LM146/LM346 Programmable Quad Operational Amplifiers

Check for Samples: LM146, LM346

FEATURES

- **(I_{SET}=10 μA)**
- **Programmable Electrical Characteristics**
- **Battery-Powered Operation**
- **Low Supply Current: 350 μA/Amplifier**
- **Ensured Gain Bandwidth Product: 0.8 MHz Min**
- **Large DC Voltage Gain: 120 dB**
- **Low Noise Voltage: 28 nV/√Hz**
- **Wide Power Supply Range: ±1.5V to ±22V**
- **Class AB Output Stage–No Crossover Distortion**
- **Ideal Pin Out for Biquad Active Filters**
- **Input Bias Currents are Temperature Compensated**

DESCRIPTION

The LM146 series of quad op amps consists of four independent, high gain, internally compensated, low power, programmable amplifiers. Two external resistors (R_{SET}) allow the user to program the gain bandwidth product, slew rate, supply current, input bias current, input offset current and input noise. For example, the user can trade-off supply current for bandwidth or optimize noise figure for a given source resistance. In a similar way, other amplifier characteristics can be tailored to the application. Except for the two programming pins at the end of the package, the LM146 pin-out is the same as the LM124 and LM148.

Connection Diagram

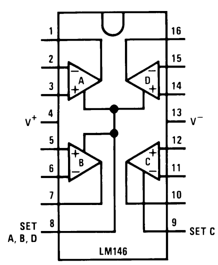


Figure 1. Dual-In-Line Package - Top View
See Package Number NFE0016A, D0016A or N16A

PROGRAMMING EQUATIONS

Total Supply Current = 1.4 mA (I_{SET}/10 μA)

Gain Bandwidth Product = 1 MHz (I_{SET}/10 μA)

Slew Rate = 0.4V/μs (I_{SET}/10 μA)

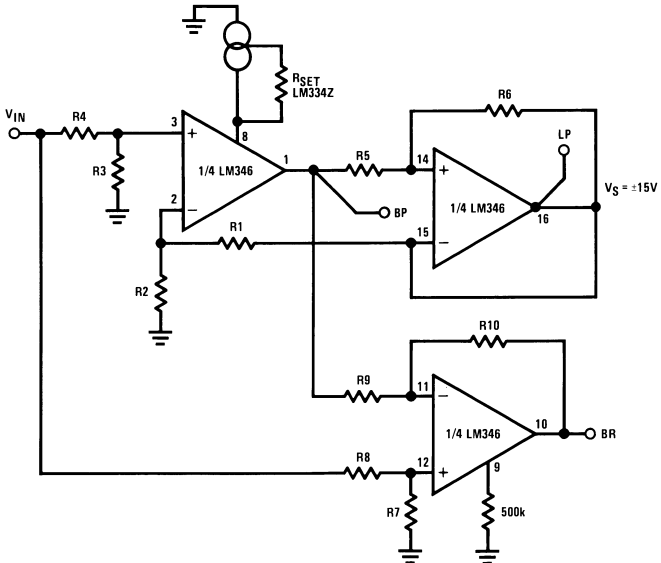
Input Bias Current ≃ 50 nA (I_{SET}/10 μA)

I_{SET} = Current into pin 8, pin 9 (see Schematic Diagram)

$$I_{SET} = \frac{V^+ - V^- - 0.6V}{R_{SET}} \quad (1)$$

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Capacitorless Active Filters (Basic Circuit)



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS(1)(2)(3)

			LM146	LM346
Supply Voltage			±22V	±18V
Differential Input Voltage(2)			±30V	±30V
CM Input Voltage(2)			±15V	±15V
Power Dissipation(4)			900 mW	500 mW
Output Short-Circuit Duration(5)			Continuous	Continuous
Operating Temperature Range			−55°C to +125°C	0°C to +70°C
Maximum Junction Temperature			150°C	100°C
Storage Temperature Range			−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)			260°C	260°C
Thermal Resistance (θ_{jA})(4)	CDIP (NFE)	Pd	900 mW	900 mW
		θ_{jA}	100°C/W	100°C/W
	SOIC (D)	θ_{jA}		115°C/W
	PDIP (N)	Pd		500 mW
		θ_{jA}		90°C/W
Soldering Information	Dual-In-Line Package	Soldering (10 seconds)	+260°C	+260°C
	Small Outline Package	Vapor Phase (60 seconds)	+215°C	+215°C
		Infrared (15 seconds)	+220°C	+220°C
ESD rating is to be determined.				

