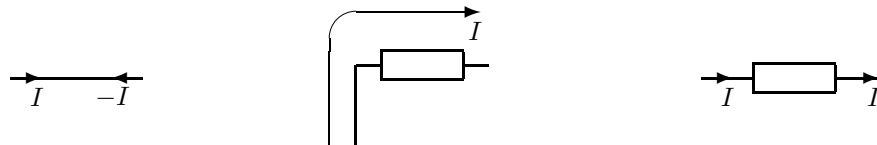
Tämä tiedosto sisältää kaikki kirjan kuvat, paitsi APLAC-kuvat, jotka ovat omana tiedostonaan *stekuva.pdf*. Mihin käyttöön tämä tiedosto sitten on tarkoitettu? Opiskelija haluaa ehkä printata sivuja 'työkirjaksi', opettaja saa kopioida kuvia luentokalvoihinsa ja esitelmöitsijä voi lainata kuvia materiaaleihinsa. Toivon, että lähde *Kimmo Silvonen, Sähkötekniikka ja elektroniikka* mainitaan kuvia lainattaessa. Muuta ilmaismateriaalia on kirjan [www-sivuilla](http://www.aplac.hut.fi/~kimmo) (huomaa tilde tai etsi sivut *Googlessa*).

1 Piirianalyysi

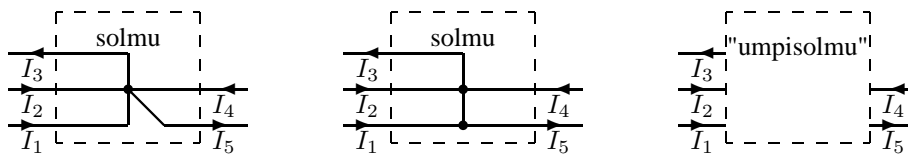
1.1 Jännite, virta ja Kirchhoffin lait



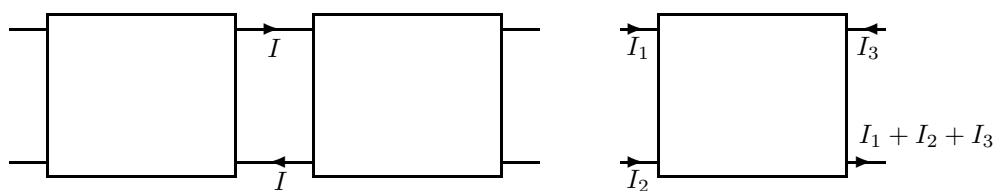
Kuva 1.



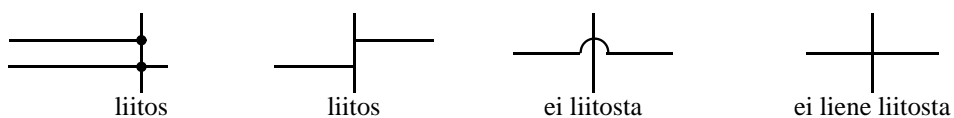
Kuva 2.



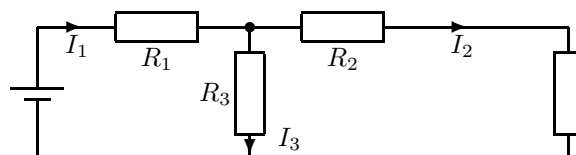
Kuva 3.



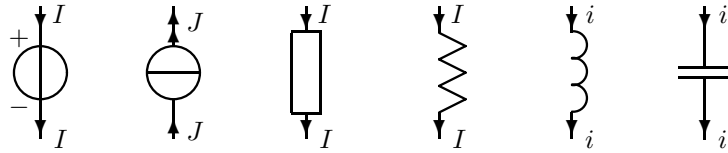
Kuva 4.



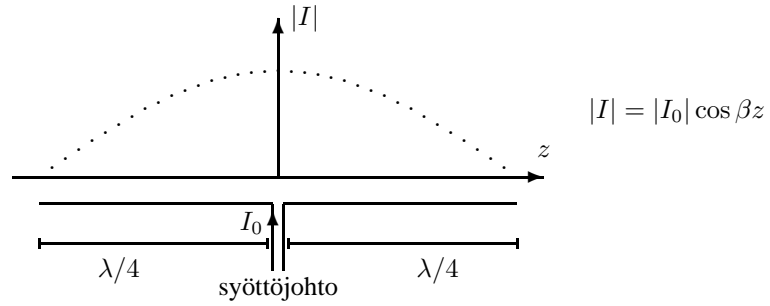
Kuva 5.



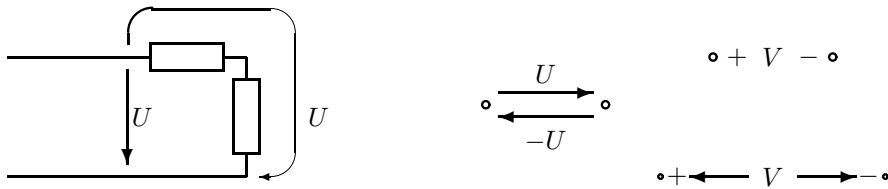
Kuva 6.



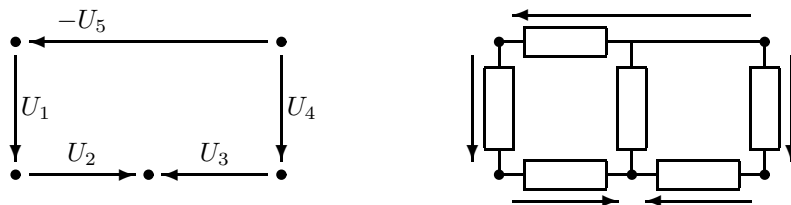
Kuva 7.



Kuva 8.



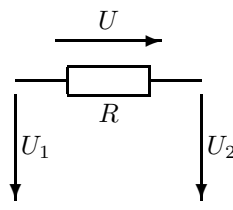
Kuva 9.



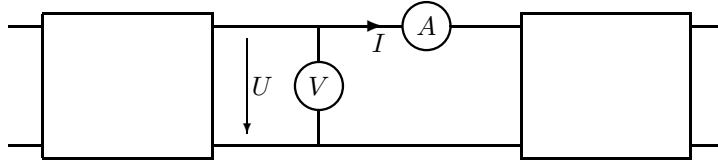
Kuva 10.



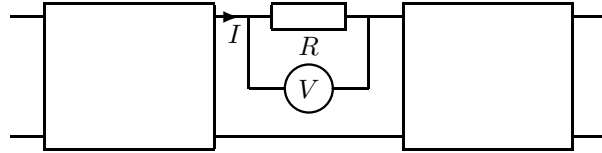
Kuva 11.



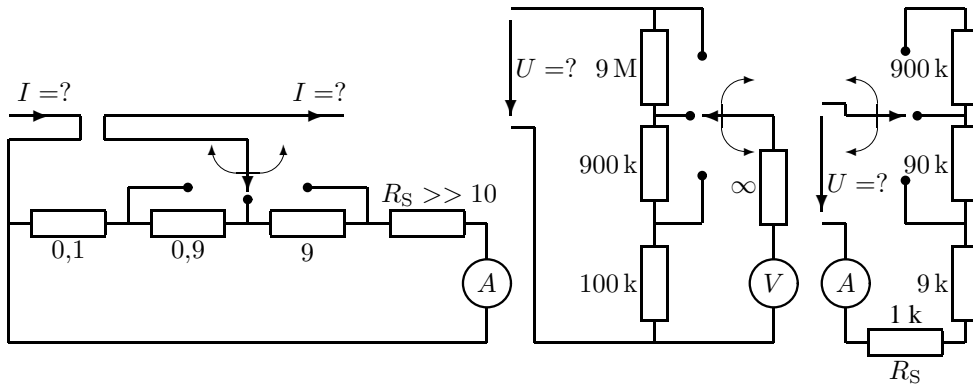
Kuva 12.



Kuva 13.

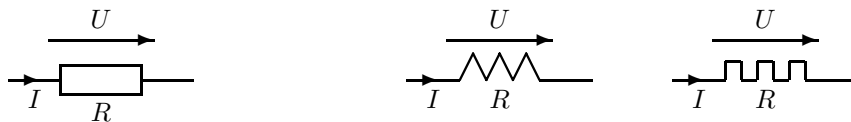


Kuva 14.

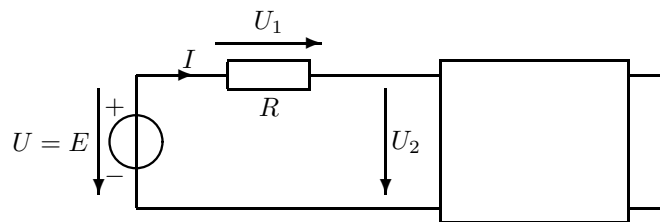


Kuva 15.

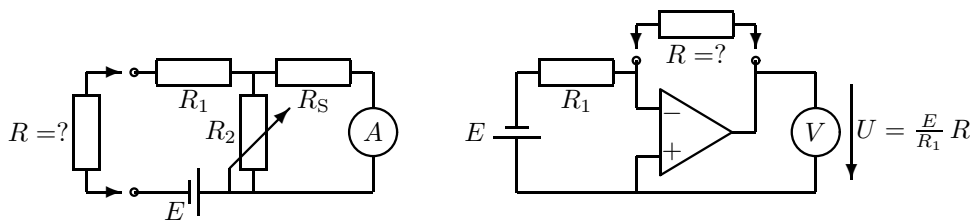
1.2 Vastus ja resistanssi



Kuva 16.

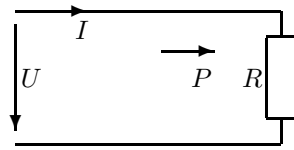


Kuva 17.

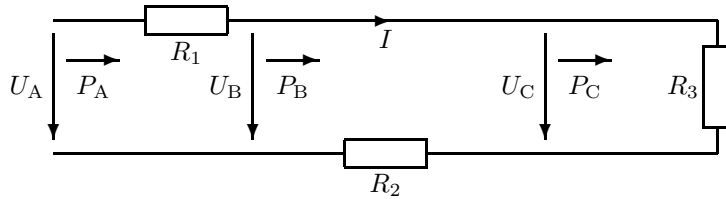


Kuva 18.

1.3 Tasavirran teho ja energia

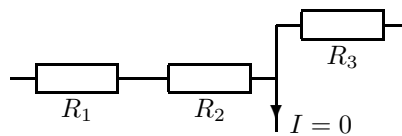


Kuva 19.

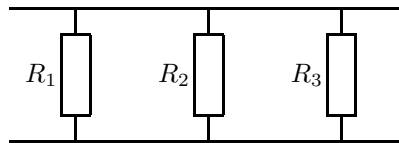


Kuva 20.

1.4 Virtapiirien peruskäsitteitä



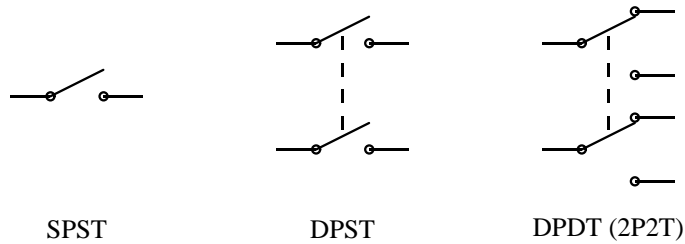
Kuva 21.



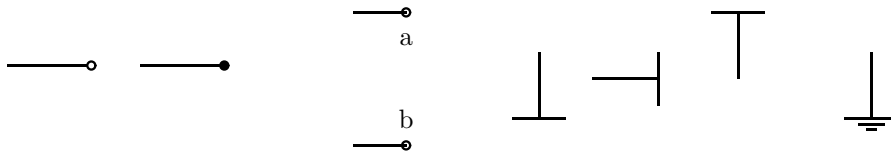
Kuva 22.



Kuva 23.

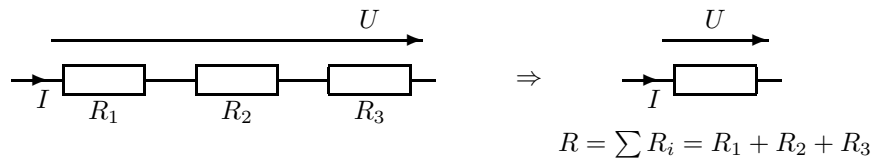


Kuva 24.



Kuva 25.

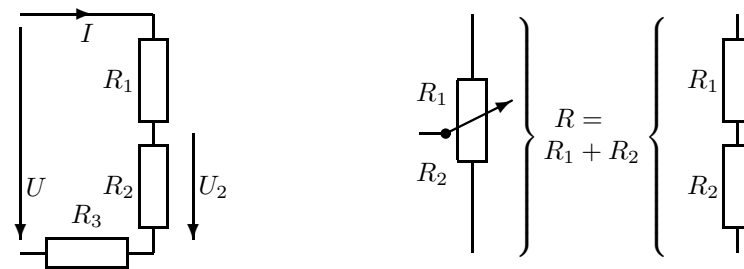
1.5 Yleisiä piirirakenteita



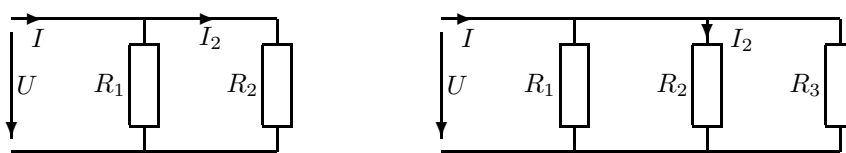
Kuva 26.



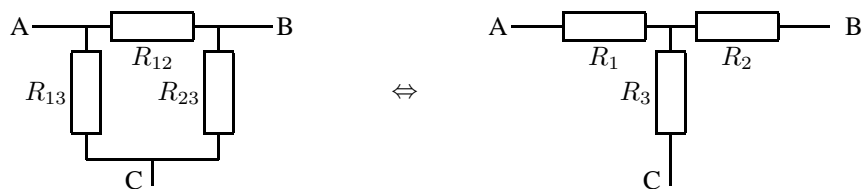
Kuva 27.



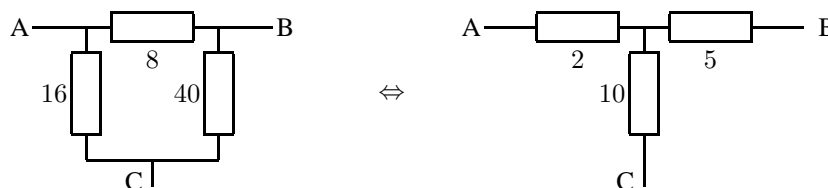
Kuva 28.



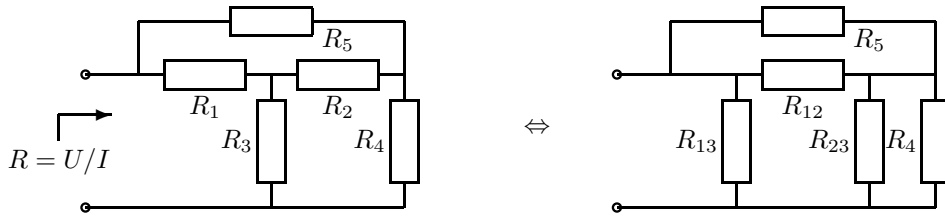
Kuva 29.



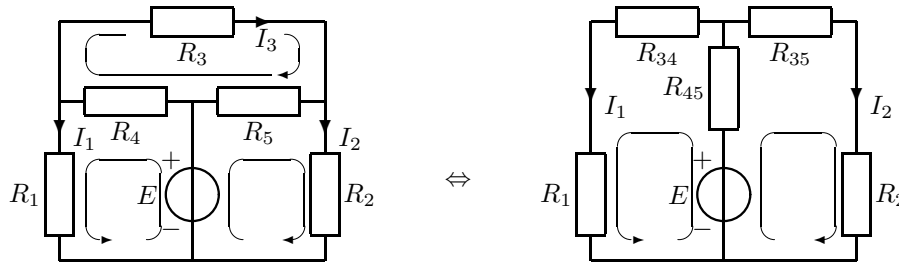
Kuva 30.



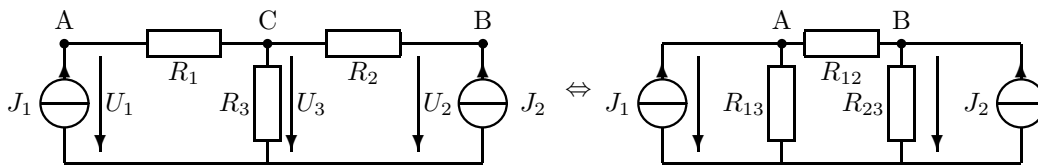
Kuva 31.



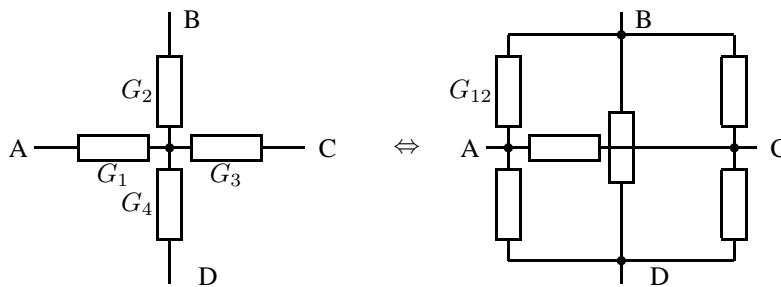
Kuva 32.



Kuva 33.

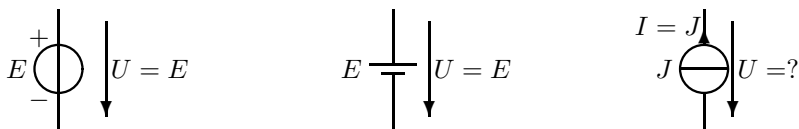


Kuva 34.

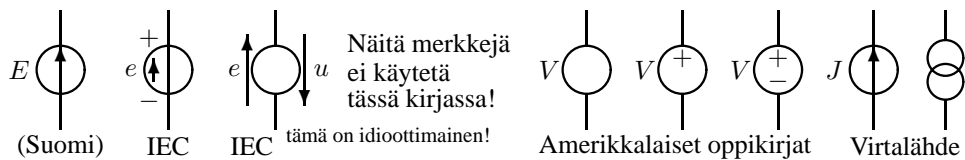


Kuva 35.

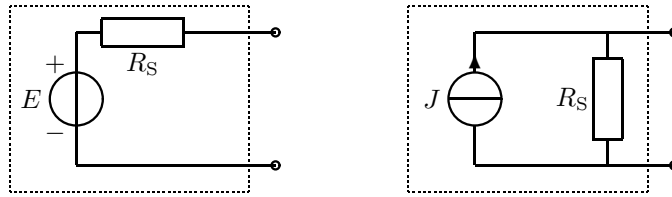
1.6 Jännite- ja virtalähteet



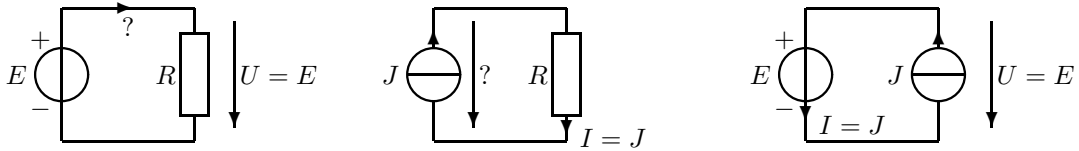
Kuva 36.



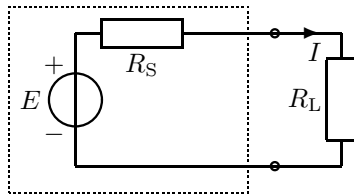
Kuva 37.



Kuva 38.

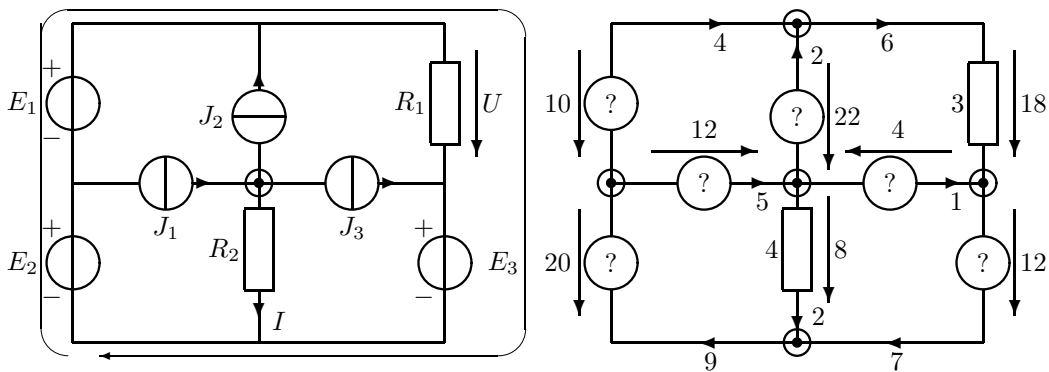


Kuva 39.

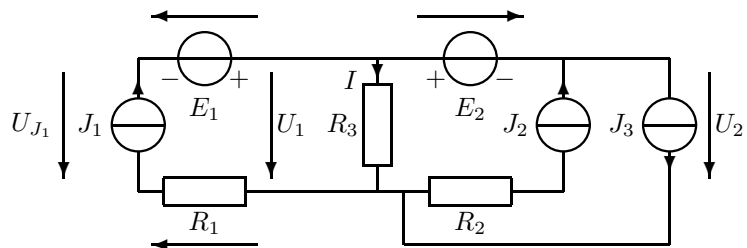


$$I = J = \frac{E}{R_S + R_L} \approx \frac{E}{R_S} = \text{vakio}$$

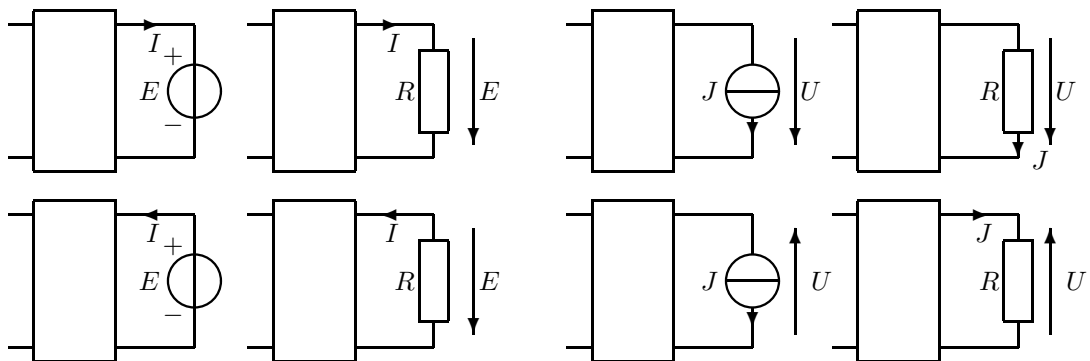
Kuva 40.



Kuva 41.

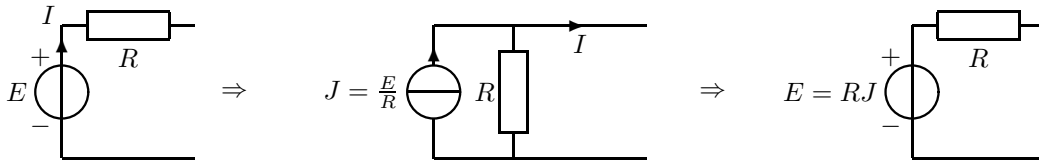


Kuva 42.

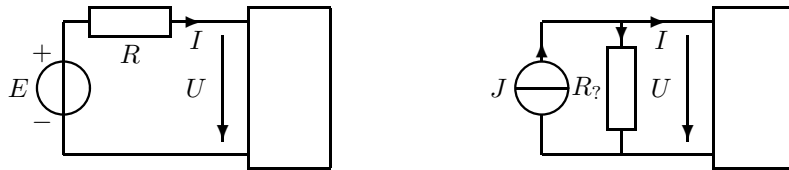


Kuva 43.

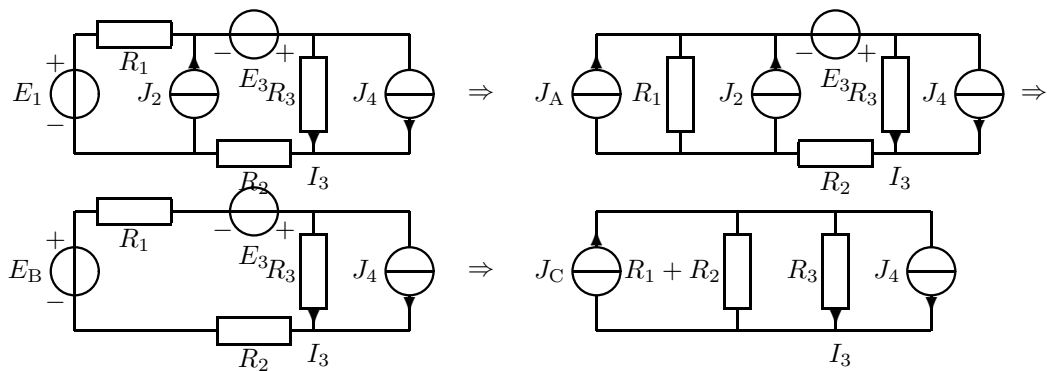
1.7 Lähdemuunnokset



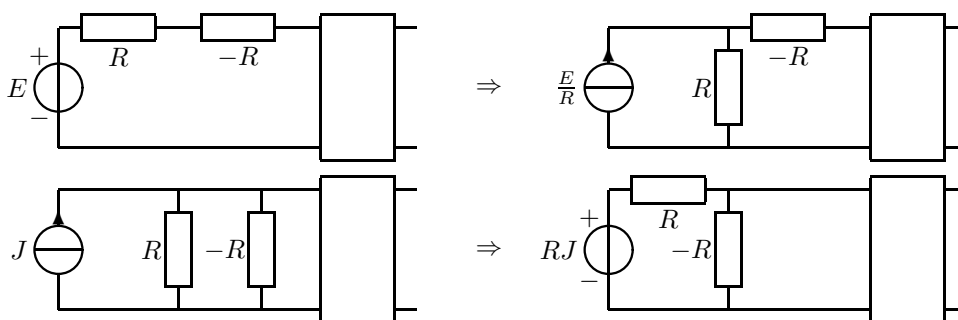
Kuva 44.



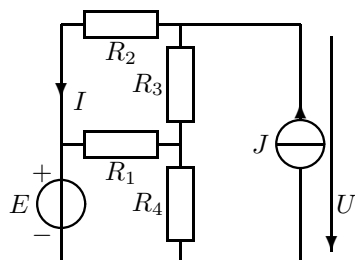
Kuva 45.



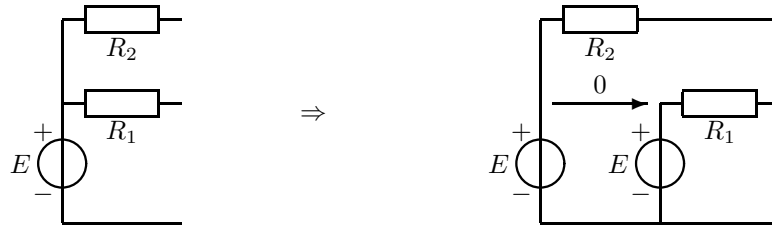
Kuva 46.



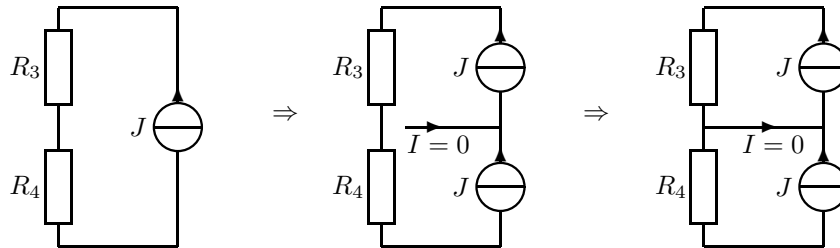
Kuva 47.



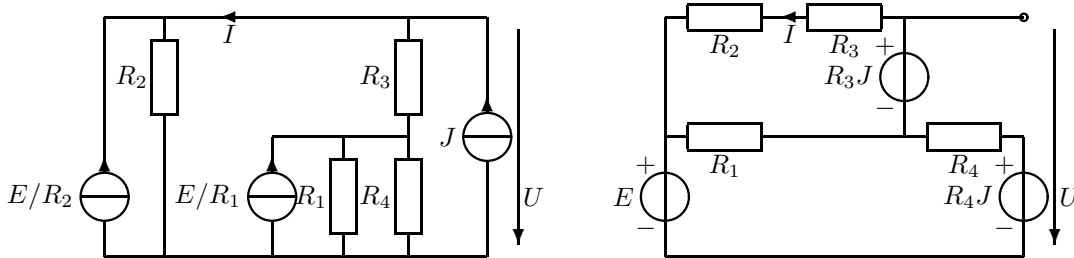
Kuva 48.



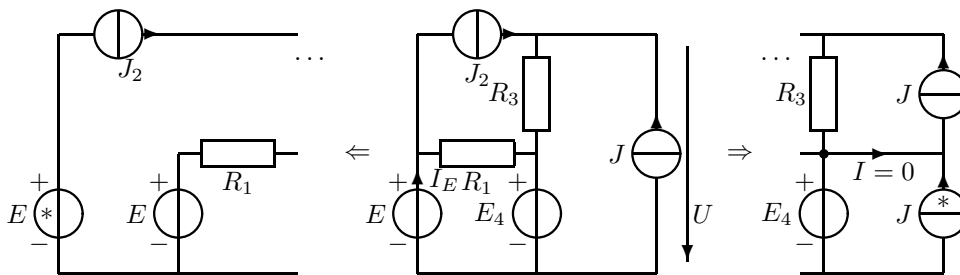
Kuva 49.



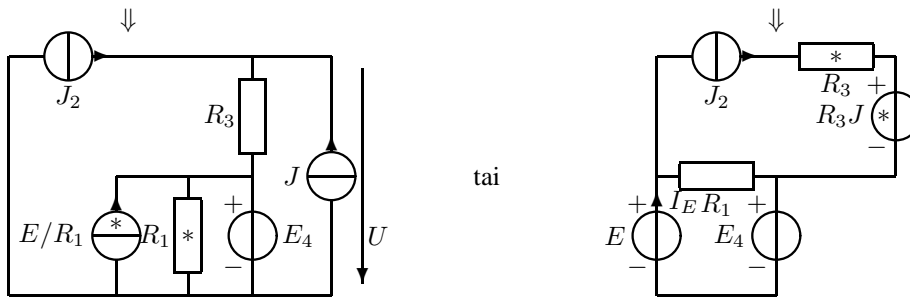
Kuva 50.



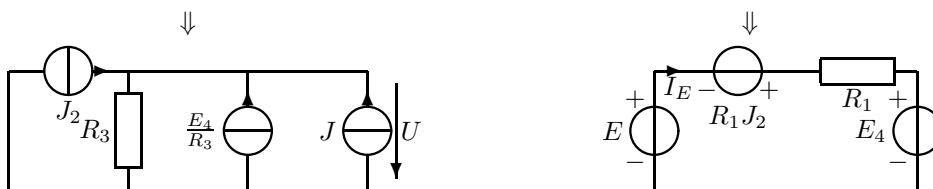
Kuva 51.



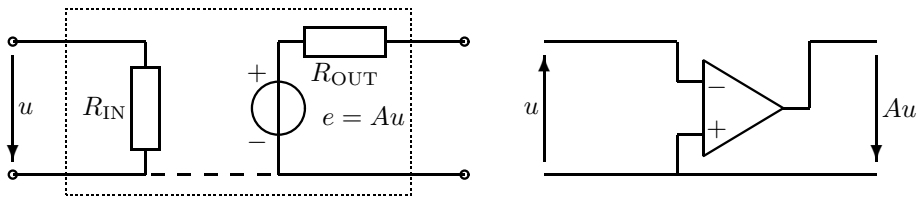
Kuva 52.



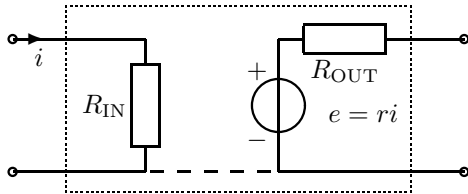
Kuva 53.



1.8 Ohjatut jännite- ja virtalähteet



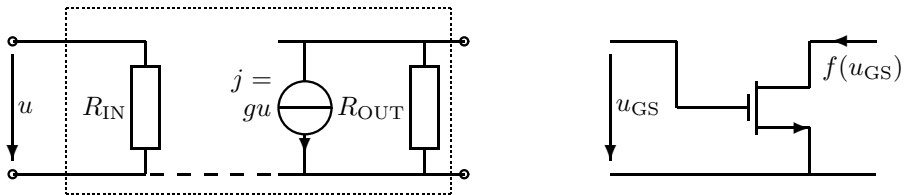
Kuva 54.



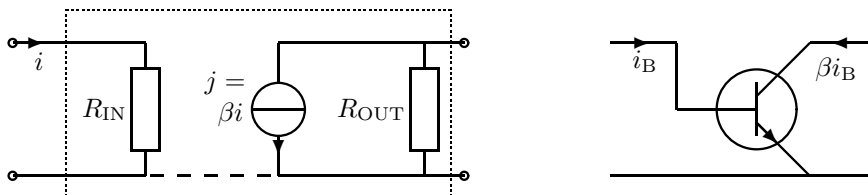
Kuva 55.



Kuva 56.



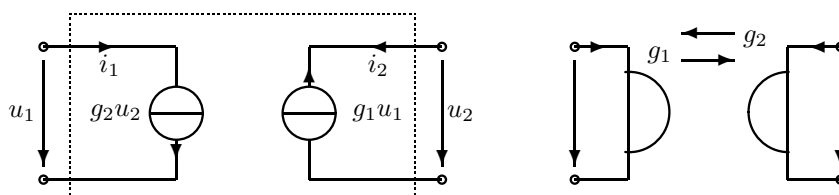
Kuva 57.



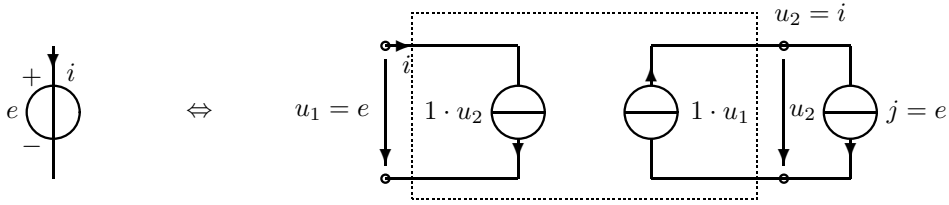
Kuva 58.



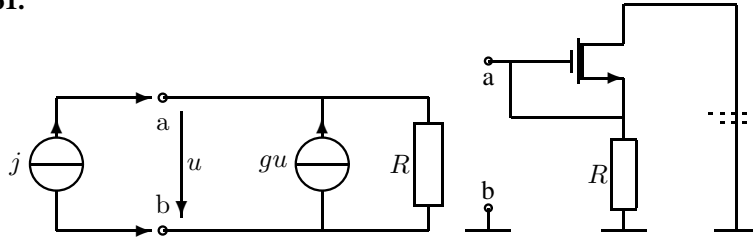
Kuva 59.



Kuva 60.

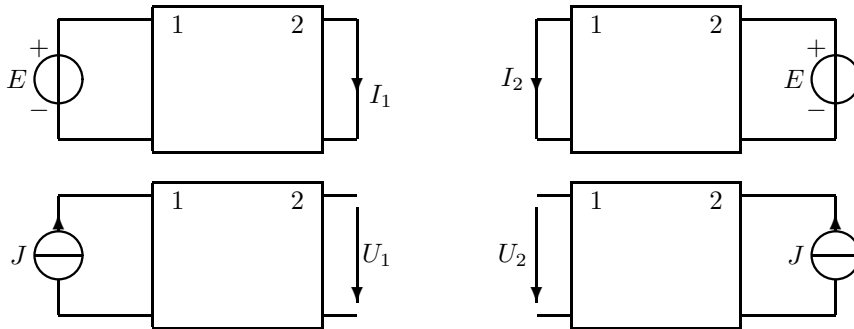


Kuva 61.

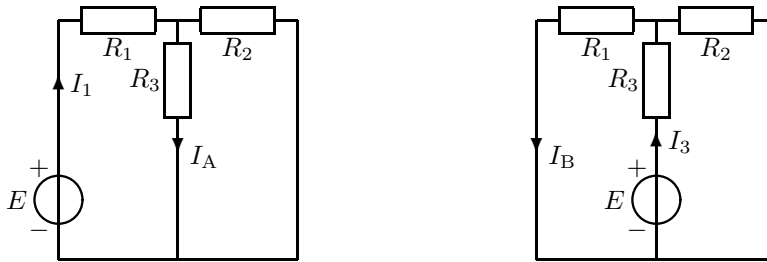


Kuva 62.

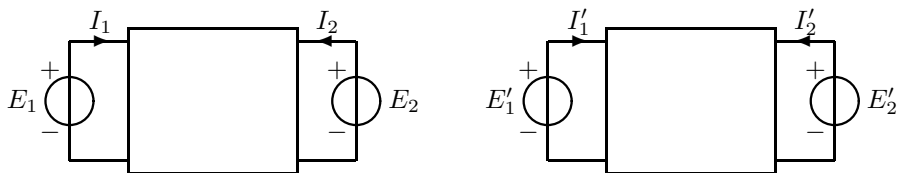
1.9 Piiriteoreemoja



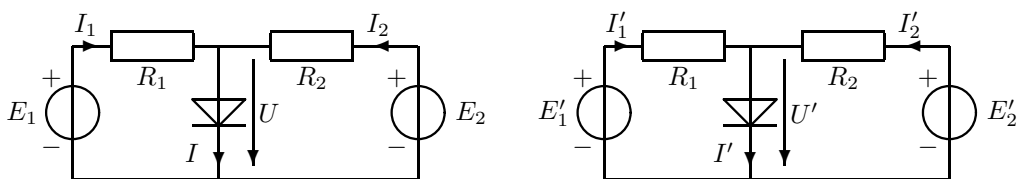
Kuva 63.



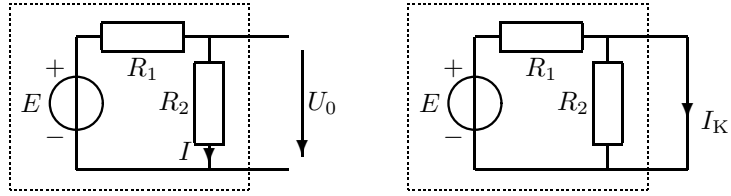
Kuva 64.



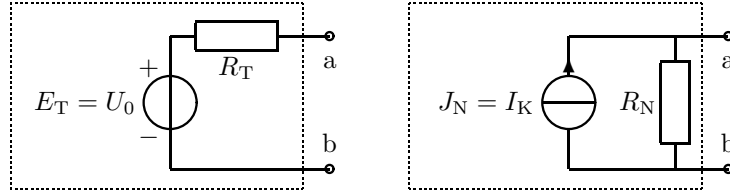
Kuva 65.



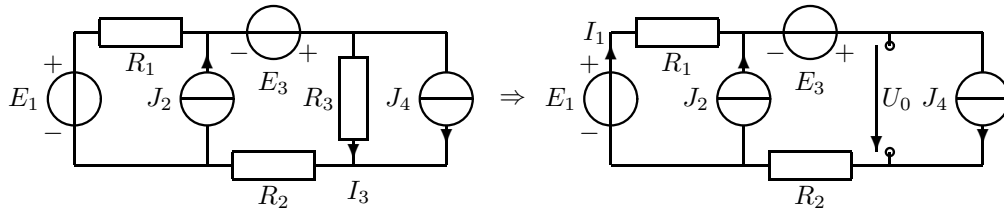
Kuva 66.



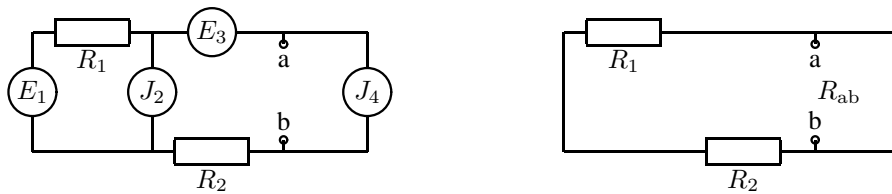
Kuva 67.



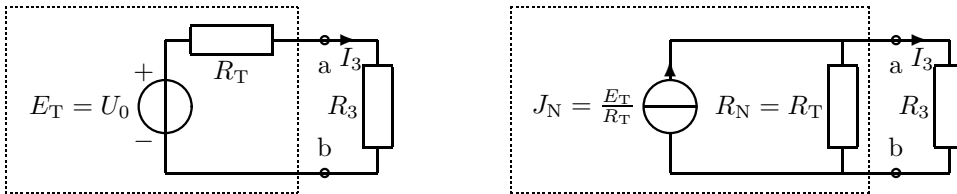
Kuva 68.



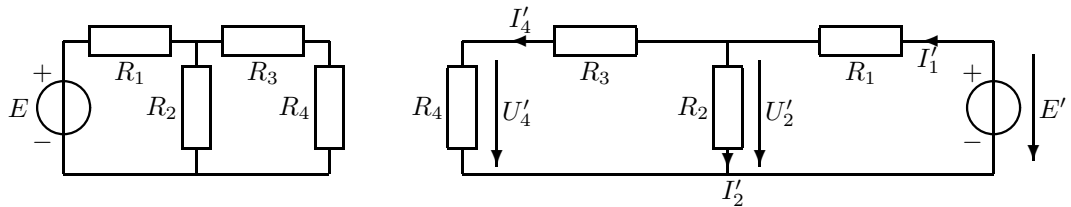
Kuva 69.



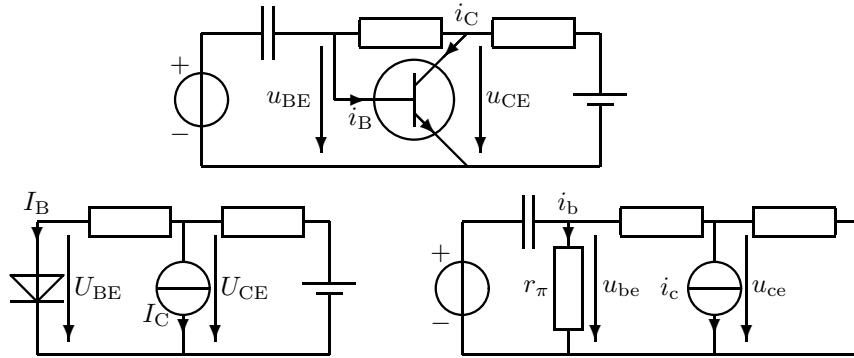
Kuva 70.



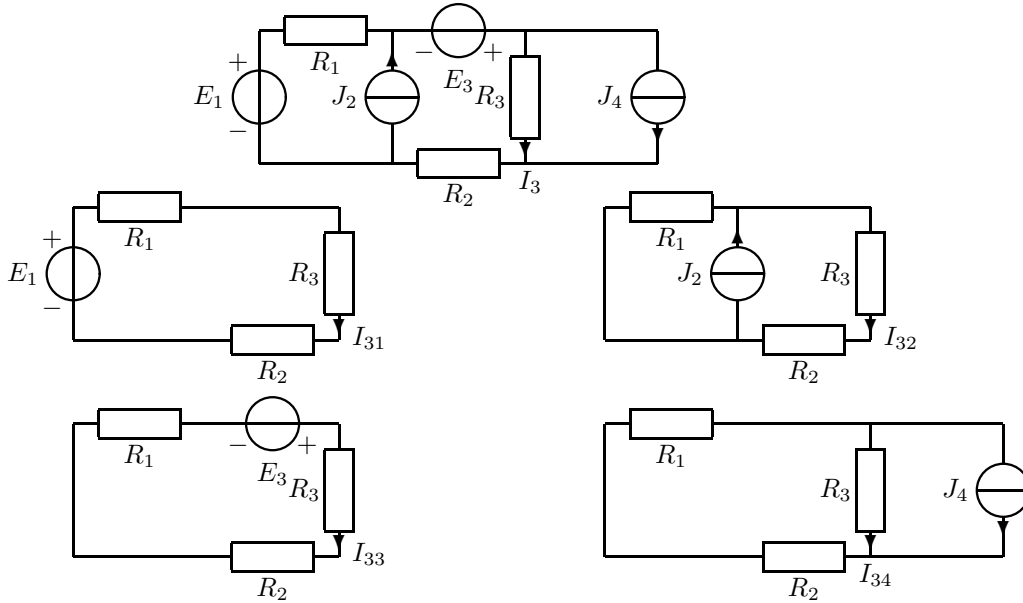
Kuva 71.



Kuva 72.

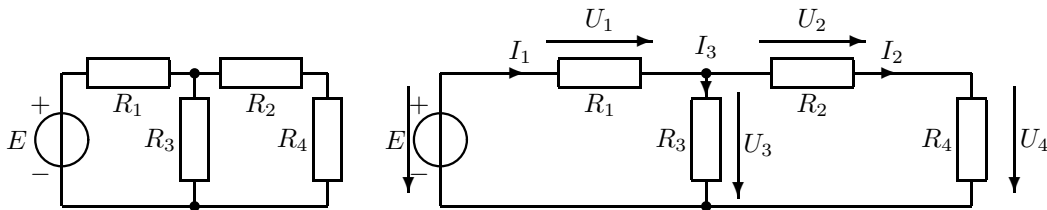


Kuva 73.

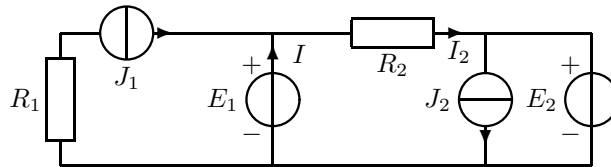


Kuva 74.

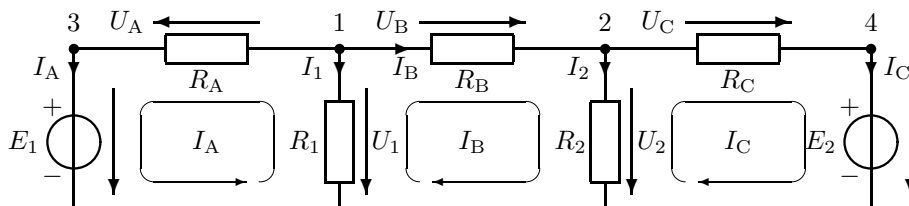
1.10 Piirianalyysimenetelmien esittely



Kuva 75.

