TSTE05 Elektronik & mätteknik

Föreläsning 8

Operationsförstärkare – Aktiva filter

Mikael Olofsson
Institutionen för Systemteknik (ISY)
Ämnesområdet Elektroniska kretsar och system

LINKÖPINGS UNIVERSITET

Projektuppgiften 1(2)

1. Förbered (hemma):
   Bestäm sökta komponentvärden

2. Labpass 2a (Freja):
   Simulera kretsen i NI Multisim - v. 12
   Verifiera kraven
   Plotta amplitudkarakteristiken
   med exakta komponent-värden
   med närmsta värden ur E6-serien
   Notera gränsfrekvenser

3. Labpass 2b (Transistorn):
   Koppla upp filtret (värden från E6-serien).
   Mät amplitudkarakteristik.
   Lyssna till filtrerad musik. Kommentarer?

4. Rapport (hemma):
   Redovisa allt: Beräkningar, kurvor, mätvärden.
   Kommentera, jämför: Likheter, skillnader, orsaker.

E-serier 1(2)

I labsalen finns:

- motstånd i E6-serien från 1 kΩ till 1 MΩ,
- kondensatorer i E6-serien från 1 nF till 100 nF.

E-serierna är approximativt exponentiellt stigande siffror.

Se kursboken, sidan 199 för fler E-serier.

E24	E12	E6	E3
10	10	10	10
11			
12	12		
13			
15	15	15	
16			
18	18		
20			
22	22	22	22
24			
27	27		
30			

E24	E12	E6	E3
33	33	33	
36			
39	39		
43			
47	47	47	47
51			
56	56		
62			
68	68	68	
75			
82	82		
91			

E-serier 2(2)

Kvoterna mellan på varandra följande siffror i en E-serie är approximativt lika. Exempelvis E6-serien:

$$\frac{15}{10} = 1.5 \quad \frac{22}{15} \approx 1.47 \quad \frac{33}{22} = 1.5$$

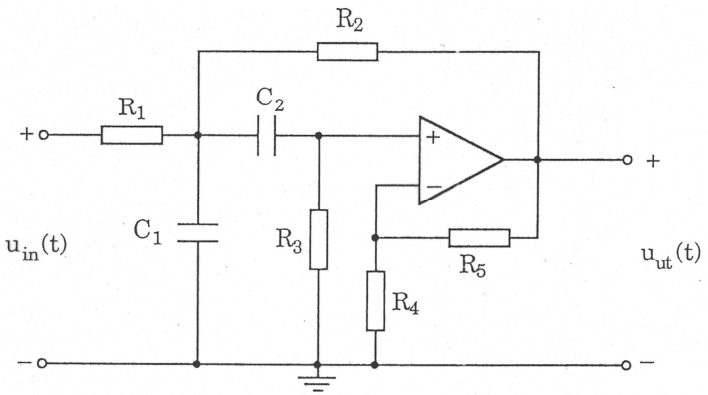
$$\frac{47}{33} \approx 1.42 \quad \frac{68}{47} \approx 1.45 \quad \frac{100}{68} \approx 1.47$$

E6
10
15
22
33
47
68

Att jämföra med:

$$\sqrt[6]{10} \approx 1.47$$

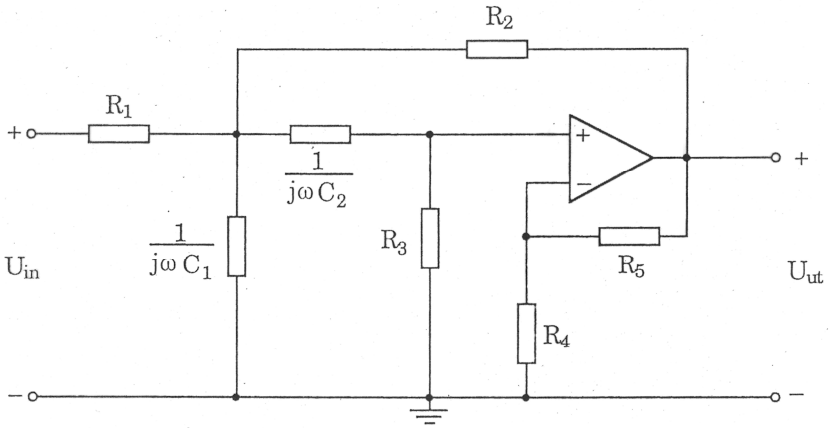
Exempel aktivt filter



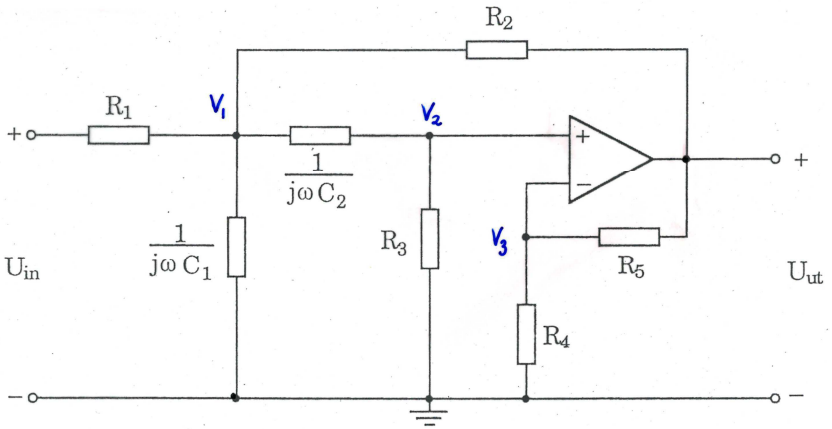
$R_1 = R_2 = R_3 = R_4 = R_5 = R = 10\ k\Omega$

Bestäm C_1 och C_2 för gränsfrekvenserna 1 Hz och 5 Hz.