(1) Refer to RETS146X for LM146J military specifications.
(2) For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
(3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(4) The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by T_{jMAX}, θ_{jA}, and the ambient temperature, T_A. The maximum available power dissipation at any temperature is $P_d=(T_{jMAX} - T_A)/\theta_{jA}$ or the 25°C P_{dMAX}, whichever is less.
(5) Any of the amplifier outputs can be shorted to ground indefinitely; however, more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.

DC ELECTRICAL CHARACTERISTICS

(V_S=±15V, I_{SET}=10 µA)(1)

Parameter	Conditions	LM146			LM346			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V_{CM}=0V, R_S≤50Ω, T_A=25°C		0.5	5		0.5	6	mV
Input Offset Current	V_{CM}=0V, T_A=25°C		2	20		2	100	nA
Input Bias Current	V_{CM}=0V, T_A=25°C		50	100		50	250	nA
Supply Current (4 Op Amps)	T_A=25°C		1.4	2.0		1.4	2.5	mA
Large Signal Voltage Gain	R_L=10 kΩ, $ΔV_{OUT}$=±10V, T_A=25°C	100	1000		50	1000		V/mV
Input CM Range	T_A=25°C	±13.5	±14		±13.5	±14		V
CM Rejection Ratio	R_S≤10 kΩ, T_A=25°C	80	100		70	100		dB
Power Supply Rejection Ratio	R_S≤10 kΩ, T_A=25°C, V_S = ±5 to ±15V	80	100		74	100		dB
Output Voltage Swing	R_L≥10 kΩ, T_A=25°C	±12	±14		±12	±14		V
Short-Circuit	T_A=25°C	5	20	35	5	20	35	mA
Gain Bandwidth Product	T_A=25°C	0.8	1.2		0.5	1.2		MHz
Phase Margin	T_A=25°C		60			60		Deg
Slew Rate	T_A=25°C		0.4			0.4		V/µs
Input Noise Voltage	f=1 kHz, T_A=25°C		28			28		8 nV/√Hz
Channel Separation	R_L=10 kΩ, $ΔV_{OUT}$=0V to ±12V, T_A=25°C		120			120		dB
Input Resistance	T_A=25°C		1.0			1.0		MΩ
Input Capacitance	T_A=25°C		2.0			2.0		pF
Input Offset Voltage	V_{CM}=0V, R_S≤50Ω		0.5	6		0.5	7.5	mV
Input Offset Current	V_{CM}=0V		2	25		2	100	nA
Input Bias Current	V_{CM}=0V		50	100		50	250	nA
Supply Current (4 Op Amps)			1.7	2.2		1.7	2.5	mA
Large Signal Voltage Gain	R_L=10 kΩ, $ΔV_{OUT}$=±10V	50	1000		25	1000		V/mV
Input CM Range		±13.5	±14		±13.5	±14		V
CM Rejection Ratio	R_S≤50Ω	70	100		70	100		dB
Power Supply Rejection Ratio	R_S≤50Ω, V_S = ±5V to ±15V	76	100		74	100		dB
Output Voltage Swing	R_L≥10 kΩ	±12	±14		±12	±14		V

(1) These specifications apply over the absolute maximum operating temperature range unless otherwise noted.

DC ELECTRICAL CHARACTERISTIC

(V_S=±15V, I_{SET}=10 µA)

Parameter	Conditions	LM146			LM346			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V_{CM}=0V, R_S≤50Ω, T_A=25°C		0.5	5		0.5	7	mV
Input Bias Current	V_{CM}=0V, T_A=25°C		7.5	20		7.5	100	nA
Supply Current (4 Op Amps)	T_A=25°C		140	250		140	300	µA
Gain Bandwidth Product	T_A=25°C	80	100		50	100		kHz

DC ELECTRICAL CHARACTERISTICS

(V_S=±1.5V, I_{SET}=10 μA)