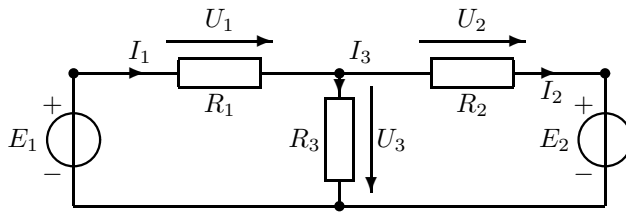


Kuva 76.

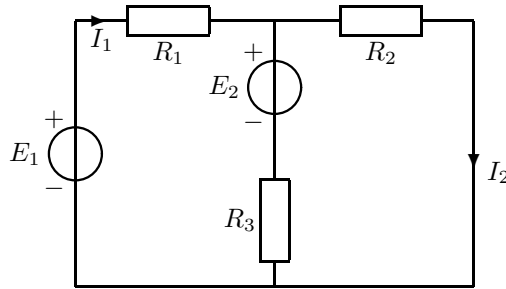


Kuva 77.

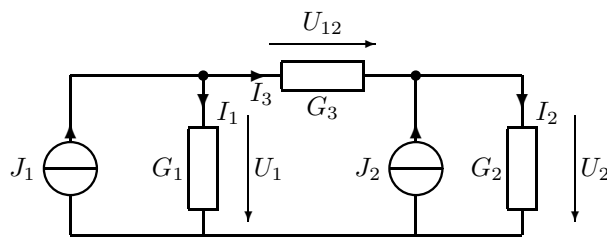
1.11 Systemaattiset piirianalyysimenetelmät



Kuva 78.



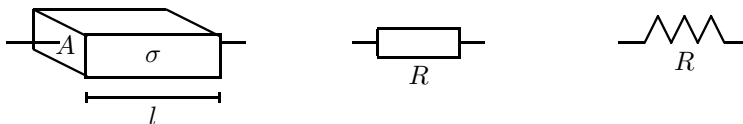
Kuva 79.



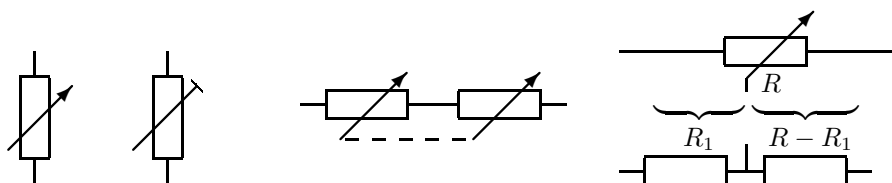
Kuva 80.

2 Passiiviset komponentit, sähkötekniikan materiaalit ja sähkömagnetiikka

2.1 Vastus, resistanssi ja johtavuus



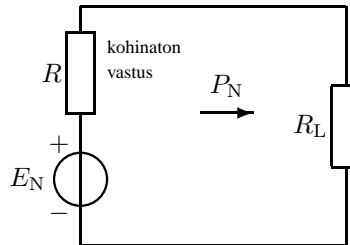
Kuva 81.



Kuva 82.



Kuva 83.

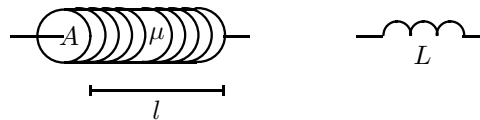


Kuva 84.

2.2 Kela, induktanssi ja permeabiliteetti



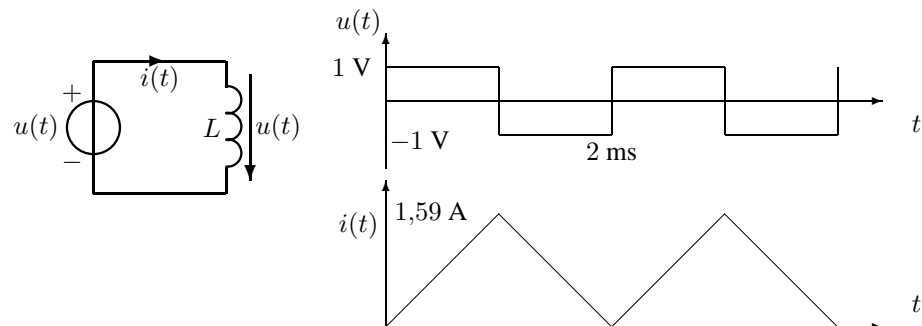
Kuva 85.



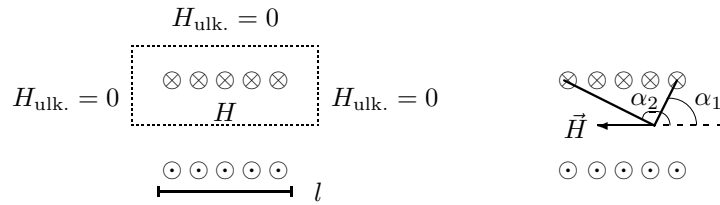
Kuva 86.



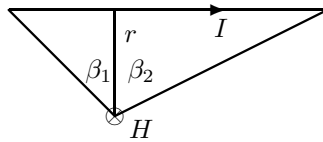
Kuva 88.



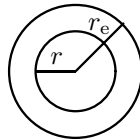
Kuva 89.



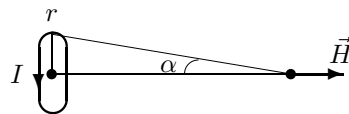
Kuva 90.



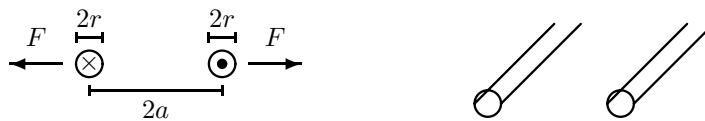
Kuva 91.



Kuva 92.

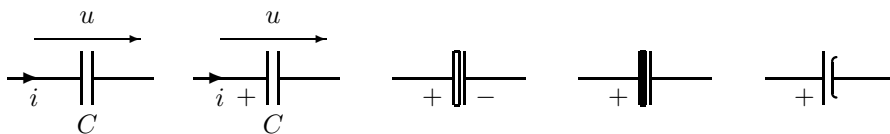


Kuva 93.



Kuva 94.

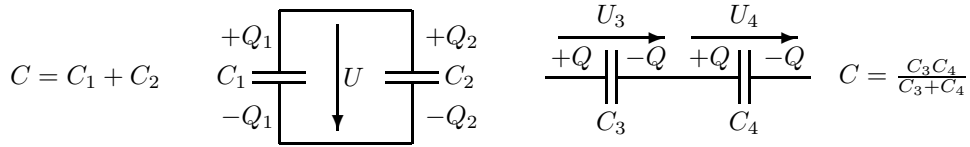
2.3 Kondensaattori, kapasitanssi ja permittiivisyys



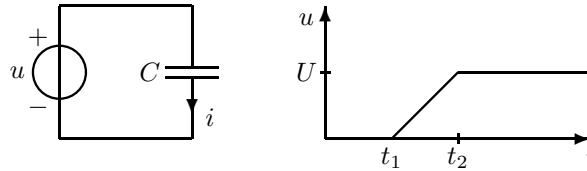
Kuva 95.



Kuva 96.



Kuva 97.



Kuva 98.



Kuva 99.

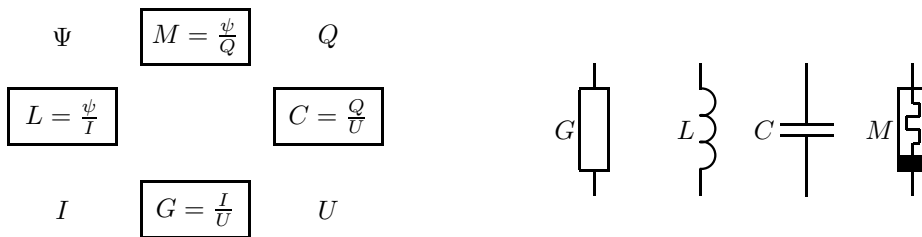


Kuva 100.



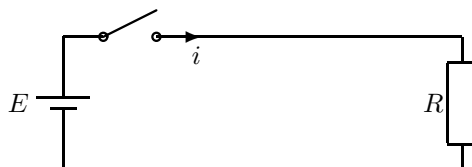
Kuva 101.

2.4 Memristori — se pitäisi keksiä

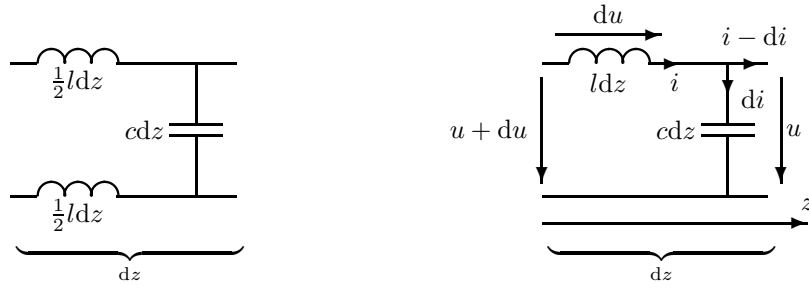


Kuva 102.

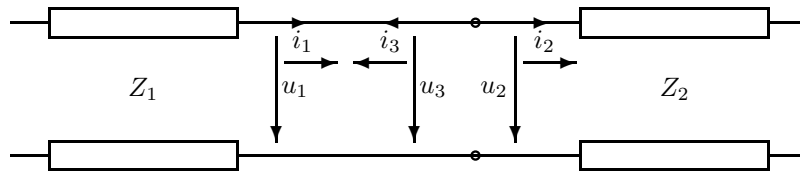
2.5 Siirtojohto, pitkä johto



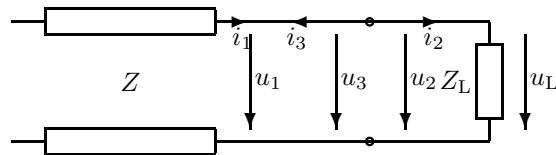
Kuva 103.



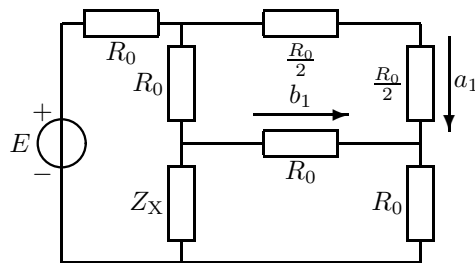
Kuva 104.



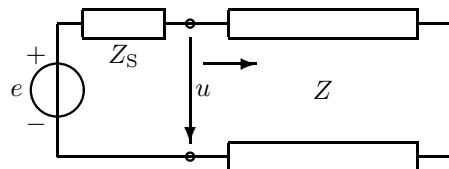
Kuva 105.



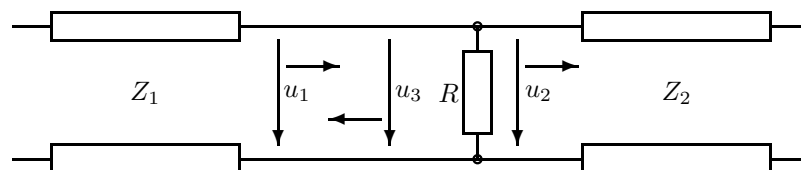
Kuva 106.



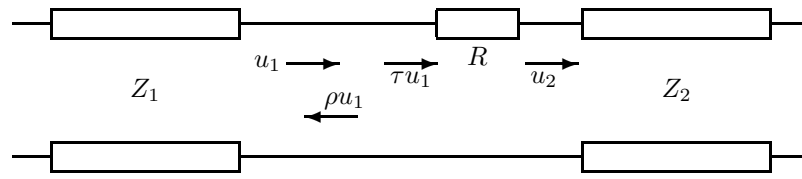
Kuva 107.



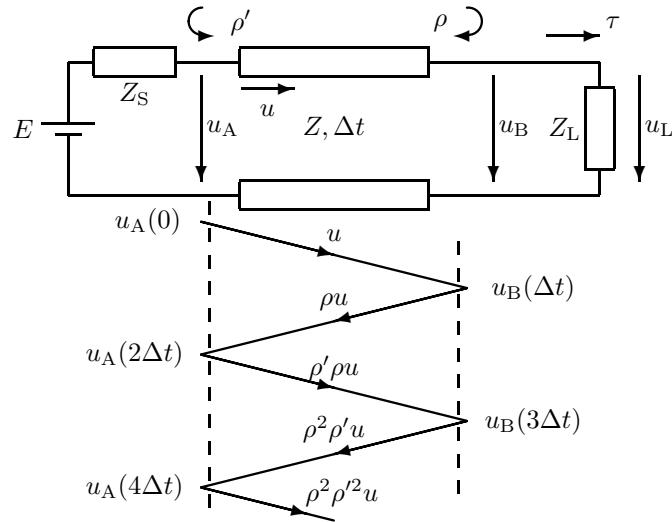
Kuva 108.



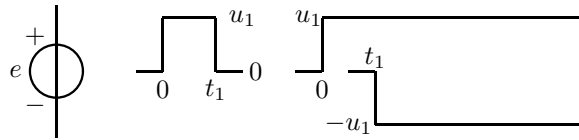
Kuva 109.



Kuva 110.

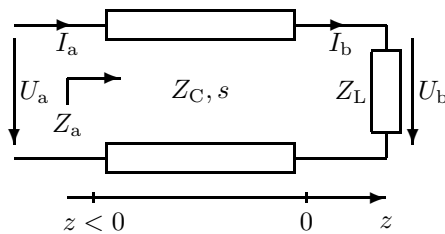


Kuva 111.

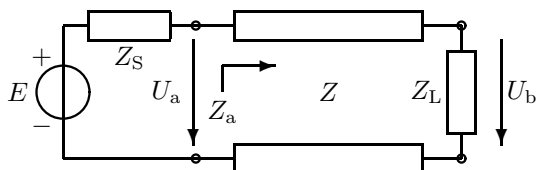


Kuva 112.

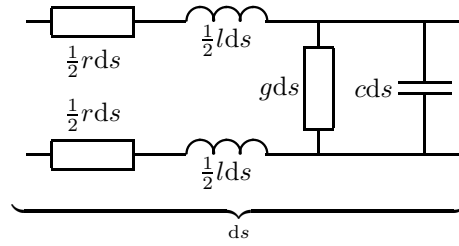
2.6 Sinimuotoiset aallot siirtojohdoilla



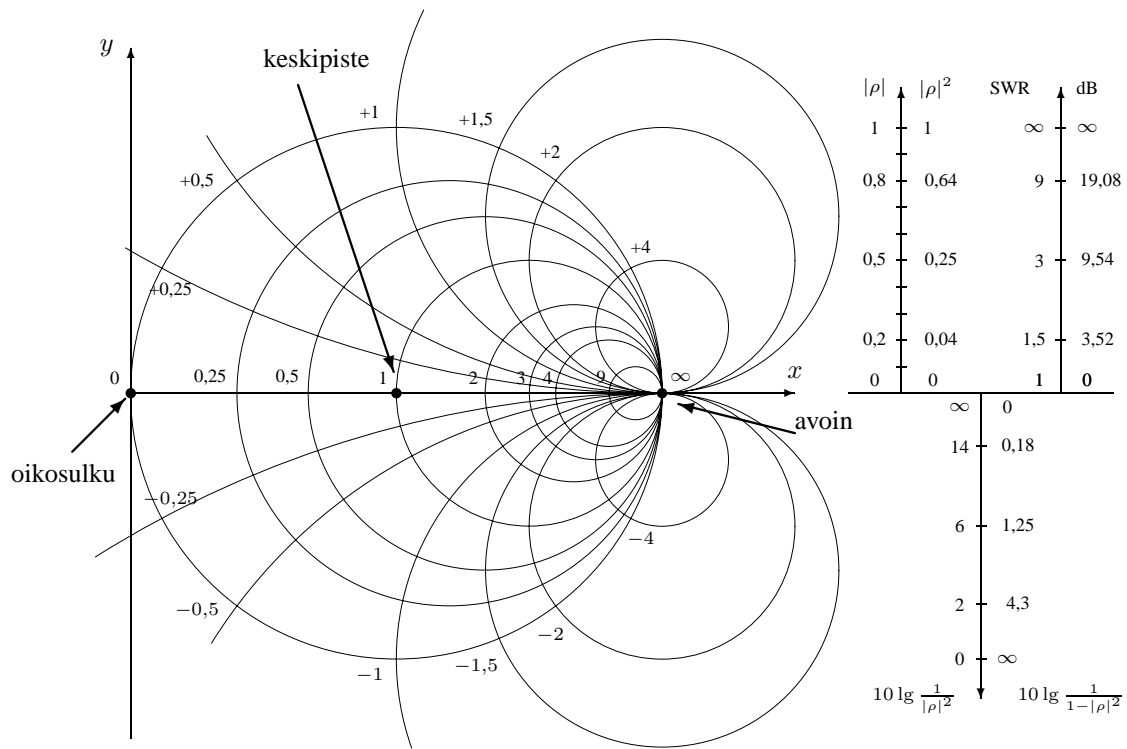
Kuva 113.



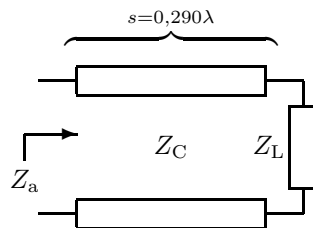
Kuva 114.



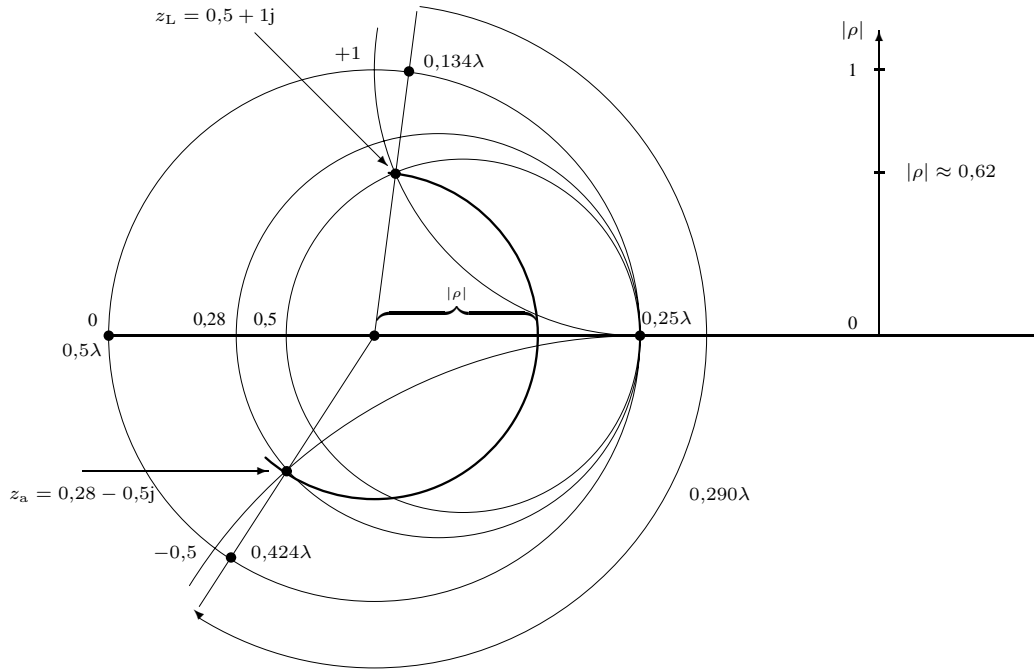
Kuva 115.



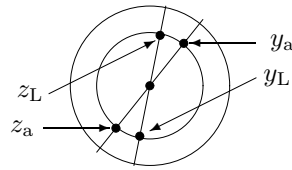
Kuva 119.



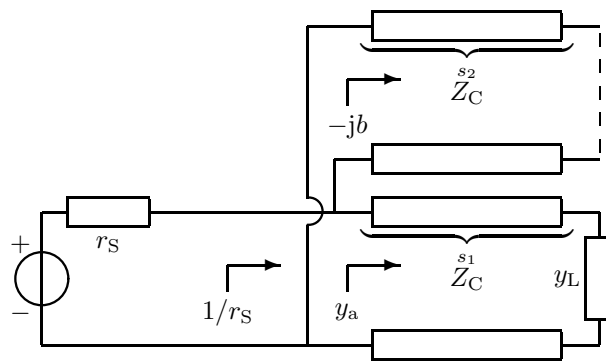
Kuva 120.



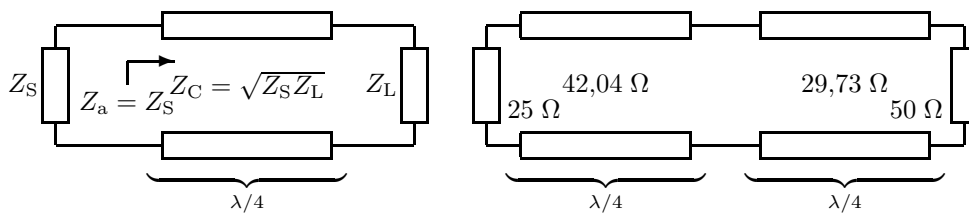
Kuva 121.



Kuva 122.

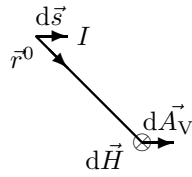


Kuva 123.

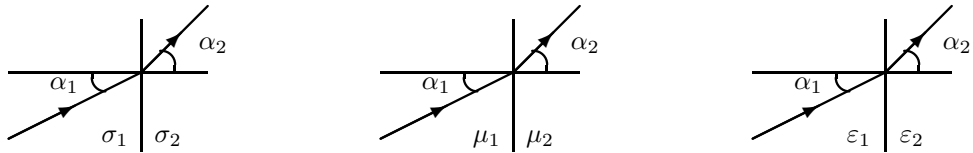


Kuva 124.

2.7 Sähkömagneetiikan matemaattinen perusta



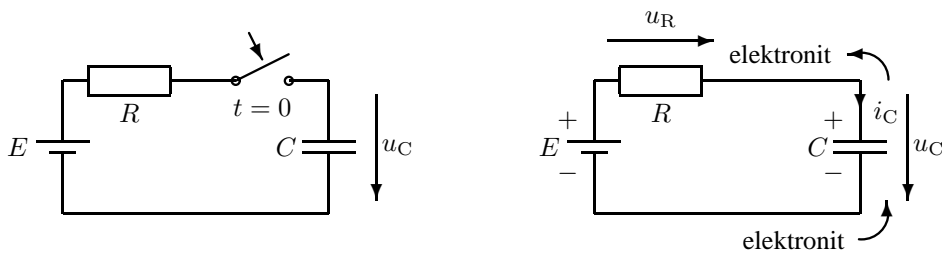
Kuva 126.



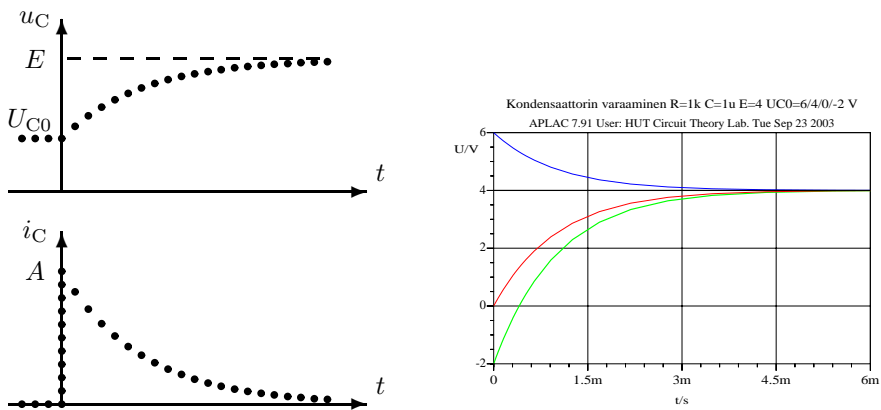
Kuva 127.

3 Muutosilmiöt, Laplace-muunnos ja Fourier-sarja

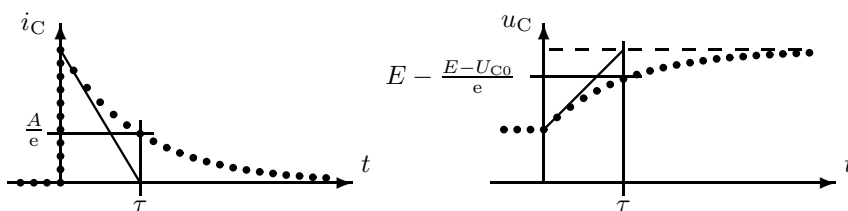
3.1 Muutosilmiöiden käsittely differentiaaliyhtälöillä



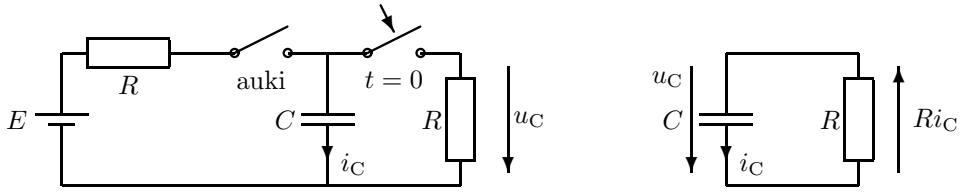
Kuva 128.



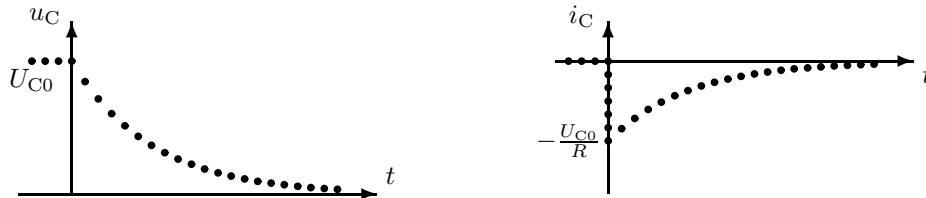
Kuva 129.



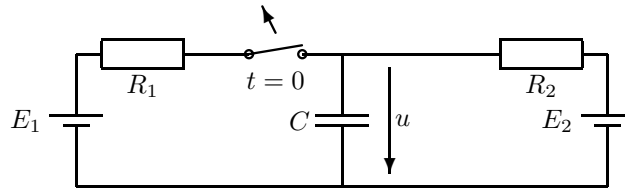
Kuva 130.



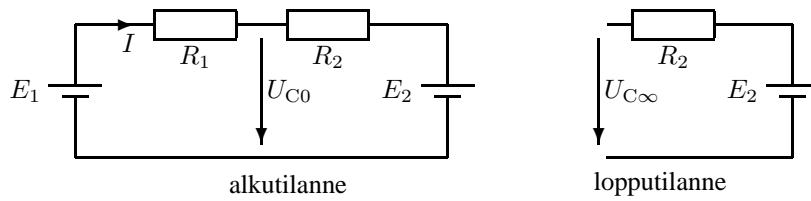
Kuva 131.



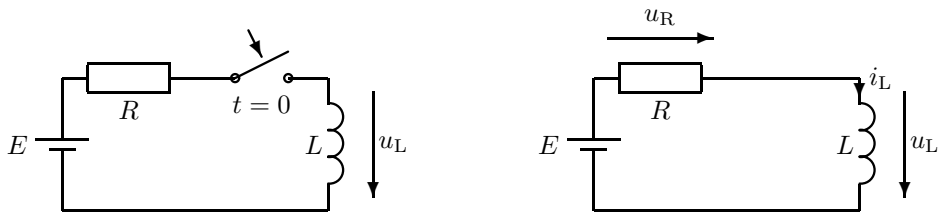
Kuva 132.



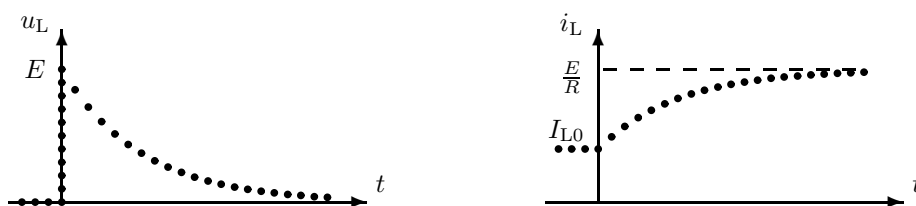
Kuva 133.



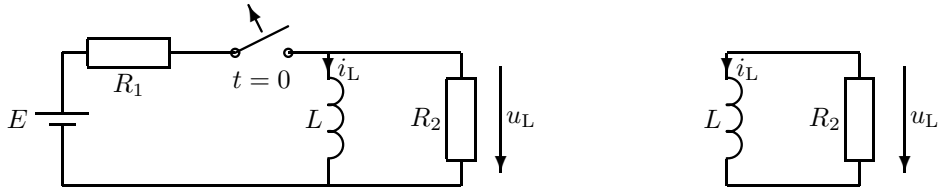
Kuva 134.



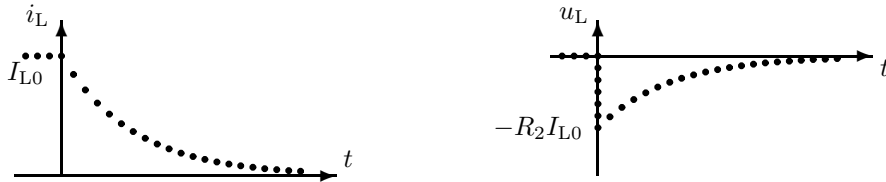
Kuva 135.



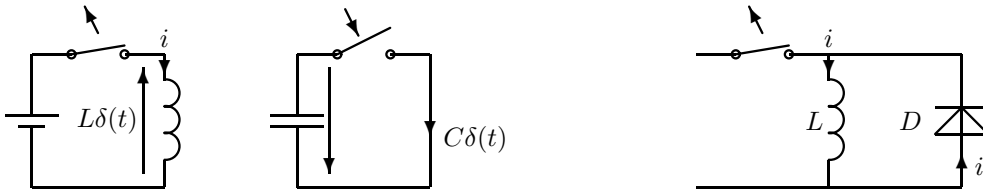
Kuva 136.



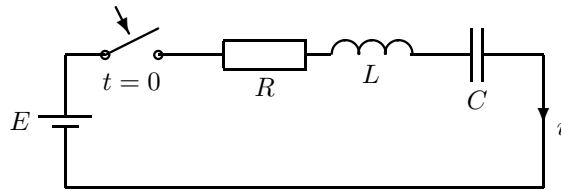
Kuva 137.



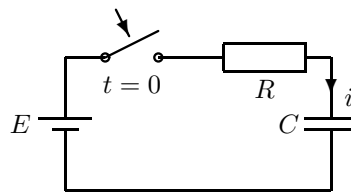
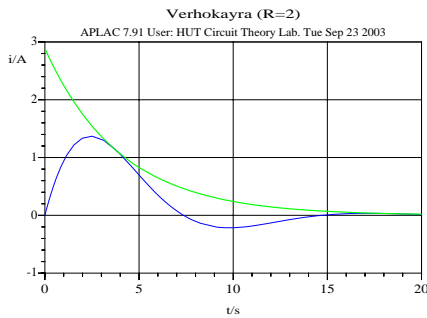
Kuva 138.



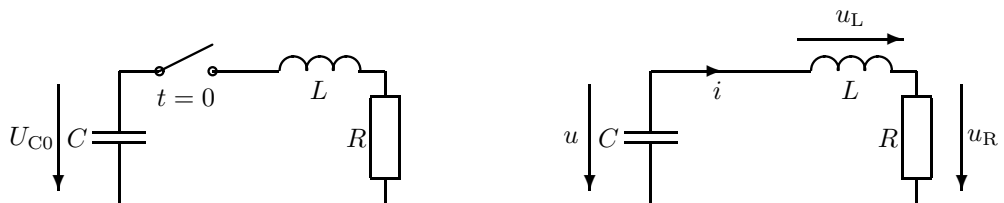
Kuva 139.



Kuva 140.

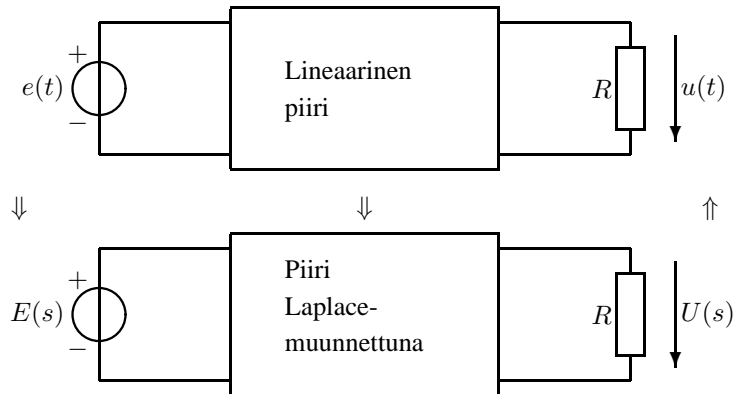


Kuva 142.



Kuva 143.

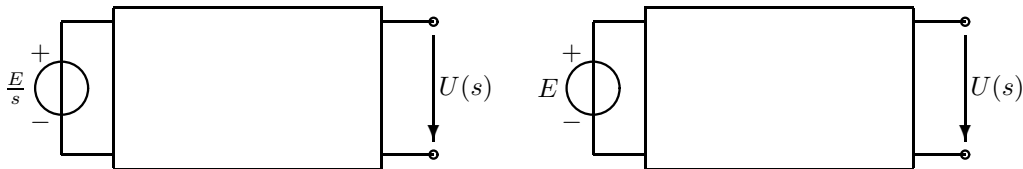
3.2 Laplace-muunnos sähkötekniikassa



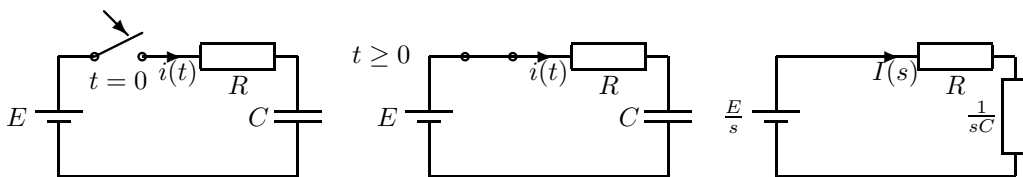
Kuva 144.



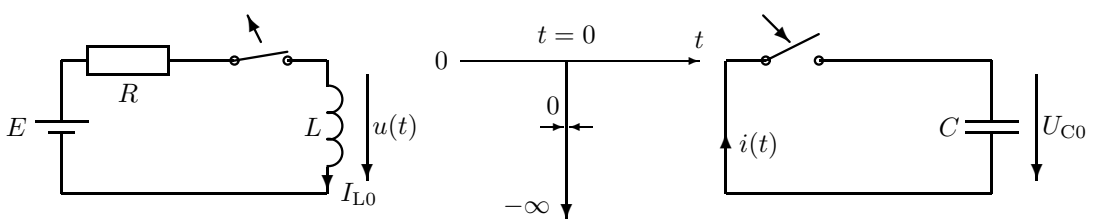
Kuva 145.



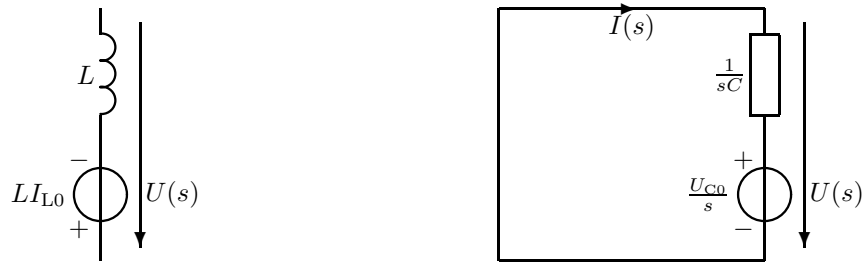
Kuva 146.



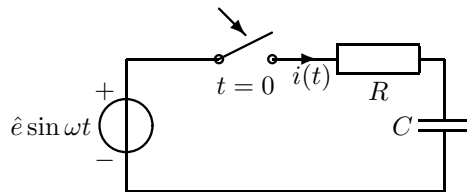
Kuva 147.



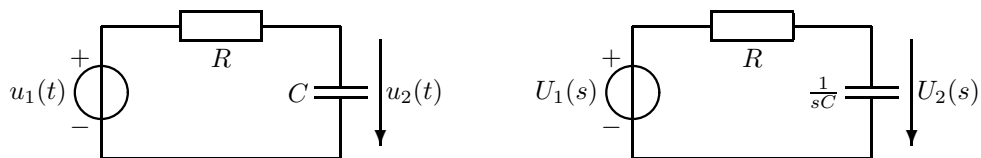
Kuva 148.



Kuva 149.

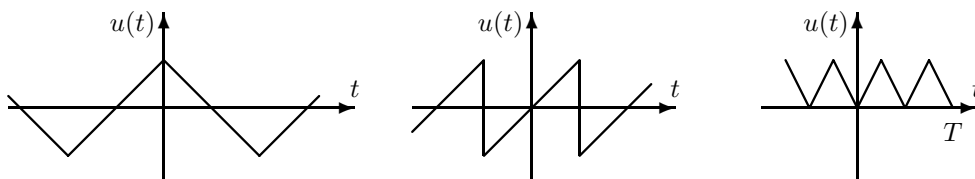


Kuva 150.

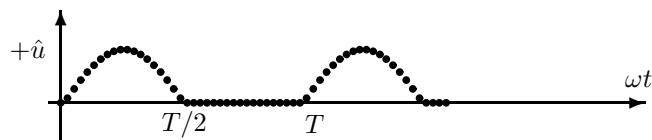


Kuva 152.

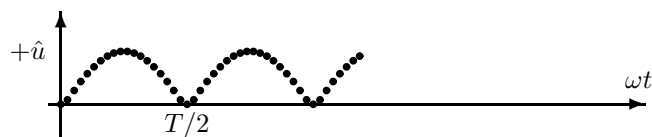
3.3 Fourier-sarja, Fourier-muunnos ja z-muunnos



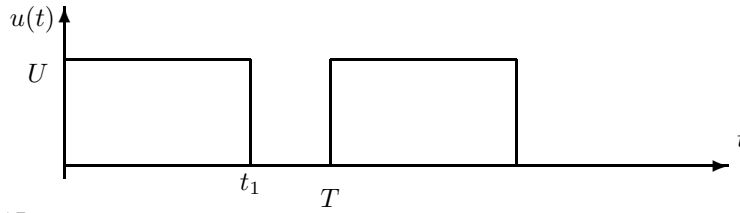
Kuva 154.



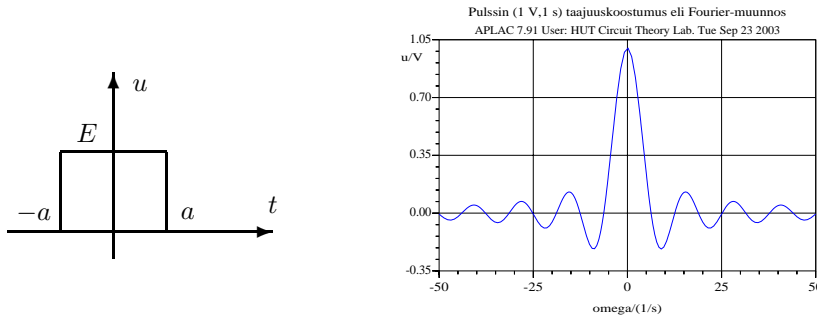
Kuva 155.



Kuva 156.



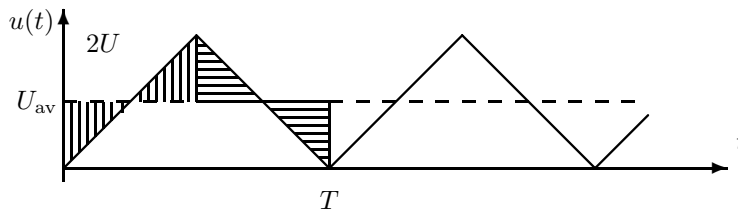
Kuva 157.



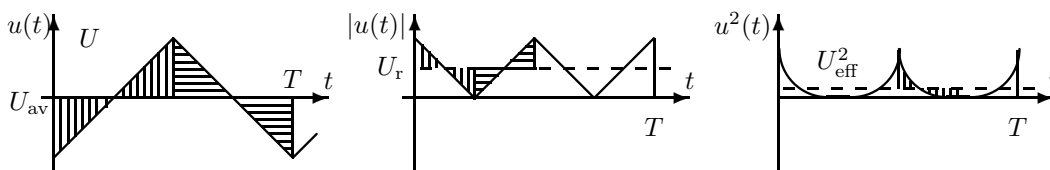
Kuva 158.

4 Vaihtovirtapiirit, osoitinlaskenta ja sähkövoimatekniikka

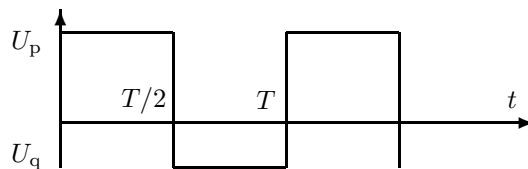
4.1 Jaksolliset vaihtovirrat



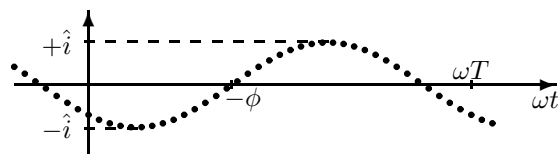
Kuva 159.



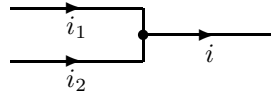
Kuva 160.



Kuva 161.

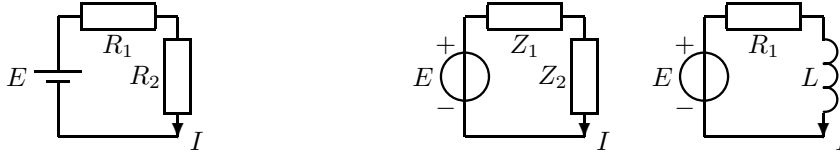


Kuva 162.

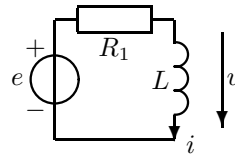


Kuva 163.

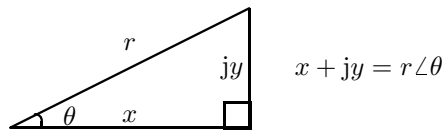
4.2 Osoitinlaskenta, kompleksiluvut



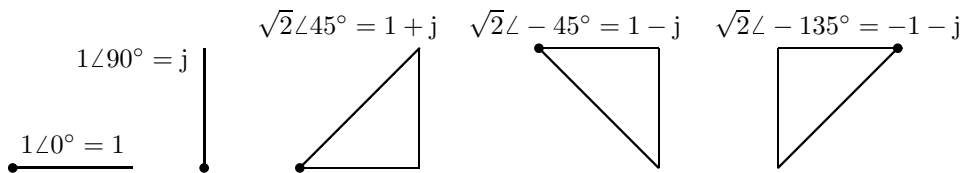
Kuva 164.



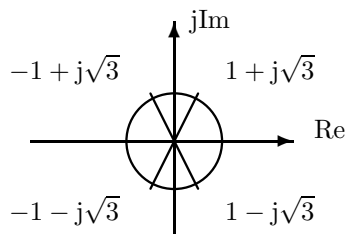
Kuva 165.



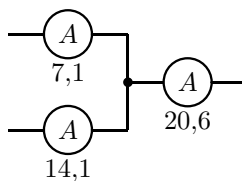
Kuva 166.



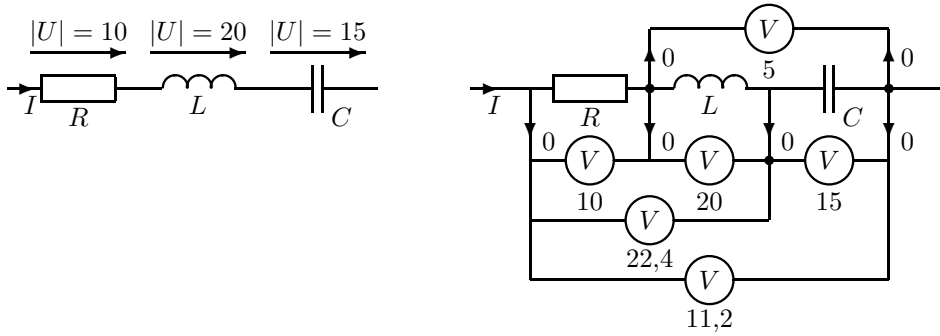
Kuva 167.



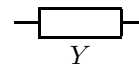
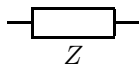
Kuva 168.



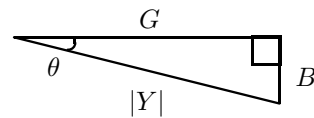
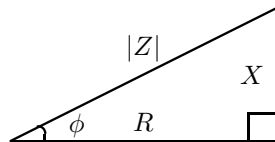
Kuva 169.



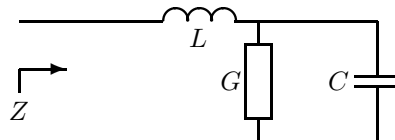
Kuva 171.



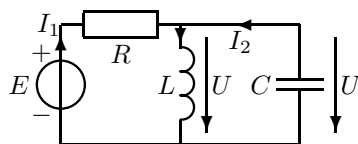
Kuva 173.



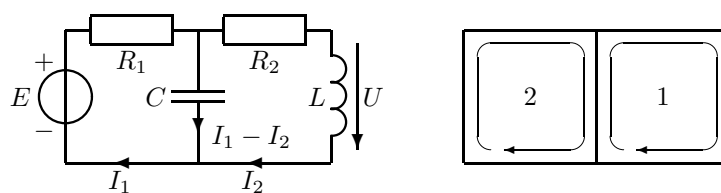
Kuva 174.



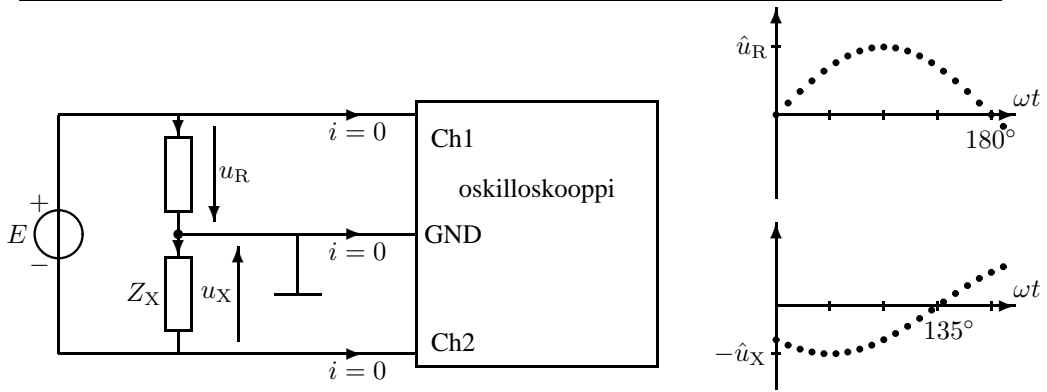
Kuva 175.