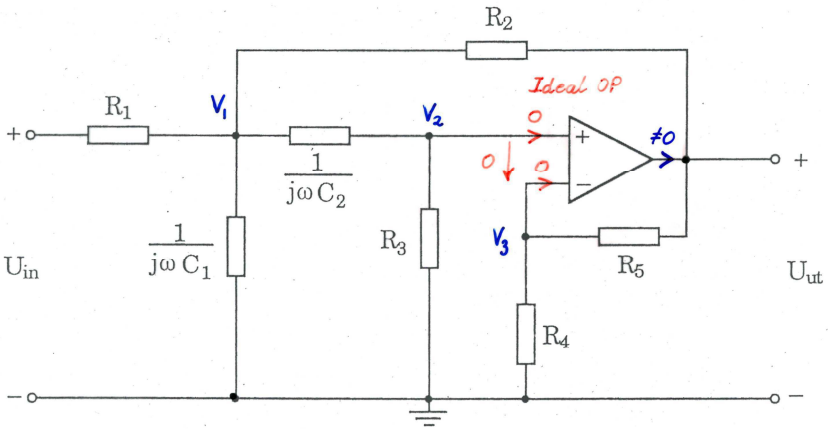
Exempel aktivt filter



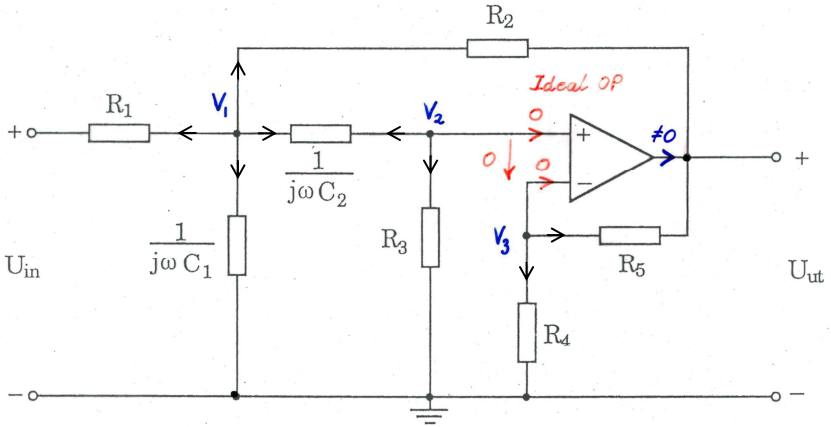
Exempel aktivt filter



Exempel aktivt filter



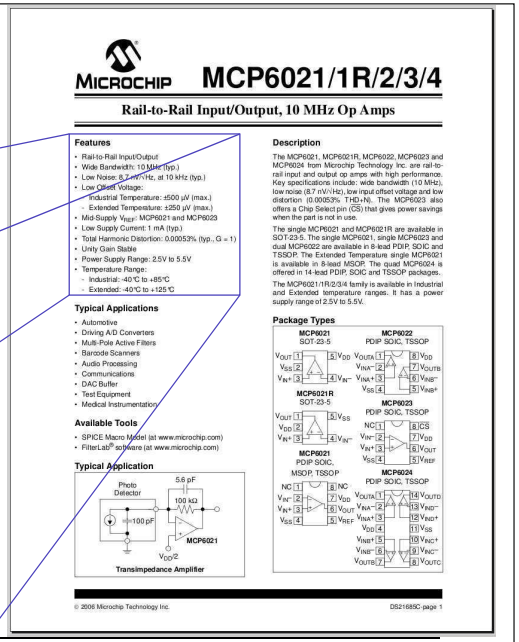
Exempel aktivt filter



Exempel på datablad – MCP602x

Features

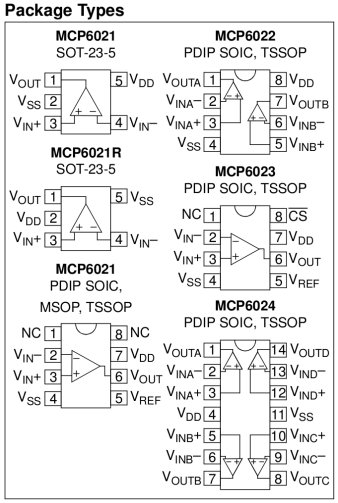
- Rail-to-Rail Input/Output
- Wide Bandwidth: 10 MHz (typ.)
- Low Noise: 8.7 nV/√Hz, at 10 kHz (typ.)
- Low Offset Voltage:
  - Industrial Temperature: ±500 µV (max.)
  - Extended Temperature: ±250 µV (max.)
- Mid-Supply V_{REF}: MCP6021 and MCP6023
- Low Supply Current: 1 mA (typ.)
- Total Harmonic Distortion: 0.00053% (typ., G = 1)
- Unity Gain Stable
- Power Supply Range: 2.5V to 5.5V
- Temperature Range:
  - Industrial: -40°C to +85°C
  - Extended: -40°C to +125°C

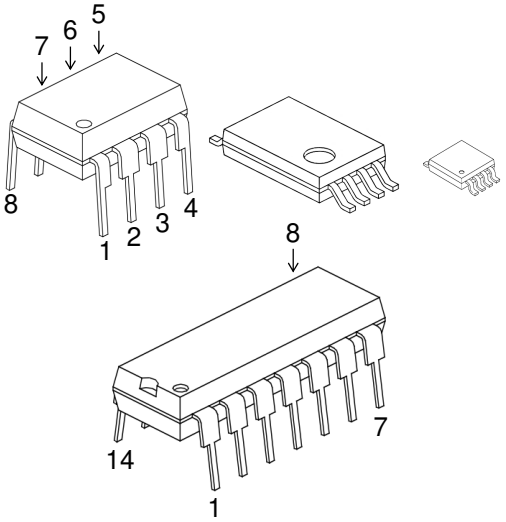

MICROCHIP MCP6021/1R/2/3/4

Rail-to-Rail Input/Output, 10 MHz Op Amps

Exempel på datablad – MCP602x

Package Types





Exempel på datablad – MCP602x

Absolute Maximum Ratings †

$V_{DD} - V_{SS}$ 7.0V
All Inputs and Outputs..... V_{SS} – 0.3V to V_{DD} + 0.3V
Difference Input Voltage ..... $|V_{DD} - V_{SS}|$
Output Short Circuit Current .....continuous
Current at Input Pins .....±2 mA
Current at Output and Supply Pins .....±30 mA
Storage Temperature.....-65°C to +150°C
Junction Temperature.....+150°C
ESD Protection on all pins (HBM; MM) ..... ≥ 2 kV; 200V

Exempel på datablad – MCP602x

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.5V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2 and R_L = 10 kΩ to V_{DD}/2.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Input Offset						
Input Offset Voltage:						
Industrial Temperature Parts	V_{OS}	-500	—	+500	µV	V_{CM} = 0V
Extended Temperature Parts	V_{OS}	-250	—	+250	µV	V_{CM} = 0V, V_{DD} = 5.0V
Extended Temperature Parts	V_{OS}	-2.5	—	+2.5	mV	V_{CM} = 0V, V_{DD} = 5.0V T_A = -40°C to +125°C
Input Offset Voltage Temperature Drift	$\Delta V_{OS}/\Delta T_A$	—	±3.5	—	µV/°C	T_A = -40°C to +125°C
Power Supply Rejection Ratio	PSRR	74	90	—	dB	V_{CM} = 0V
Input Current and Impedance						
Input Bias Current	I_B	—	1	—	pA	
Industrial Temperature Parts	I_B	—	30	150	pA	T_A = +85°C
Extended Temperature Parts	I_B	—	640	5,000	pA	T_A = +125°C
Input Offset Current	I_{OS}	—	±1	—	pA	
Common-Mode Input Impedance	Z_{CM}	—	10^{13}||6	—	Ω||pF	
Differential Input Impedance	Z_{DIFF}	—	10^{13}||3	—	Ω||pF	

Exempel på datablad – MCP602x

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.5V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2 and R_L = 10 kΩ to V_{DD}/2.