Parameter	Conditions	LM146			LM346			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V_{CM}=0V, R_S≤50Ω, T_A=25°C		0.5	5		0.5	7	mV
Input CM Range	T_A=25°C	±0.7			±0.7			V
CM Rejection Ratio	R_S≤50Ω, T_A=25°C		80			80		dB
Output Voltage Swing	R_L≥10 kΩ, T_A=25°C	±0.6			±0.6			V

TYPICAL PERFORMANCE CHARACTERISTICS

Input Bias Current vs I_{SET}

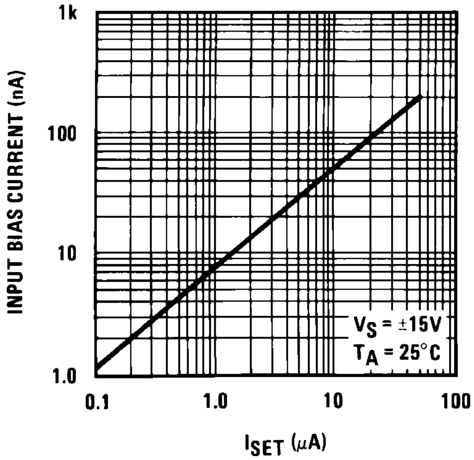


Figure 2.

Supply Current vs I_{SET}

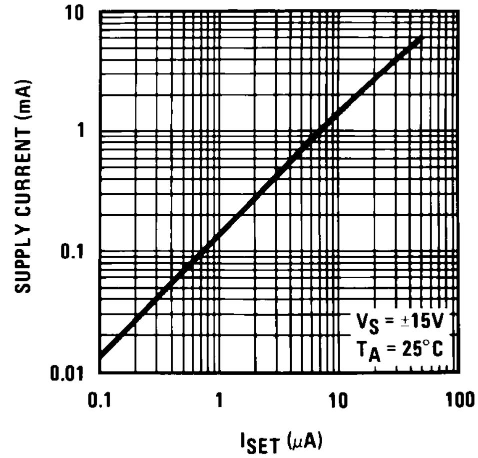


Figure 3.

Open Loop Voltage Gain vs I_{SET}

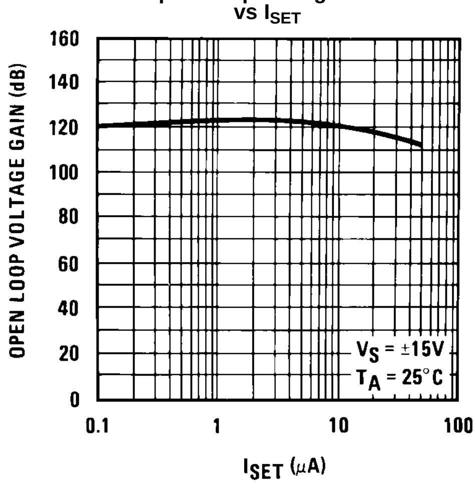


Figure 4.

Slew Rate vs I_{SET}

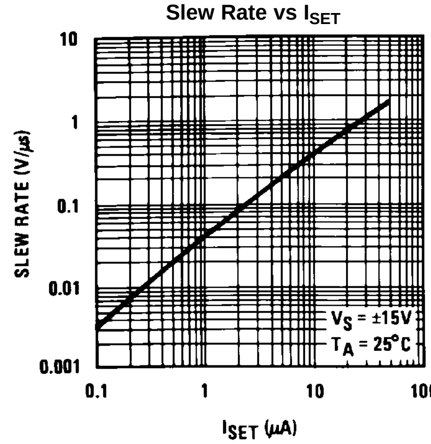


Figure 5.

Gain Bandwidth Product vs I_{SET}

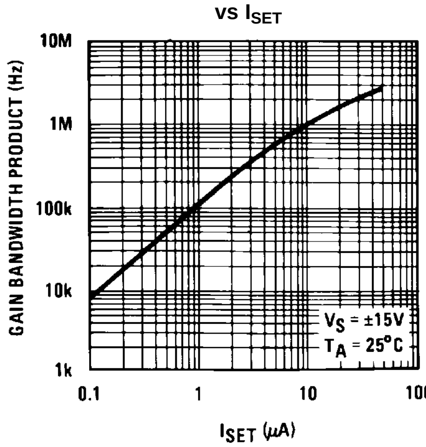


Figure 6.