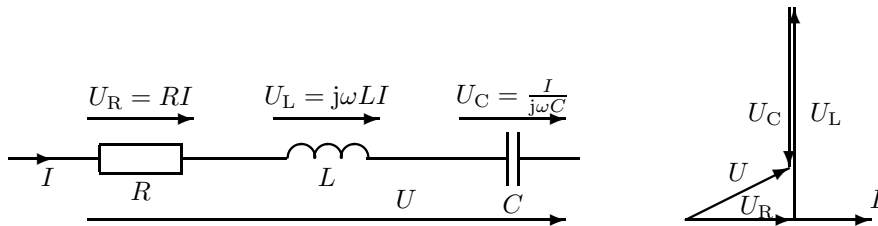
Kuva 176.



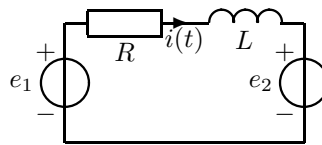
Kuva 177.



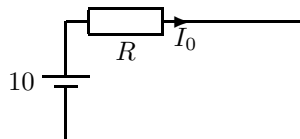
Kuva 178.



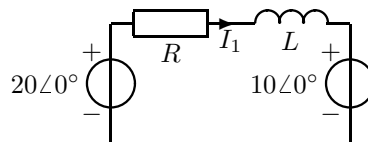
Kuva 179.



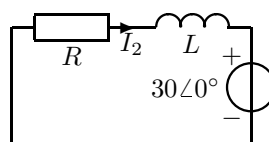
Kuva 180.



Kuva 181.

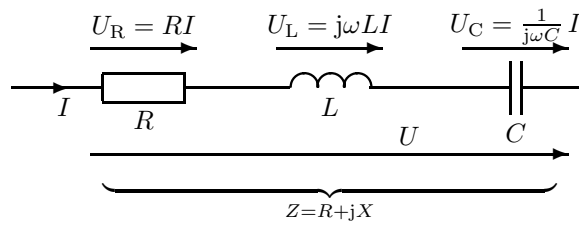


Kuva 182.

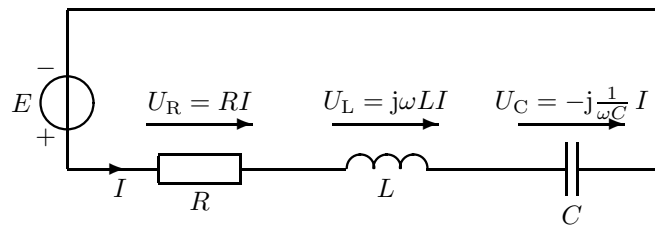


Kuva 183.

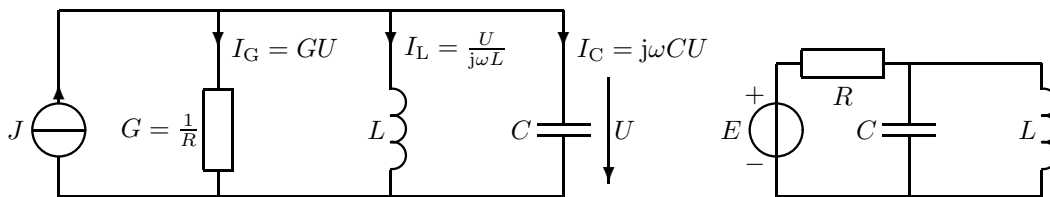
4.3 Resonanssipiirit



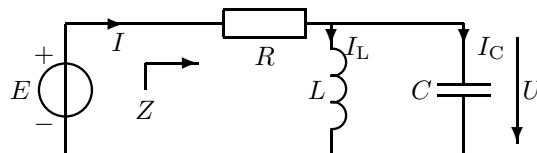
Kuva 184.



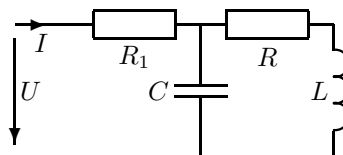
Kuva 185.



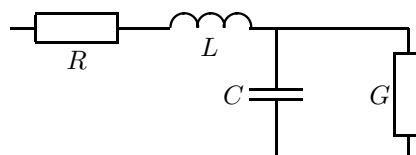
Kuva 187.



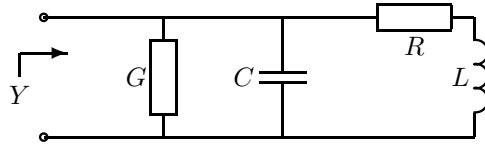
Kuva 189.



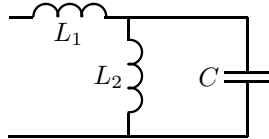
Kuva 190.



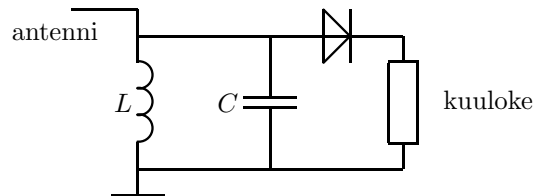
Kuva 191.



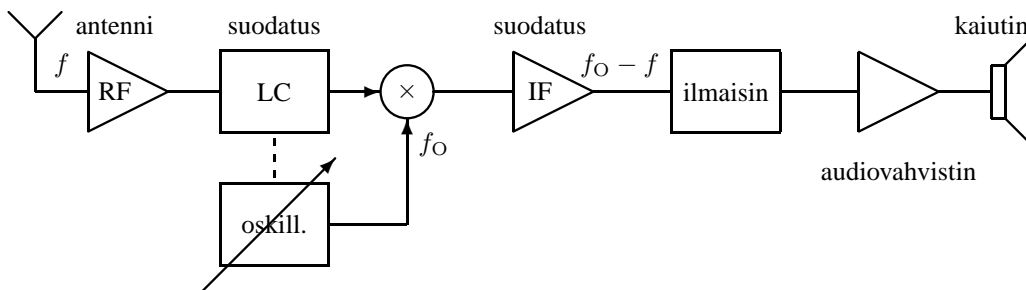
Kuva 192.



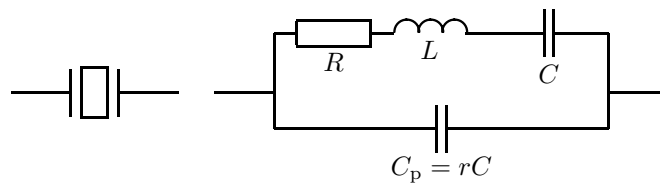
Kuva 194.



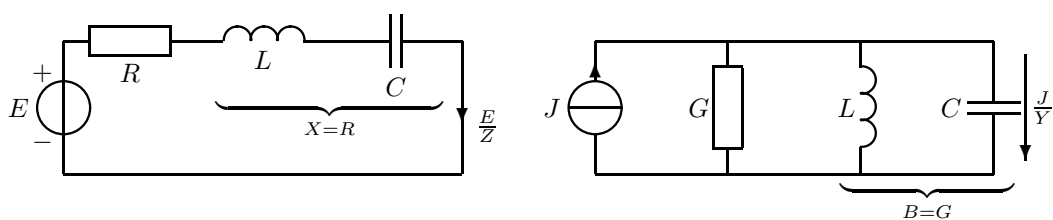
Kuva 196.



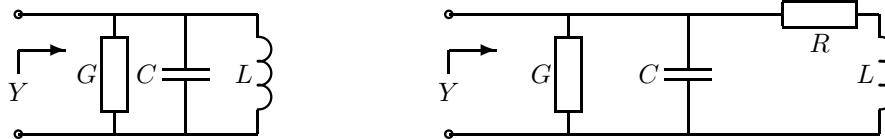
Kuva 197.



Kuva 198.

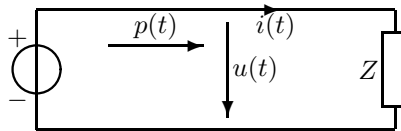


Kuva 200.

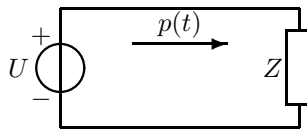


Kuva 201.

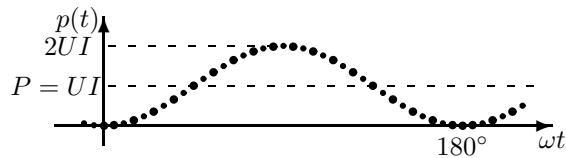
4.4 Vaihtovirran teho ja kompleksinen teho



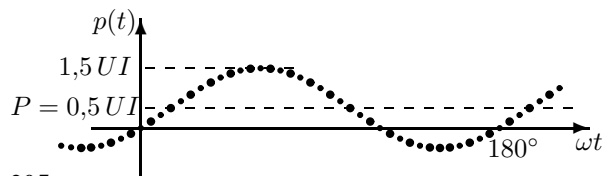
Kuva 202.



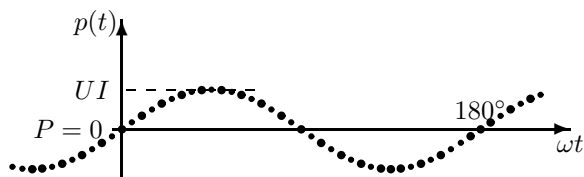
Kuva 203.



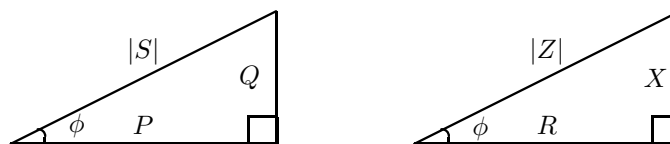
Kuva 204.



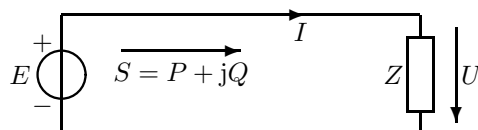
Kuva 205.



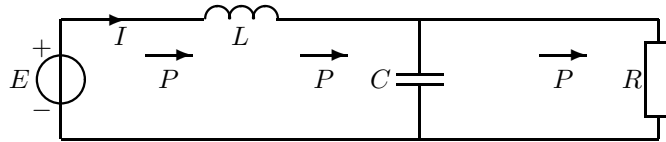
Kuva 206.



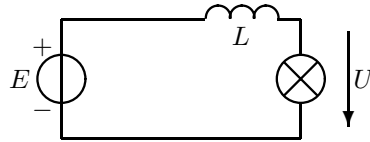
Kuva 207.



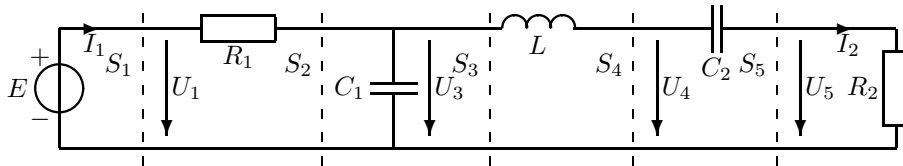
Kuva 208.



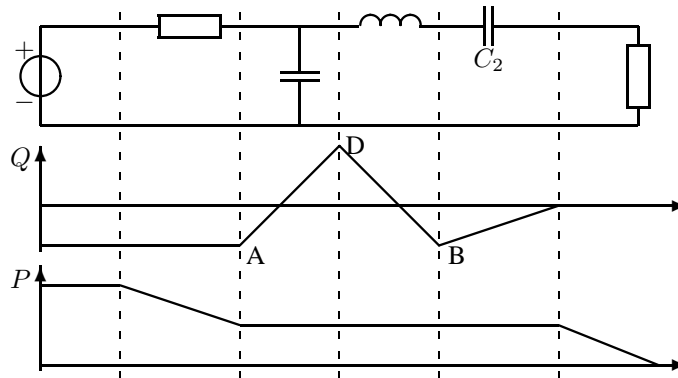
Kuva 209.



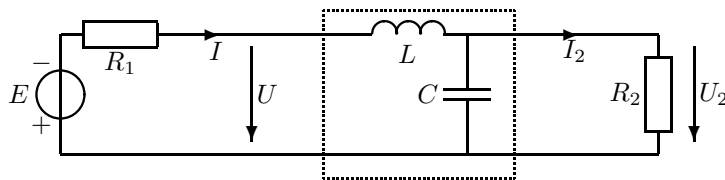
Kuva 210.



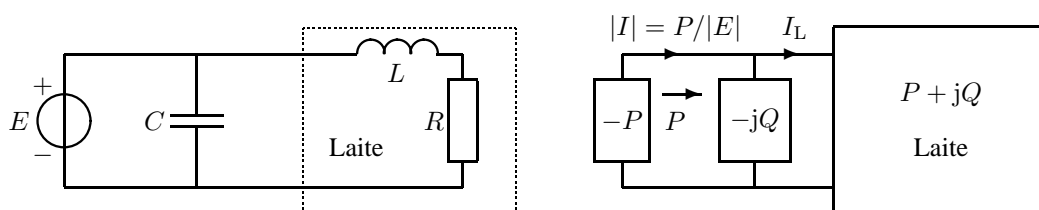
Kuva 211.



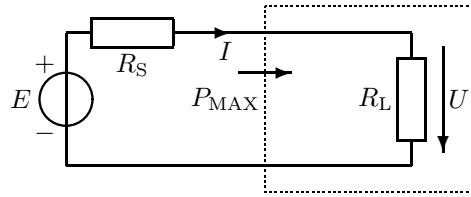
Kuva 212.



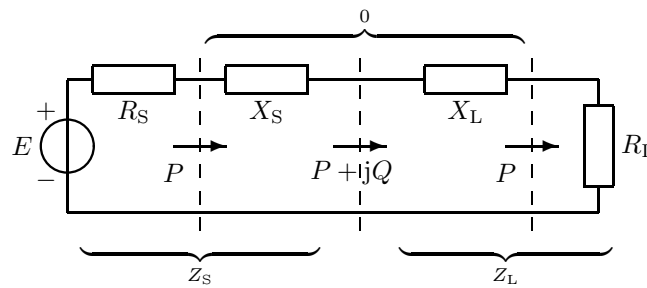
Kuva 213.



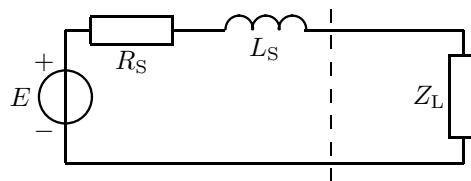
Kuva 214.



Kuva 215.



Kuva 217.

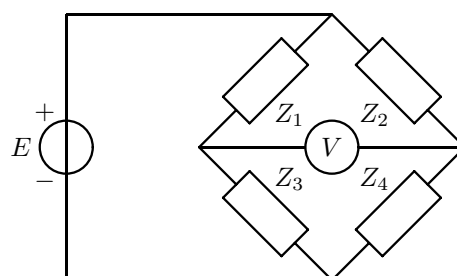


Kuva 218.

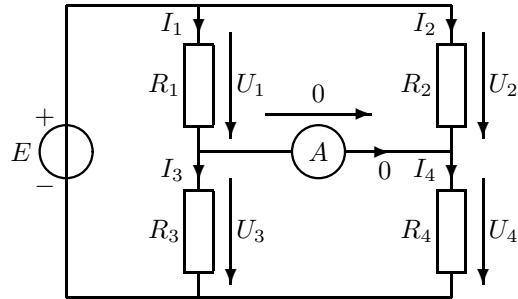


Kuva 219.

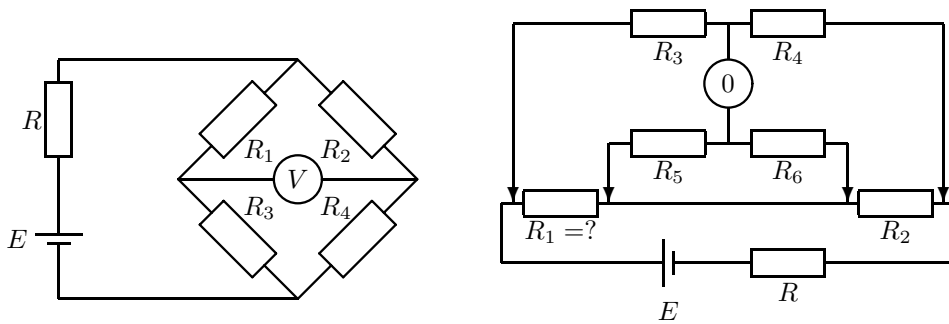
4.5 Mittasillat tarkkuusmittauksiin



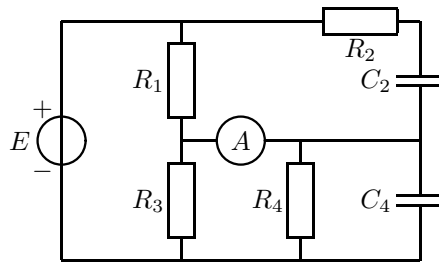
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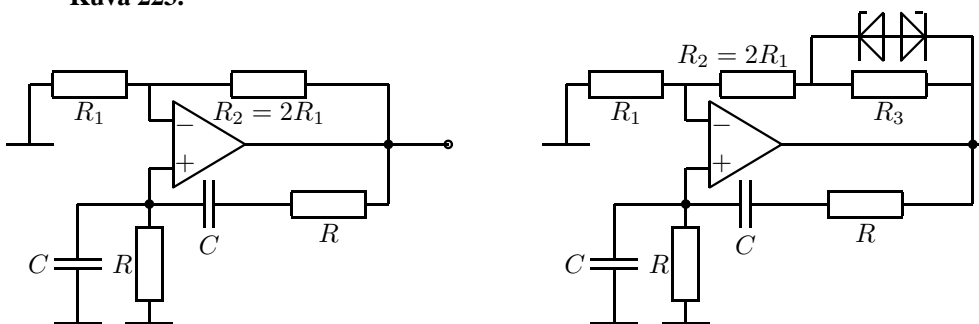
Kuva 221.



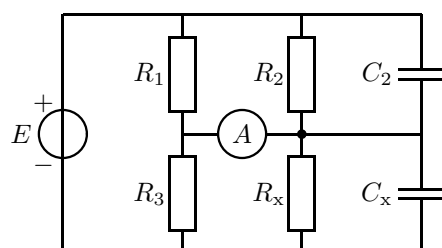
Kuva 222.



Kuva 223.

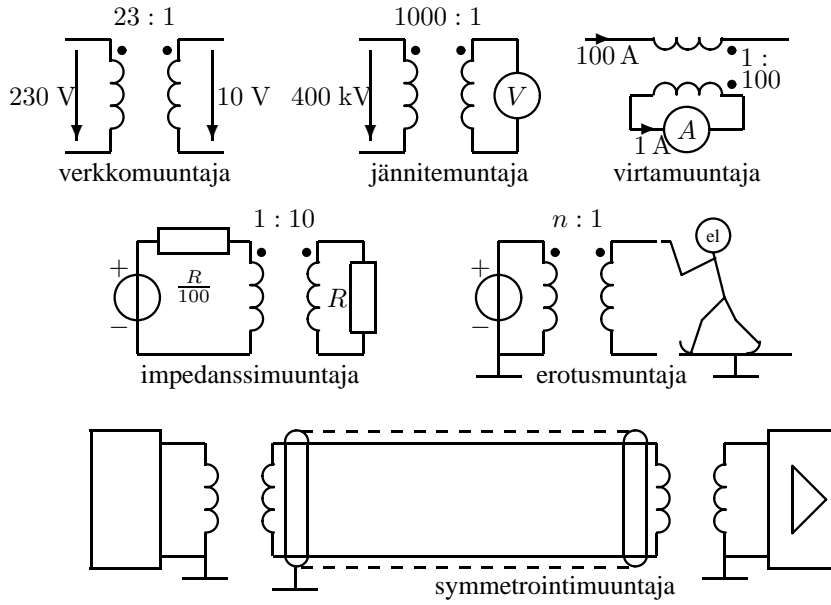


Kuva 224.



Kuva 225.

4.6 Muuntajat



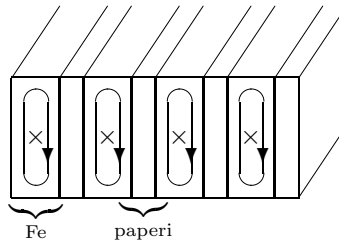
Kuva 226.



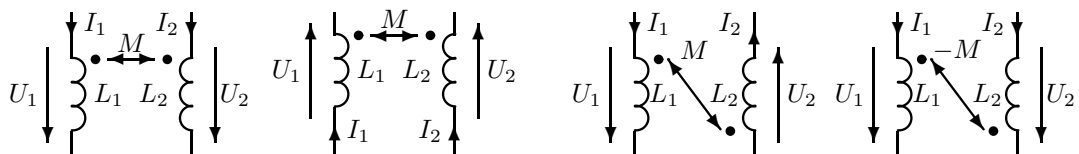
Kuva 227.



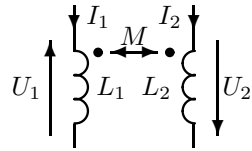
Kuva 228.



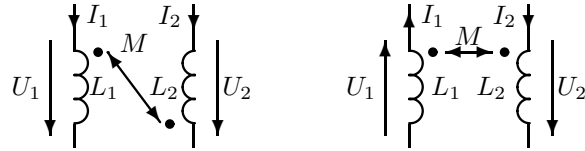
Kuva 229.



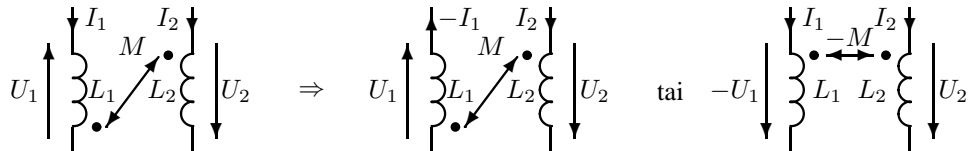
Kuva 230.



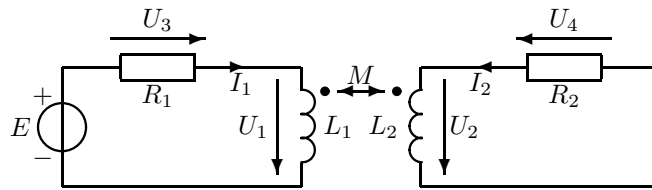
Kuva 231.



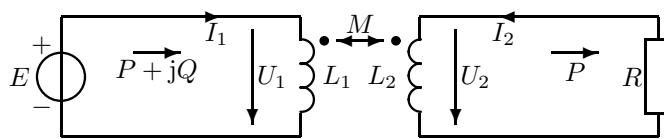
Kuva 232.



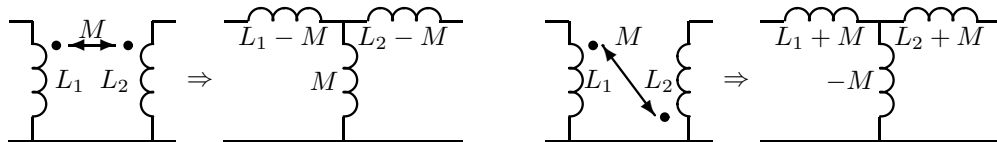
Kuva 233.



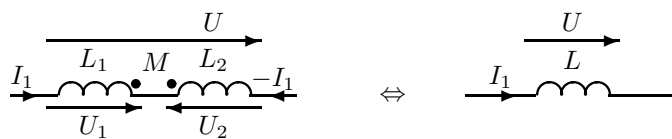
Kuva 234.



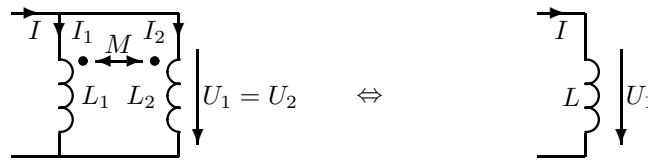
Kuva 235.



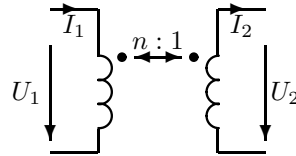
Kuva 236.



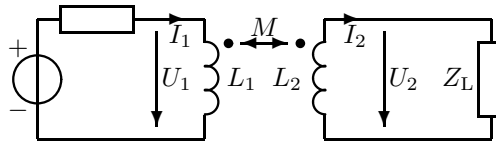
Kuva 237.



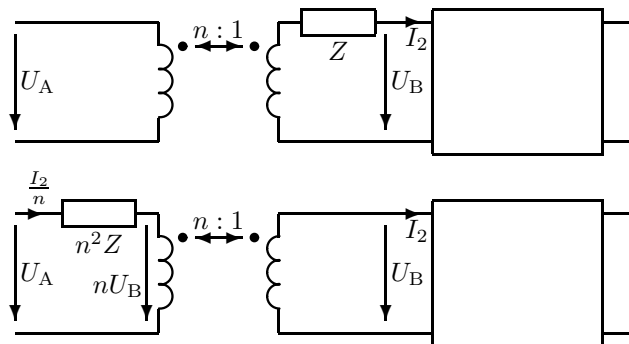
Kuva 238.



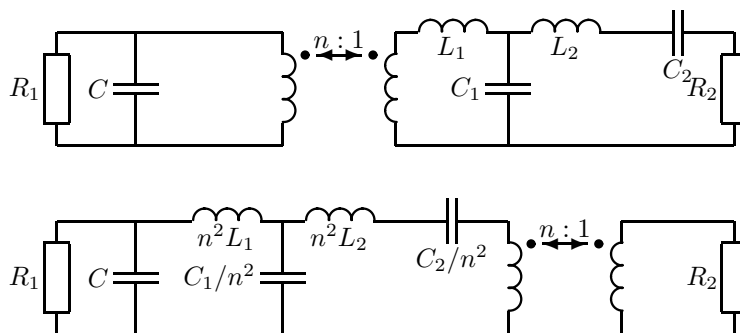
Kuva 239.



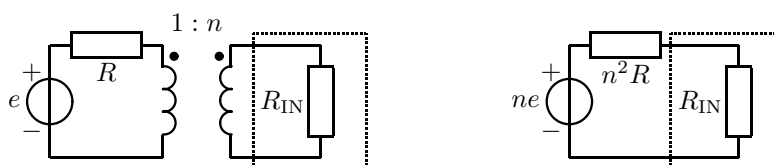
Kuva 240.



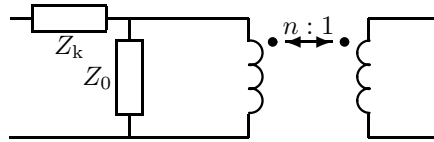
Kuva 241.



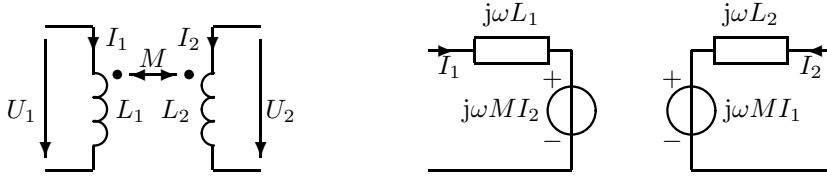
Kuva 242.



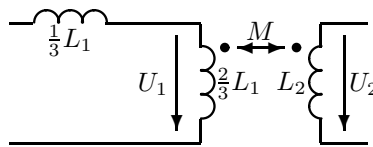
Kuva 243.



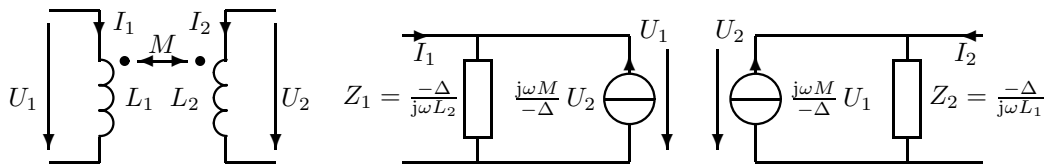
Kuva 244.



Kuva 245.

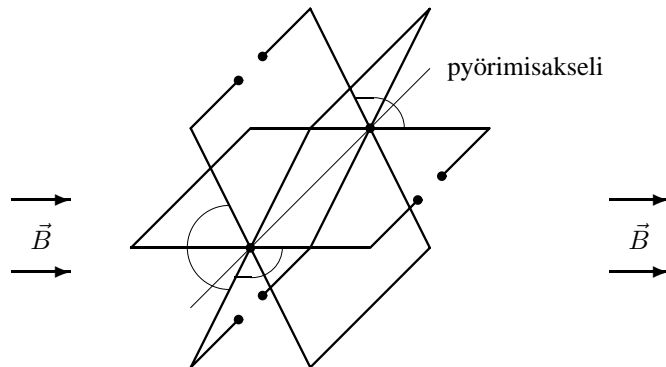


Kuva 246.

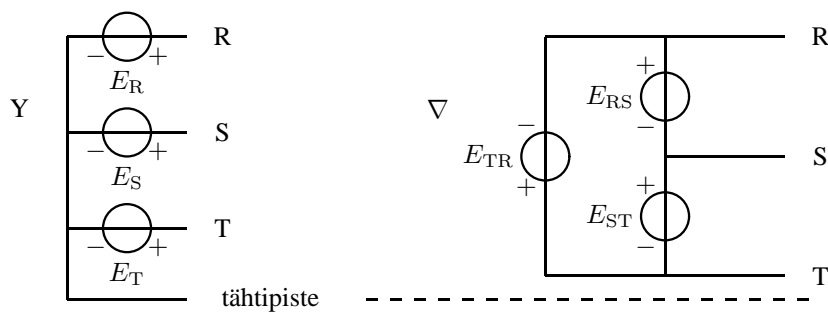


Kuva 247.

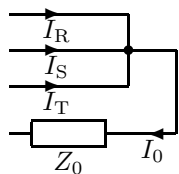
4.7 Kolmivaihejärjestelmä ja sähkö energian lähteenä



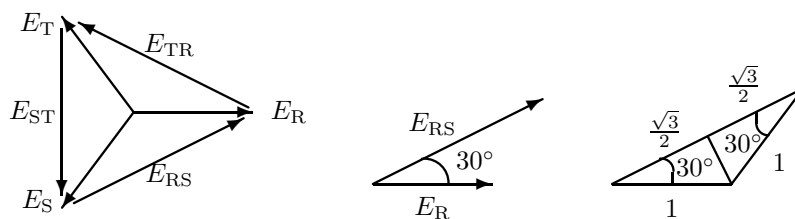
Kuva 248.



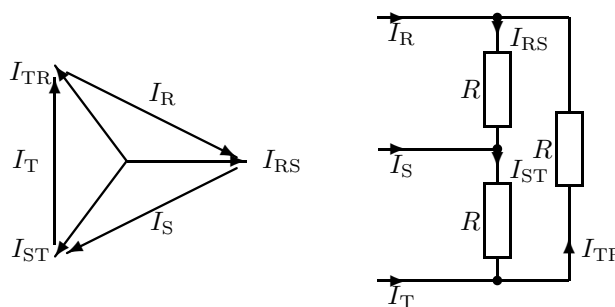
Kuva 249.



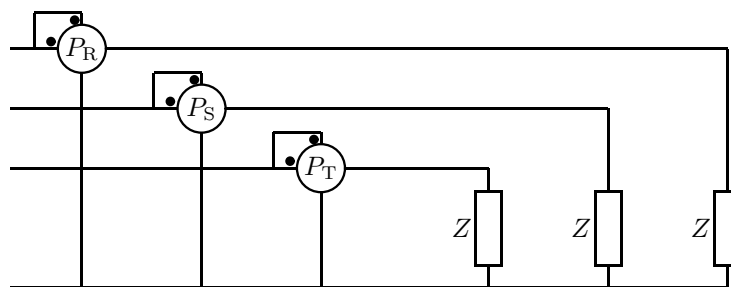
Kuva 250.



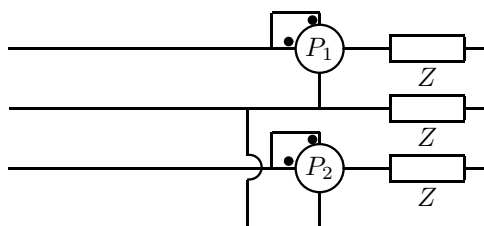
Kuva 251.



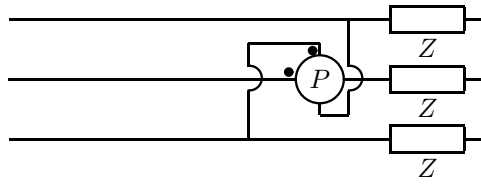
Kuva 252.



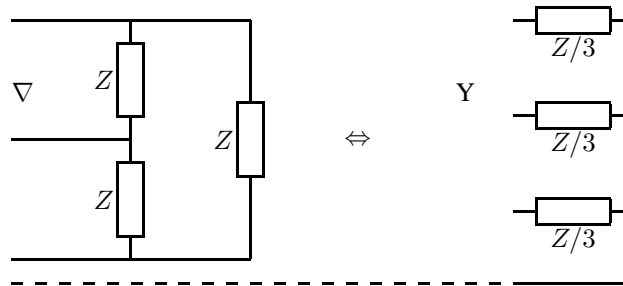
Kuva 253.



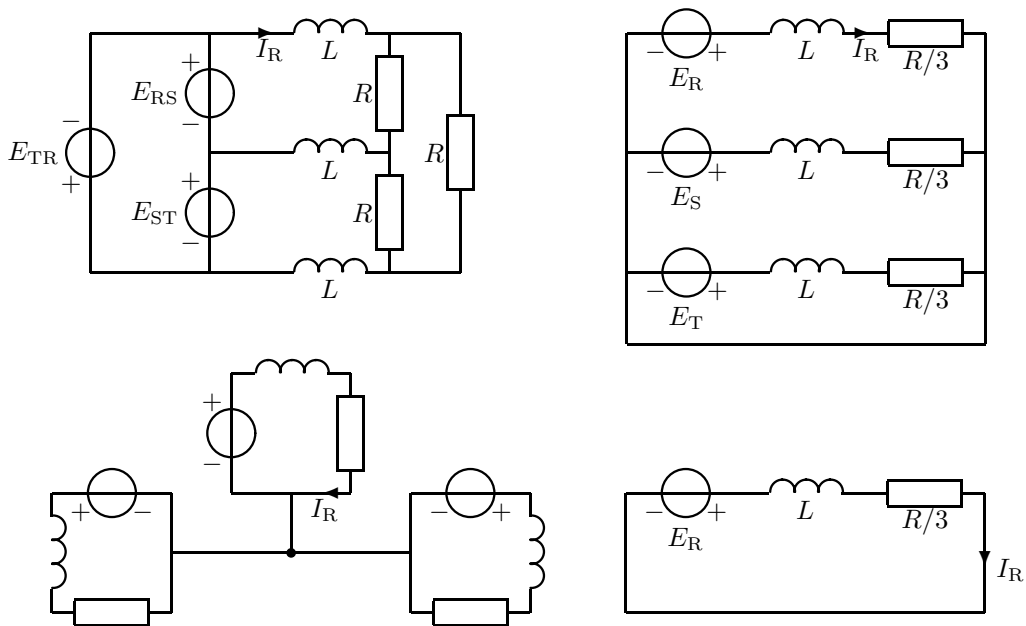
Kuva 254.



Kuva 255.



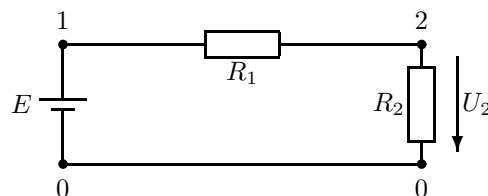
Kuva 256.



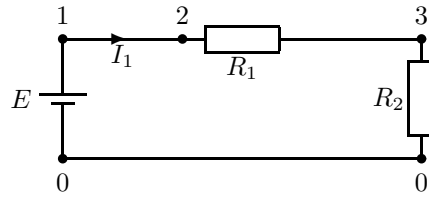
Kuva 257.

5 Piirisimulointiohjelmat

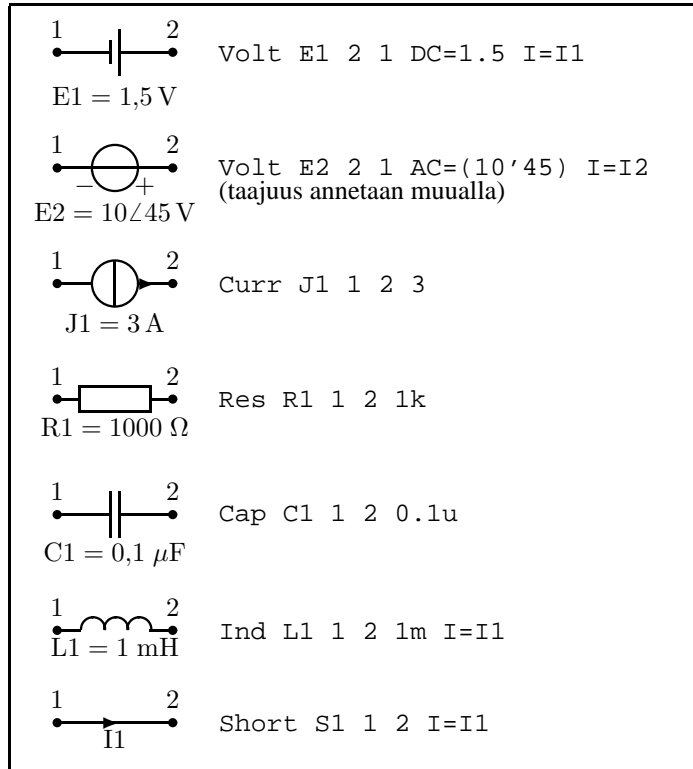
5.1 Yleistä



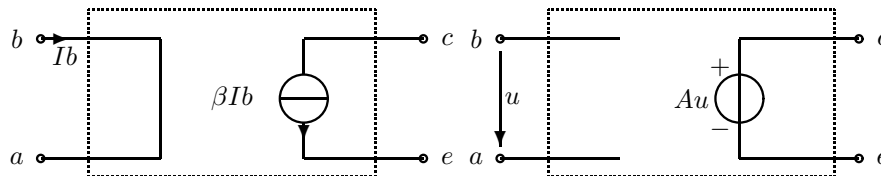
Kuva 258.



Kuva 259.



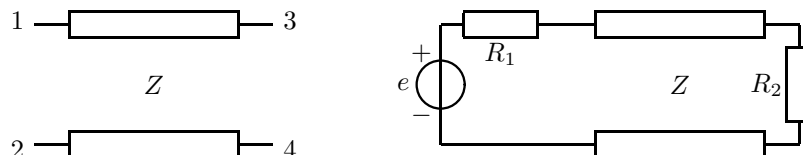
Kuva 260.



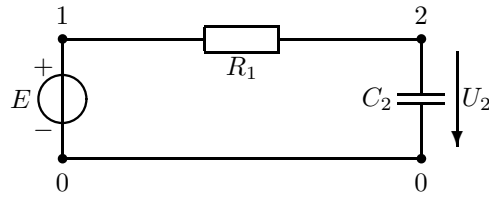
Kuva 261.



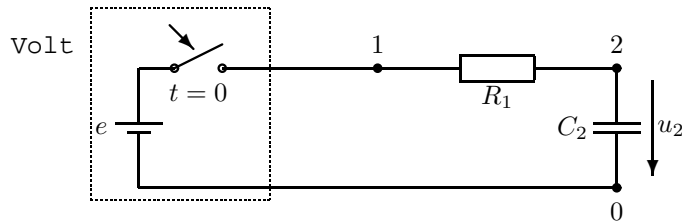
Kuva 262.



Kuva 263.



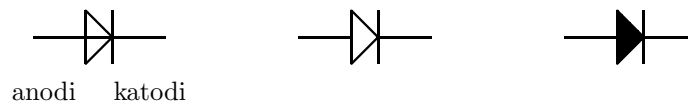
Kuva 264.



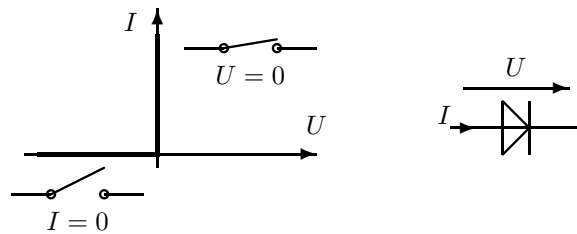
Kuva 266.

6 Diodi

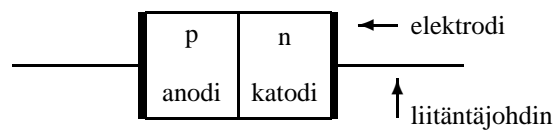
6.1 Diodityypit



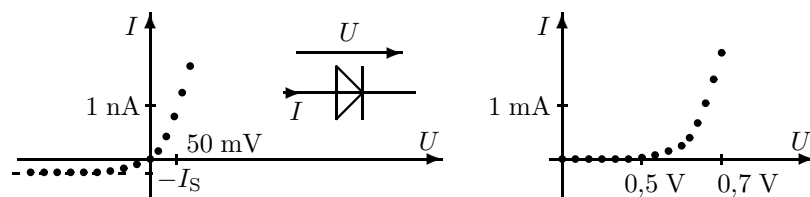
Kuva 268.



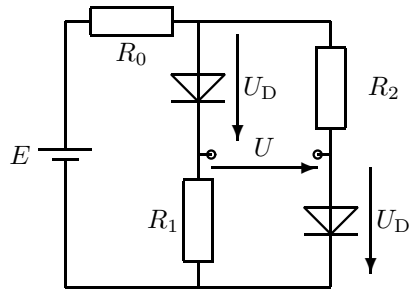
Kuva 269.



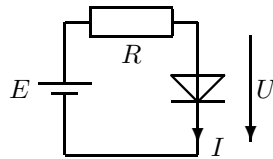
Kuva 270.



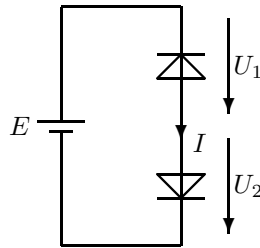
Kuva 271.



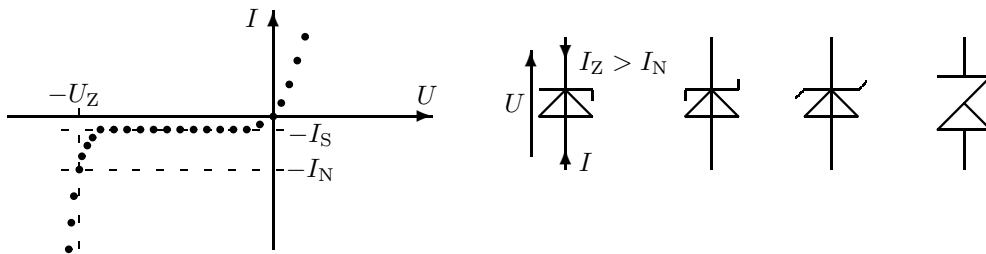
Kuva 273.



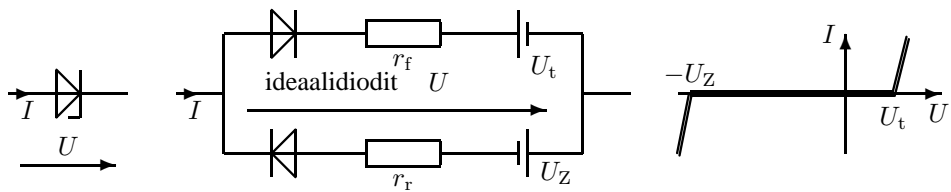
Kuva 274.



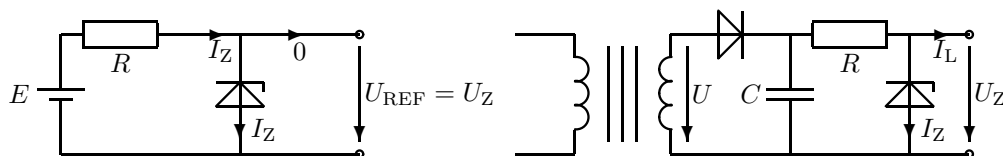
Kuva 275.



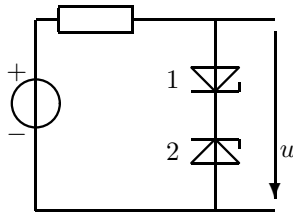
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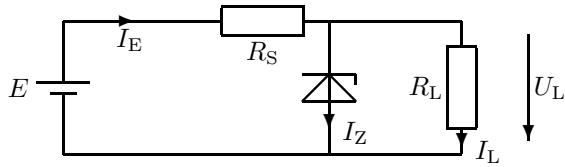
Kuva 277.



Kuva 278.



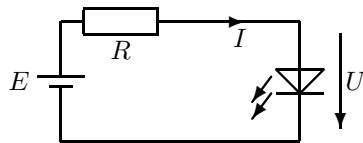
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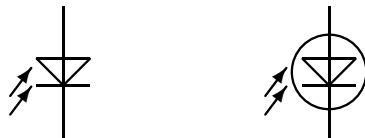
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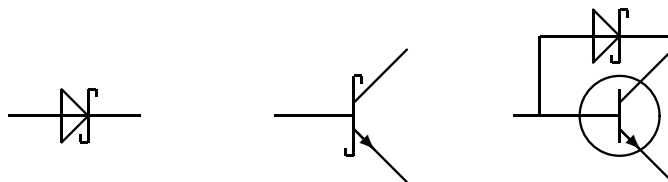
Kuva 281.



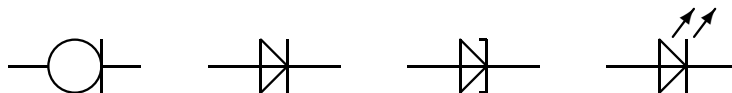
Kuva 282.



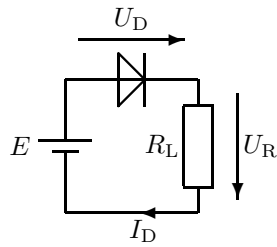
Kuva 283.



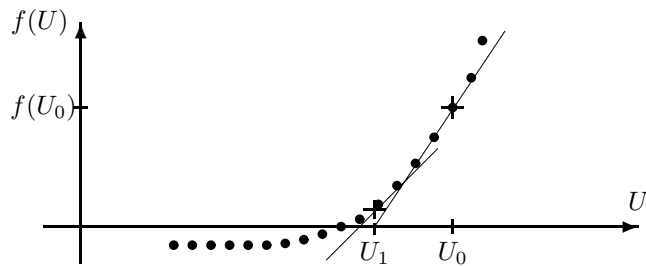
Kuva 284.



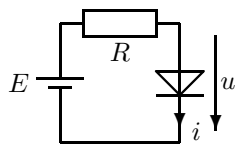
Kuva 285.



