

TSTE05 Elektronik & mätteknik

Föreläsning 8

Operationsförstärkare – Aktiva filter

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Projektuppgiften 1(2)

1. Förbered (hemma):

Bestäm söka komponentvärden

2. Labpass 2a (Freja):

Simulera kretsen i NI Multisim

- v. 12

Verifiera kraven

Plotta amplitudkaraktistiken
med **exakta** komponent-

värden
med närmsta värden
ur **E6-serien**

Notera gränshfrekvenser

3. Labpass 2b (Transistorn):

Koppla upp filtret
(värden från E6-serien).

Mät amplitudkaraktistisk.

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	E24	E12	E6	E3
10	10	10	10	33	33	33	
11				36			
12	12			39	39		
13				43			
15	15	15		47	47	47	47
16				51			
18	18			56	56		
20				62			
22	22	22	22	68	68	68	
24				75			
27	27			82	82		
30				91			

E-serier 2(2)

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

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

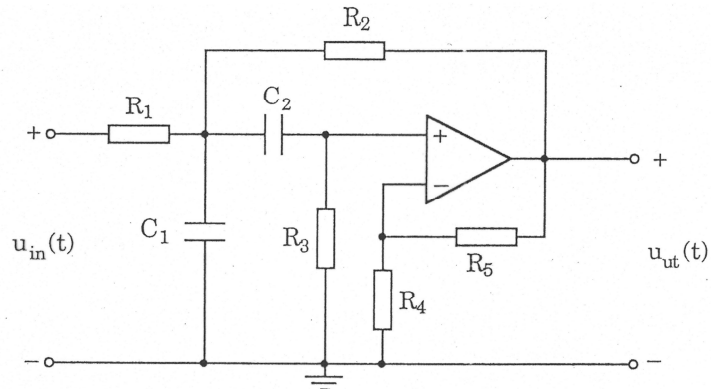
$$\frac{47}{33} \approx 1.42 \quad \frac{68}{47} \approx 1.45 \quad \frac{100}{68} \approx 1.47$$

Att jämföra med:

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

E6
10
15
22
33
47
68

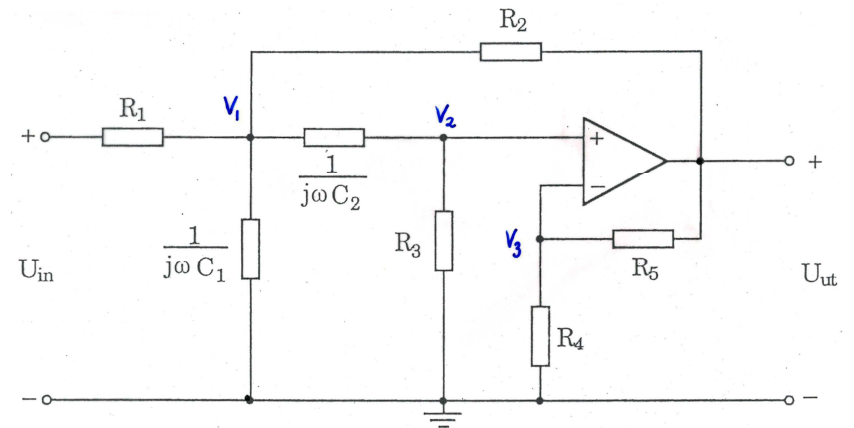
Exempel aktivt filter



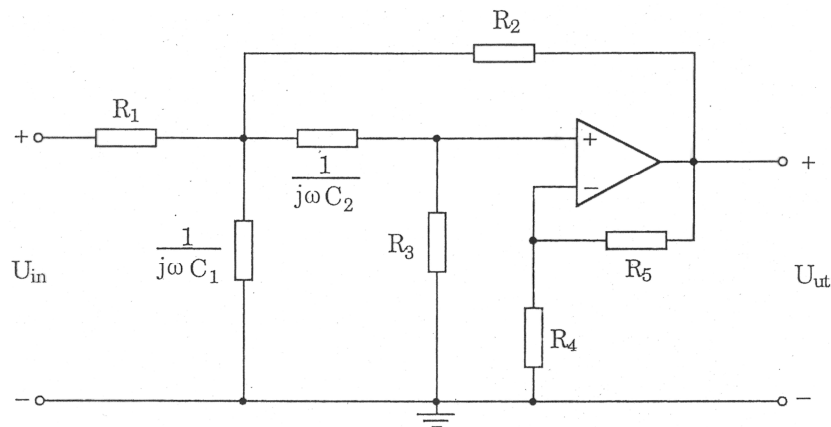
$$R_1 = R_2 = R_3 = R_4 = R_5 = R = 10 \text{ k}\Omega$$