Phase Margin vs I_{SET}

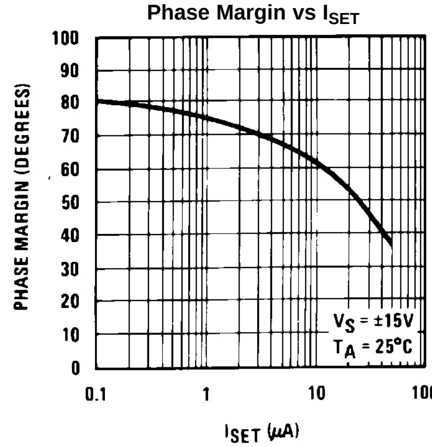


Figure 7.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Input Offset Voltage vs I_{SET}

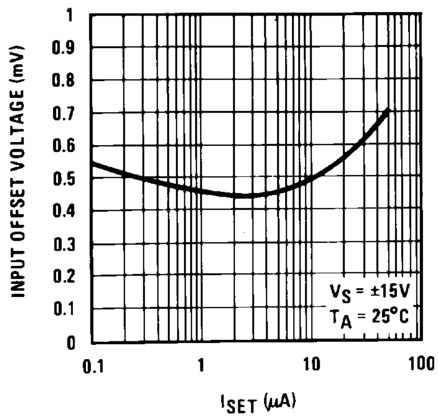


Figure 8.

Common-Mode Rejection Ratio vs I_{SET}

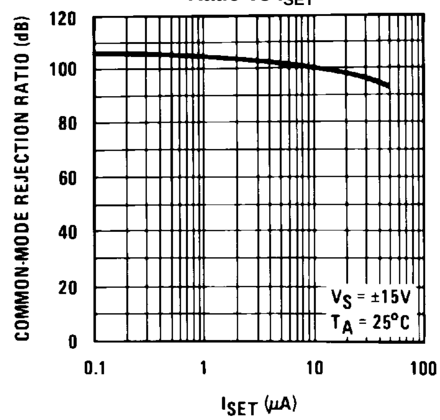


Figure 9.

Power Supply Rejection Ratio vs I_{SET}

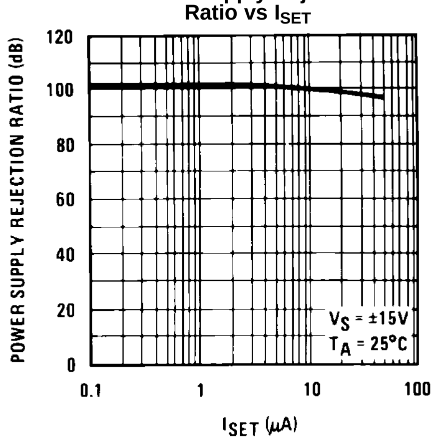


Figure 10.

Open Voltage Swing vs Supply Voltage

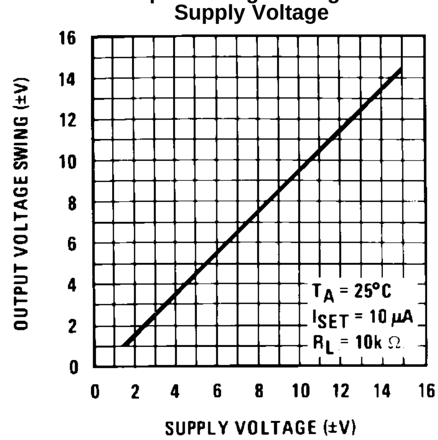


Figure 11.

Input Voltage Range vs Supply Voltage

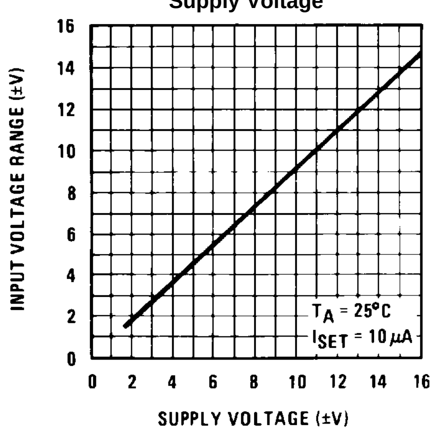


Figure 12.