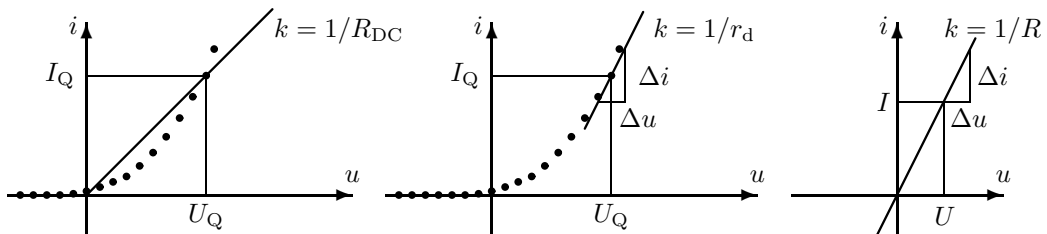
Kuva 286.



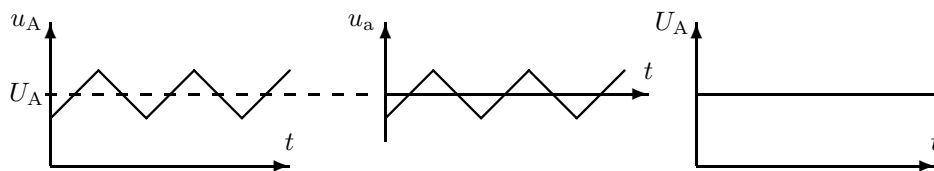
Kuva 287.



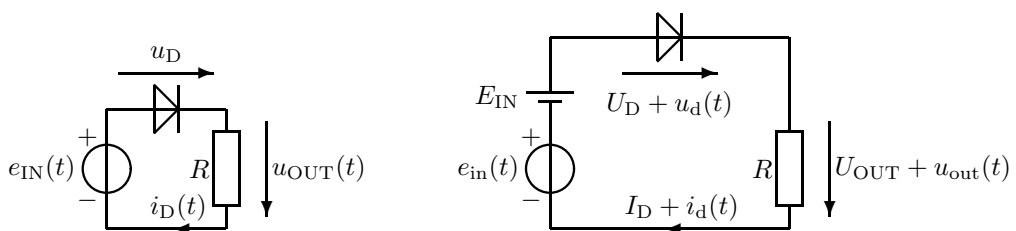
Kuva 288.



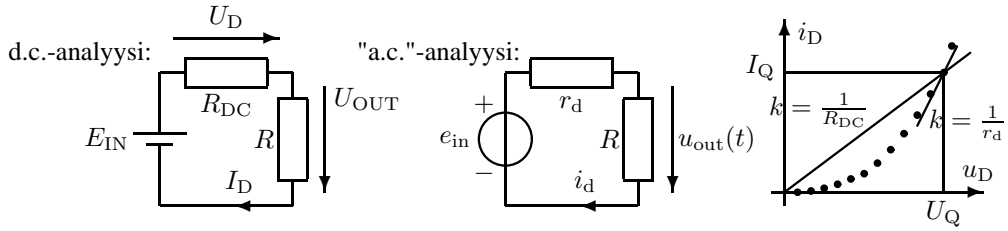
Kuva 289.



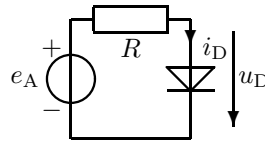
Kuva 290.



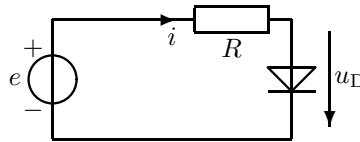
Kuva 291.



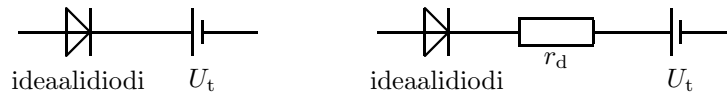
Kuva 292.



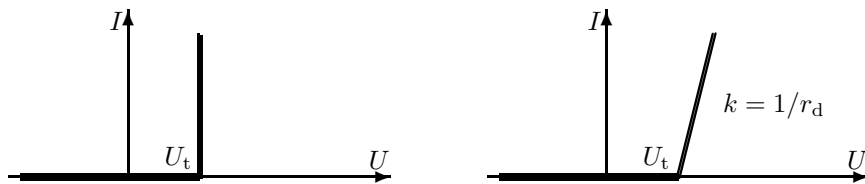
Kuva 293.



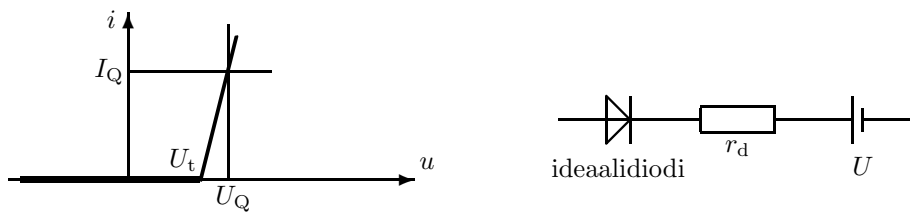
Kuva 294.



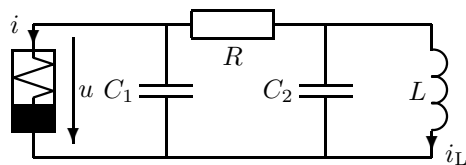
Kuva 295.



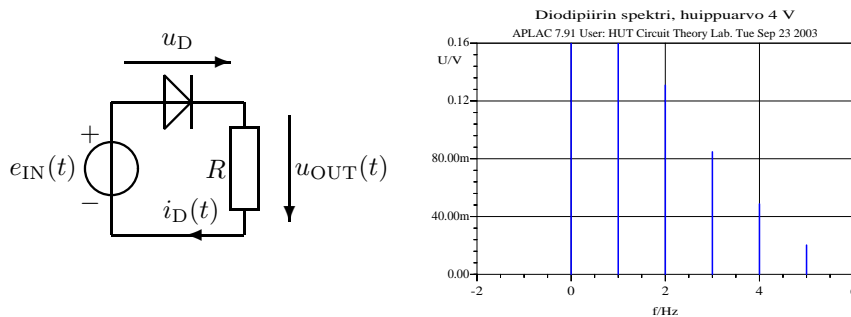
Kuva 296.



Kuva 297.



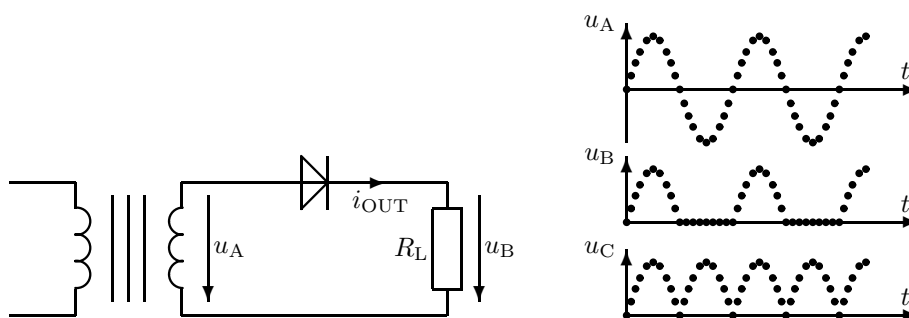
Kuva 298.



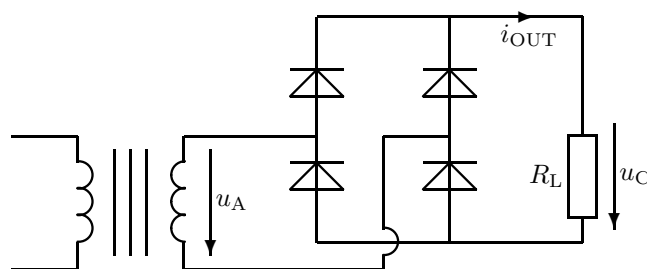
Kuva 301.

7 Tasasuuntaajat ja tehollähteet

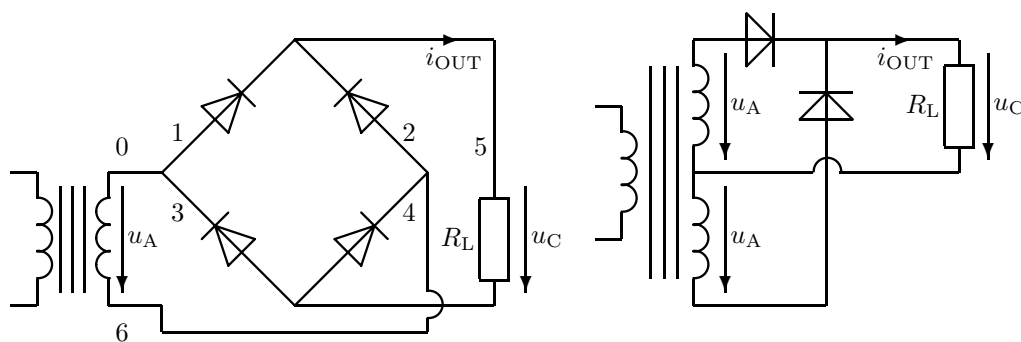
7.1 Puoliaalto- ja kokoaaltotasasuuntaus



Kuva 302.



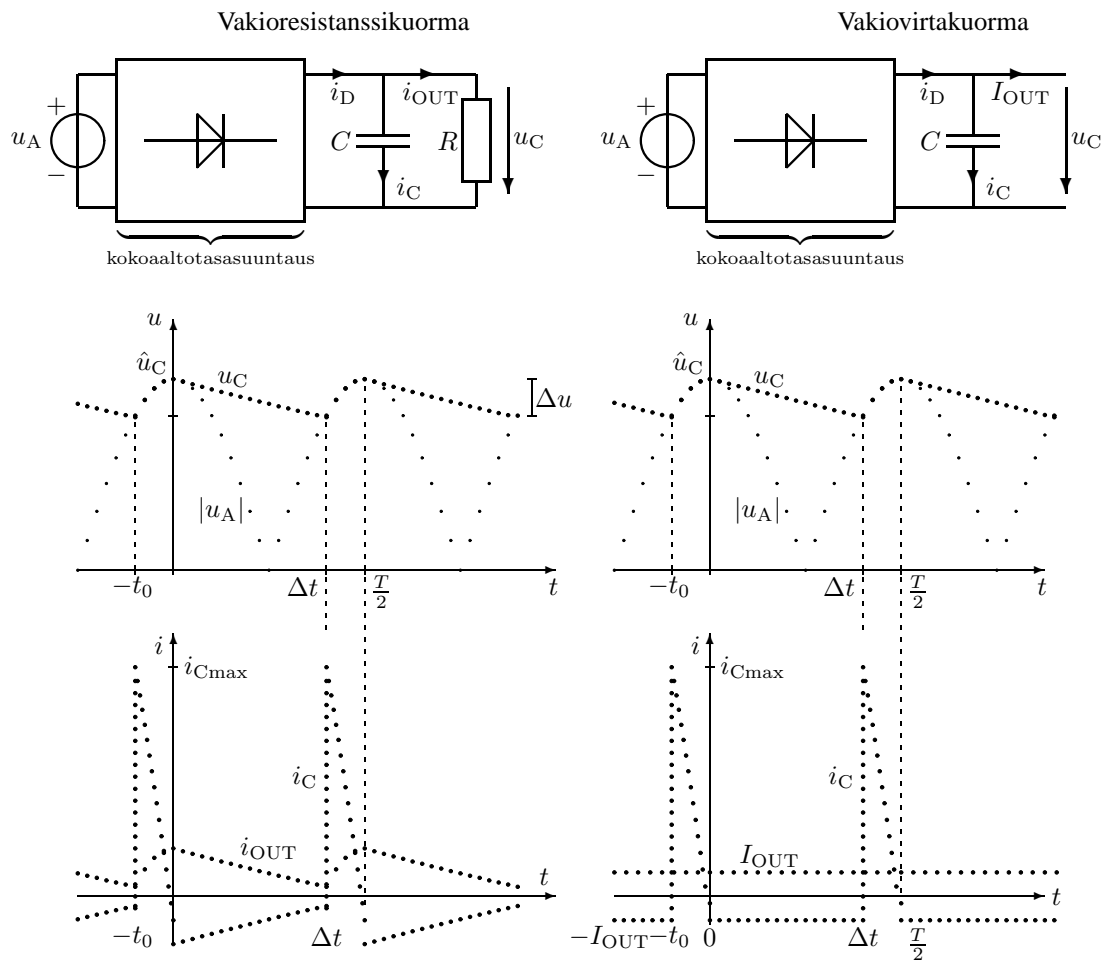
Kuva 303.



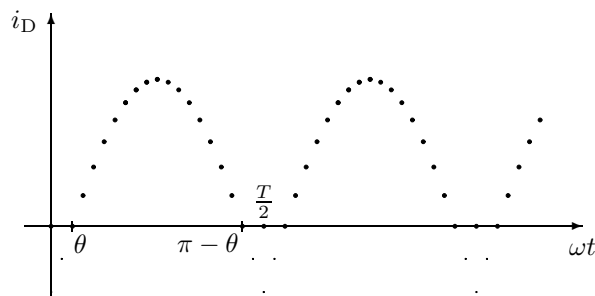
Kuva 304.

7.2 Tasasuunnatun jännitteen spektri

7.3 Huipputasasuuntaaja

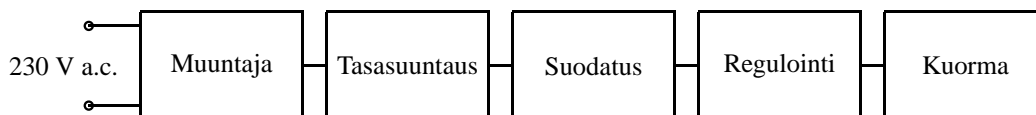


Kuva 305.

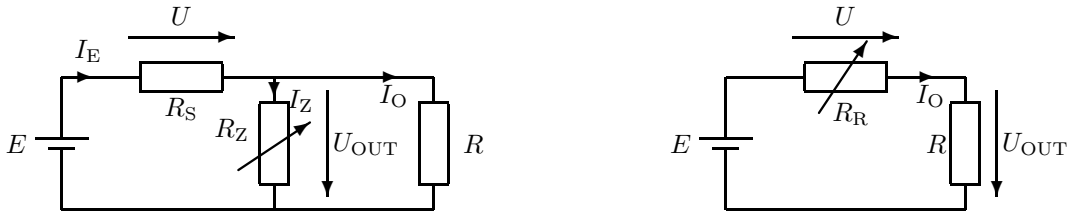


Kuva 306.

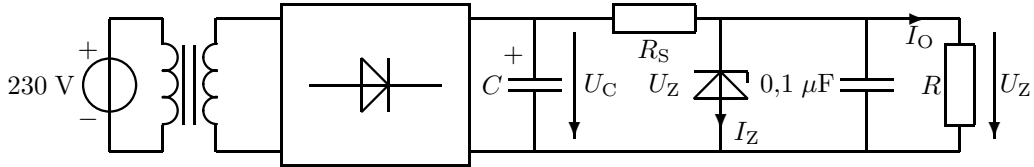
7.4 Lineaariset teholähteet



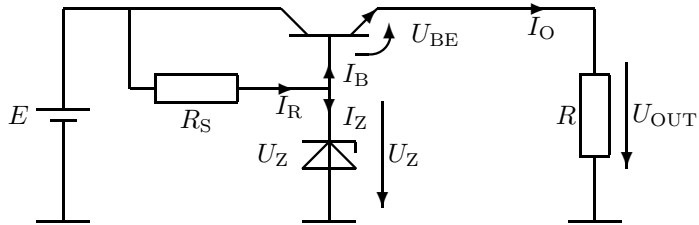
Kuva 307.



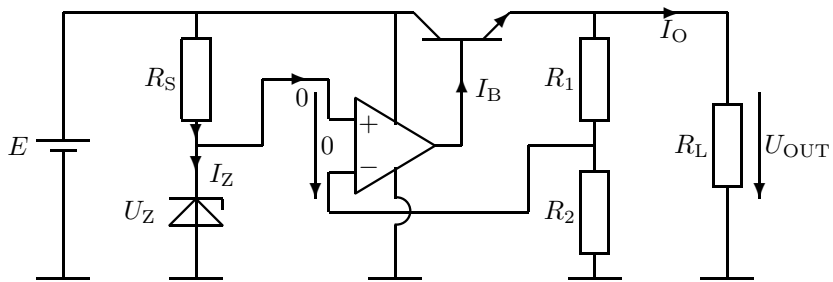
Kuva 308.



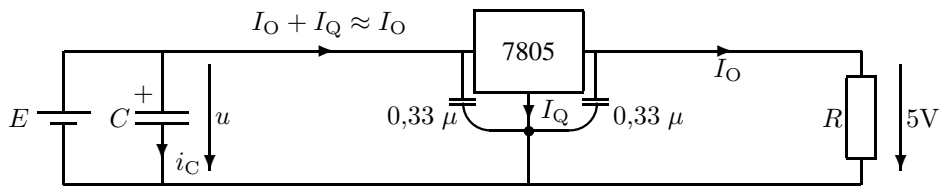
Kuva 309.



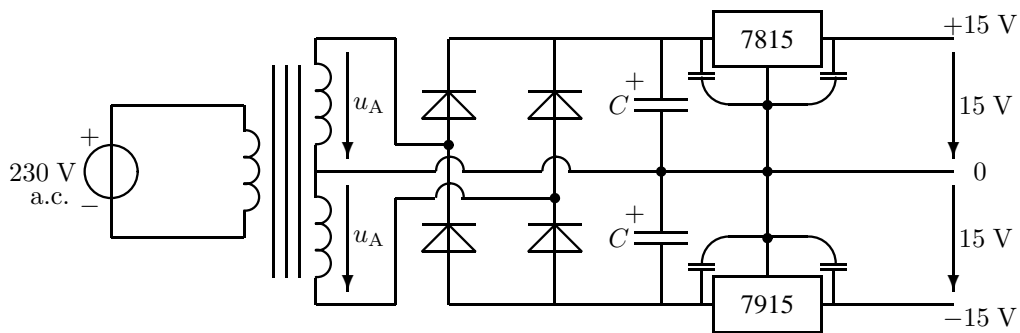
Kuva 310.



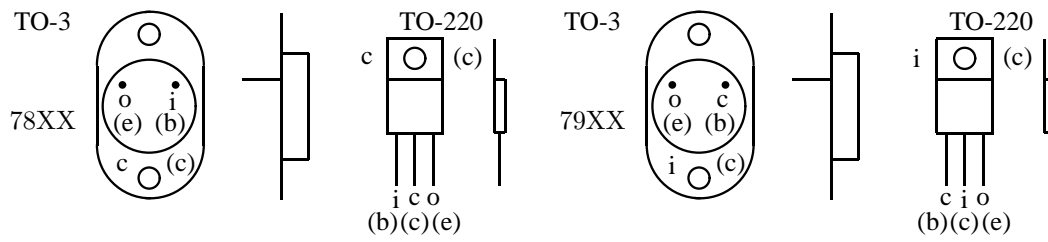
Kuva 311.



Kuva 312.

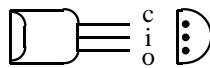


Kuva 313.



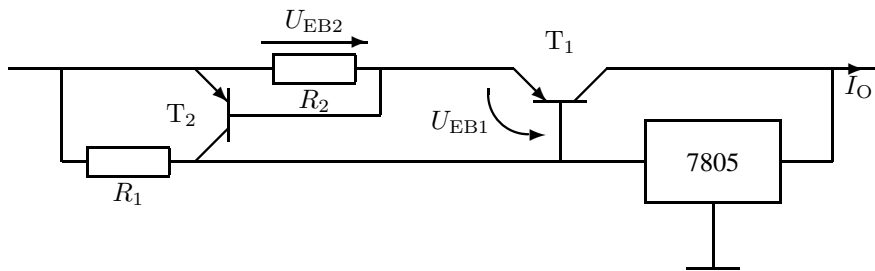
Kuva 314.

TO-92 7800/7900

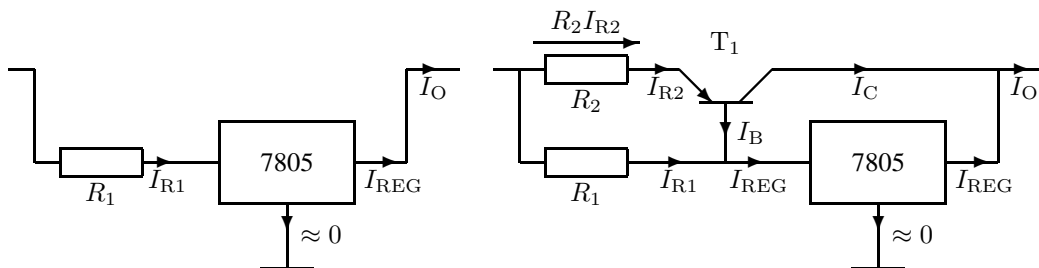


Päältä katsottuna

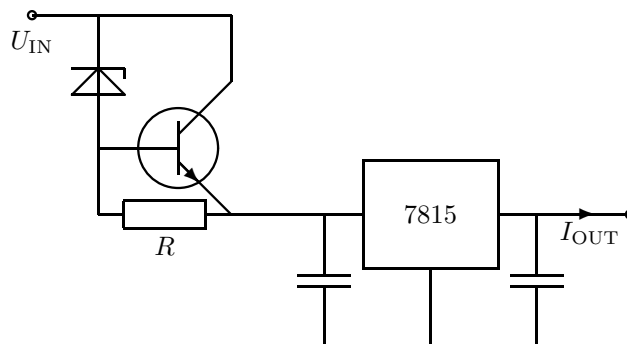
Kuva 315.



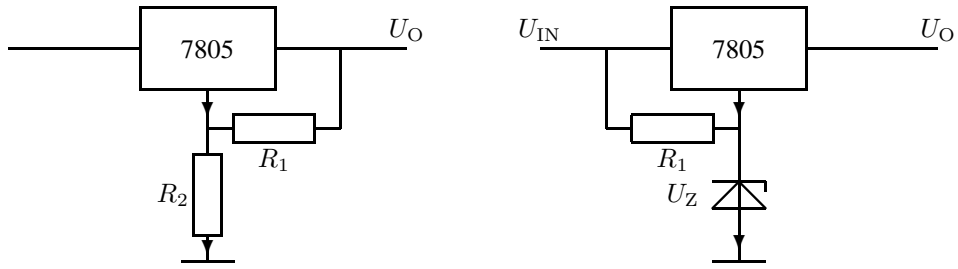
Kuva 316.



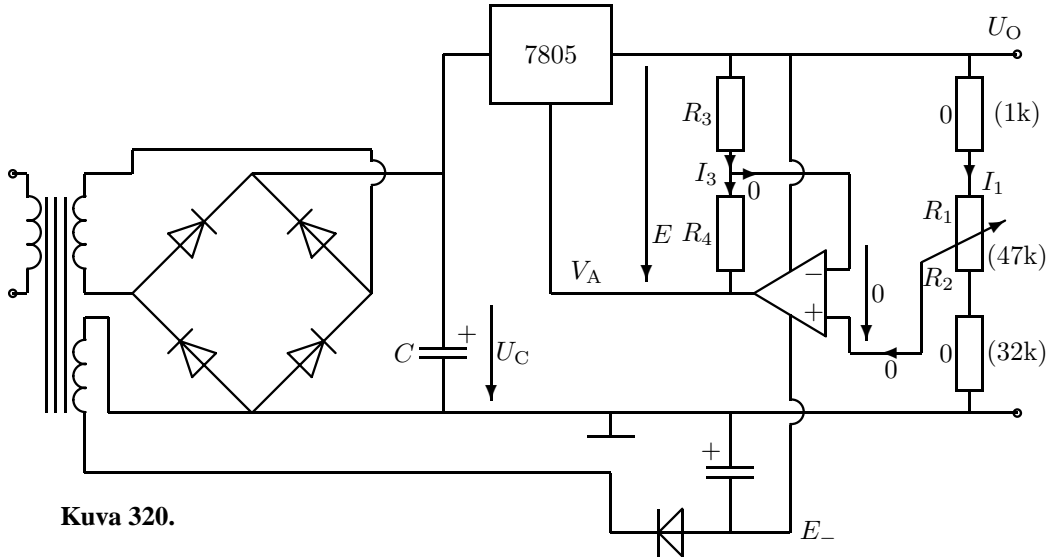
Kuva 317.



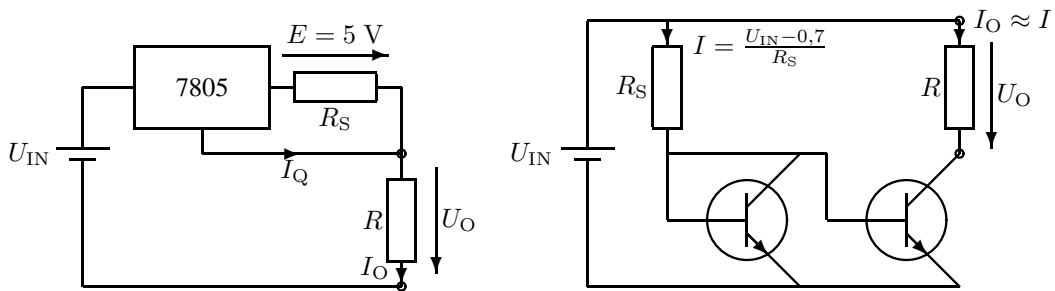
Kuva 318.



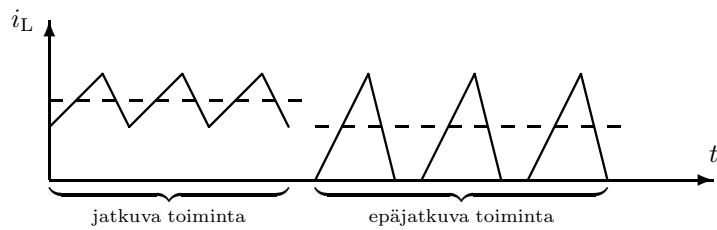
Kuva 319.



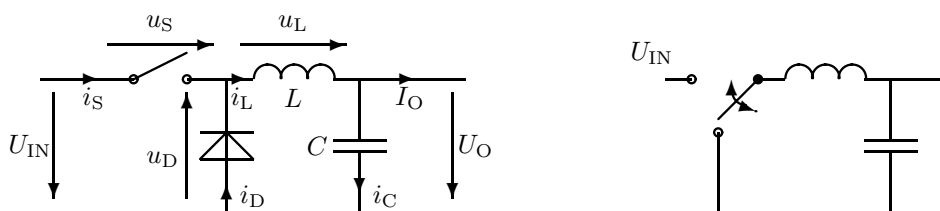
Kuva 320.



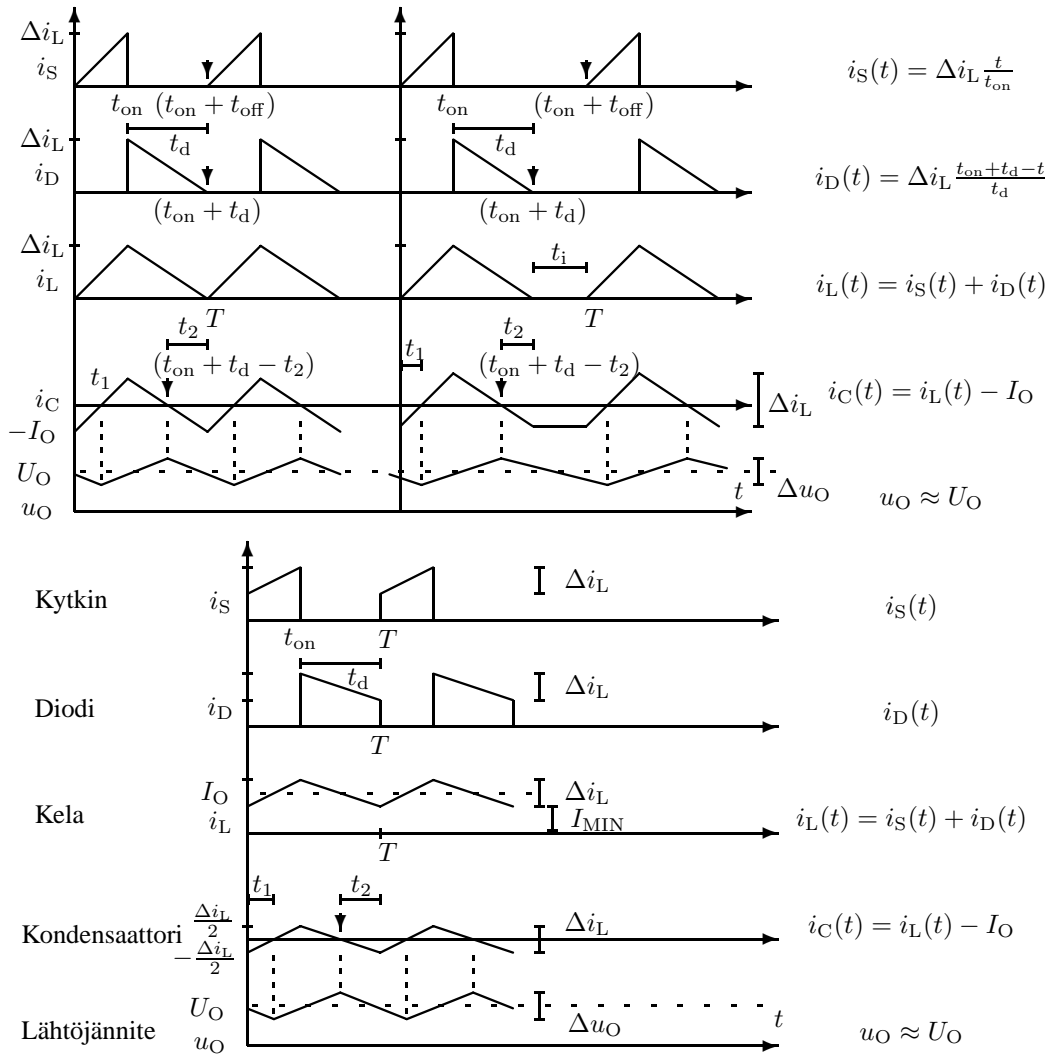
Kuva 321.



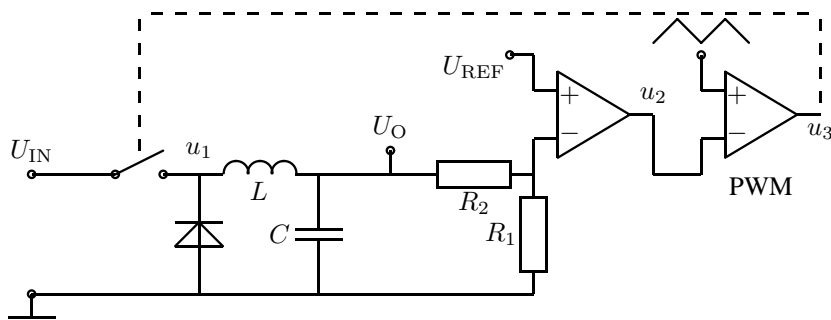
Kuva 322.



Kuva 323.

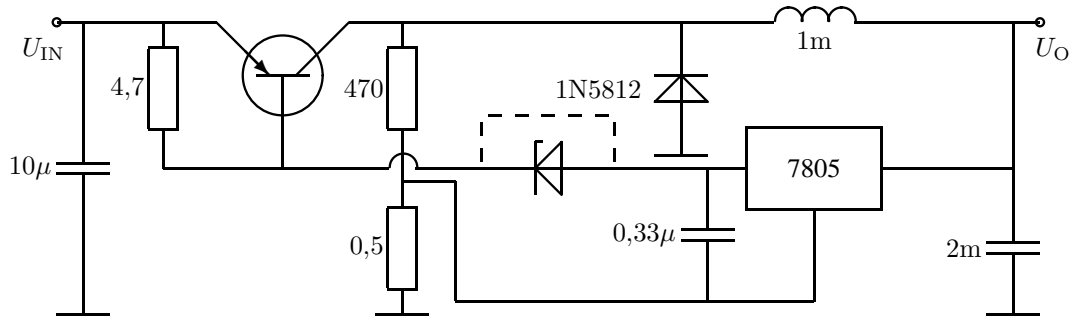


Kuva 324.

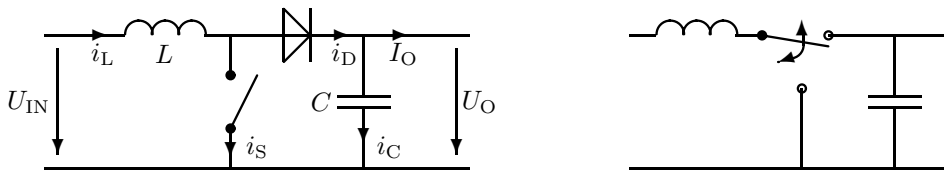


U_O	u_2	u_3	u_1
liian pieni	suuri		
liian suuri	pieni		

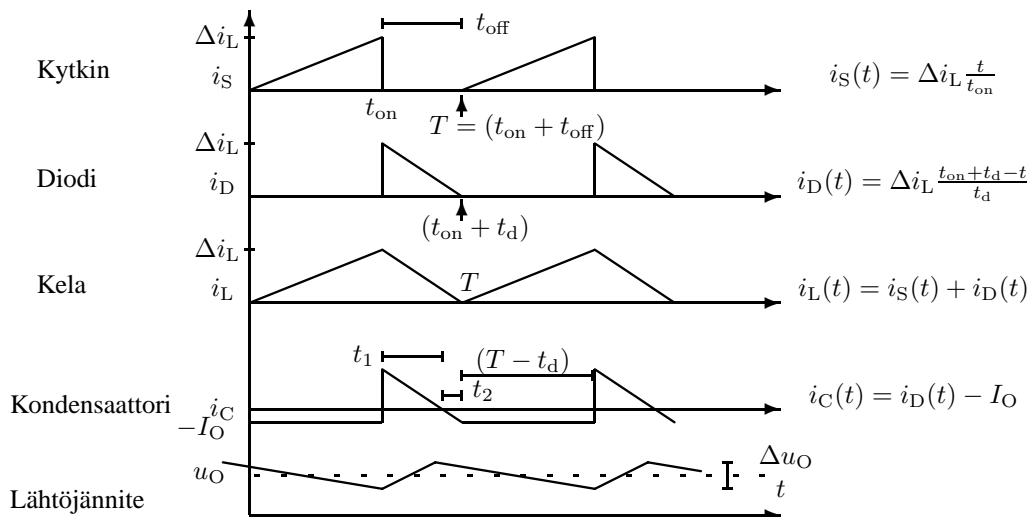
Kuva 325.



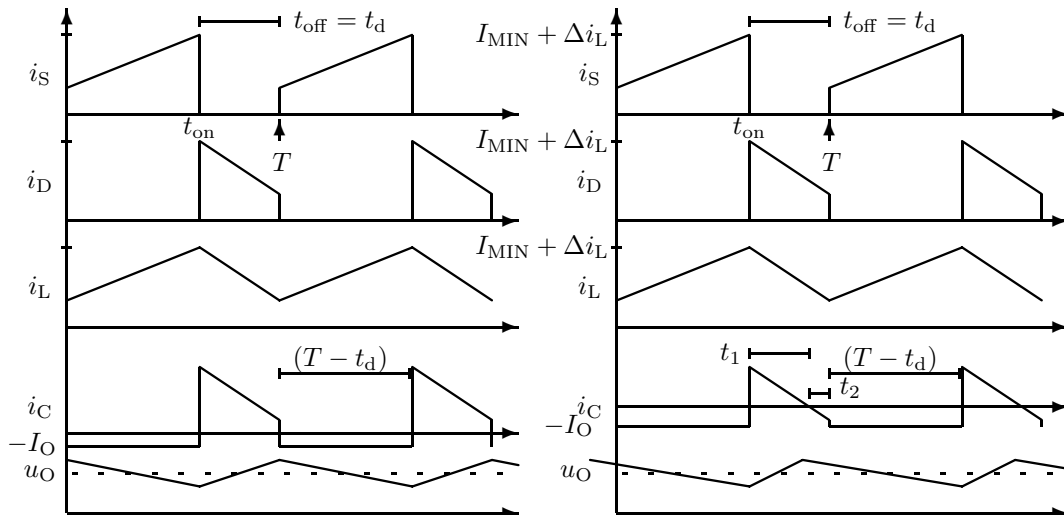
Kuva 327.



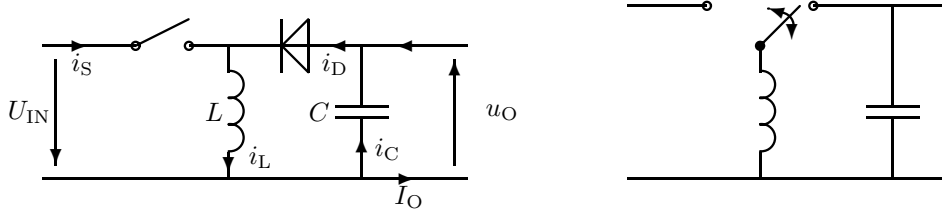
Kuva 328.



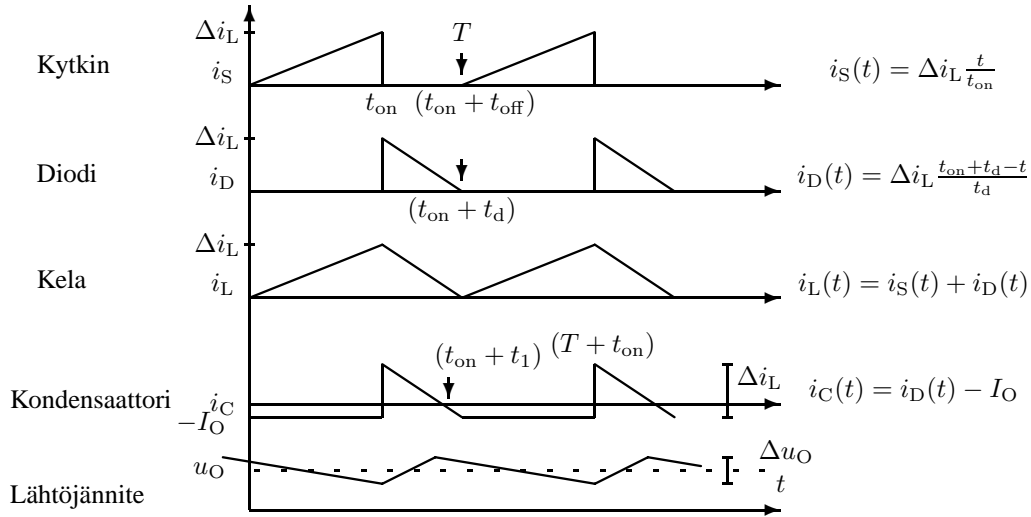
Kuva 329.



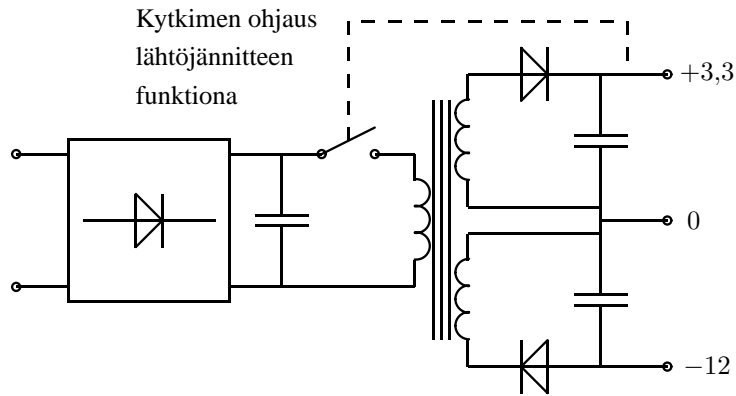
Kuva 330.



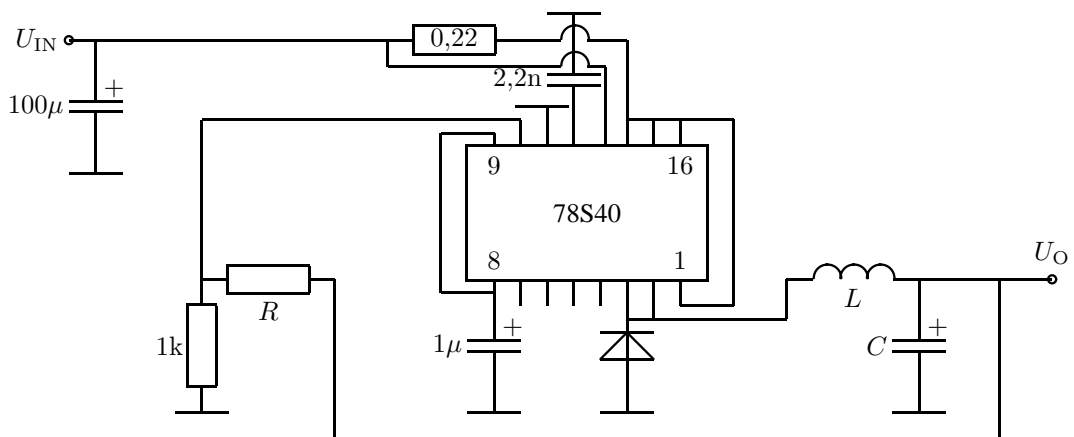
Kuva 332.



Kuva 333.

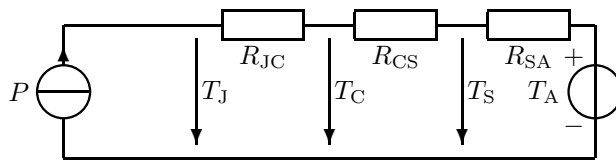


Kuva 335.

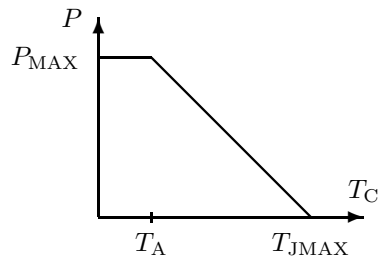


Kuva 336.

7.5 Jäähdytyslementin mitoitus



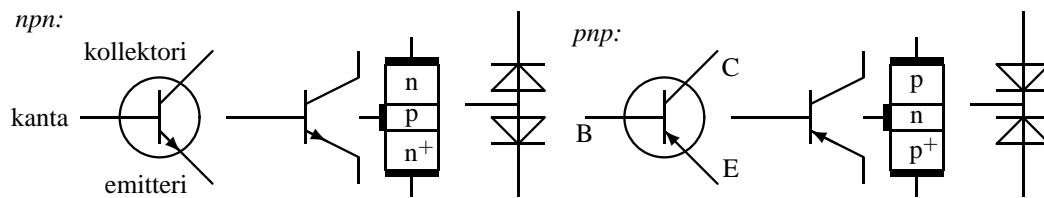
Kuva 337.



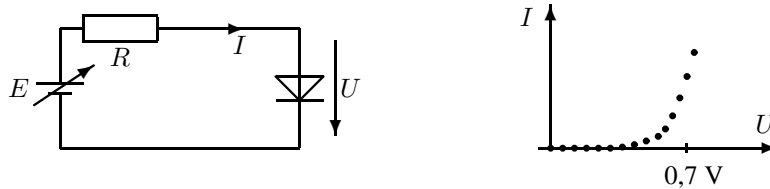
Kuva 338.

8 Bipolaaritransistori

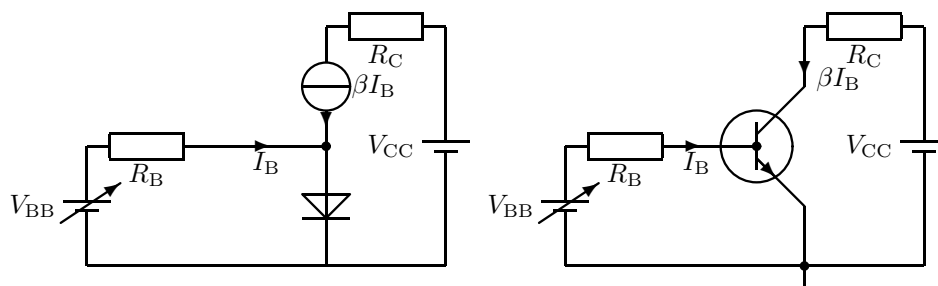
8.1 Transistorin rakenne ja toiminta, virtavahvistus



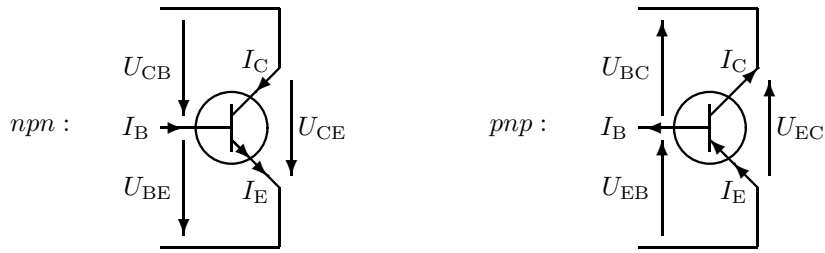
Kuva 339.



Kuva 340.

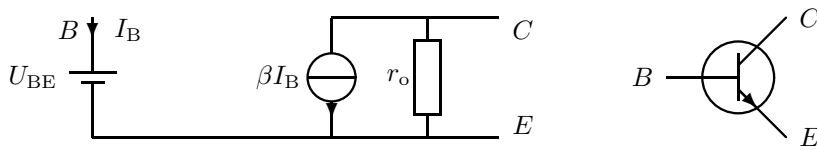


Kuva 341.

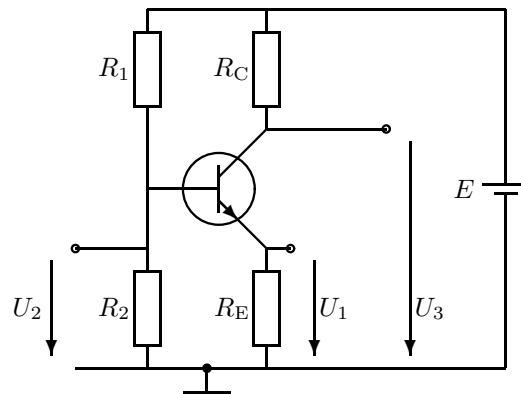


Kuva 342.