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

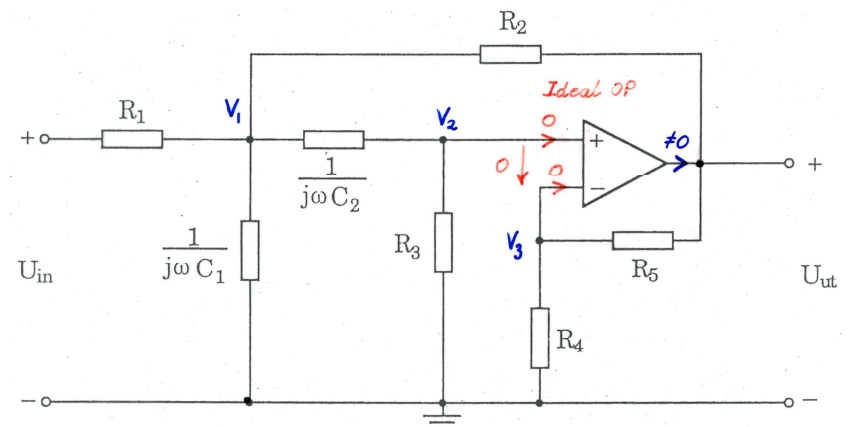
Exempel aktivt filter



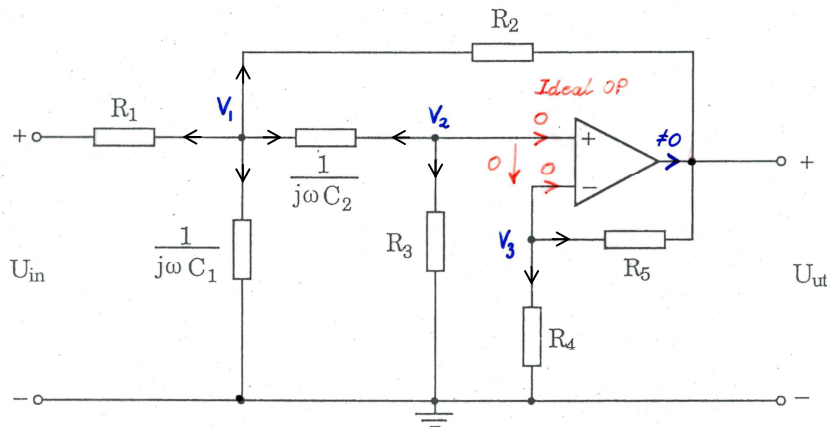
Exempel aktivt filter



Exempel aktivt filter



Exempel aktivt filter



Exempel på datablad – MCP602x

Package Types

MCP6021 SOT-23-5 	MCP6022 PDIP SOIC, TSSOP
MCP6021R SOT-23-5 	MCP6023 PDIP SOIC, TSSOP
MCP6021 PDIP SOIC, MSOP, TSSOP 	MCP6024 PDIP SOIC, TSSOP

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

- Features**
- Rail-to-Rail Input/Output
 - Wide Bandwidth: 10 MHz (typ.)
 - Low Noise: 8.7 nV/√Hz, at 10 kHz (typ.)
 - Low Offset Voltage:
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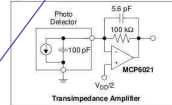
Typical Applications

- Automotive
- Driving A/D Converters
- Multi-Line Active Filters
- Barcode Scanners
- Audio Processing
- Communications
- DAC Buffer
- Test Equipment
- Medical Instrumentation

Available Tools

- SPICE Macro Model (at www.microchip.com)
- FilterLab® software (at www.microchip.com)

Typical Application



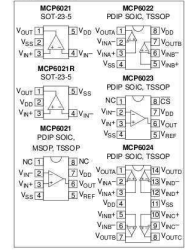
Description

The MCP6021, MCP6021R, MCP6022, MCP6023 and MCP6024 from Microchip Technology Inc. are rail-to-rail input and output op amps with high performance. Key specifications include: wide bandwidth (10 MHz), low noise (8.7 nV/√Hz), low input offset voltage and low distortion (0.00053% THD_N). The MCP6023 also offers a Chip Select pin (CS) that gives power savings when the part is not in use.