Input Bias Current vs Input Common-Mode Voltage

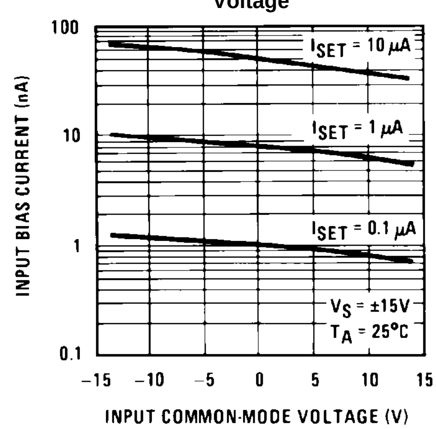


Figure 13.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Input Bias Current vs Temperature

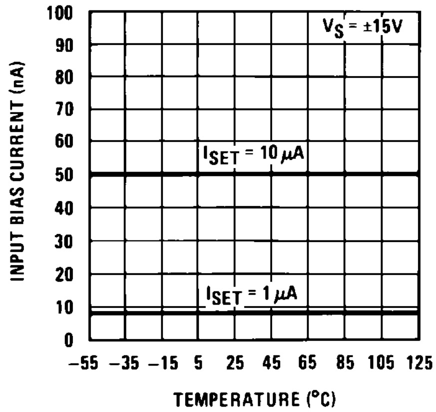


Figure 14.

Input Offset Current vs Temperature

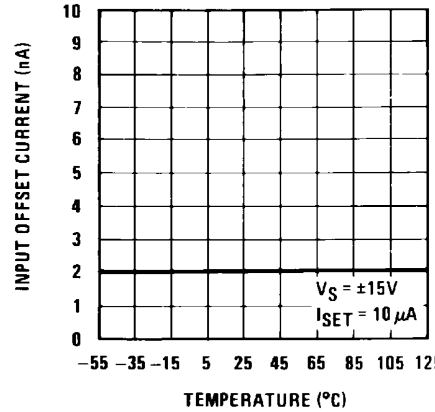


Figure 15.

Supply Current vs Temperature

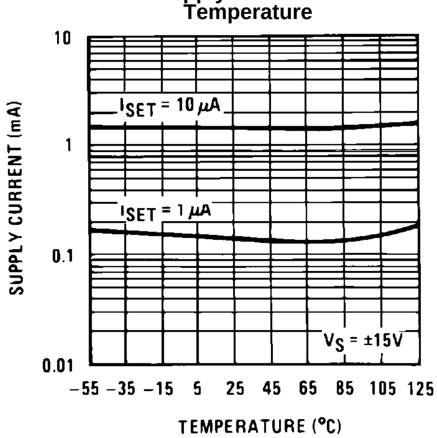


Figure 16.

Open Loop Voltage Gain vs Temperature

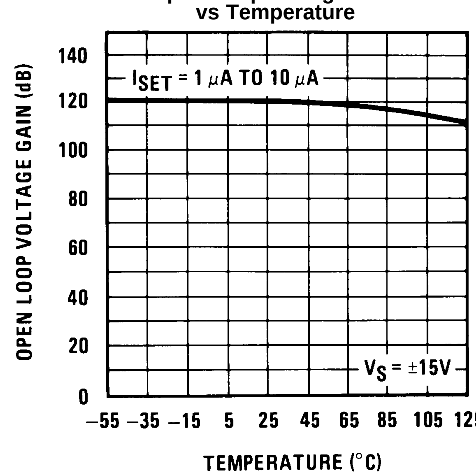


Figure 17.

Gain Bandwidth Product vs Temperature

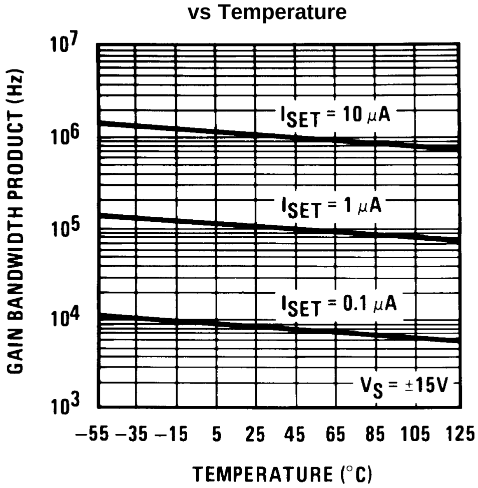


Figure 18.