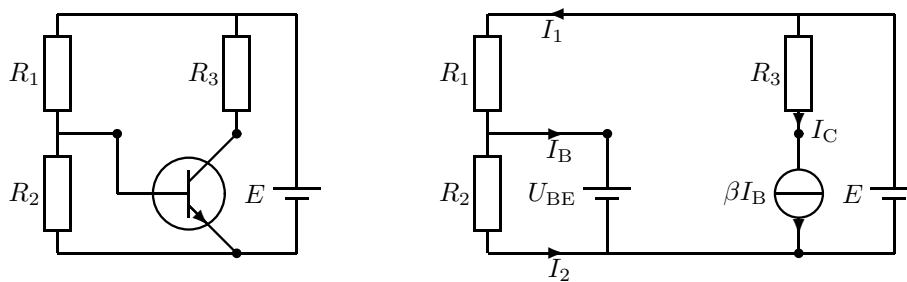
8.2 Transistorin toiminta tasavirralla



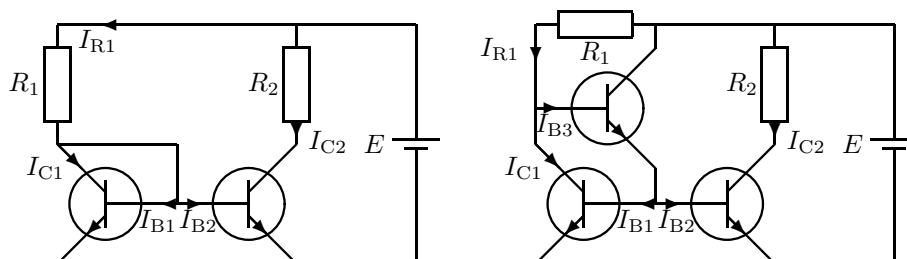
Kuva 343.



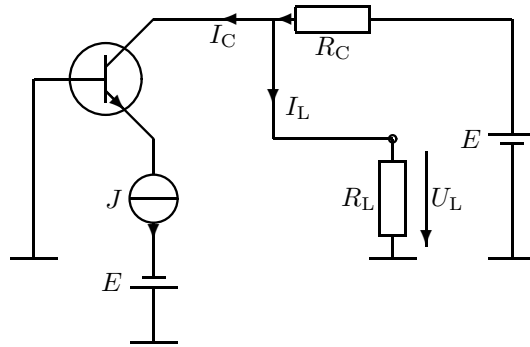
Kuva 344.



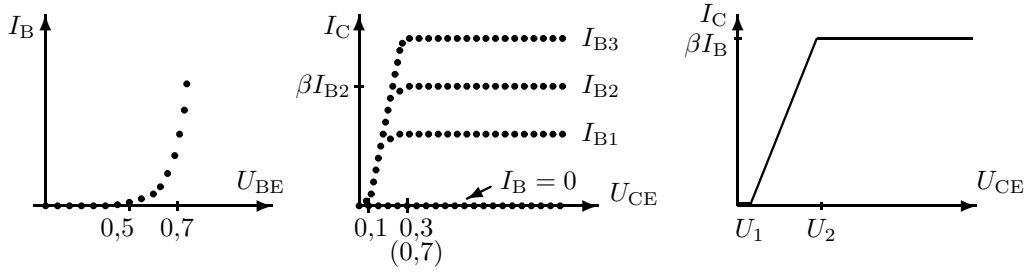
Kuva 345.



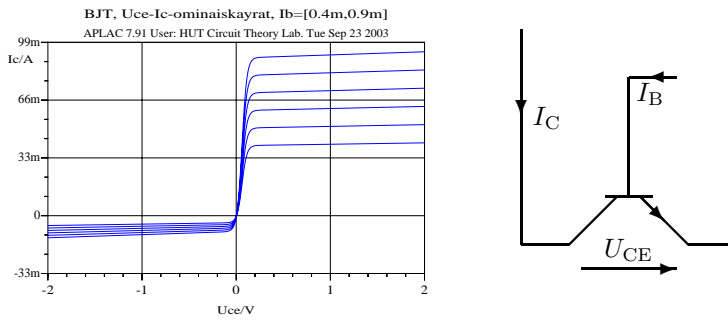
Kuva 346.



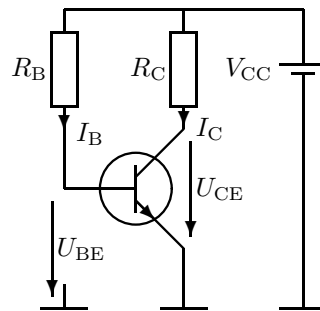
Kuva 347.



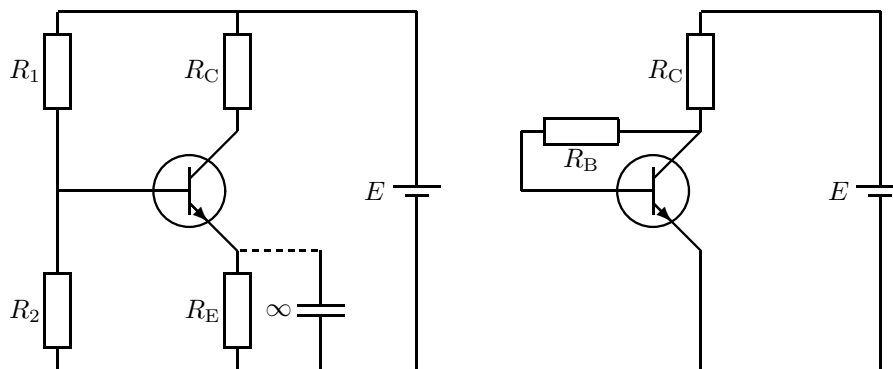
Kuva 348.



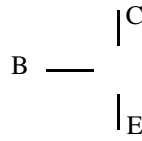
Kuva 349.



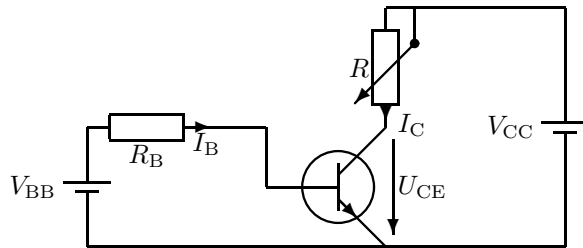
Kuva 352.



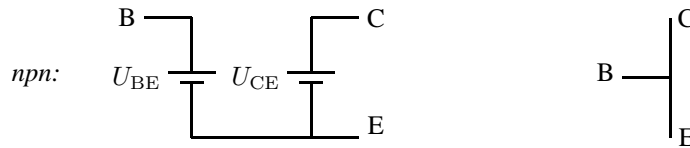
Kuva 354.



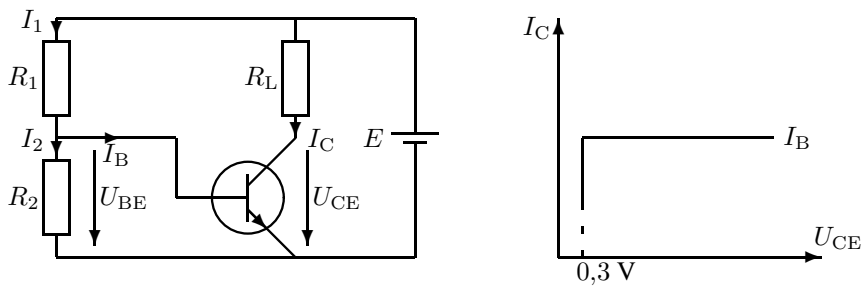
Kuva 355.



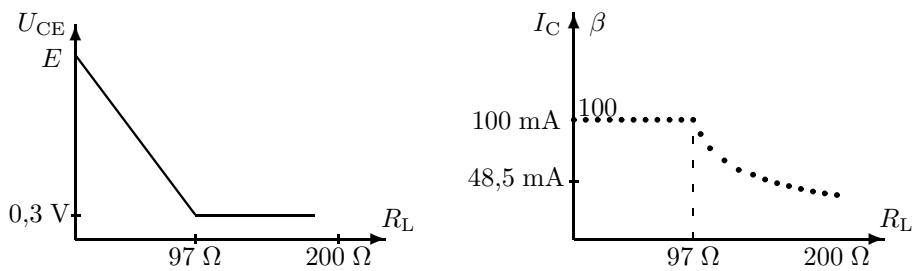
Kuva 356.



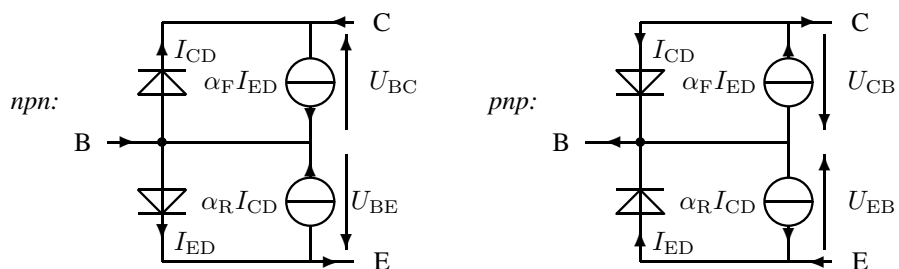
Kuva 358.



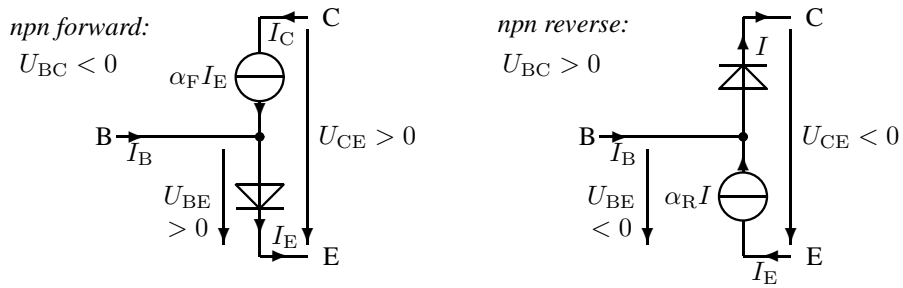
Kuva 359.



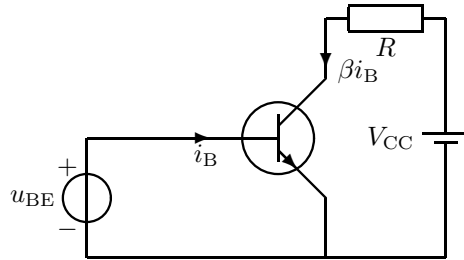
Kuva 360.



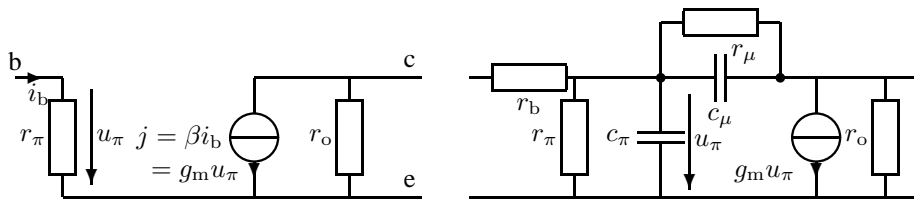
Kuva 361.



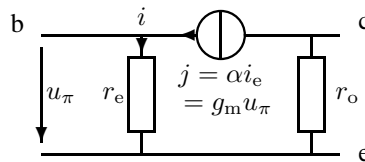
Kuva 362.



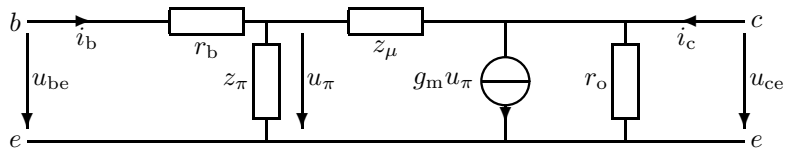
Kuva 363.



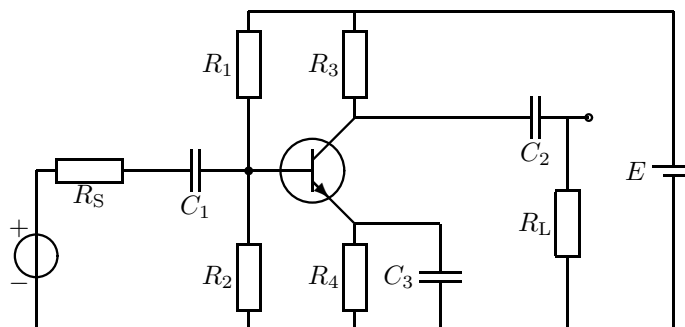
Kuva 364.



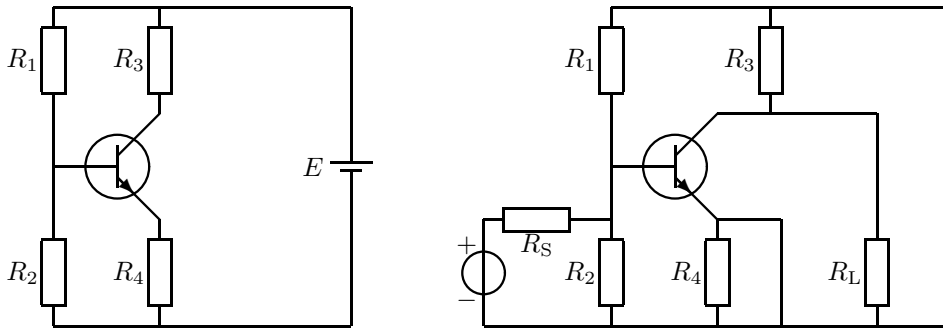
Kuva 365.



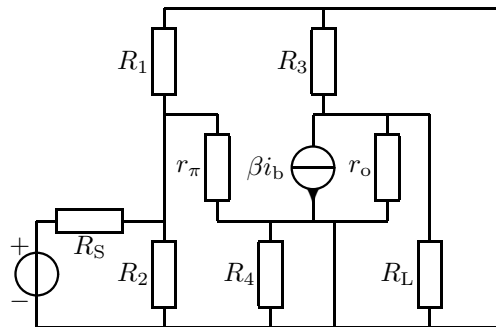
Kuva 366.



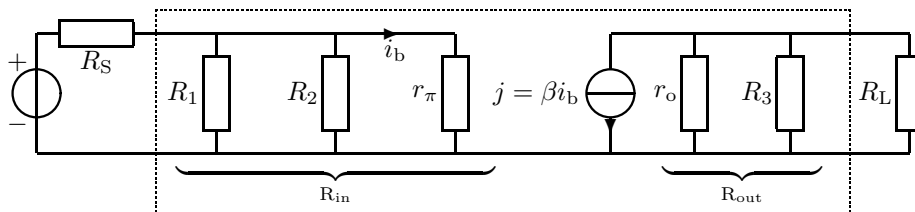
Kuva 367.



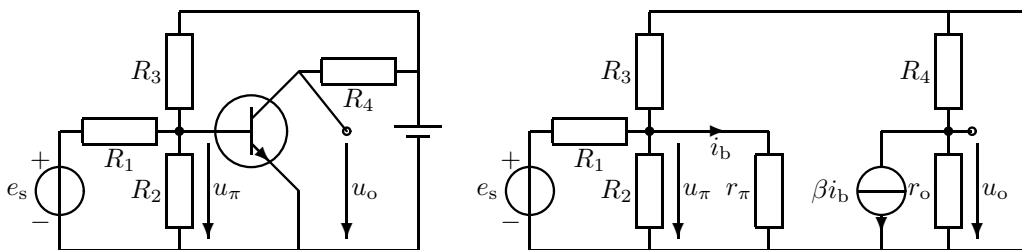
Kuva 368.



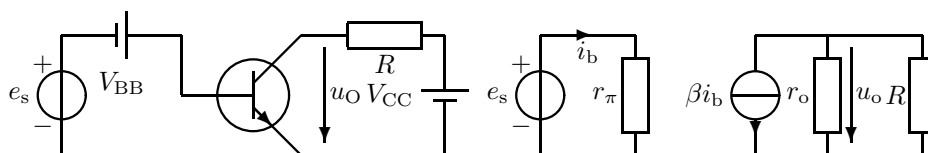
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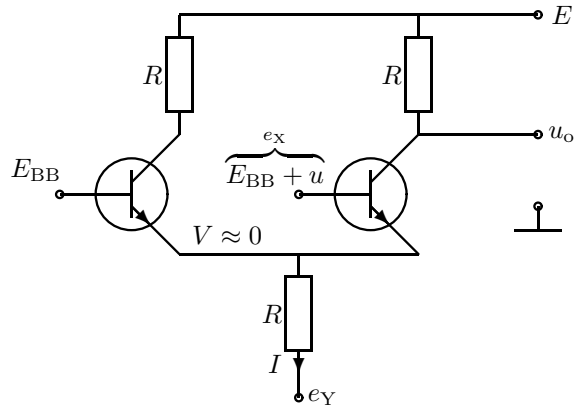
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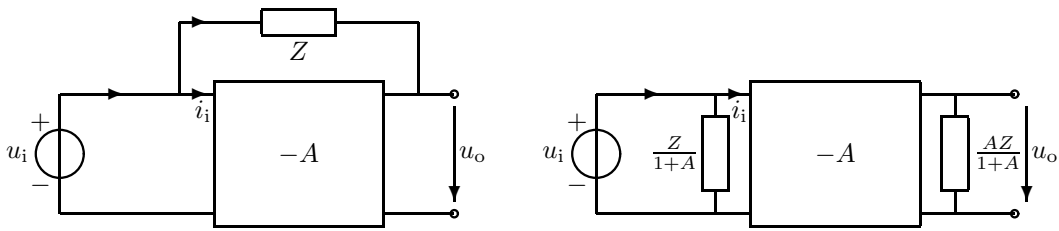
Kuva 371.



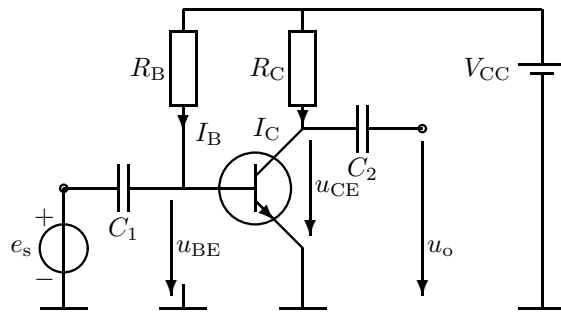
Kuva 372.



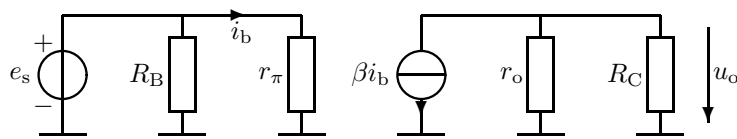
Kuva 373.



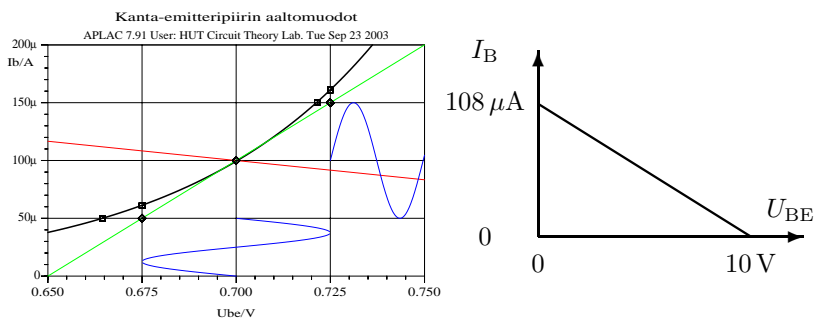
Kuva 374.



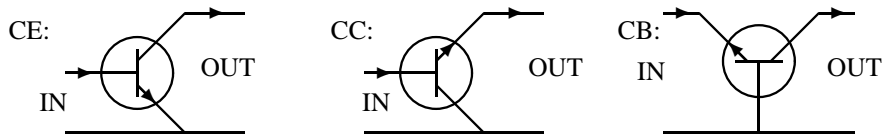
Kuva 375.



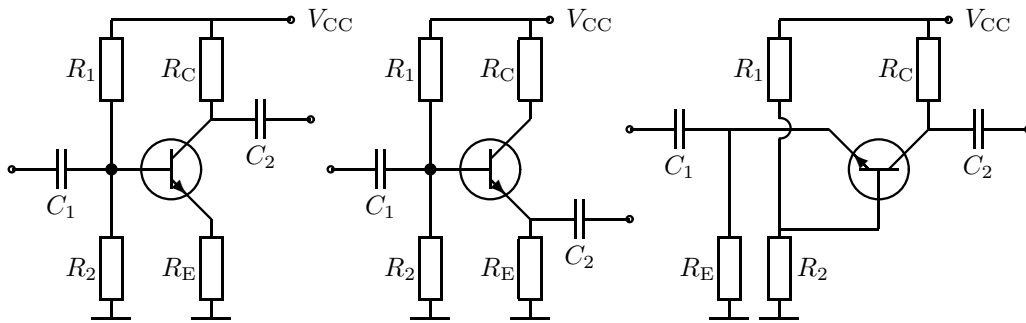
Kuva 376.



Kuva 377.

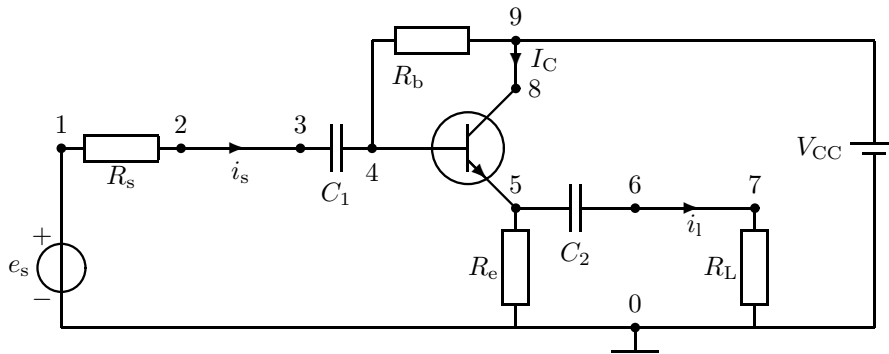


Kuva 379.

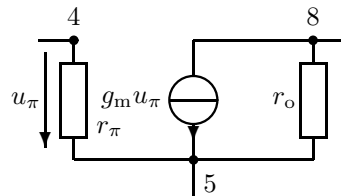


Kuva 380.

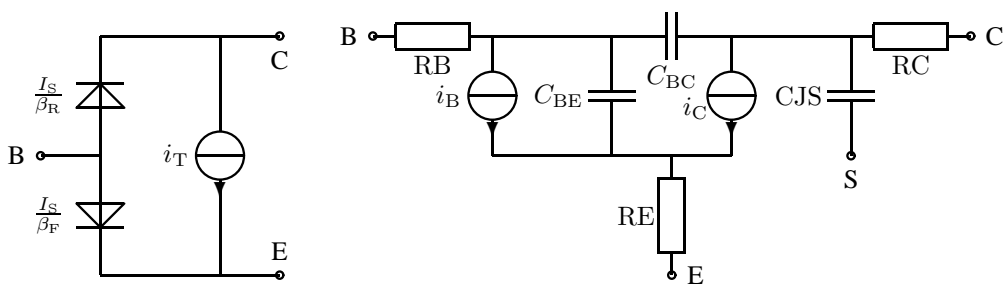
8.3 Transistori APLACissa



Kuva 382.



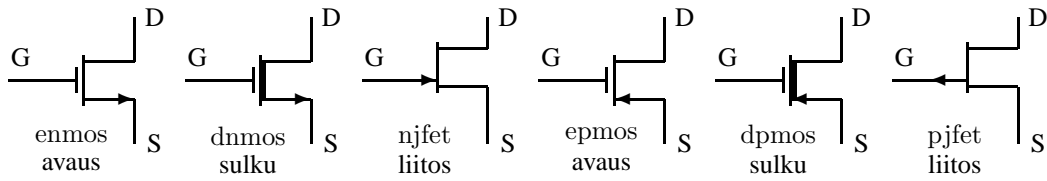
Kuva 384.



Kuva 385.

9 Kanavatransistorit

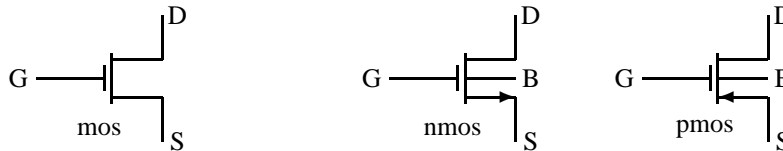
9.1 FET-tyypit



Kuva 386.

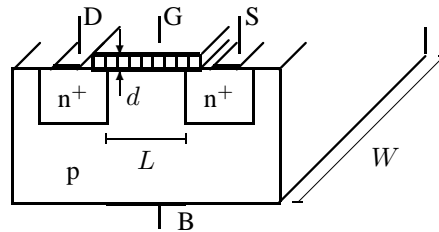


Kuva 387.

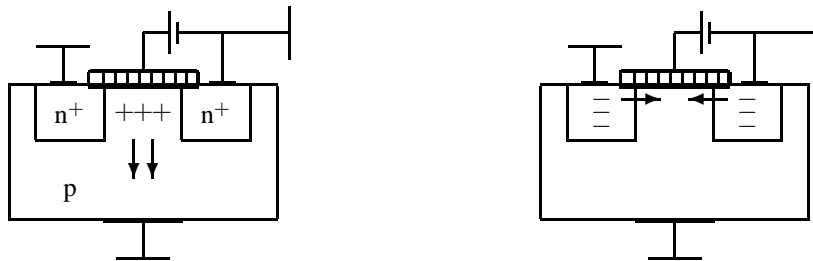


Kuva 388.

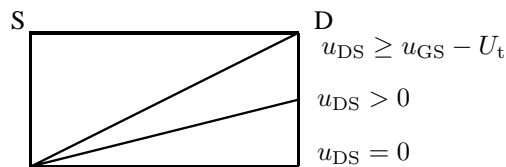
9.2 Mosfet eli eristehilatransistori



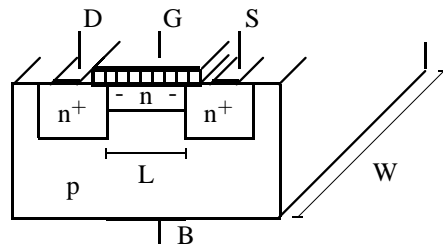
Kuva 389.



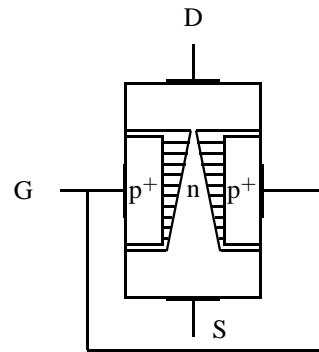
Kuva 390.



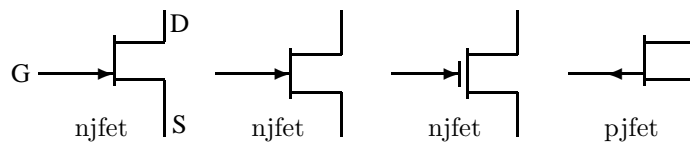
Kuva 391.



Kuva 394.



Kuva 397.

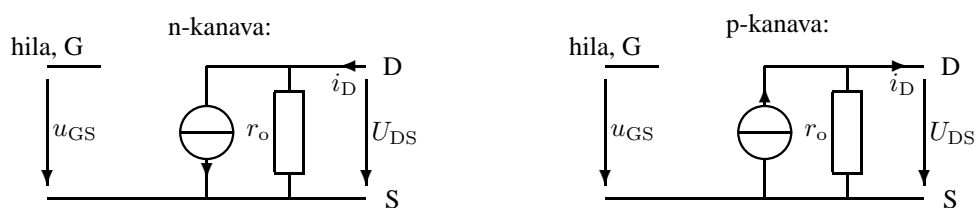


Kuva 398.

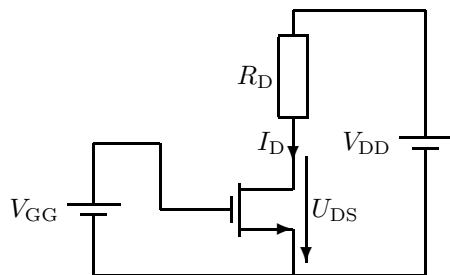
9.3 Fettien matemaattinen käsittely



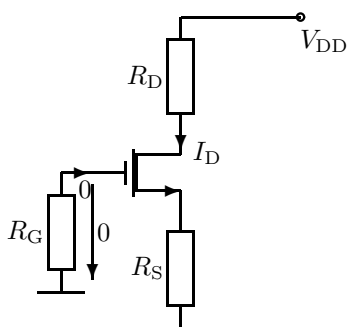
Kuva 400.



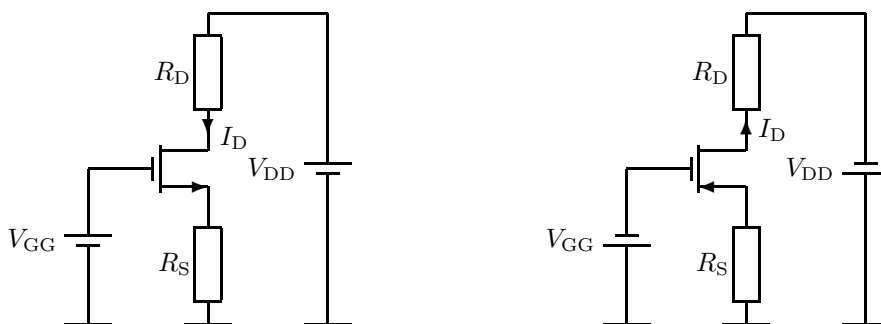
Kuva 401.



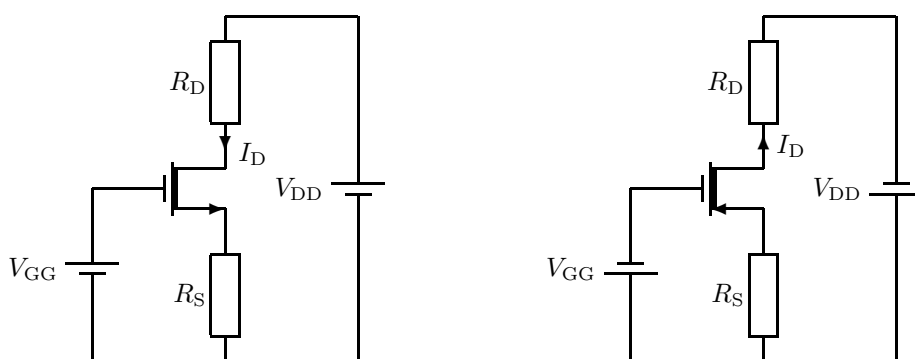
Kuva 402.



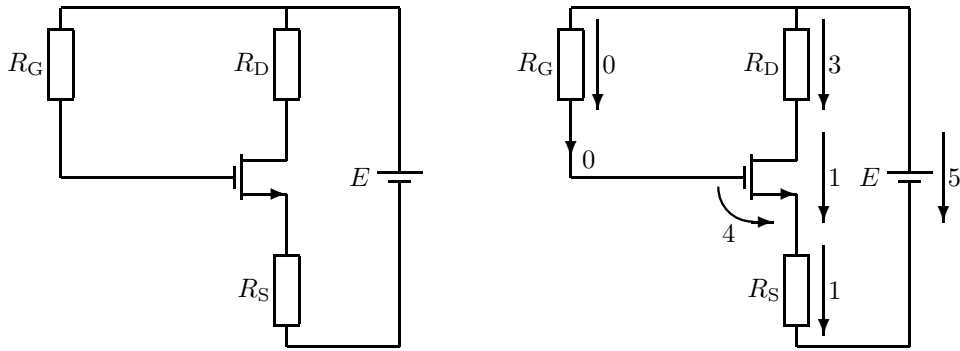
Kuva 403.



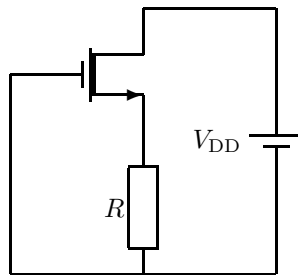
Kuva 404.



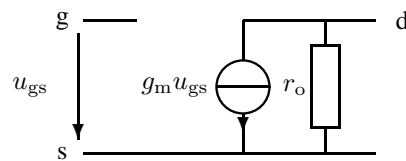
Kuva 405.



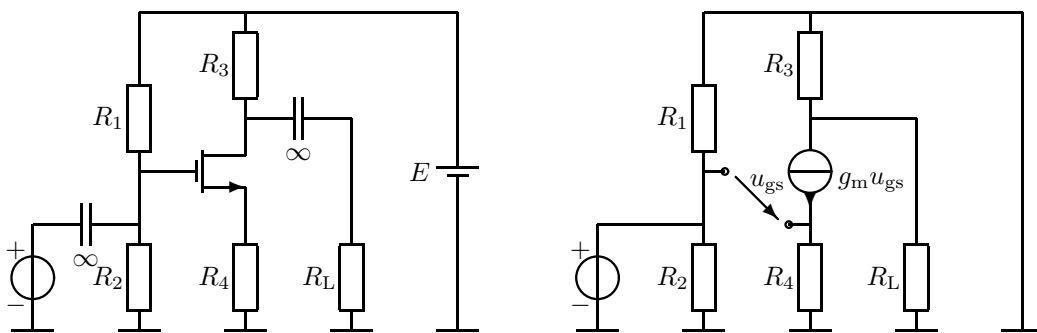
Kuva 406.



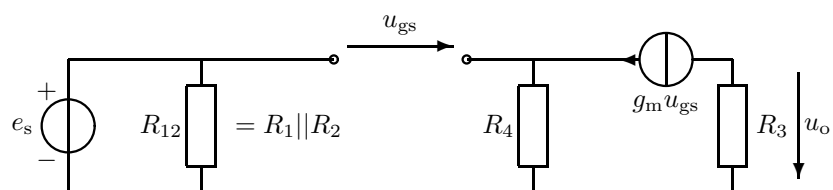
Kuva 407.



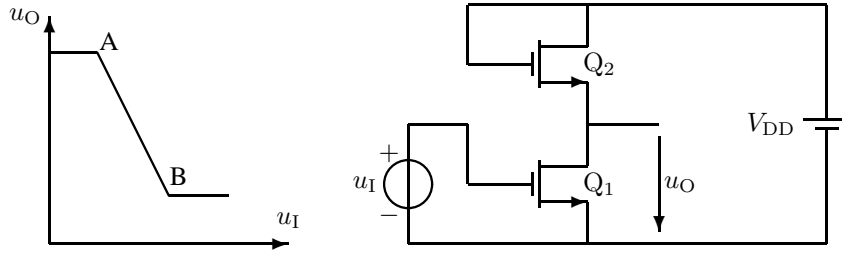
Kuva 408.



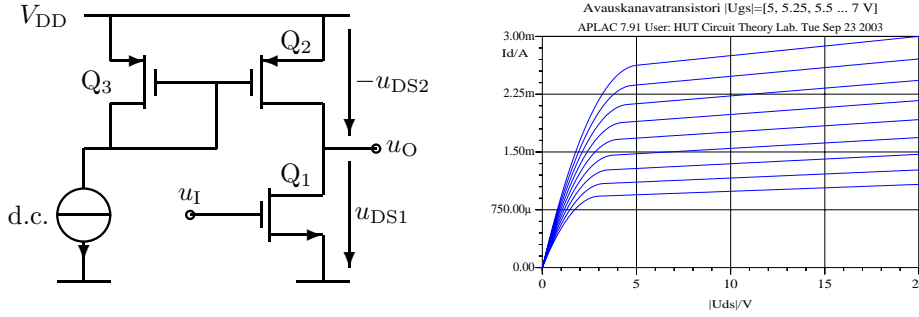
Kuva 409.



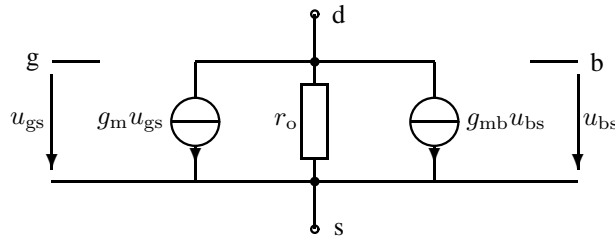
Kuva 410.



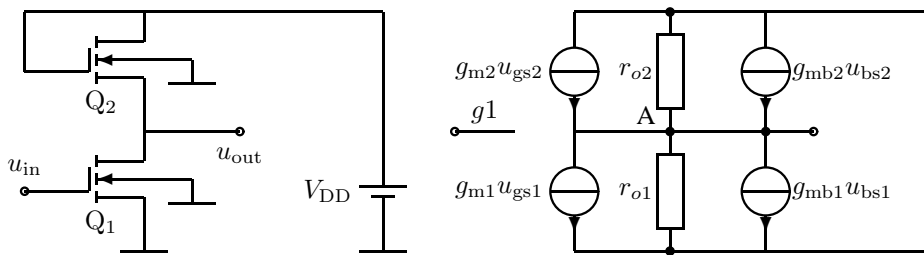
Kuva 411.



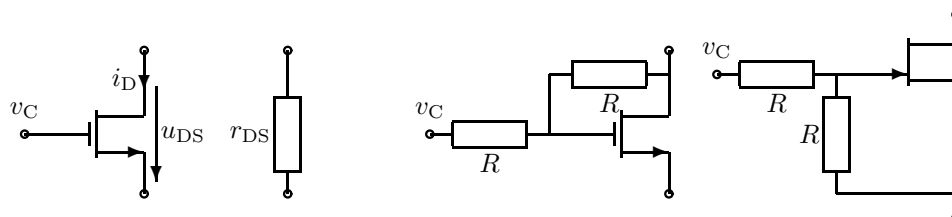
Kuva 412.



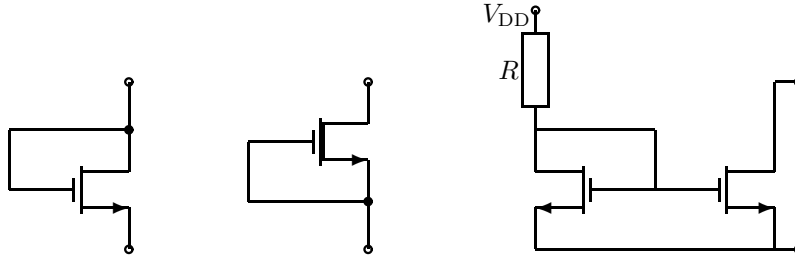
Kuva 414.



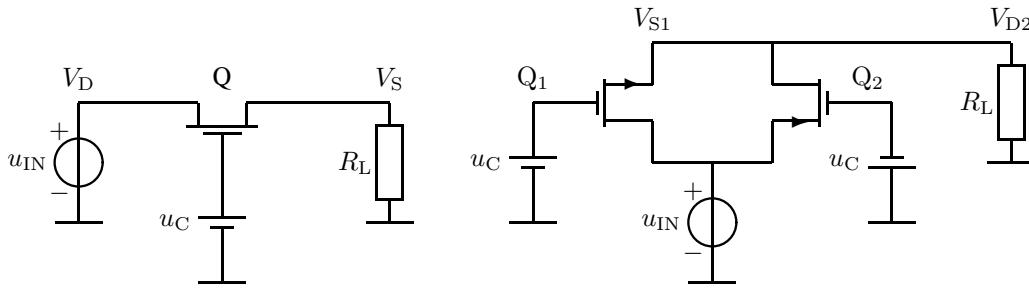
Kuva 415.



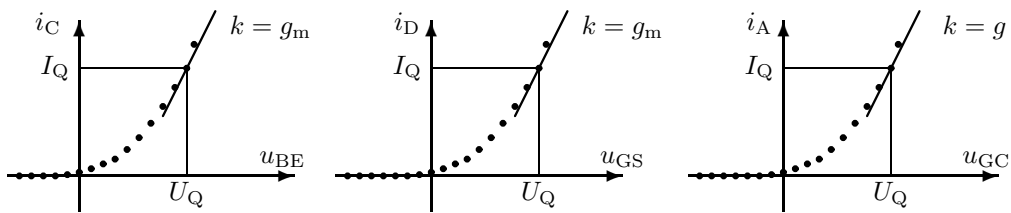
Kuva 417.



Kuva 418.

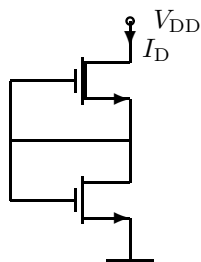


Kuva 419.

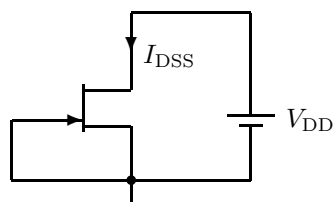


Kuva 420.

9.4 Kanavatransistorit APLACissa



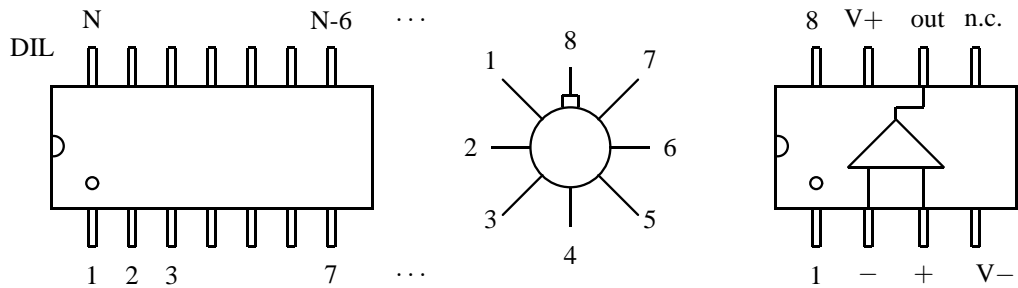
Kuva 421.



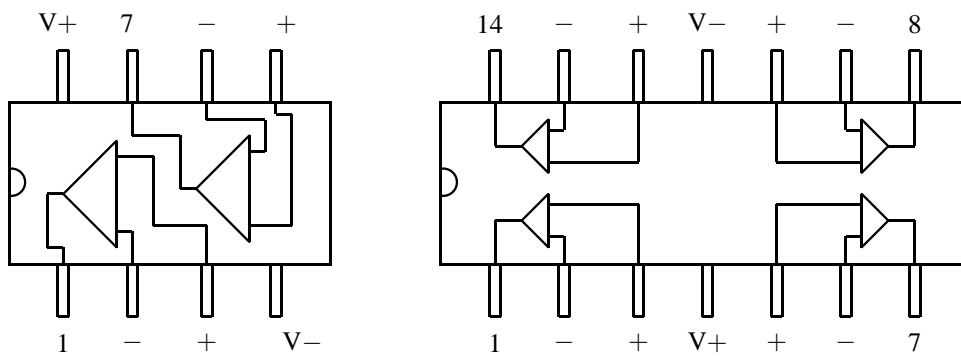
Kuva 422.

10 Operaatiovahvistin ja muut mikropiirit

10.1 Mikropiirien luokittelu



Kuva 423.

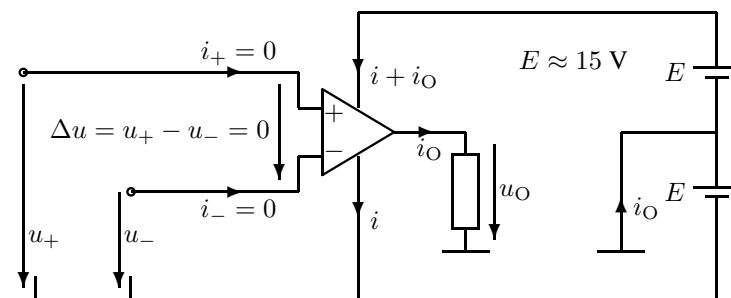


Kuva 424.

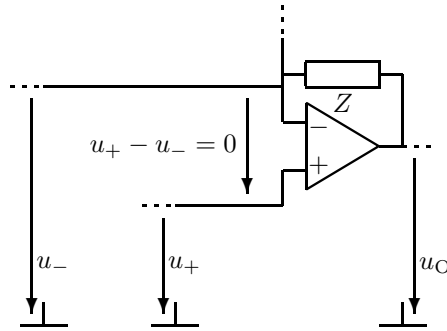
10.2 Operaatiovahvistin



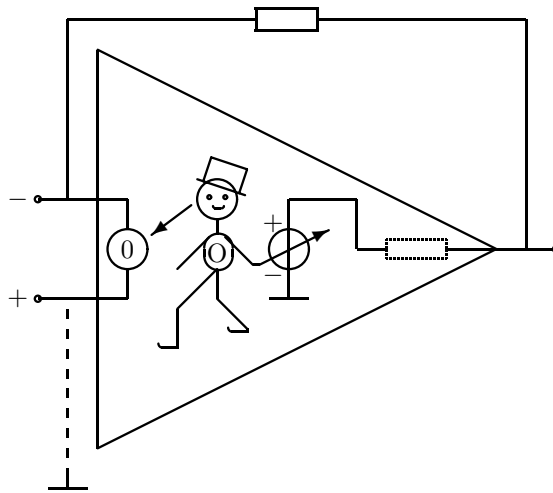
Kuva 425.



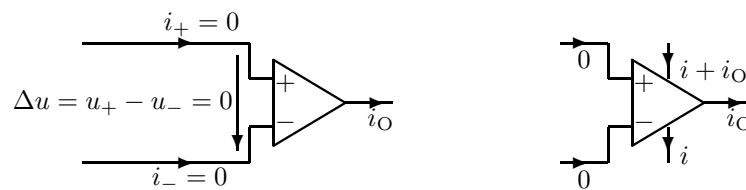
Kuva 426.



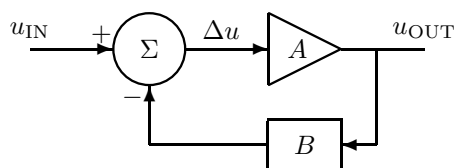
Kuva 427.



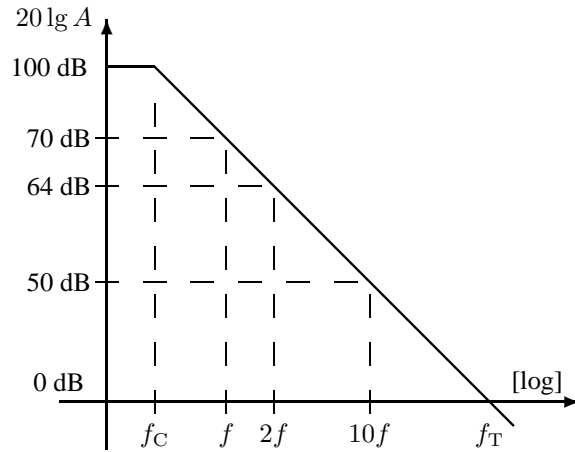
Kuva 428.



Kuva 429.

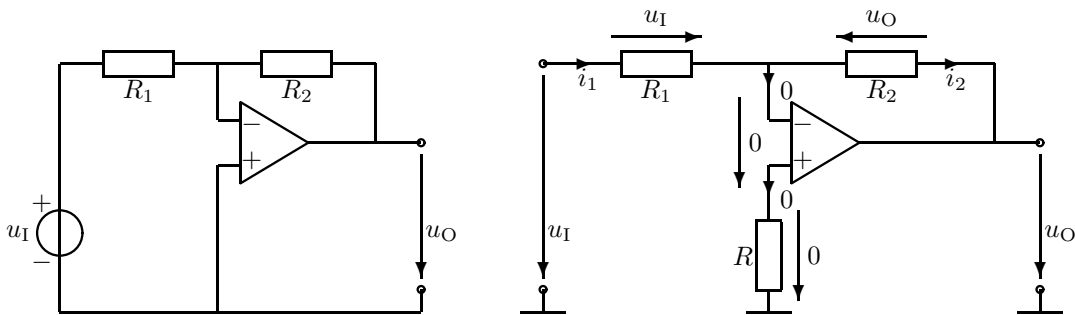


Kuva 430.