The single MCP6021 and MCP6021R are available in SOT-23-5. The single MCP6022, single MCP6023 and dual MCP6022 are available in 8-lead PDIP SOIC and TSSOP. The Extended Temperature single MCP6021 is available in 8-lead MSOP. The quad MCP6024 is offered in 14-lead PDIP SOIC and TSSOP packages.

The MCP6021 1R/2/3/4 family is available in industrial and Extended temperature ranges. It has a power supply range of 2.5V to 5.5V.

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, $T_A = +25^\circ\text{C}$, $V_{DD} = +2.5\text{V to } +5.5\text{V}$, $V_{SS} = \text{GND}$, $V_{CM} = V_{DD}/2$, $V_{OUT} = V_{DD}/2$ and $R_L = 10\text{ k}\Omega$ to $V_{DD}/2$.

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

Exempel på datablad – MCP602x

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{DD} = +2.5\text{V to } +5.5\text{V}$, $V_{SS} = \text{GND}$, $V_{CM} = V_{DD}/2$, $V_{OUT} = V_{DD}/2$, $R_L = 10\text{ k}\Omega$ to $V_{DD}/2$ and $C_L = 60\text{ pF}$.

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

Exempel på datablad – MCP602x

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, $T_A = +25^\circ\text{C}$, $V_{DD} = +2.5\text{V to } +5.5\text{V}$, $V_{SS} = \text{GND}$, $V_{CM} = V_{DD}/2$, $V_{OUT} = V_{DD}/2$ and $R_L = 10\text{ k}\Omega$ 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	$V_{DD} = 5\text{V}$, $V_{CM} = -0.3\text{V to } 5.3\text{V}$
	CMRR	70	85	—	dB	$V_{DD} = 5\text{V}$, $V_{CM} = 3.0\text{V to } 5.3\text{V}$
	CMRR	74	90	—	dB	$V_{DD} = 5\text{V}$, $V_{CM} = -0.3\text{V to } 3.0\text{V}$
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	—	$\mu\text{V}/^\circ\text{C}$	$T_A = -40^\circ\text{C to } +125^\circ\text{C}$
Open-Loop Gain						
DC Open-Loop Gain (Large Signal)	A_{OL}	90	110	—	dB	$V_{CM} = 0\text{V}$, $V_{OUT} = V_{SS}+0.3\text{V to } V_{DD}-0.3\text{V}$
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	$V_{DD} = 2.5\text{V}$
	I_{SC}	—	± 22	—	mA	$V_{DD} = 5.5\text{V}$
Power Supply						
Supply Voltage	V_S	2.5	—	5.5	V	
Quiescent Current per Amplifier	I_Q	0.5	1.0	1.35	mA	$I_Q = 0$

Exempel på datablad – MCP602x

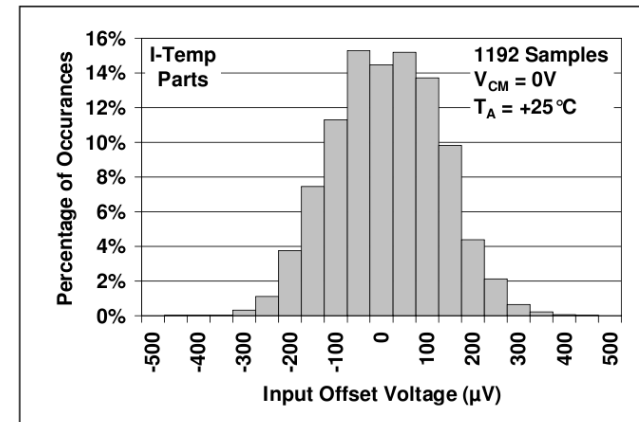


FIGURE 2-1: Input Offset Voltage, (Industrial Temperature Parts).

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