Slew Rate vs Temperature

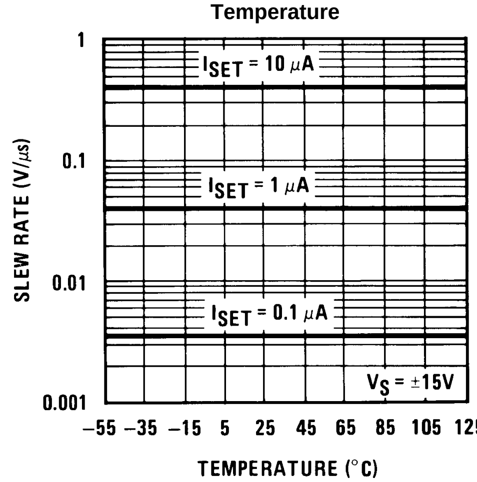


Figure 19.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Input Noise Voltage vs Frequency

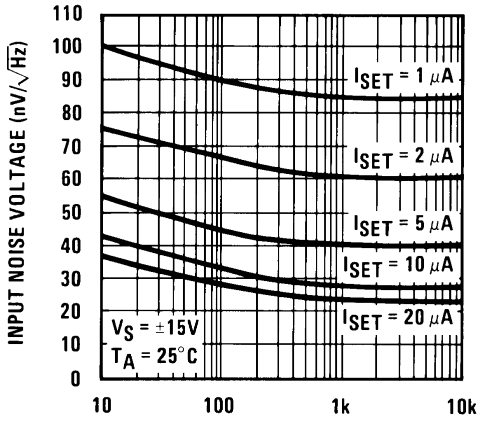


Figure 20.

Input Noise Current vs Frequency

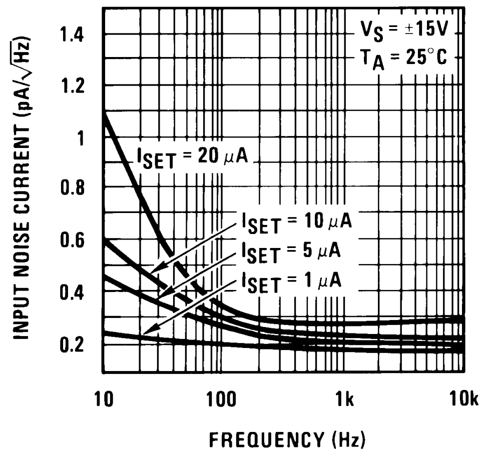


Figure 21.

Power Supply Rejection Ratio vs Frequency

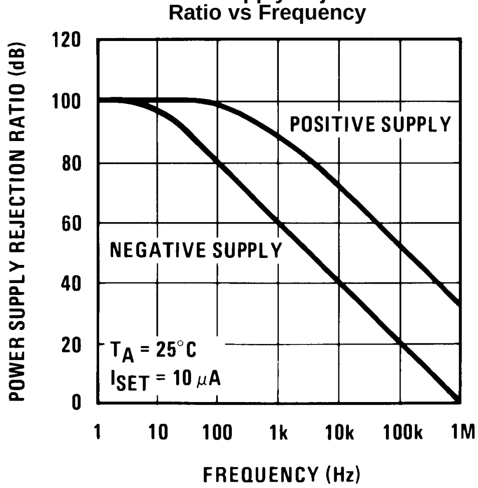


Figure 22.

Voltage Follower Pulse Response

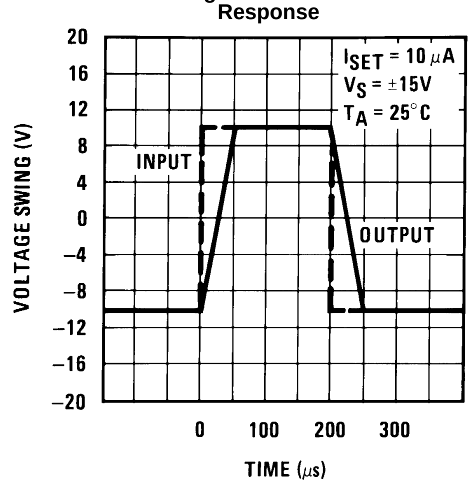


Figure 23.