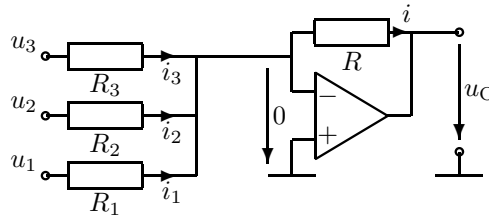


Kuva 431.

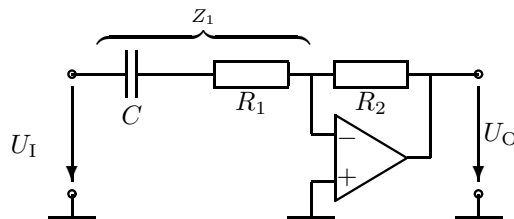
10.3 Operaatiovahvistimen peruskenttöjä



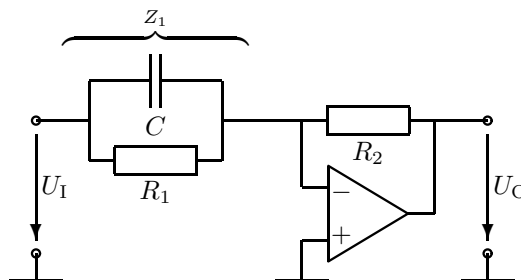
Kuva 432.



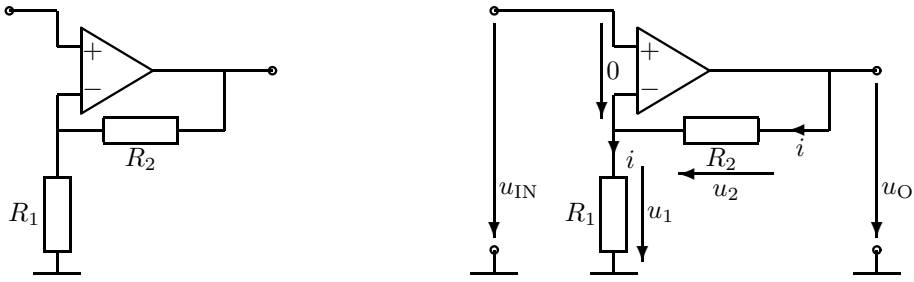
Kuva 433.



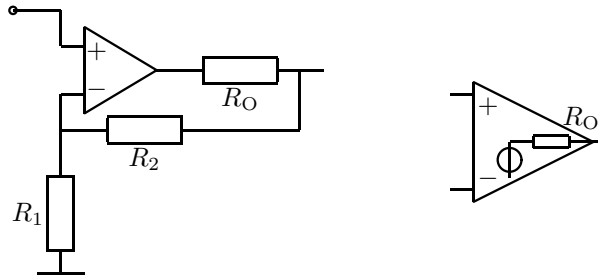
Kuva 434.



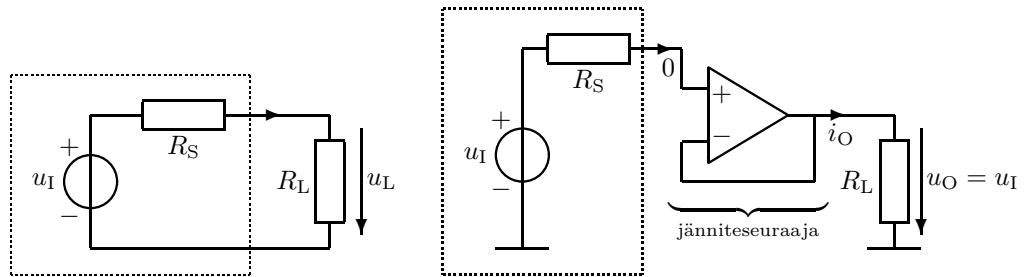
Kuva 435.



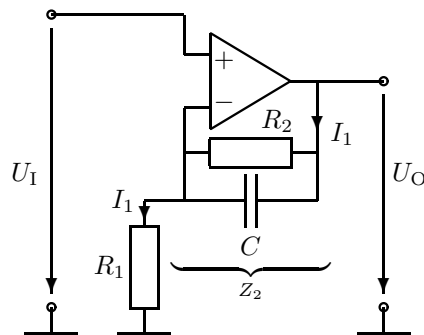
Kuva 437.



Kuva 438.

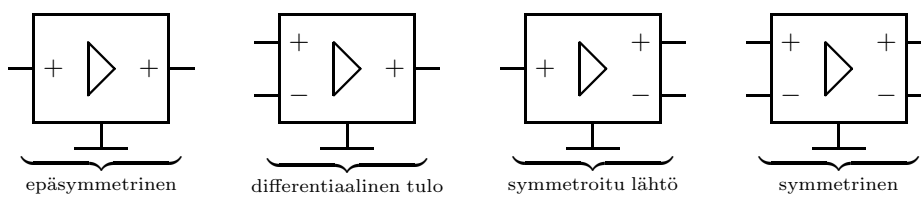


Kuva 439.

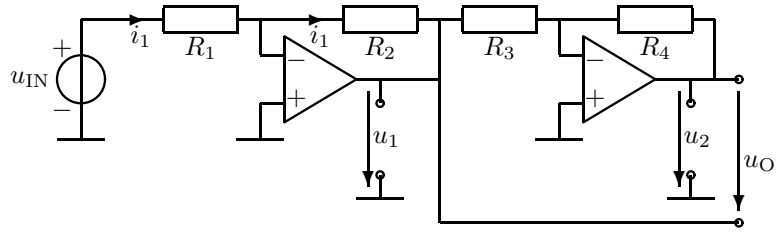


Kuva 440.

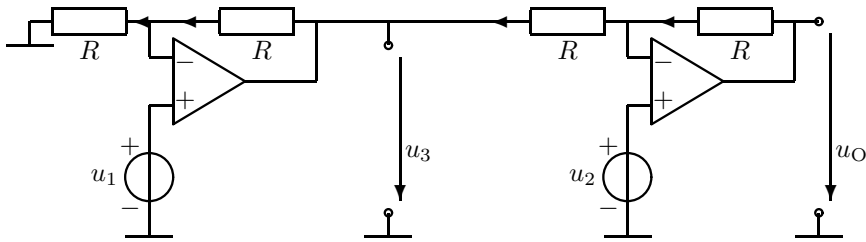
10.4 Operaatiovahvistin signaalinkäsittelyssä



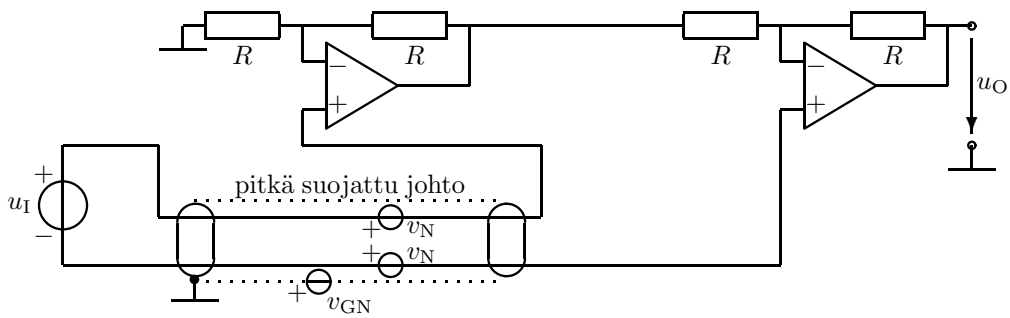
Kuva 442.



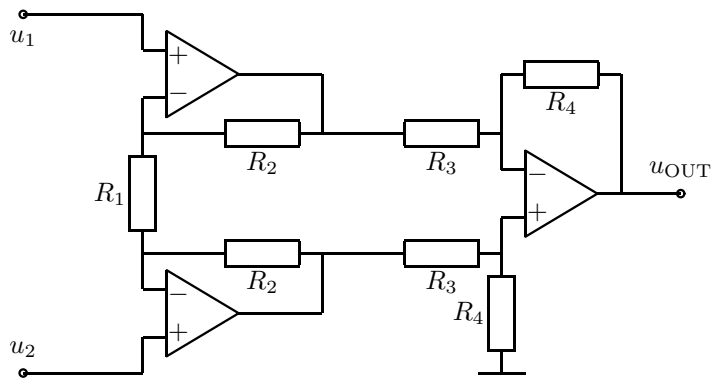
Kuva 443.



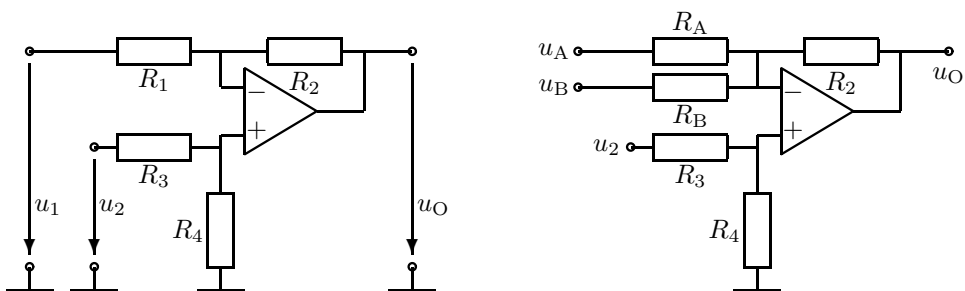
Kuva 444.



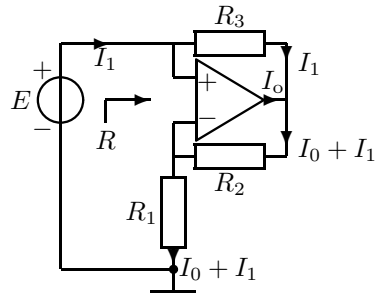
Kuva 445.



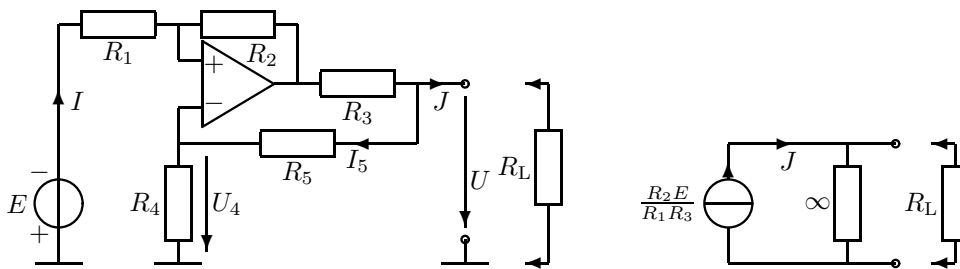
Kuva 446.



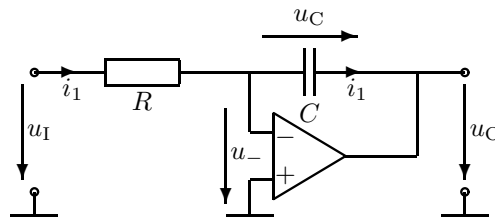
Kuva 447.



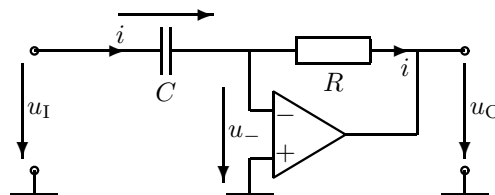
Kuva 448.



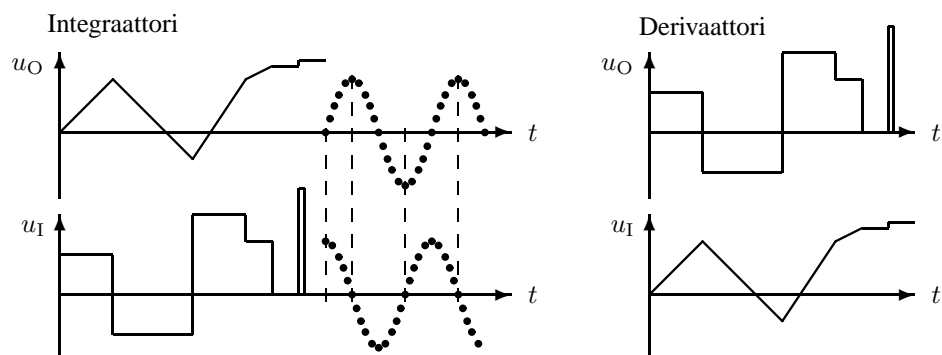
Kuva 449.



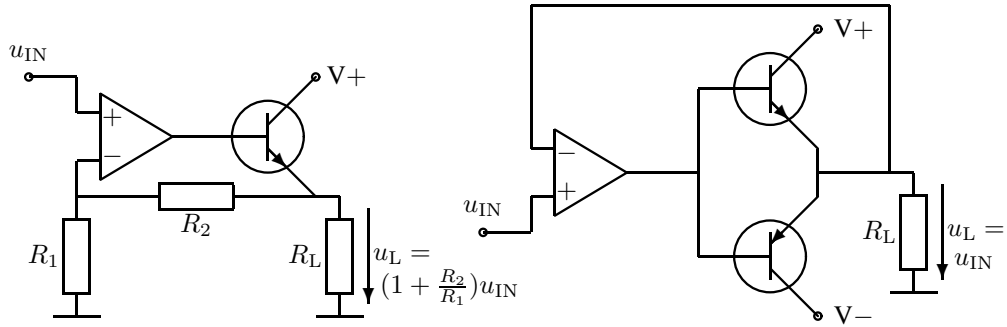
Kuva 450.



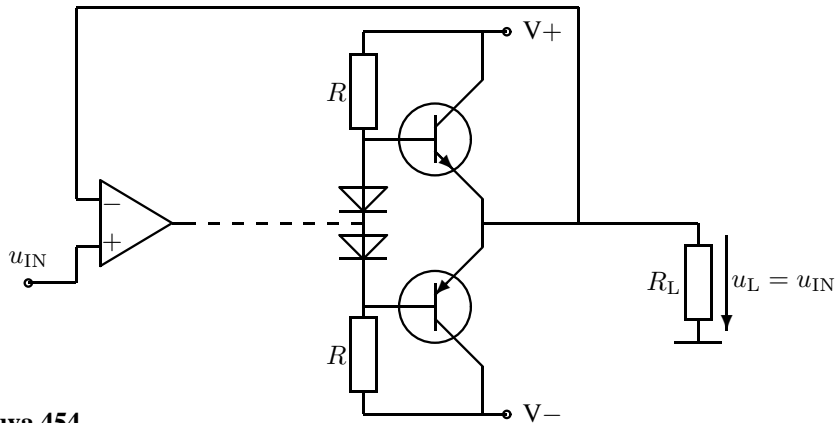
Kuva 451.



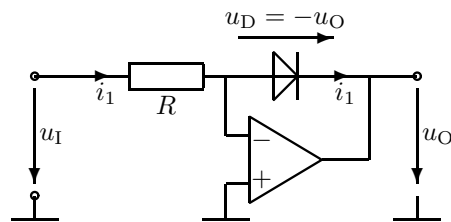
Kuva 452.



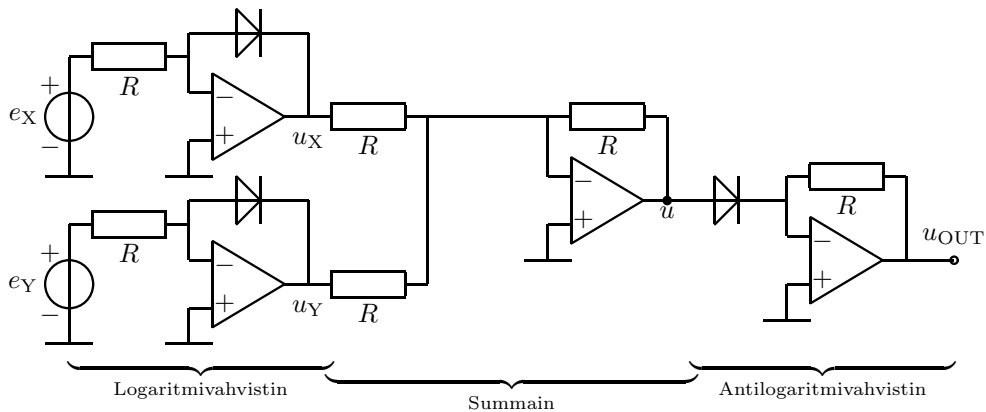
Kuva 453.



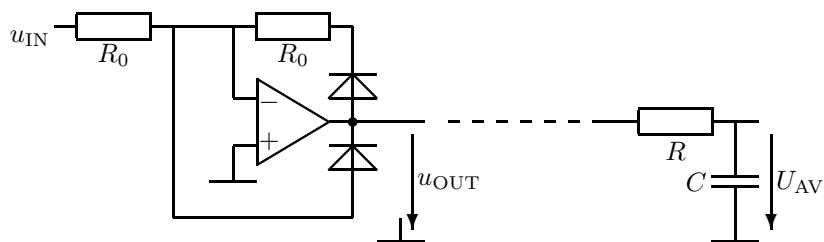
Kuva 454.



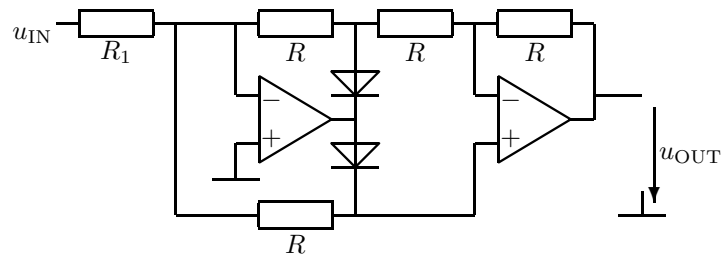
Kuva 455.



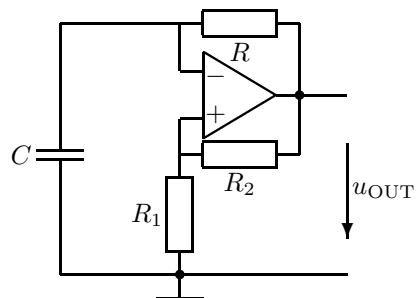
Kuva 456.



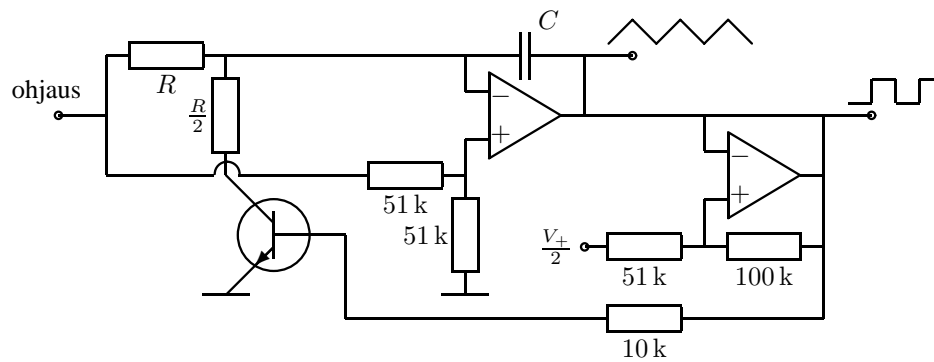
Kuva 457.



Kuva 458.

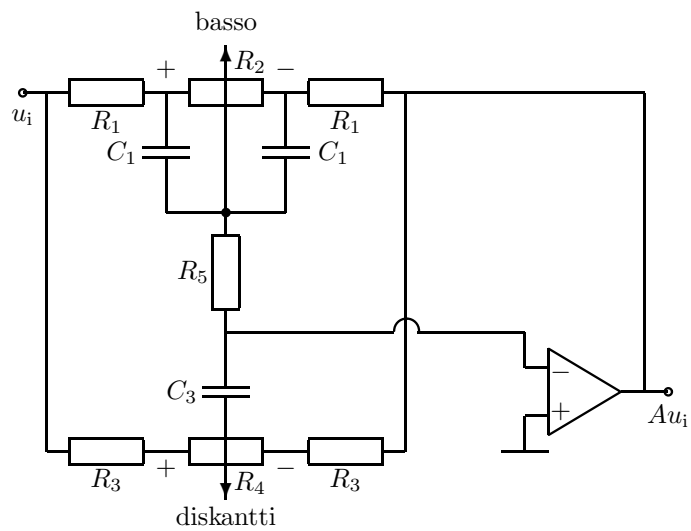


Kuva 459.

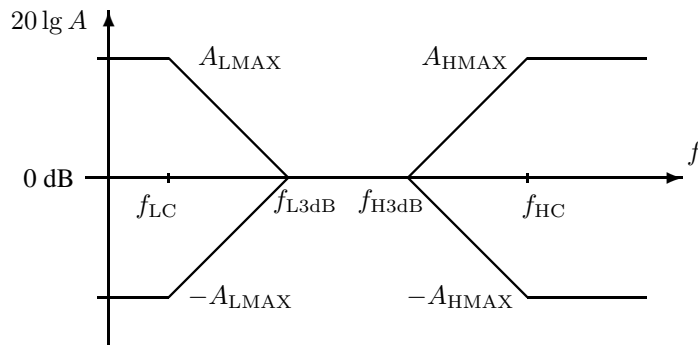


Kuva 460.

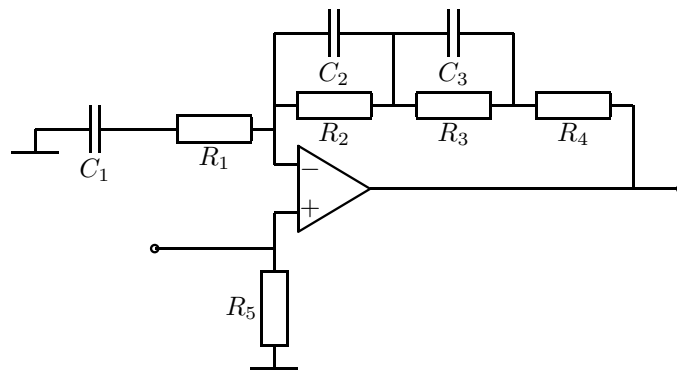
10.5 Audiosovelluksia



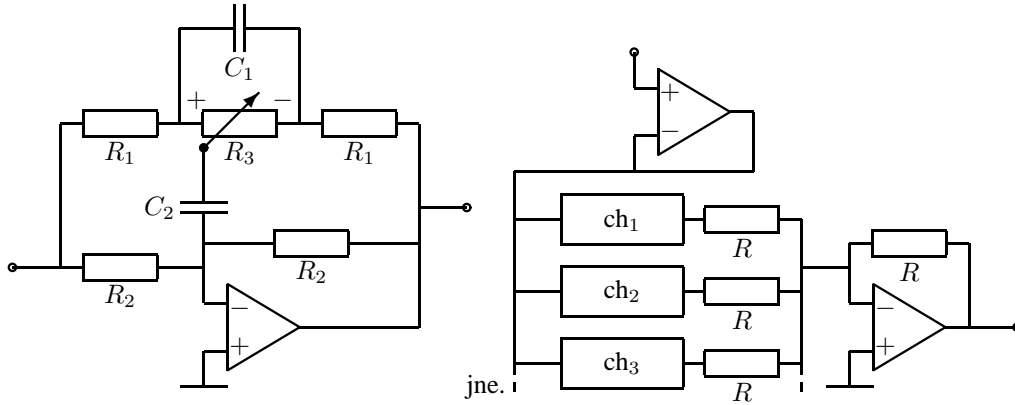
Kuva 462.



Kuva 463.

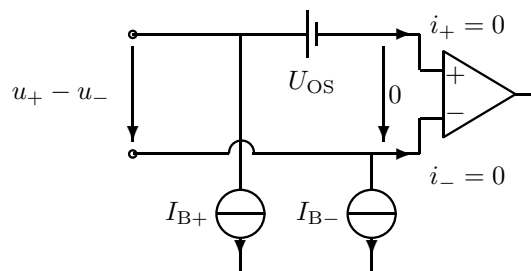


Kuva 465.

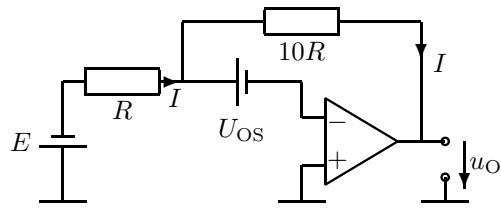


Kuva 467.

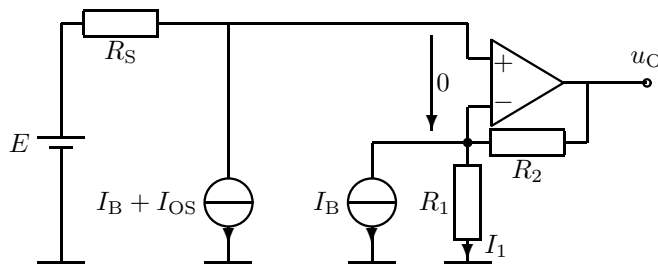
10.6 Operaatiovahvistimen epäideaalisuuksia



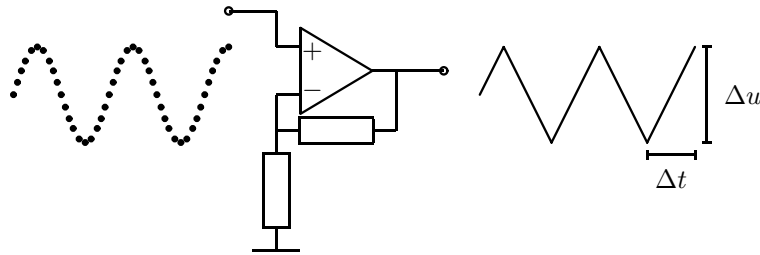
Kuva 469.



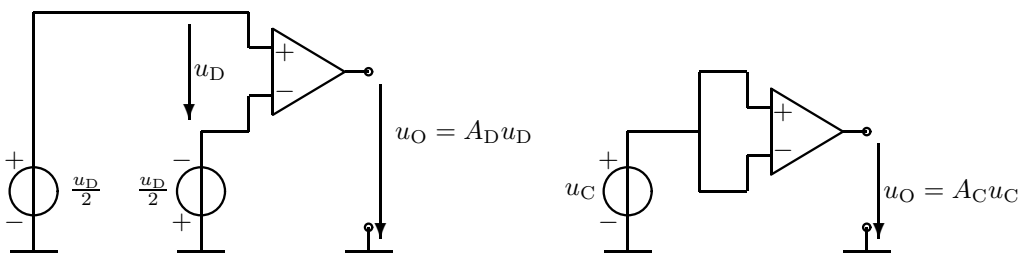
Kuva 470.



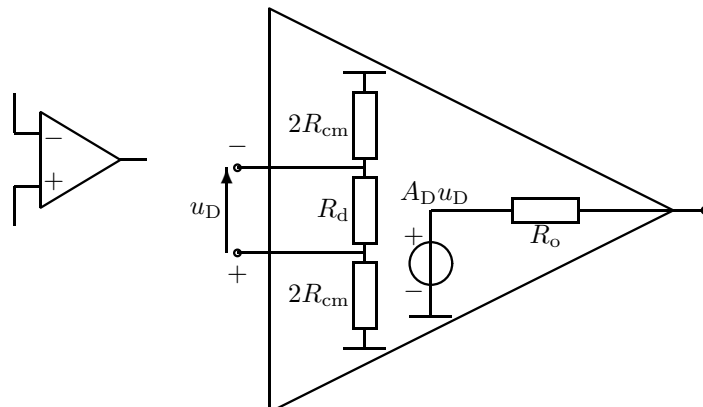
Kuva 471.



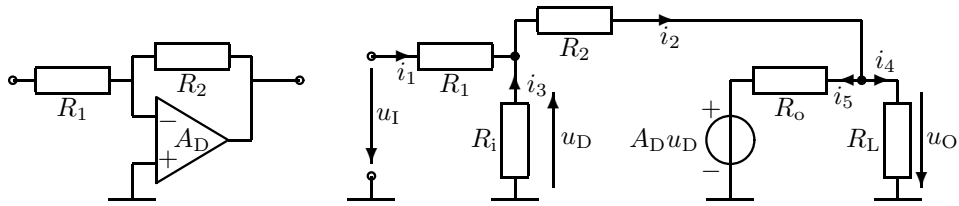
Kuva 472.



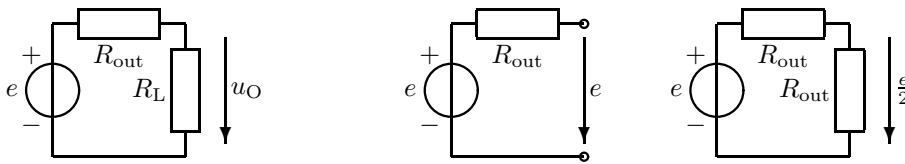
Kuva 473.



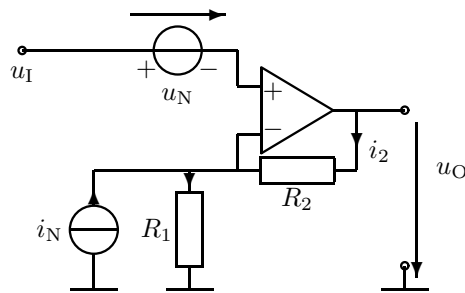
Kuva 474.



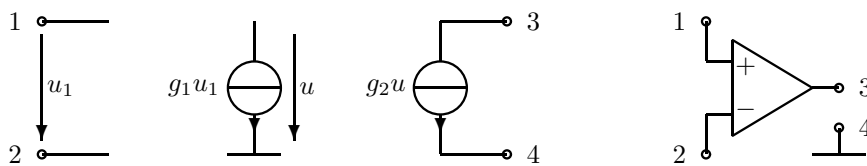
Kuva 475.



Kuva 476.

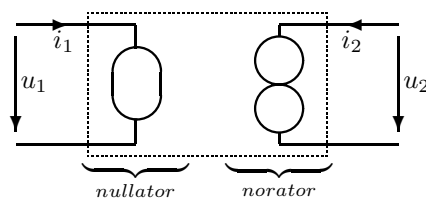


Kuva 477.

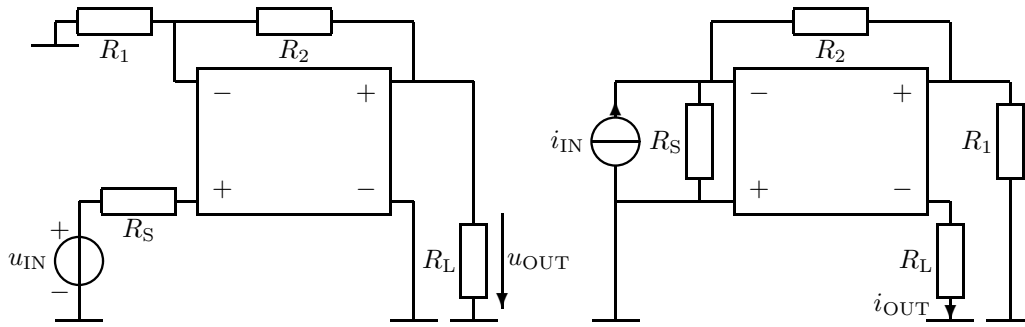


Kuva 478.

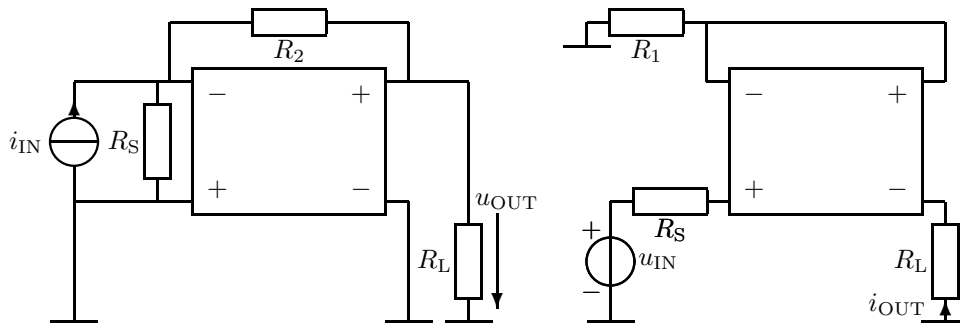
10.7 Uusia vahvistintopologioita



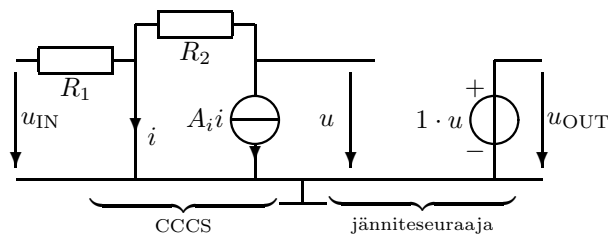
Kuva 480.



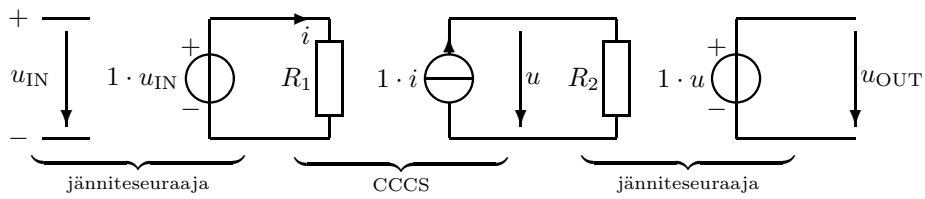
Kuva 481.



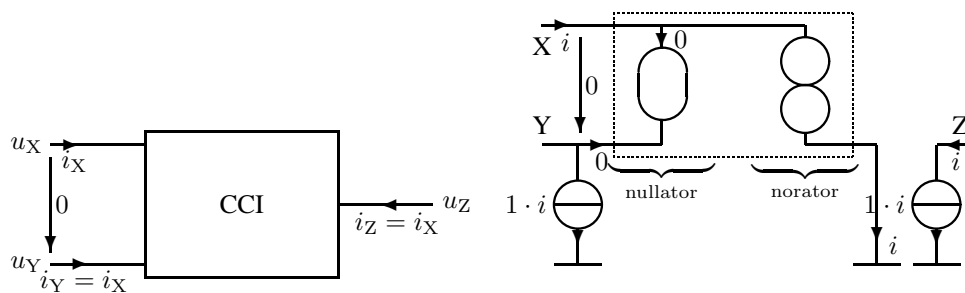
Kuva 482.



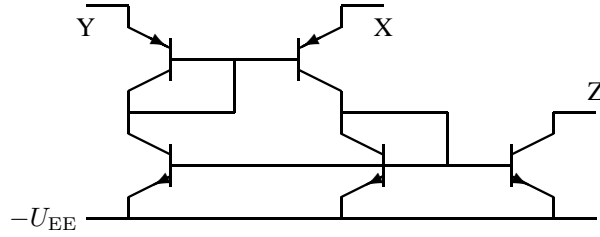
Kuva 483.



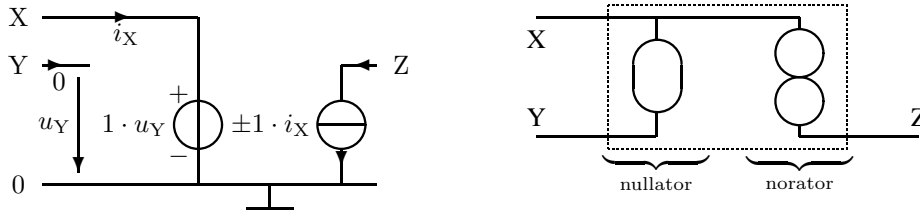
Kuva 484.



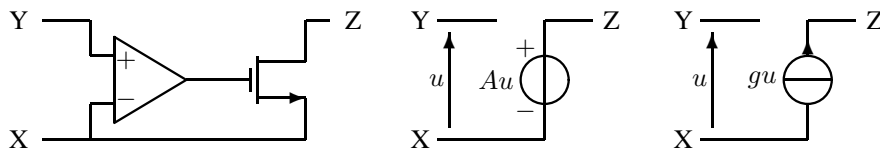
Kuva 485.



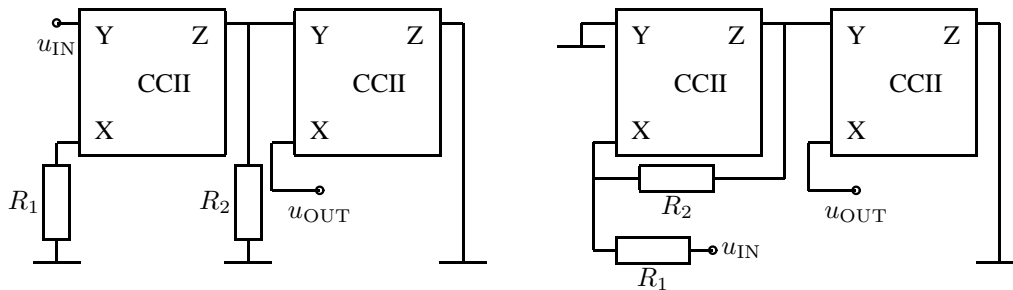
Kuva 486.



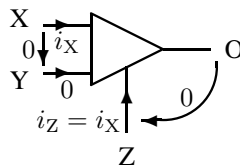
Kuva 487.



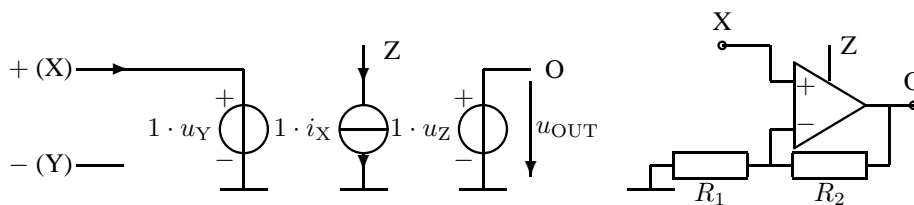
Kuva 488.



Kuva 489.



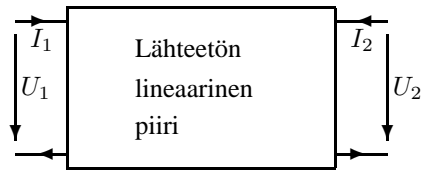
Kuva 490.



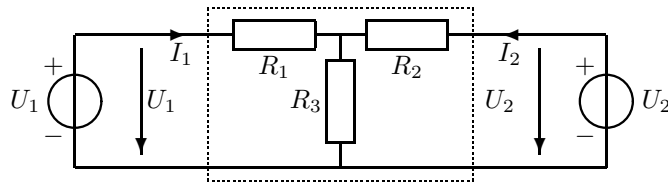
Kuva 491.

11 Kaksiporttiparametrit

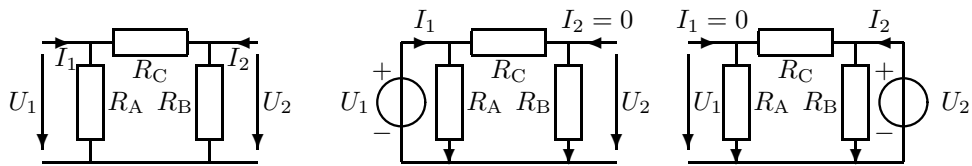
11.1 Jännitteiden ja virtojen parametriesitykset



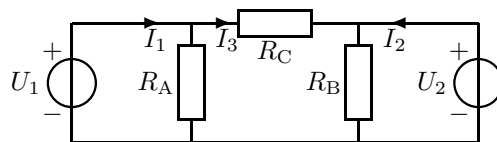
Kuva 492.



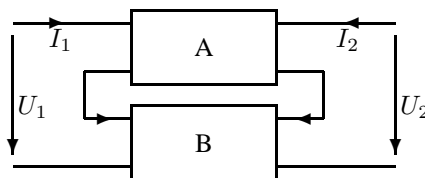
Kuva 493.



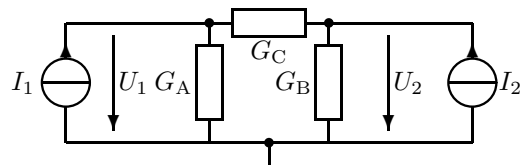
Kuva 494.



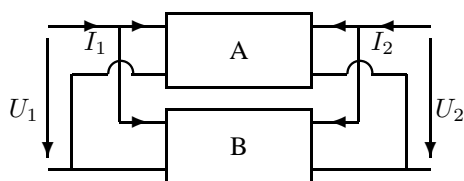
Kuva 495.



Kuva 496.



Kuva 497.



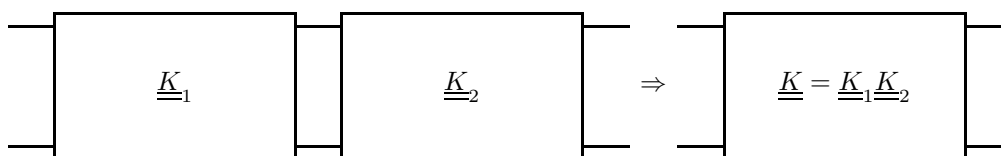
Kuva 498.



Kuva 499.



Kuva 500.



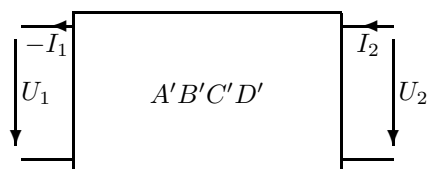
Kuva 501.



Kuva 502.

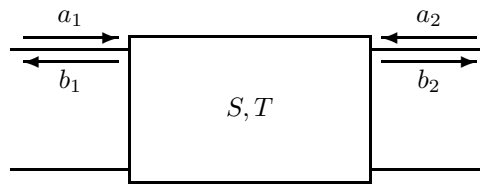


Kuva 503.

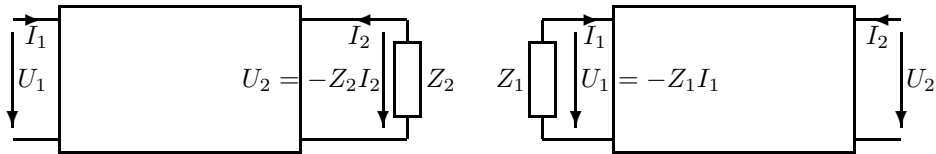


Kuva 504.

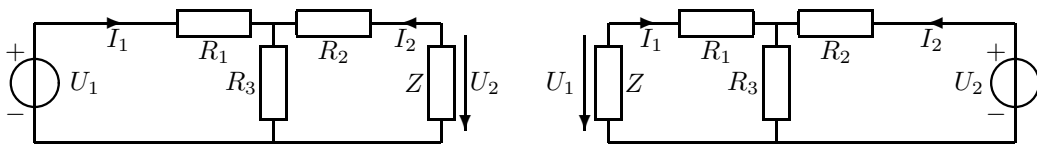
11.2 Sirontaparametrit



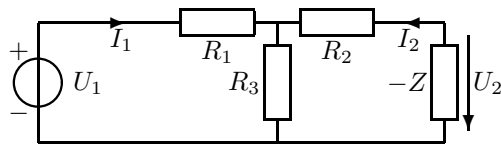
Kuva 505.



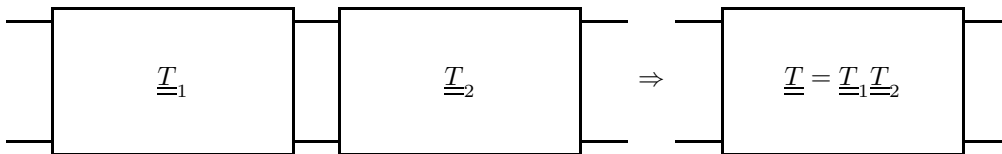
Kuva 506.



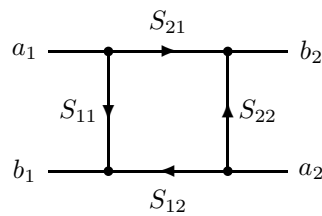
Kuva 507.



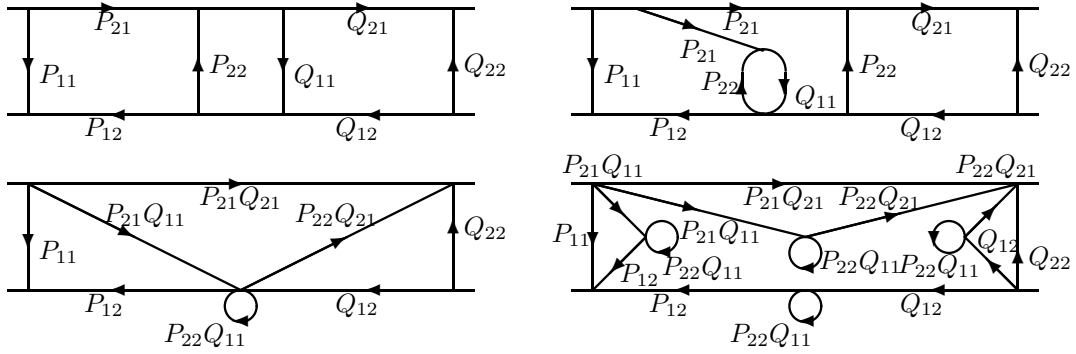
Kuva 508.



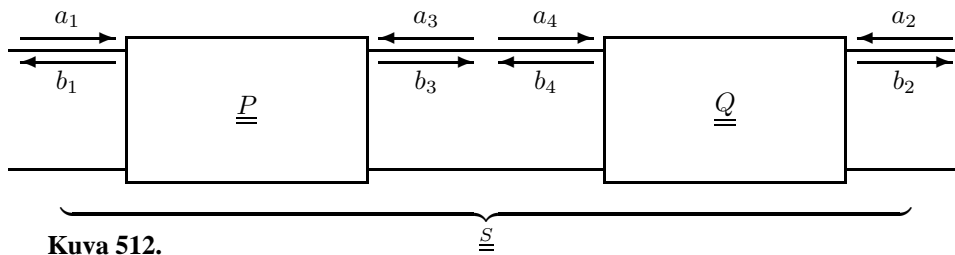
Kuva 509.



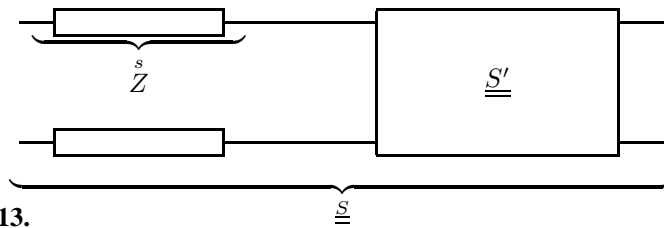
Kuva 510.