Parameters	Sym	Min	Typ	Max	Units	Conditions
Common-Mode						
Common-Mode Input Range	V_{CMR}	V_{SS}-0.3	—	V_{DD}+0.3	V	
Common-Mode Rejection Ratio	CMRR	74	90	—	dB	V_{DD} = 5V, V_{CM} = -0.3V to 5.3V
	CMRR	70	85	—	dB	V_{DD} = 5V, V_{CM} = 3.0V to 5.3V
	CMRR	74	90	—	dB	V_{DD} = 5V, V_{CM} = -0.3V to 3.0V
Voltage Reference (MCP6021 and MCP6023 only)						
V_{REF} Accuracy (V_{REF} – V_{DD}/2)	V_{REF_ACC}	-50	—	+50	mV	
V_{REF} Temperature Drift	$\Delta V_{REF}/\Delta T_A$	—	±100	—	µV/°C	T_A = -40°C to +125°C
Open-Loop Gain						
DC Open-Loop Gain (Large Signal)	A_{OL}	90	110	—	dB	V_{CM} = 0V, V_{OUT} = V_{SS}+0.3V to V_{DD}-0.3V
Output						
Maximum Output Voltage Swing	V_{OL}, V_{OH}	V_{SS}+15	—	V_{DD}-20	mV	0.5V output overdrive
Output Short Circuit Current	I_{SC}	—	±30	—	mA	V_{DD} = 2.5V
	I_{SC}	—	±22	—	mA	V_{DD} = 5.5V
Power Supply						
Supply Voltage	V_S	2.5	—	5.5	V	
Quiescent Current per Amplifier	I_Q	0.5	1.0	1.35	mA	I_O = 0

Exempel på datablad – MCP602x

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, T_A = +25°C, V_{DD} = +2.5V to +5.5V, V_{SS} = GND, V_{CM} = V_{DD}/2, V_{OUT} ≈ V_{DD}/2, R_L = 10 kΩ to V_{DD}/2 and C_L = 60 pF.

Parameters	Sym	Min	Typ	Max	Units	Conditions
AC Response						
Gain Bandwidth Product	GBWP	—	10	—	MHz	
Phase Margin at Unity-Gain	PM	—	65	—	°	G = +1
Settling Time, 0.2%	t_{SETTLE}	—	250	—	ns	G = +1, V_{OUT} = 100 mV_{p-p}
Slew Rate	SR	—	7.0	—	V/µs	
Total Harmonic Distortion Plus Noise						
f = 1 kHz, G = +1 V/V	THD+N	—	0.00053	—	%	V_{OUT} = 0.25V to 3.25V (1.75V ± 1.50V_{PK}), V_{DD} = 5.0V, BW = 22 kHz
f = 1 kHz, G = +1 V/V, R_L = 600Ω	THD+N	—	0.00064	—	%	V_{OUT} = 0.25V to 3.25V (1.75V ± 1.50V_{PK}), V_{DD} = 5.0V, BW = 22 kHz
f = 1 kHz, G = +1 V/V	THD+N	—	0.0014	—	%	V_{OUT} = 4V_{P-P}, V_{DD} = 5.0V, BW = 22 kHz
f = 1 kHz, G = +10 V/V	THD+N	—	0.0009	—	%	V_{OUT} = 4V_{P-P}, V_{DD} = 5.0V, BW = 22 kHz
f = 1 kHz, G = +100 V/V	THD+N	—	0.005	—	%	V_{OUT} = 4V_{P-P}, V_{DD} = 5.0V, BW = 22 kHz
Noise						
Input Noise Voltage	E_{ni}	—	2.9	—	µVp-p	f = 0.1 Hz to 10 Hz
Input Noise Voltage Density	e_{ni}	—	8.7	—	nV/√Hz	f = 10 kHz
Input Noise Current Density	i_{ni}	—	3	—	fA/√Hz	f = 1 kHz

Exempel på datablad – MCP602x

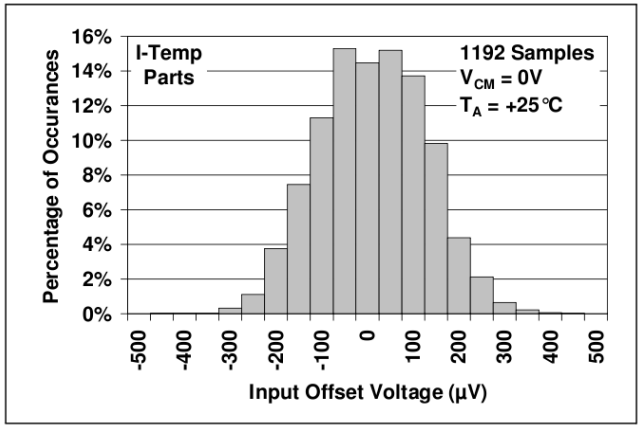


FIGURE 2-1: *Input Offset Voltage, (Industrial Temperature Parts).*

Mikael Olofsson
ISY/EKS

www.liu.se

LINKÖPINGS UNIVERSITET