Voltage Follower Transient Response

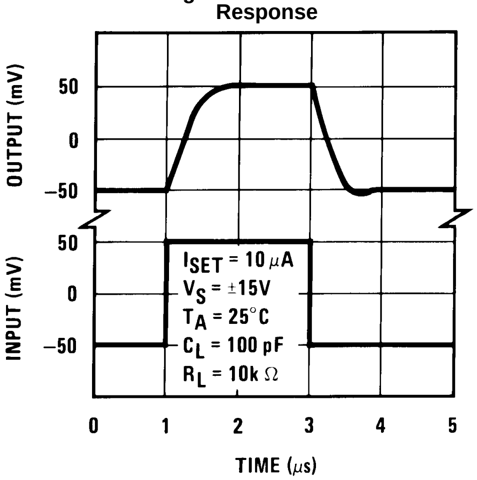


Figure 24.

Transient Response Test Circuit

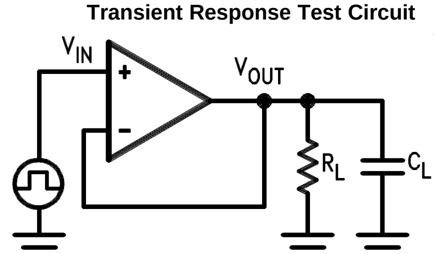


Figure 25.

APPLICATION HINTS

Avoid reversing the power supply polarity; the device will fail.

COMMON-MODE INPUT VOLTAGE

The negative common-mode voltage limit is one diode drop above the negative supply voltage. Exceeding this limit on either input will result in an output phase reversal. The positive common-mode limit is typically 1V below the positive supply voltage. No output phase reversal will occur if this limit is exceeded by either input.

OUTPUT VOLTAGE SWING VS I_{SET}

For a desired output voltage swing the value of the minimum load depends on the positive and negative output current capability of the op amp. The maximum available positive output current, (I_{CL+}), of the device increases with I_{SET} whereas the negative output current (I_{CL-}) is independent of I_{SET}. Figure 26 illustrates the above.

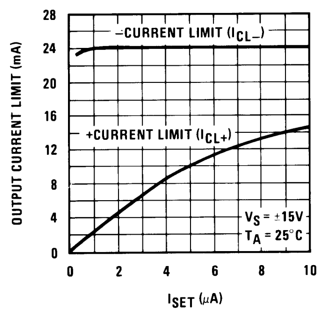


Figure 26. Output Current Limit vs I_{SET}

INPUT CAPACITANCE

The input capacitance, C_{IN}, of the LM146 is approximately 2 pF; any stray capacitance, C_S, (due to external circuit circuit layout) will add to C_{IN}. When resistive or active feedback is applied, an additional pole is added to the open loop frequency response of the device. For instance with resistive feedback (Figure 27), this pole occurs at ½π (R1||R2) (C_{IN} + C_S). Make sure that this pole occurs at least 2 octaves beyond the expected −3 dB frequency corner of the closed loop gain of the amplifier; if not, place a lead capacitor in the feedback such that the time constant of this capacitor and the resistance it parallels is equal to the $R_I(C_S + C_{IN})$, where R_I is the input resistance of the circuit.

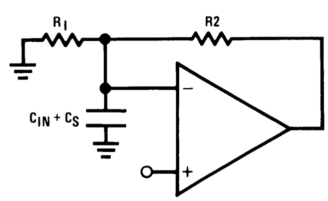


Figure 27. Resistive Feedback Circuit Example

TEMPERATURE EFFECT ON THE GBW

The GBW (gain bandwidth product), of the LM146 is directly proportional to I_{SET} and inversely proportional to the absolute temperature. When using resistors to set the bias current, I_{SET}, of the device, the GBW product will decrease with increasing temperature. Compensation can be provided by creating an I_{SET} current directly proportional to temperature (see Typical Applications).

ISOLATION BETWEEN AMPLIFIERS

The LM146 die is isothermally layed out such that crosstalk between *all 4* amplifiers is in excess of −105 dB (DC). Optimum isolation (better than −110 dB) occurs between amplifiers A and D, B and C; that is, if amplifier A dissipates power on its output stage, amplifier D is the one which will be affected the least, and vice versa. Same argument holds for amplifiers B and C.