Kuva 511.

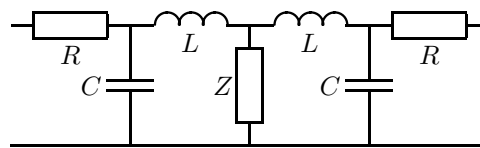


Kuva 512.

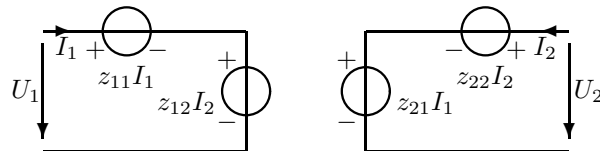


Kuva 513.

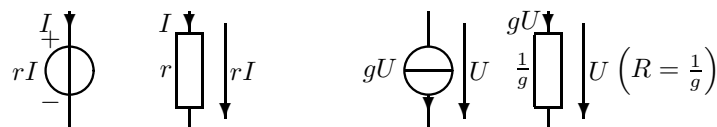
11.3 Parametriesitysten sijaiskytkennät ja muunnoskaavat



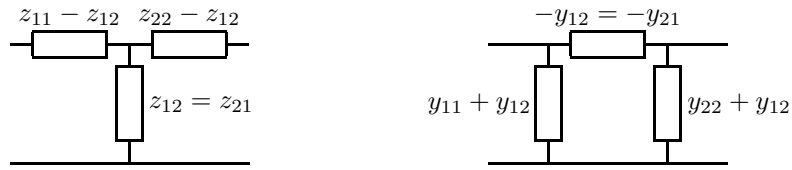
Kuva 514.



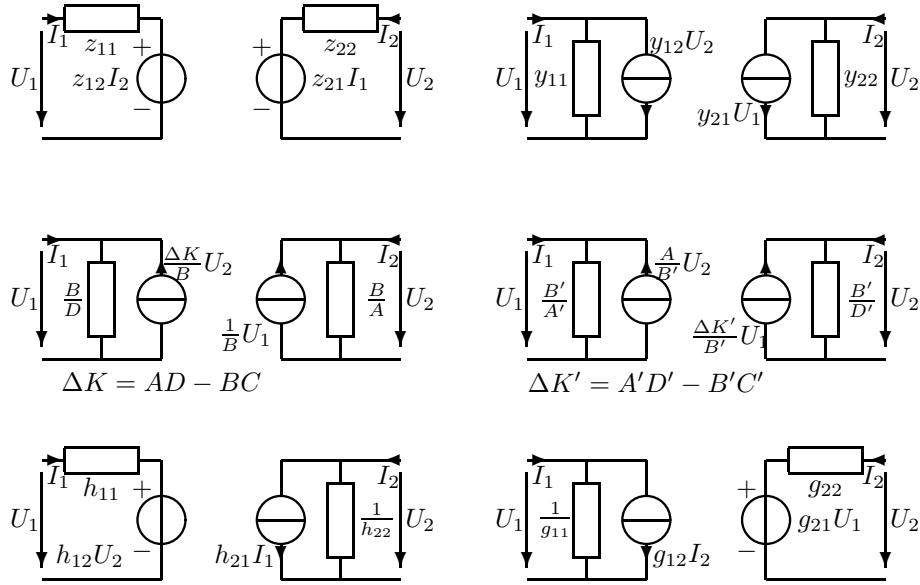
Kuva 515.



Kuva 516.



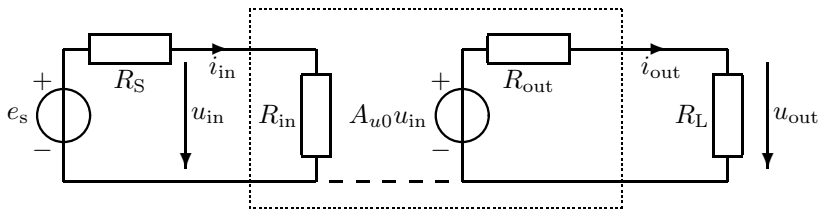
Kuva 517.



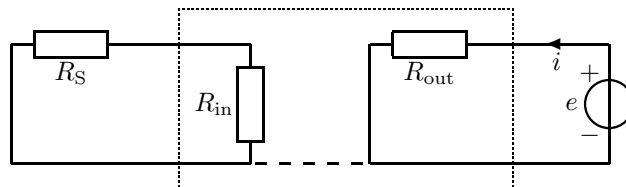
Kuva 518.

12 Vahvistimet ja takaisinkytkentä

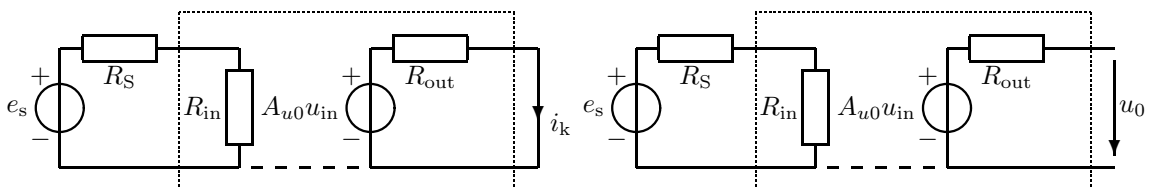
12.1 Ideaalivahvistimet



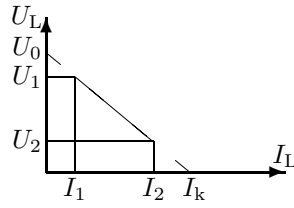
Kuva 519.



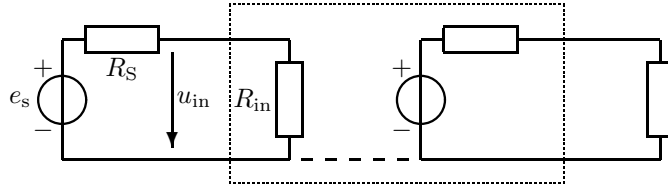
Kuva 520.



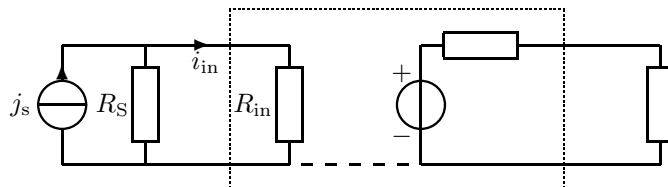
Kuva 521.



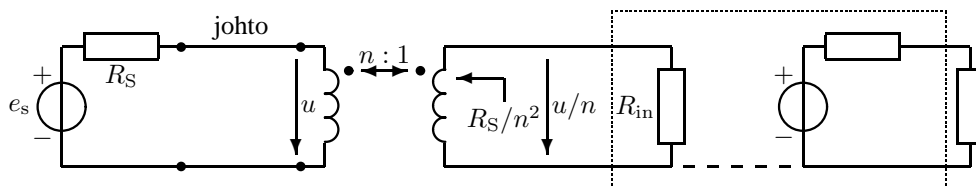
Kuva 522.



Kuva 523.

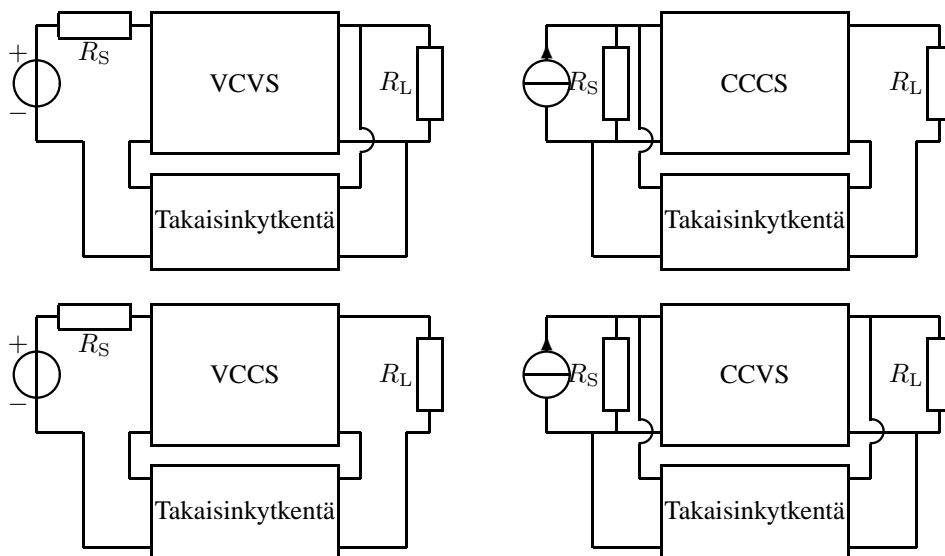


Kuva 524.

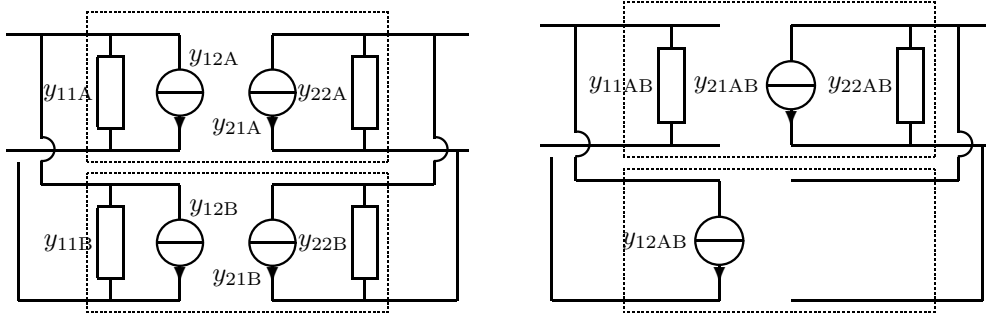


Kuva 525.

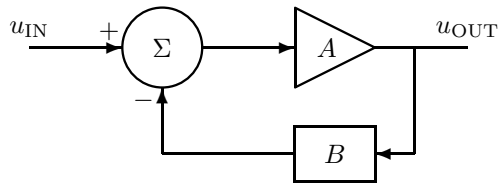
12.2 Takaisinkytkentä



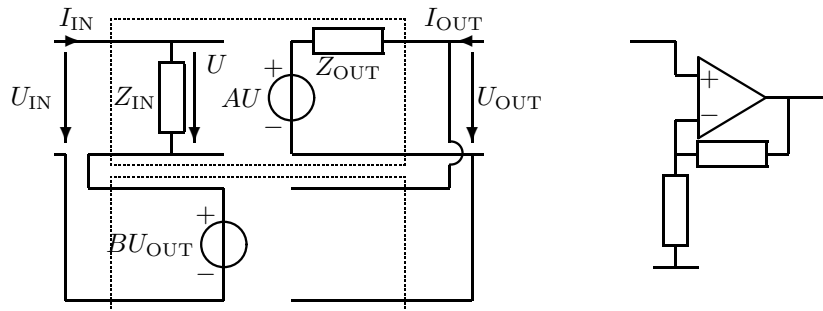
Kuva 526.



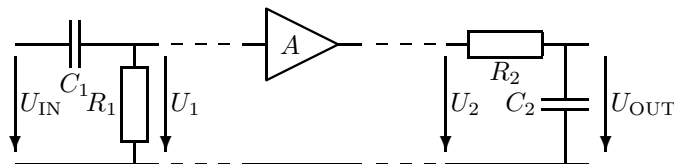
Kuva 527.



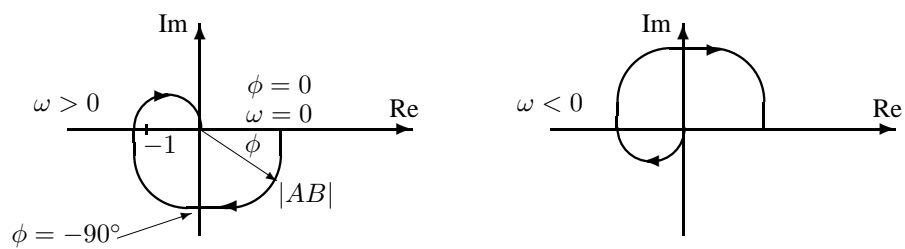
Kuva 528.



Kuva 529.



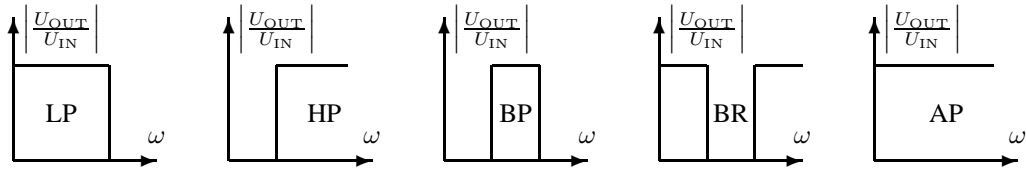
Kuva 530.



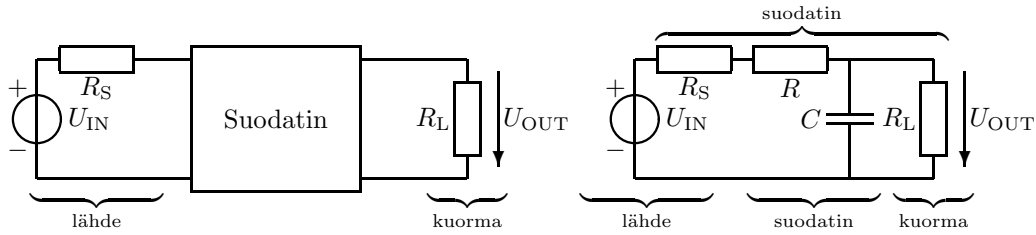
Kuva 531.

13 Suodattimet

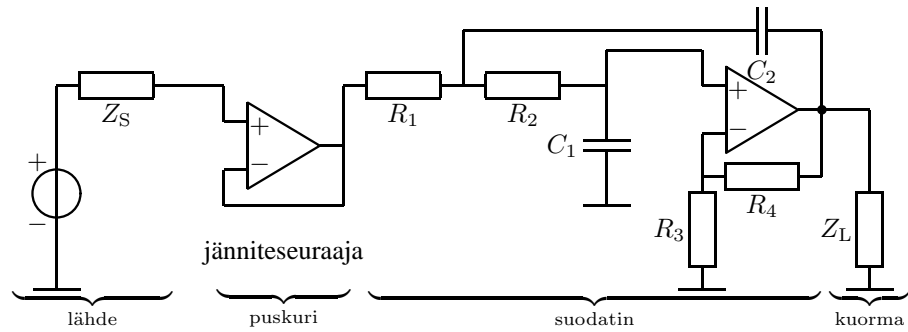
13.1 Matemaattinen analyysi ja peruskäsitteet



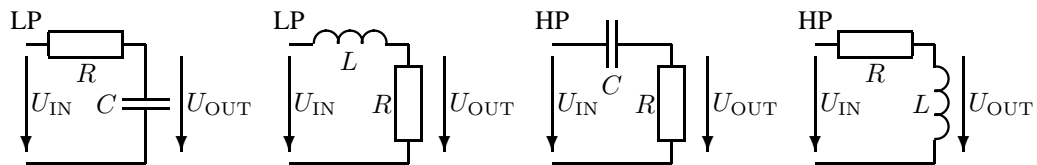
Kuva 532.



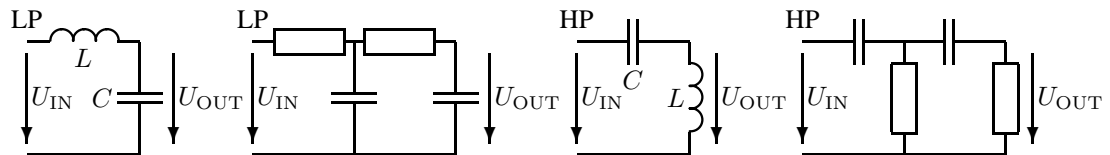
Kuva 533.



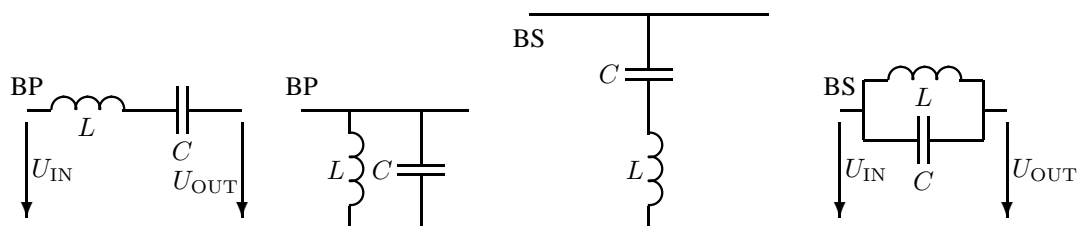
Kuva 534.



Kuva 535.

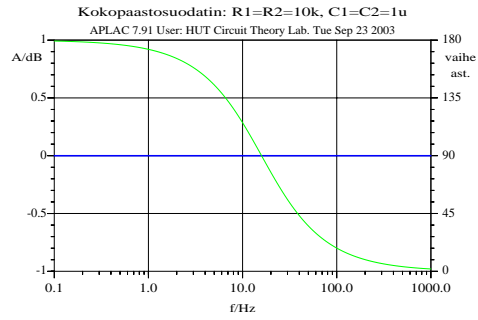
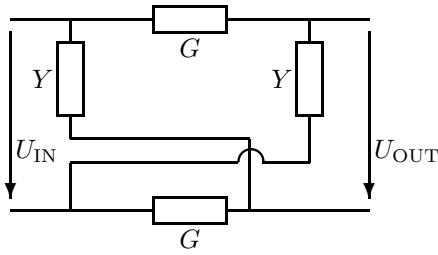


Kuva 536.

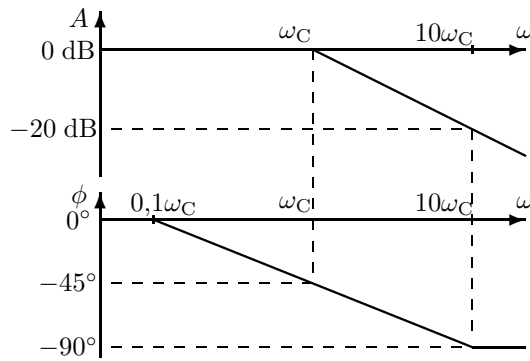


Kuva 537.

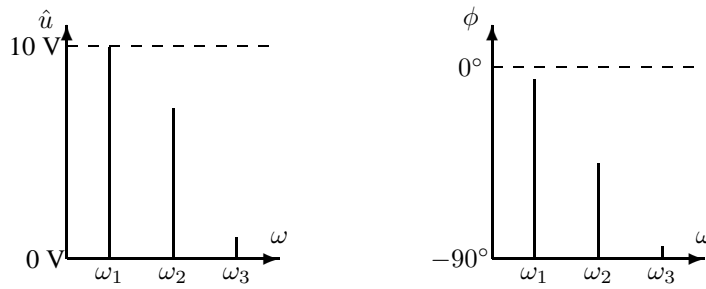
AP



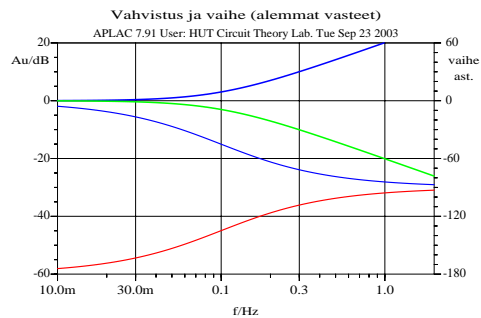
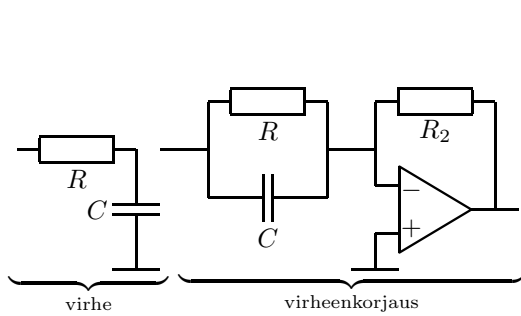
Kuva 538.



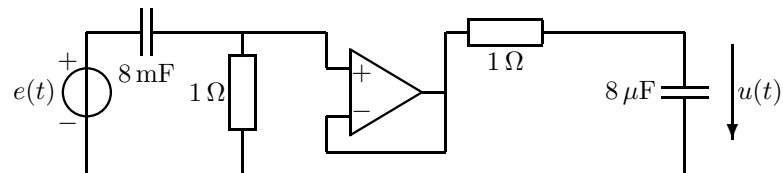
Kuva 540.



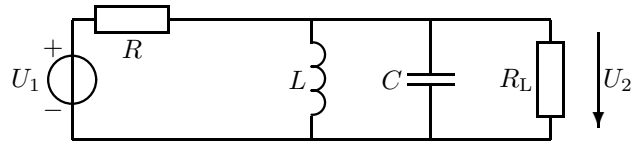
Kuva 541.



Kuva 543.

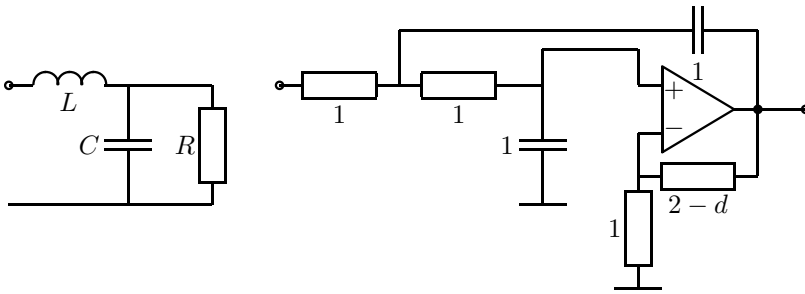


Kuva 544.

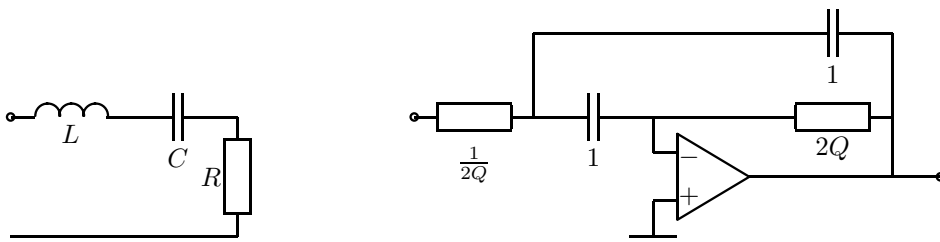


Kuva 549.

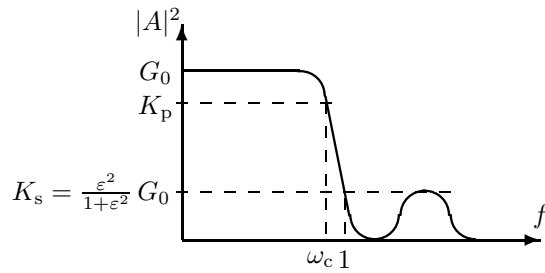
13.2 Suodatinaprosimaatiot



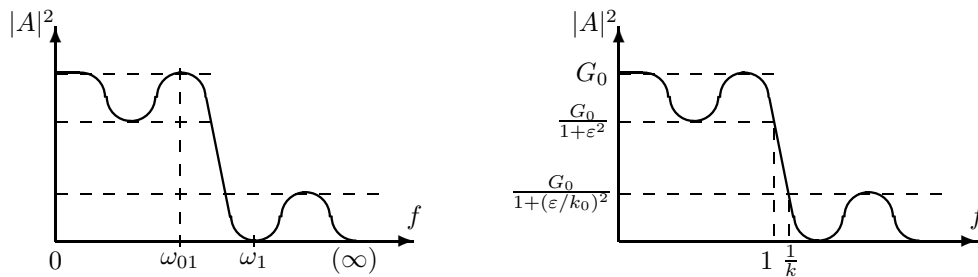
Kuva 551.



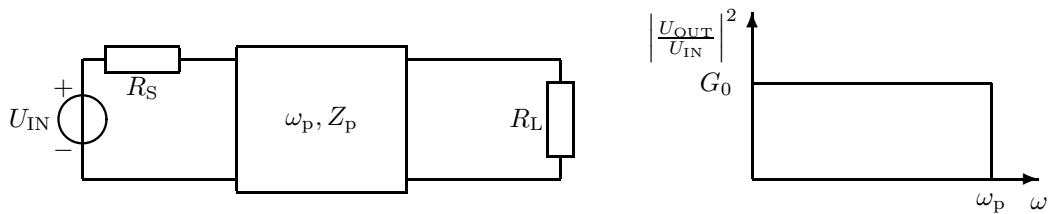
Kuva 553.



Kuva 555.

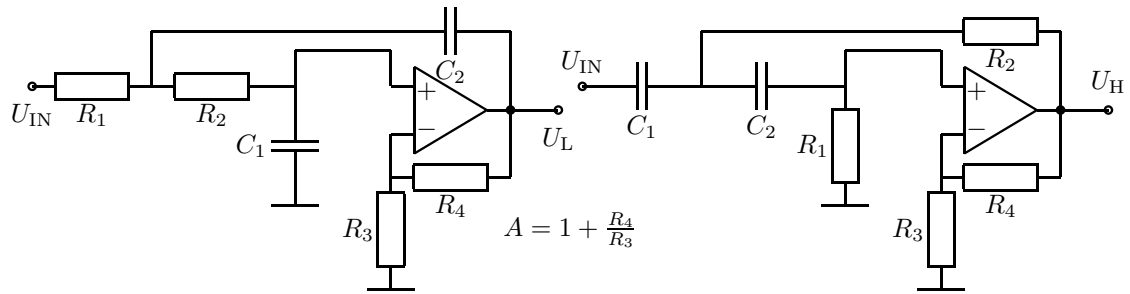


Kuva 556.

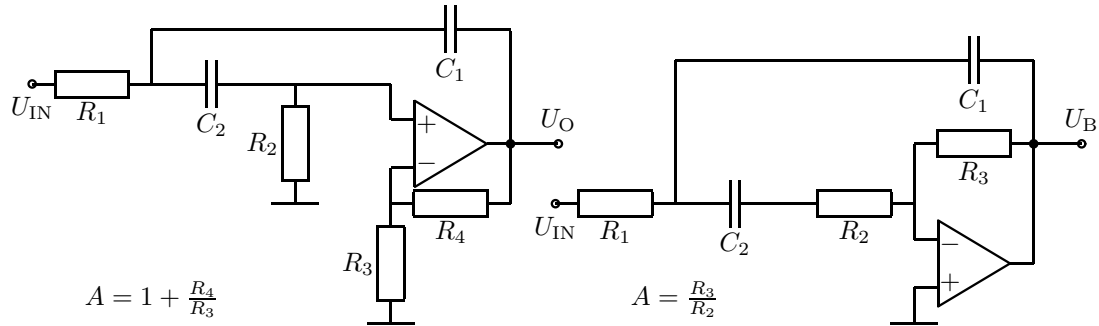


Kuva 560.

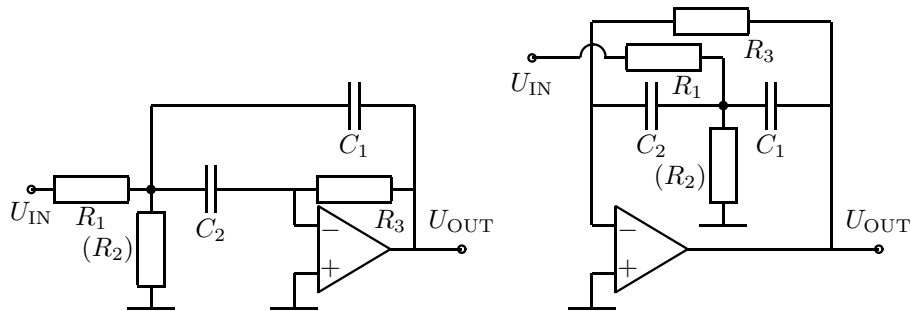
13.3 Aktiiviset RC-suodattimet



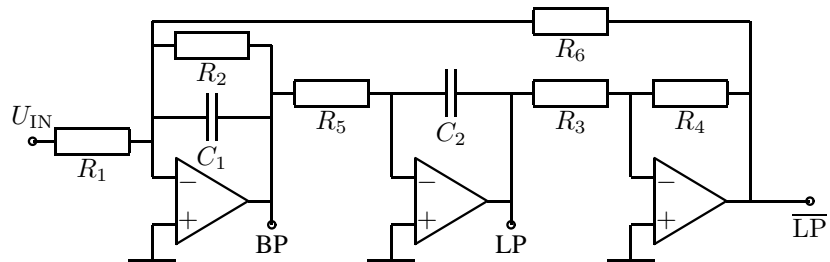
Kuva 561.



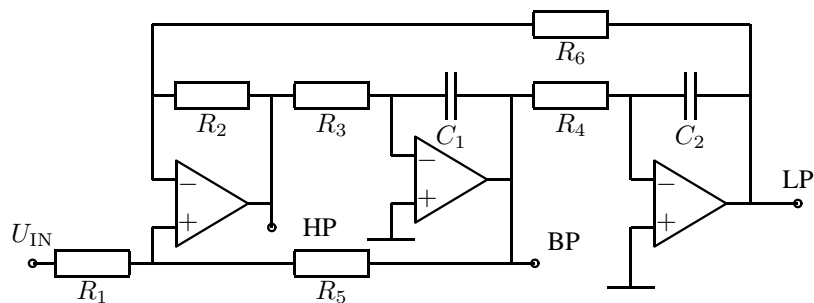
Kuva 562.



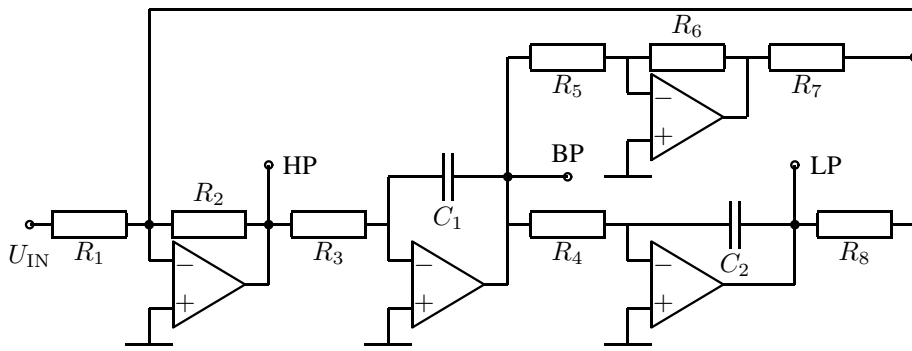
Kuva 564.



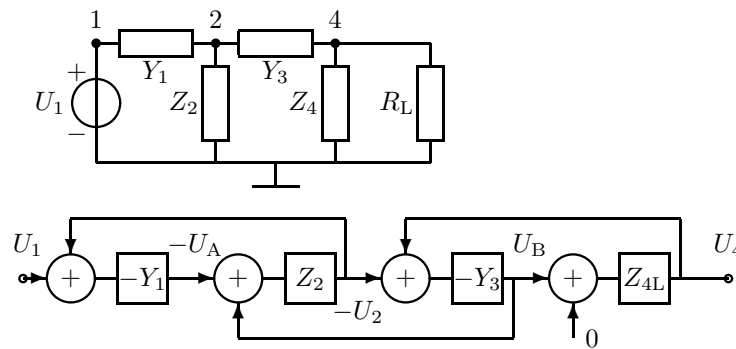
Kuva 565.



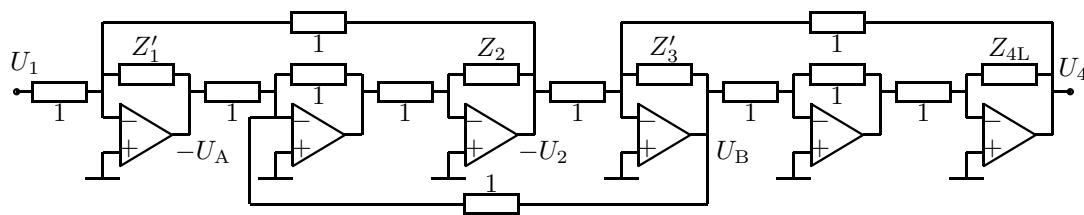
Kuva 566.



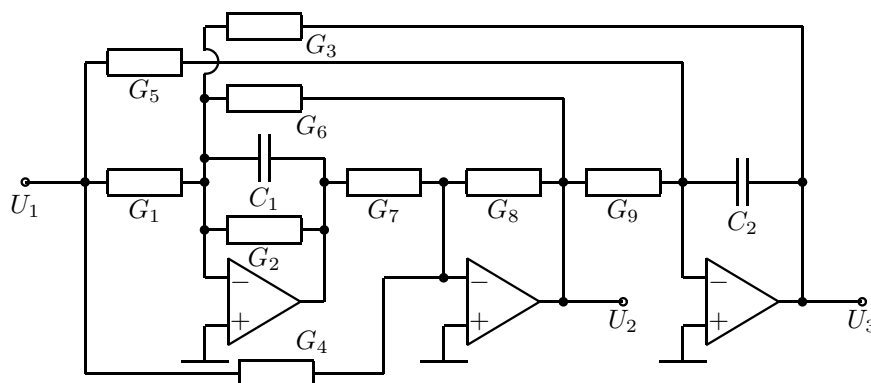
Kuva 567.



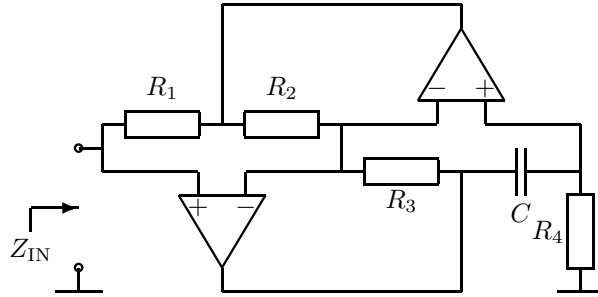
Kuva 568.



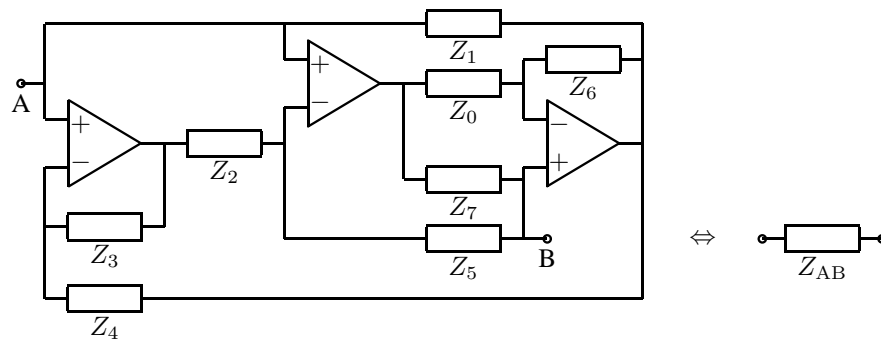
Kuva 569.



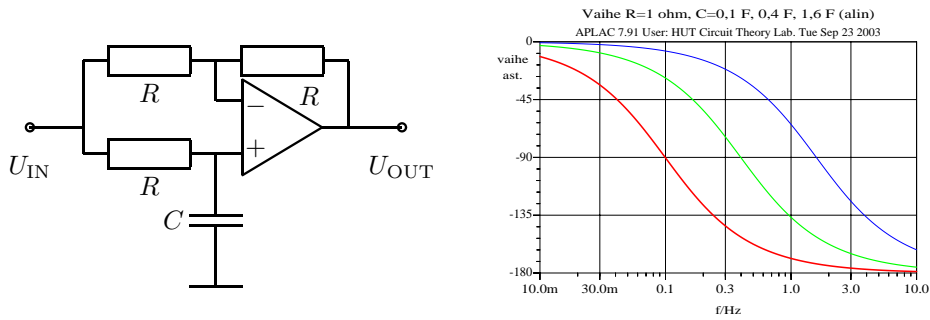
Kuva 570.



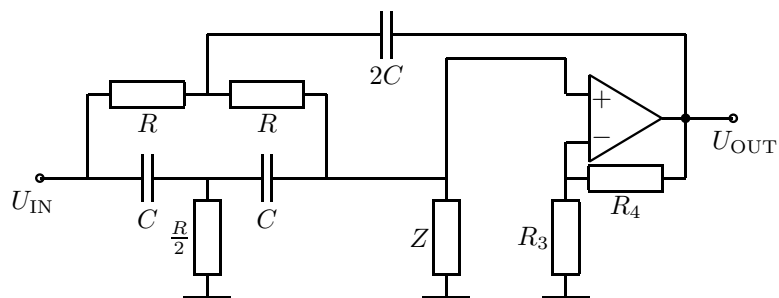
Kuva 571.



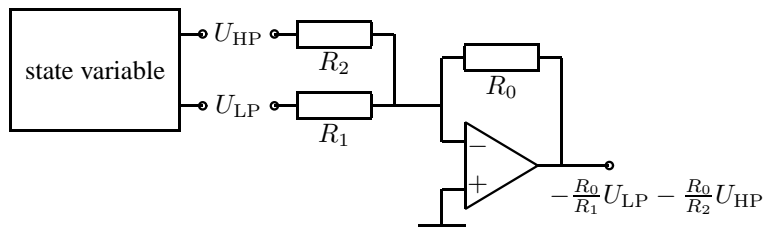
Kuva 572.



Kuva 573.

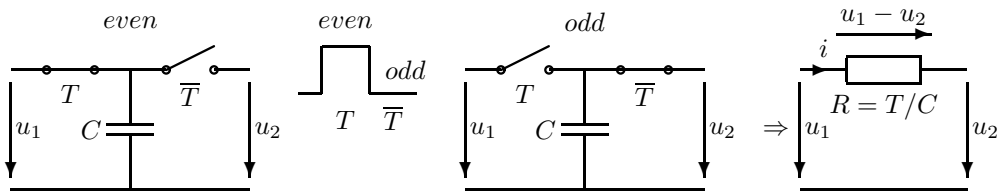


Kuva 574.

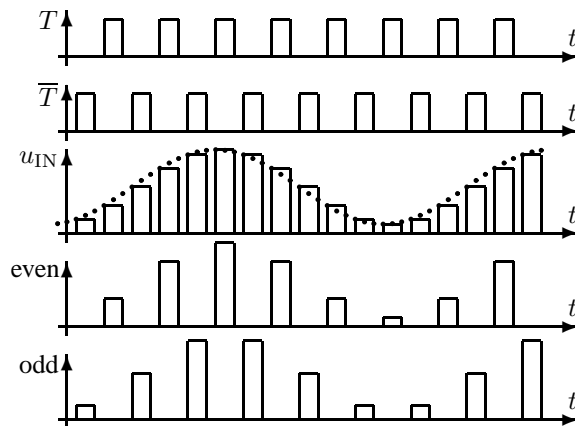


Kuva 576.

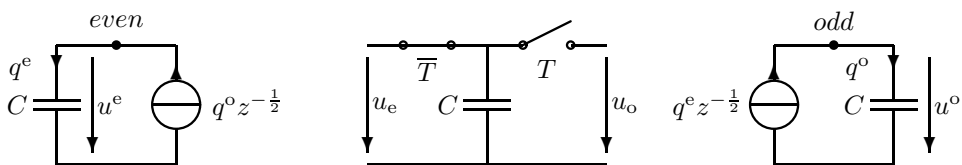
13.4 Kytkin-kapasitanssi- eli SC-suodattimet



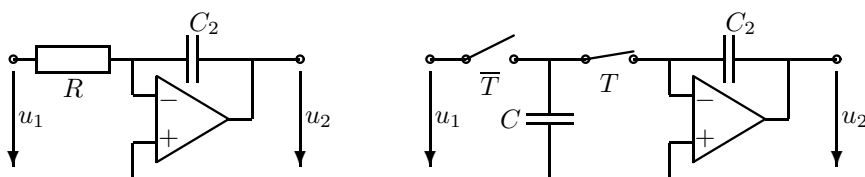
Kuva 577.



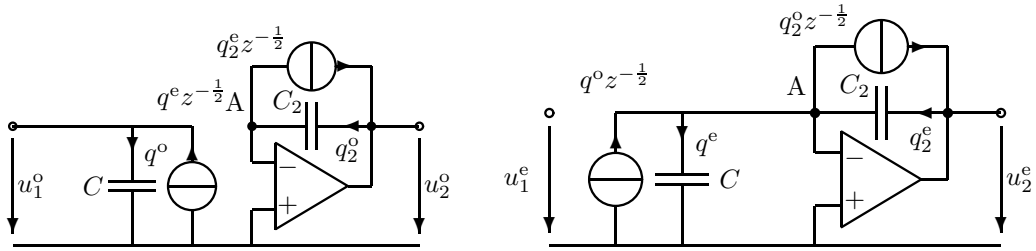
Kuva 578.



Kuva 579.

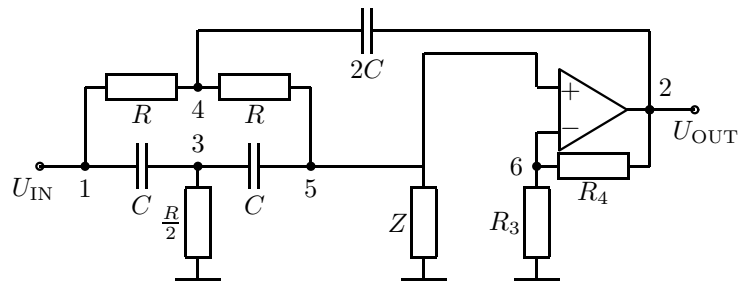


Kuva 580.



Kuva 581.

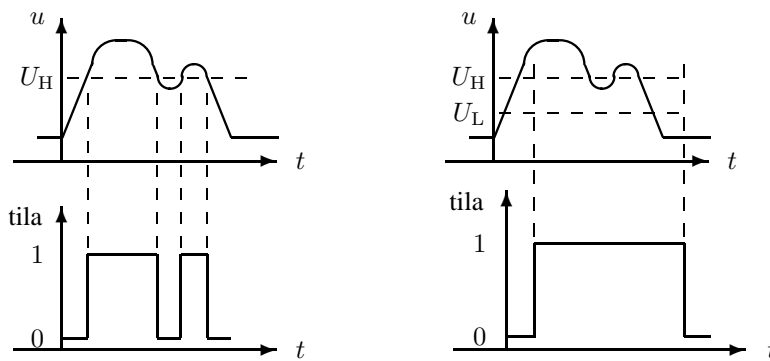
13.5 APLAC suodatinsuunnittelun tukena



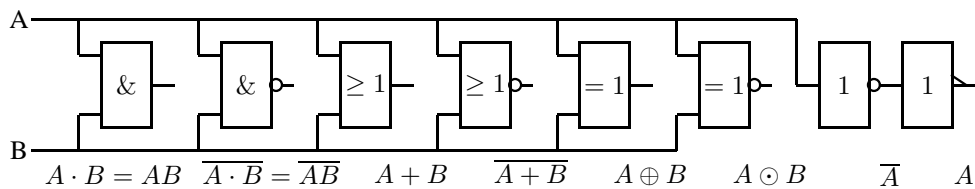
Kuva 582.

14 Digitaalitekniikka

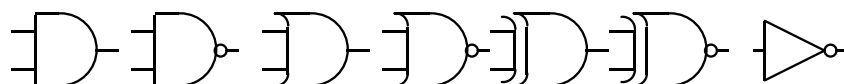
14.1 Logiikkapiirit



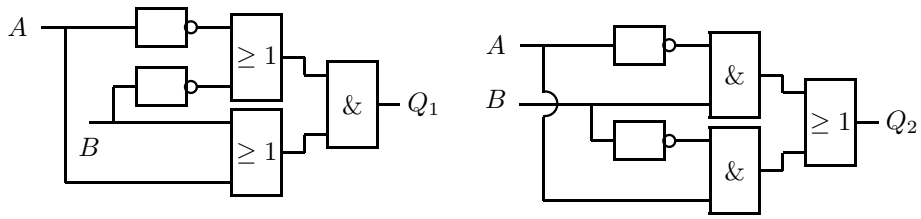
Kuva 587.



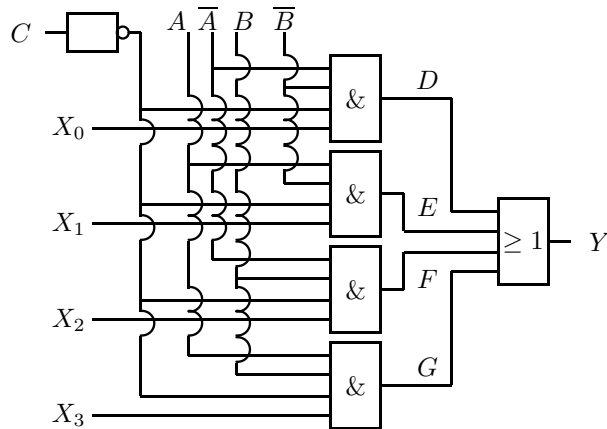
Kuva 588.



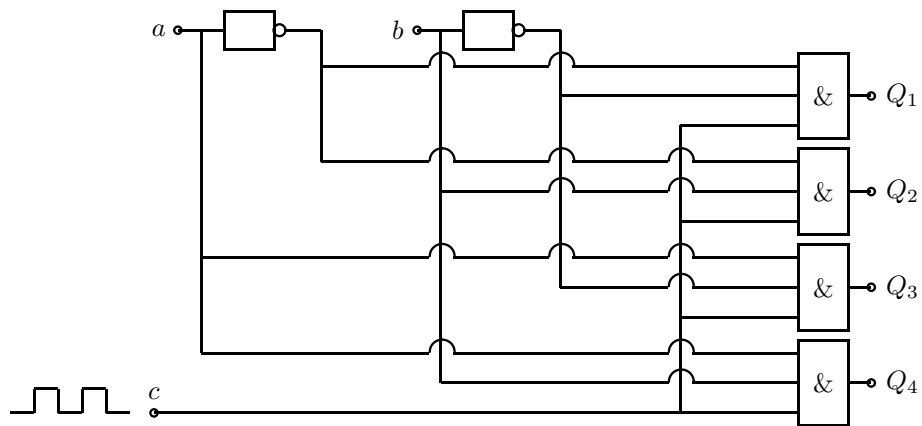
Kuva 589.



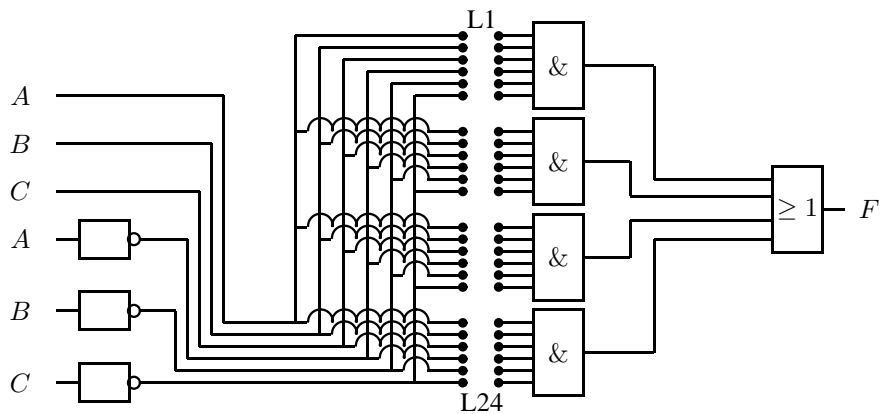
Kuva 590.



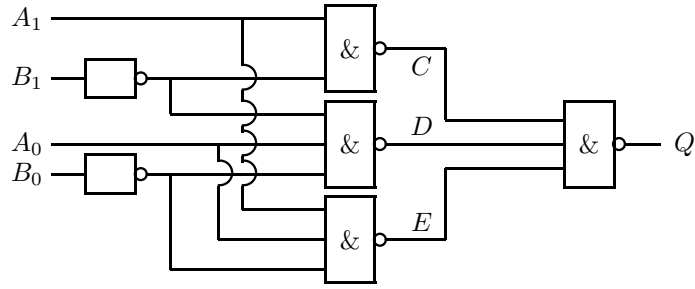
Kuva 591.



Kuva 592.



Kuva 593.



Kuva 594.

	AB	AB	AB	AB
	00	01	11	10
CD	0	0	0	0
01	1	0	0	0
11	0	0	0	0
10	0	0	0	0

	AB	AB	AB	AB
	00	01	11	10
CD				
01	f			
11				
10				

Kuva 595.

	AB			
	00	01	11	10
CD				
01		1	1	
11				
10				

	$\overline{A}\overline{B}$	$\overline{A}B$	$A\overline{B}$	AB
$\overline{C}\overline{D}$				
$\overline{C}D$		1	1	
$C\overline{D}$				
CD				

	AB			
	00	01	11	10
CD				
01		1	1	
11		1	1	
10				

Kuva 596.

	AB			
	00	01	11	10
CD	1	1		
01	1	1		
11	1	1		
10	1	1		

	AB			
	00	01	11	10
CD				
01	1	1	1	1
11	1	1	1	1
10				

Kuva 597.

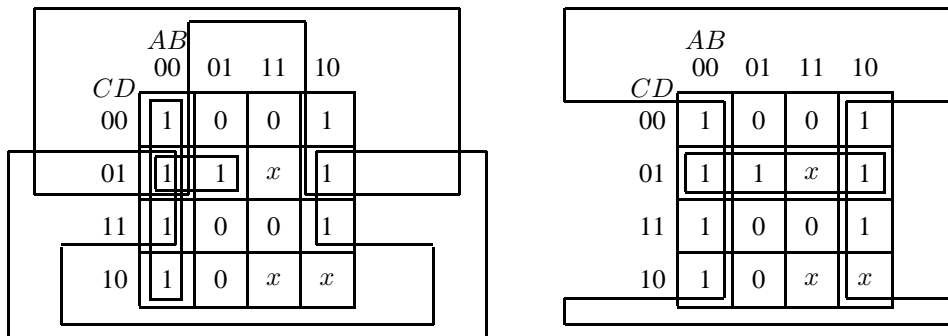
	AB			
	00	01	11	10
CD	1			1
01				
11				
10	1			1

	AB			
	10	00	01	11
CD	1	1		
00	1	1		
01				
11				

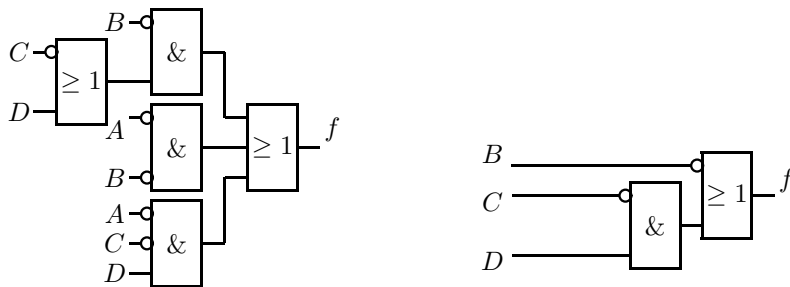
Kuva 598.

	AB			
	00	01	11	10
CD				
00	1	1		1
01	1	1	1	
11	1	1	1	
10	1	1		

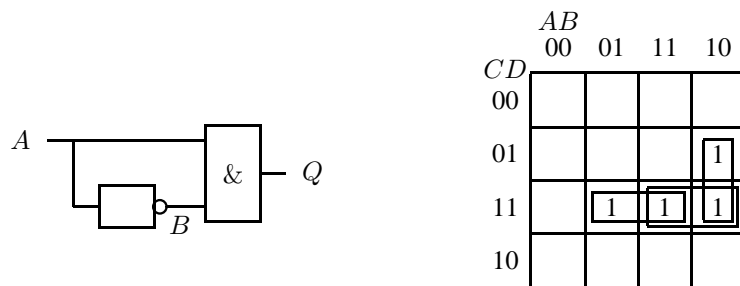
Kuva 599.



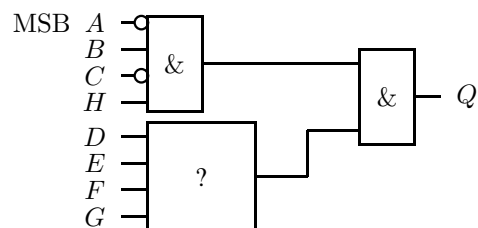
Kuva 600.



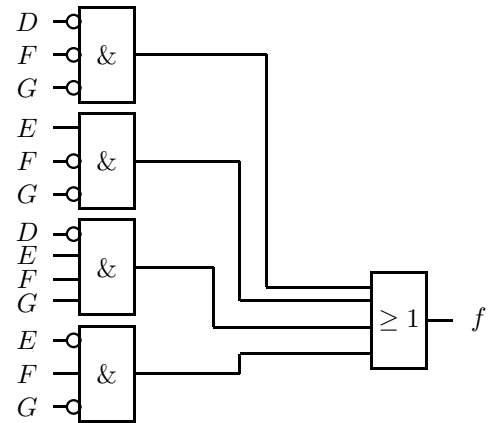
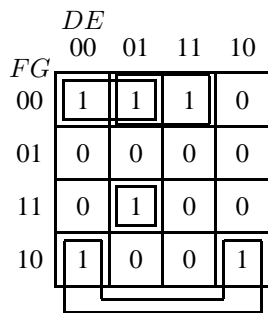
Kuva 601.



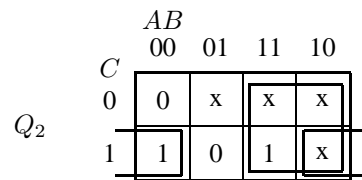
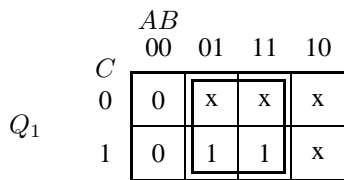
Kuva 602.



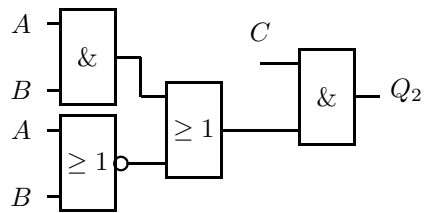
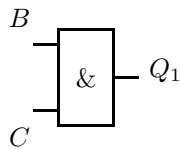
Kuva 603.



Kuva 604.



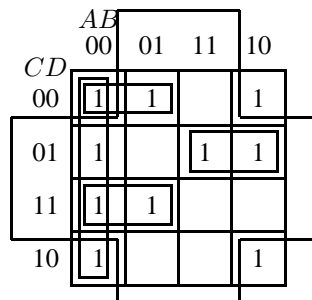
Kuva 605.



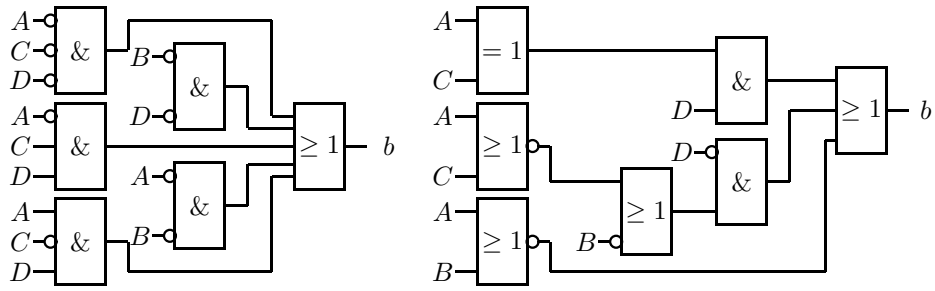
Kuva 606.



Kuva 607.

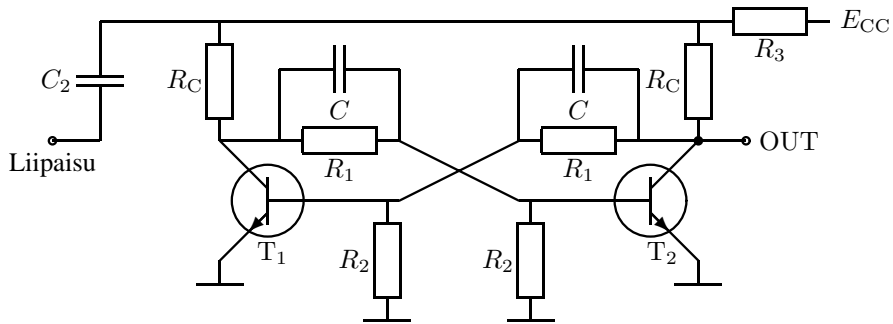


Kuva 608.

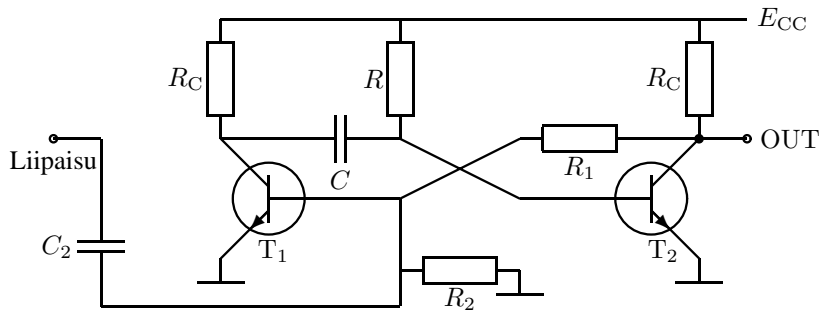


Kuva 609.

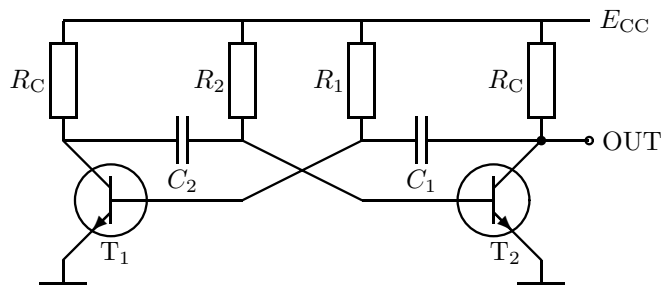
14.2 Sekvenssiipiirit



Kuva 610.



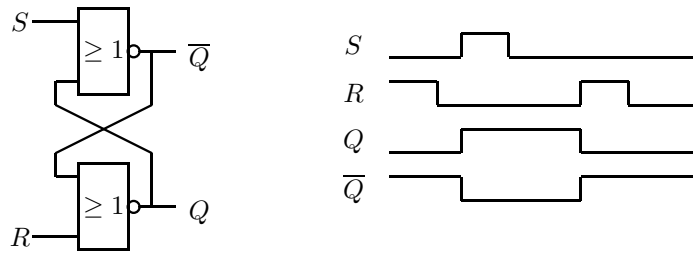
Kuva 612.



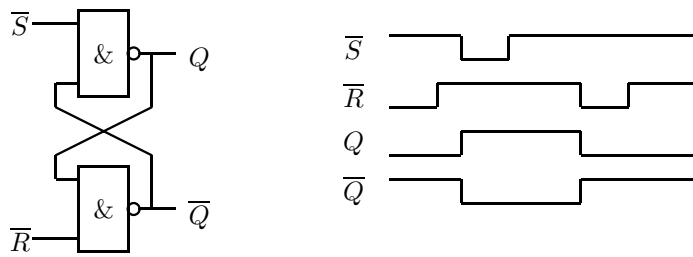
Kuva 614.



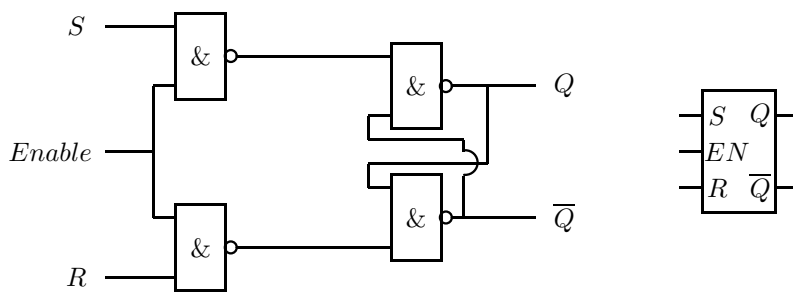
Kuva 616.



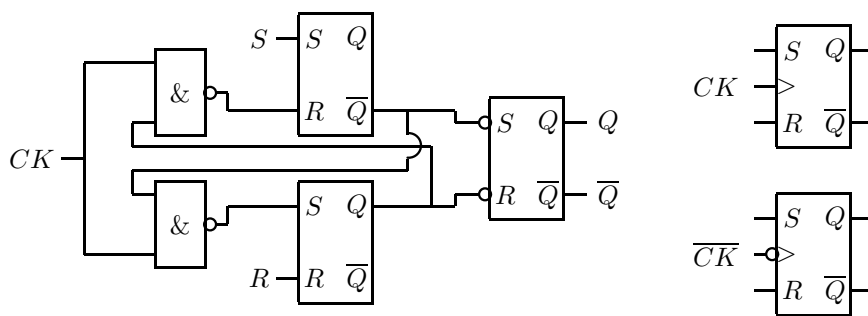
Kuva 617.



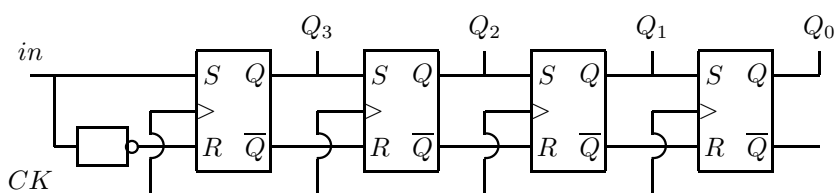
Kuva 618.



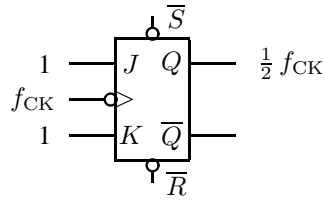
Kuva 619.



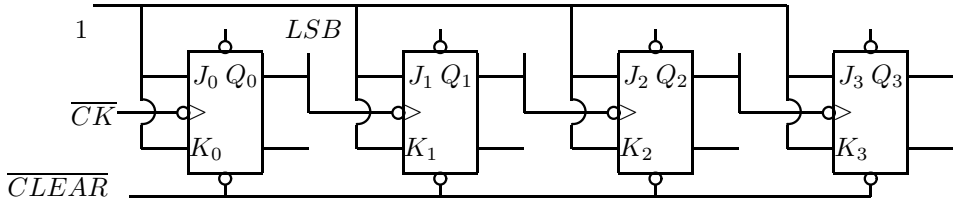
Kuva 620.



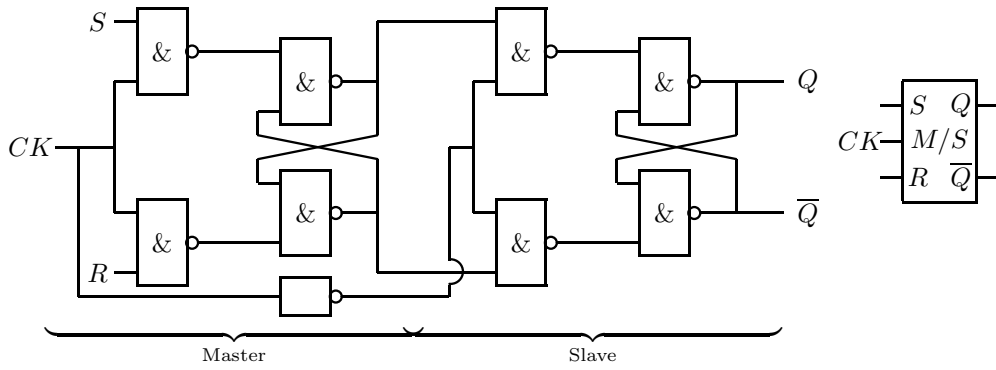
Kuva 621.



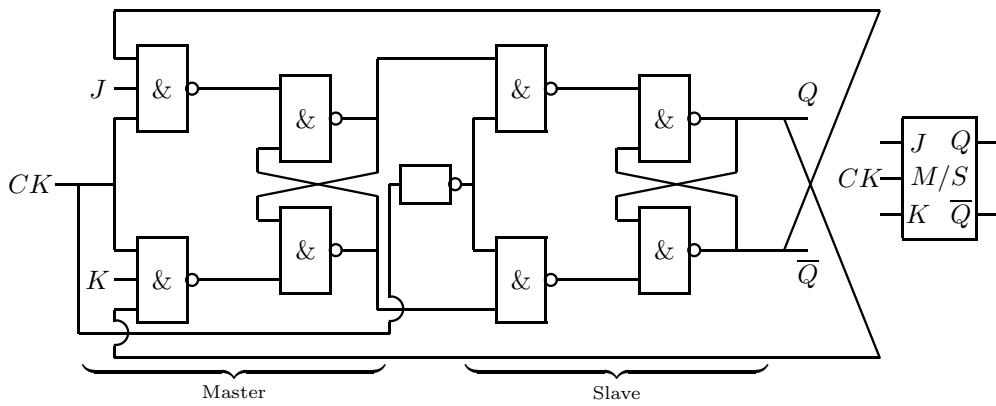
Kuva 628.



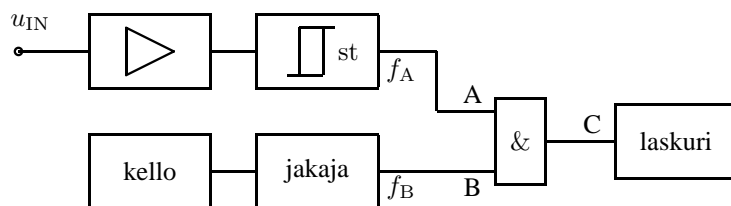
Kuva 629.



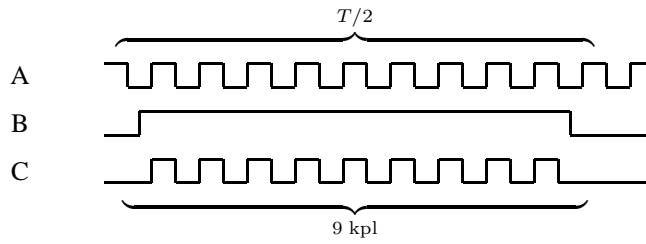
Kuva 630.



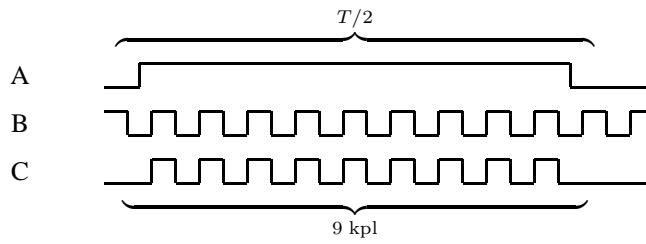
Kuva 631.



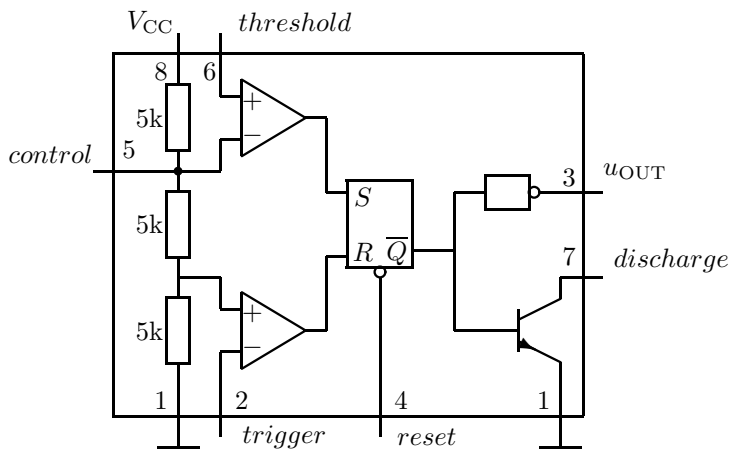
Kuva 632.



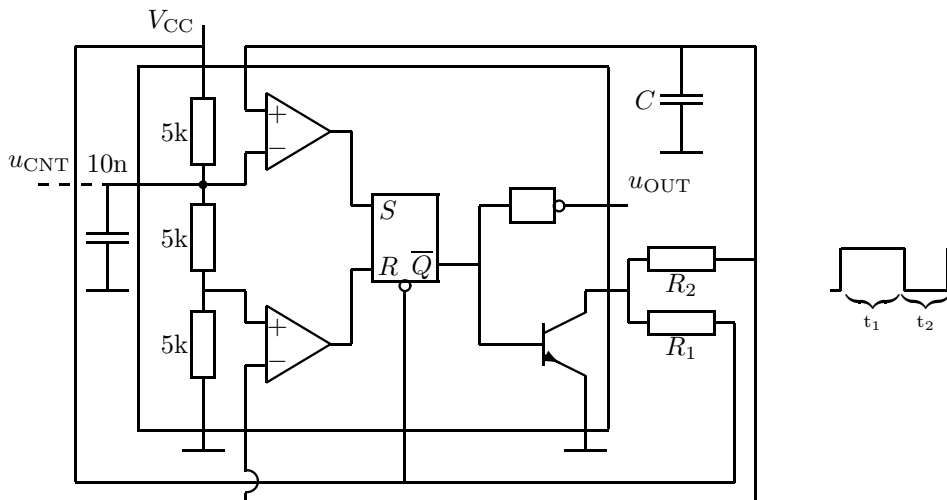
Kuva 633.



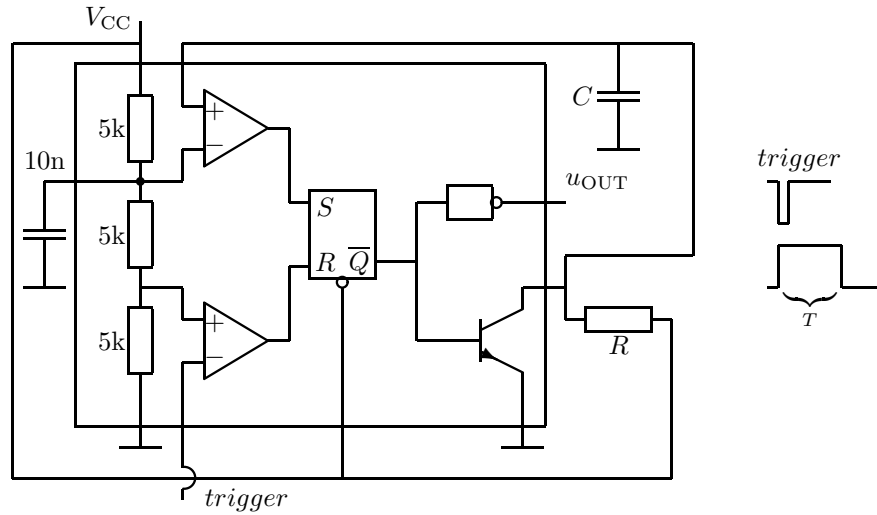
Kuva 634.



Kuva 635.

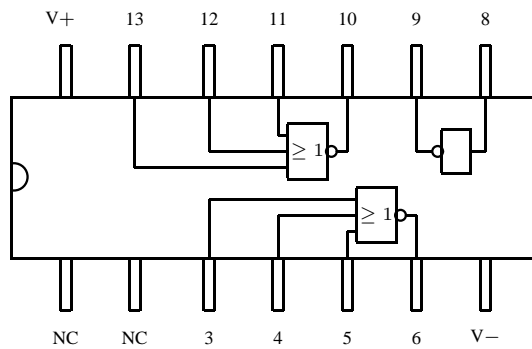


Kuva 636.

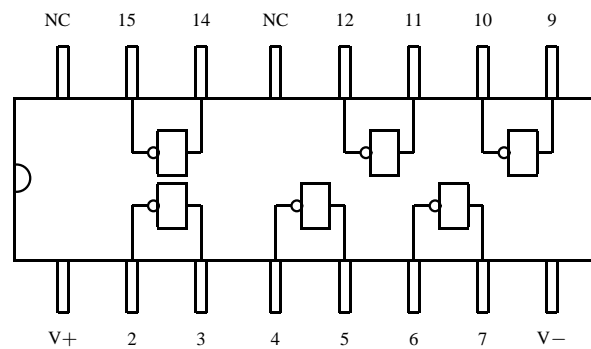


Kuva 637.

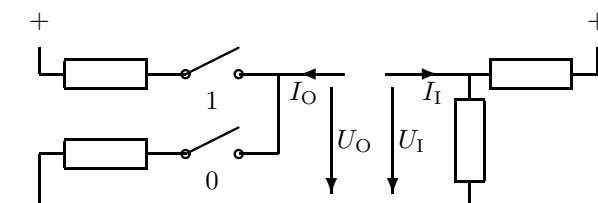
14.3 Digitaaliset mikropiirit käytännössä



Kuva 638.



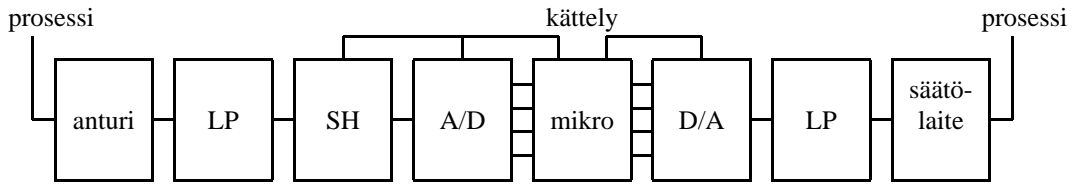
Kuva 639.



Kuva 640.

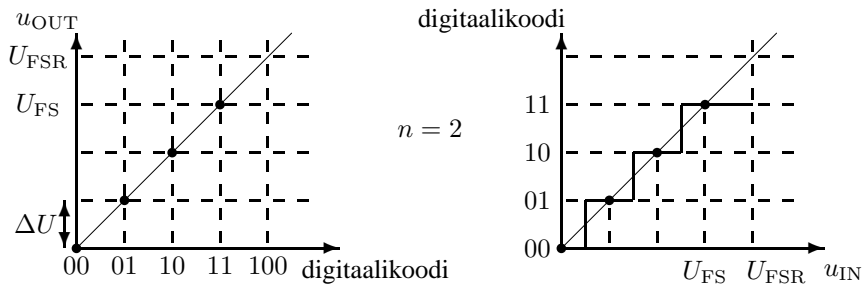
15 A/D- ja D/A-muuntimet

15.1 Esimerkki mittaus- ja säätöjärjestelmästä

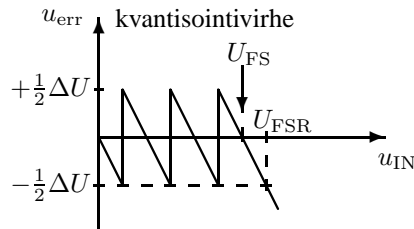


Kuva 641.

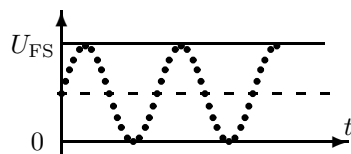
15.2 Kvantisointi, resoluutio ja signaalikohinasuhde



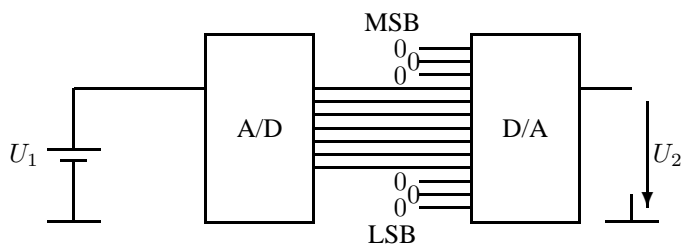
Kuva 642.



Kuva 643.

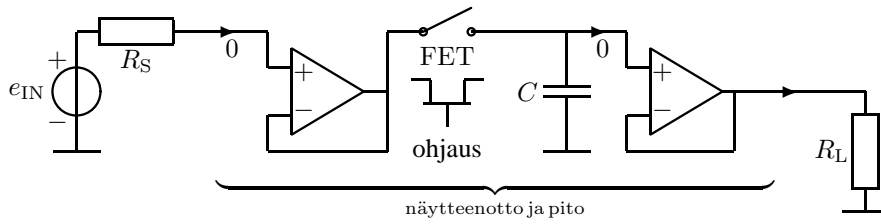


Kuva 644.

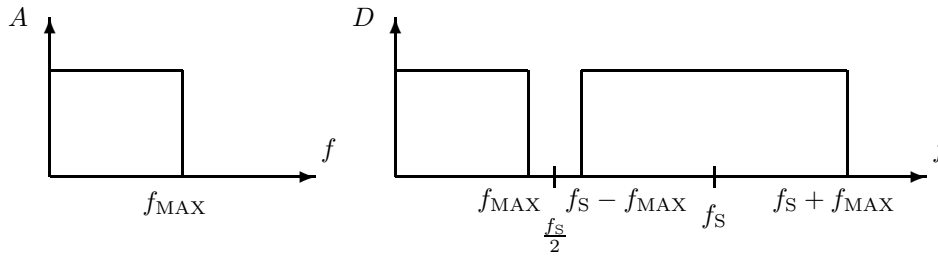


Kuva 645.

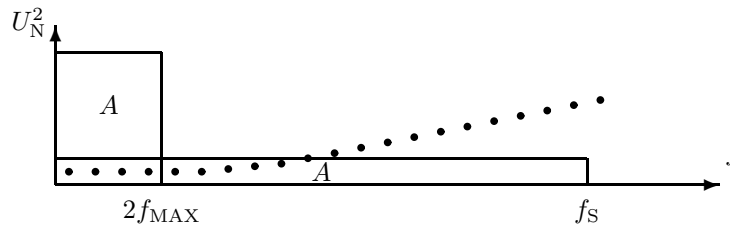
15.3 Näytteistys



Kuva 646.

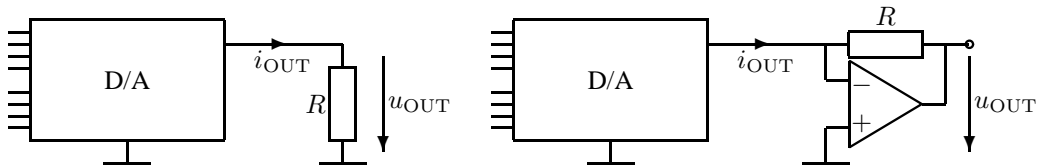


Kuva 647.

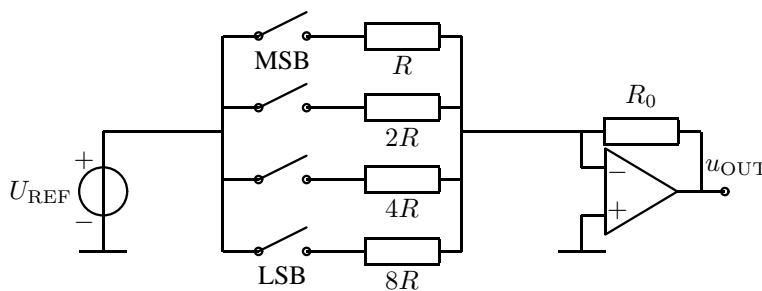


Kuva 648.

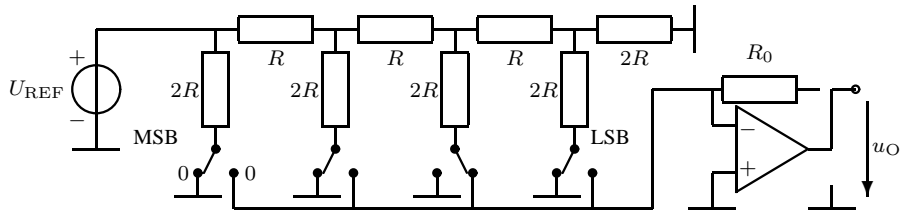
15.4 D/A-muuntimet (DAC)



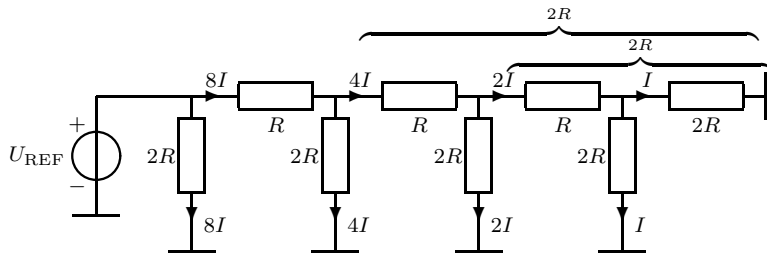
Kuva 649.



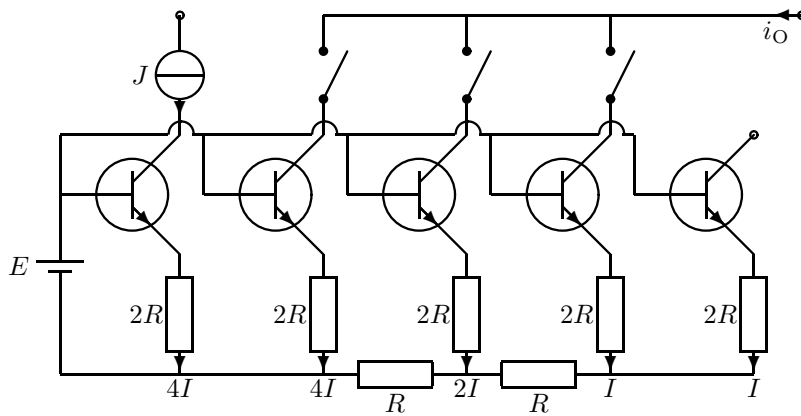
Kuva 650.



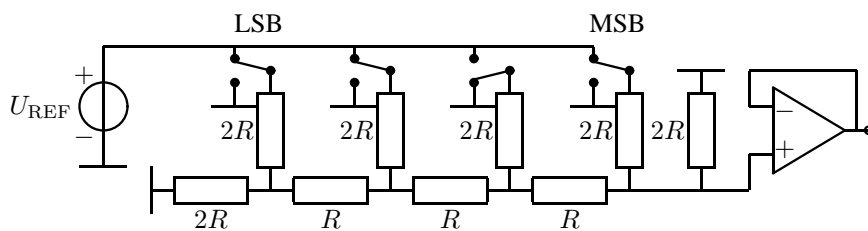
Kuva 651.



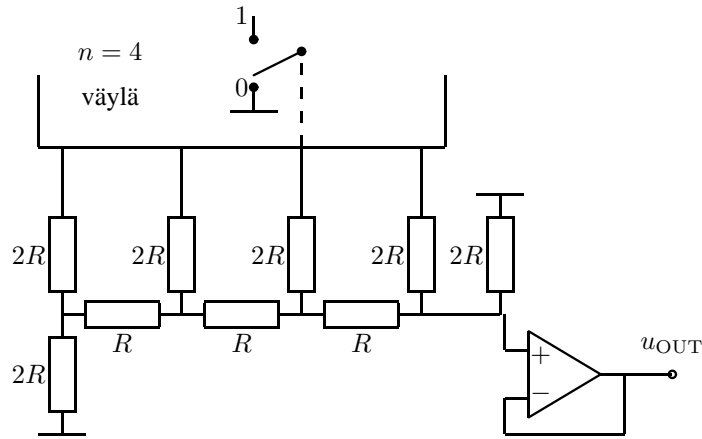
Kuva 652.



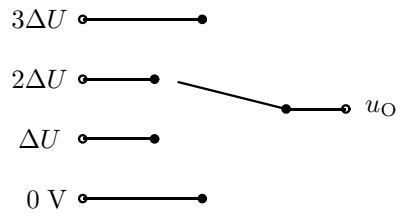
Kuva 653.



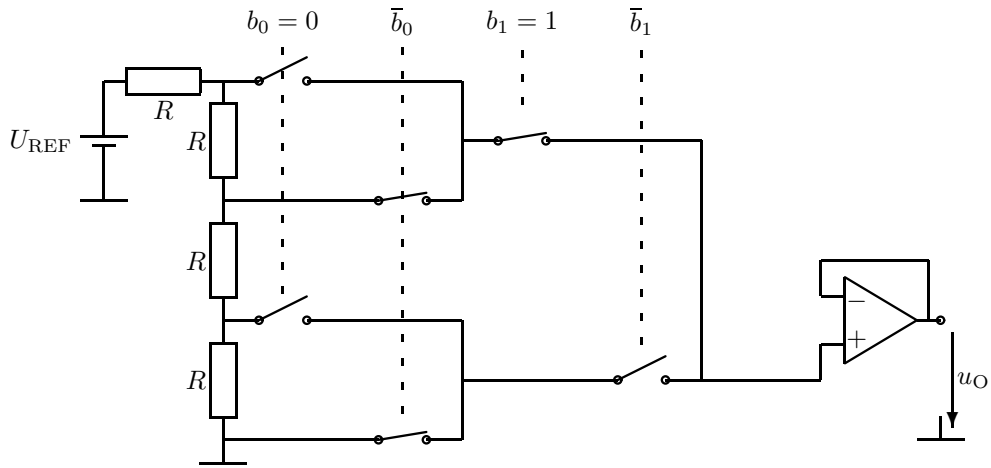
Kuva 654.



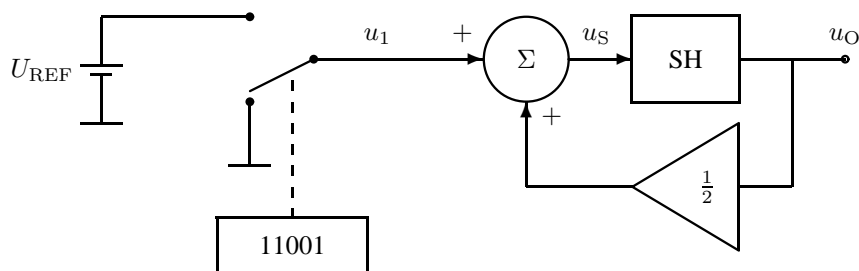
Kuva 655.



Kuva 656.

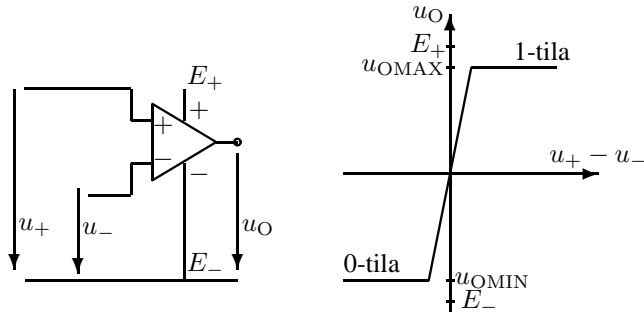


Kuva 657.

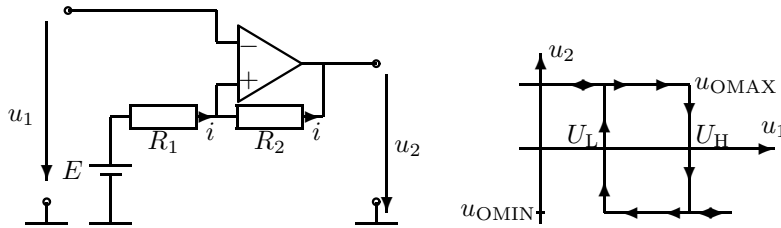


Kuva 658.

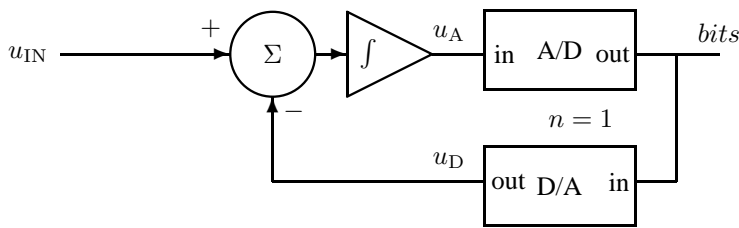
15.5 A/D-muuntimet (ADC)



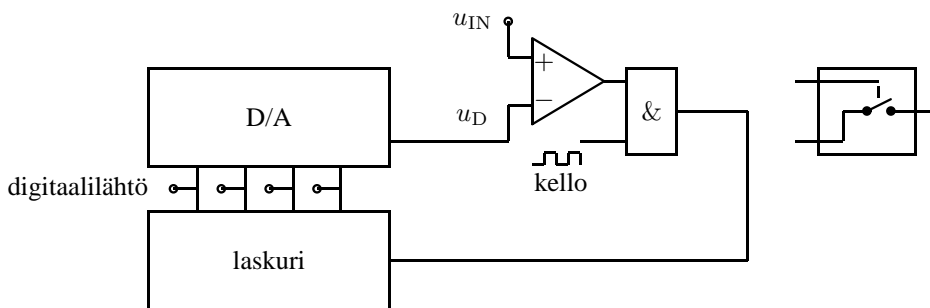
Kuva 659.



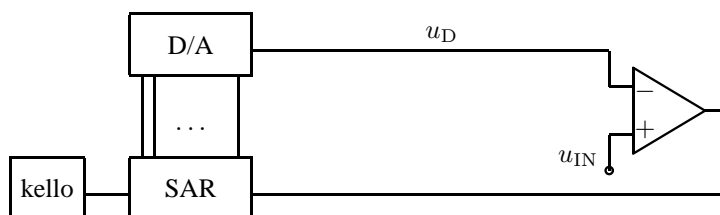
Kuva 660.



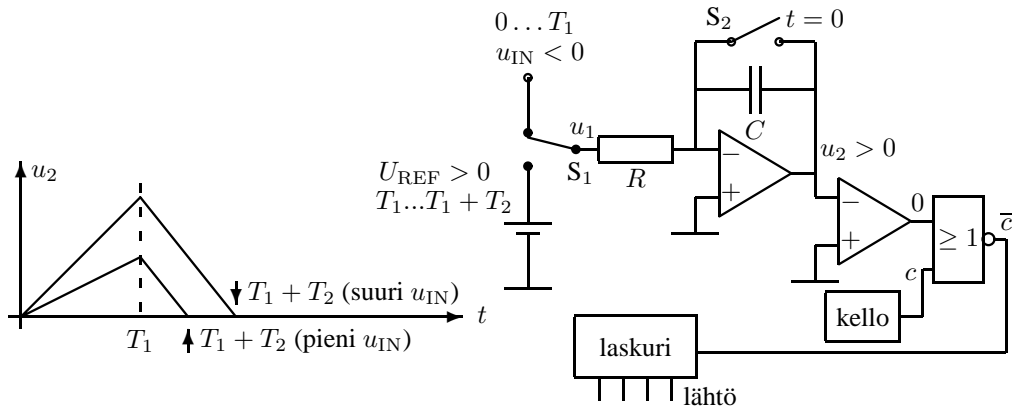
Kuva 661.



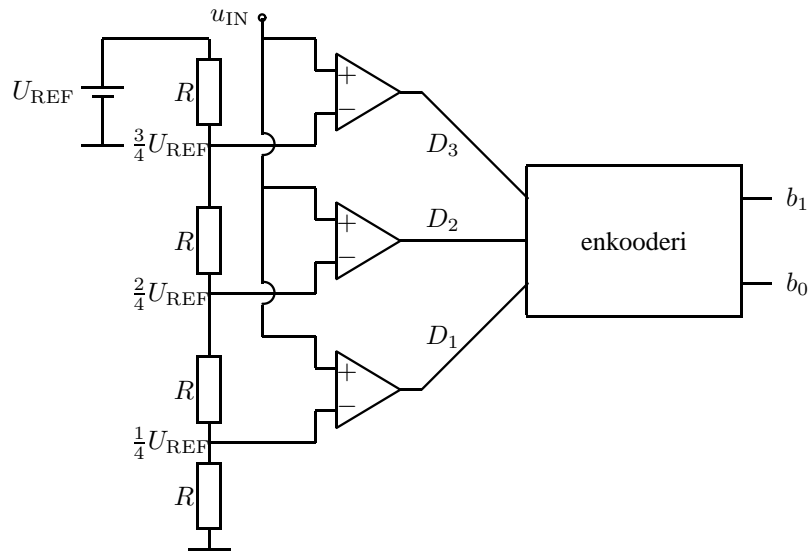
Kuva 662.



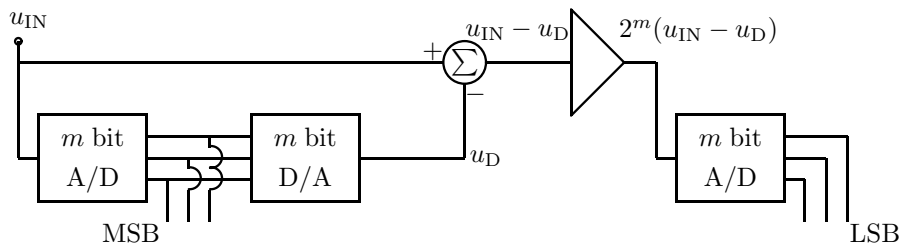
Kuva 663.



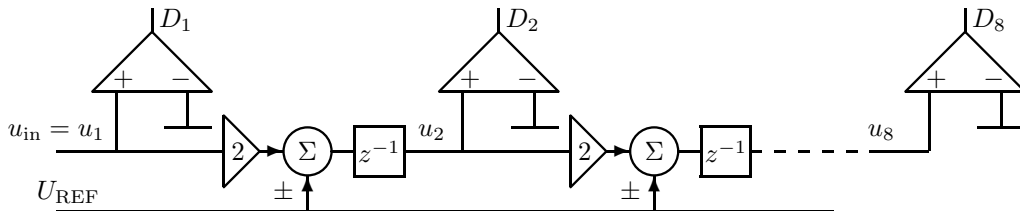
Kuva 664.



Kuva 665.



Kuva 666.



Kuva 667.