LM146 TYPICAL PERFORMANCE SUMMARY

The LM146 typical behaviour is shown in Figure 28. The device is fully predictable. As the set current, I_{SET}, increases, the speed, the bias current, and the supply current increase while the noise power decreases proportionally and the V_{OS}remains constant. The usable GBW range of the op amp is 10 kHz to 3.5−4 MHz.

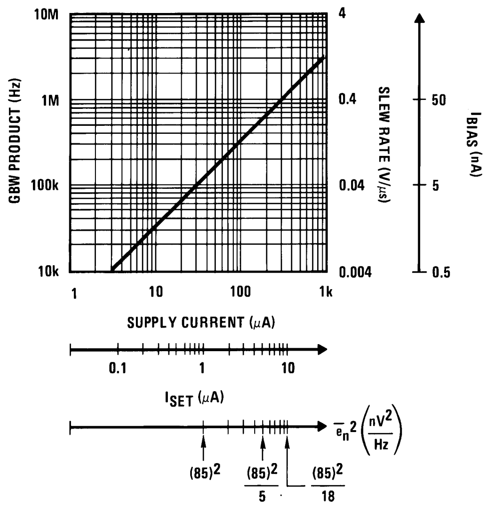


Figure 28. LM146 Typical Characteristics

Low Power Supply Operation: The quad op amp operates down to ±1.3V supply. Also, since the internal circuitry is biased through programmable current sources, no degradation of the device speed will occur.

SPEED VS POWER CONSUMPTION

LM146 vs LM4250 (single programmable). Through Figure 29, we observe that the LM146's power consumption has been optimized for GBW products above 200 kHz, whereas the LM4250 will reach a GBW of no more than 300 kHz. For GBW products below 200 kHz, the LM4250 will consume less power.

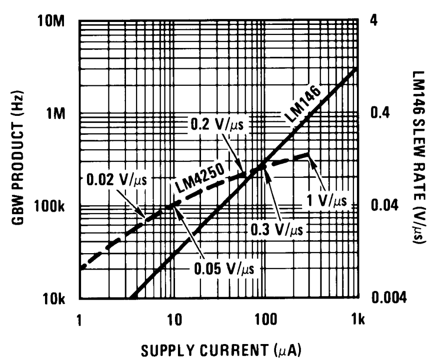
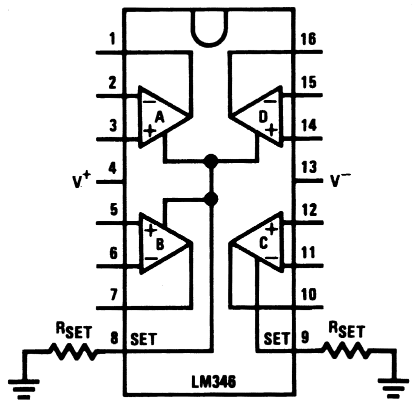


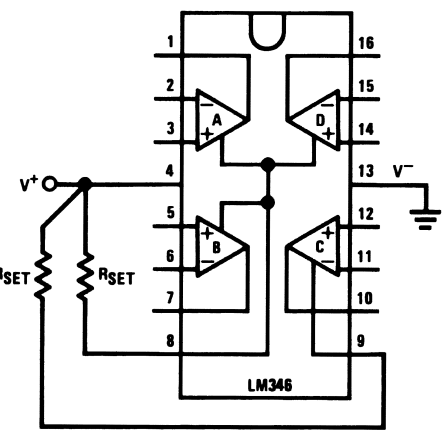
Figure 29. LM146 vs LM4250

Typical Applications



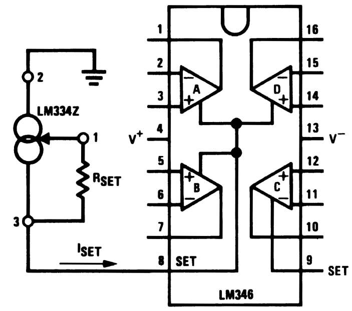
$$I_{SET} \cong \frac{|V^-| - 0.6V}{R_{SET}}$$

Figure 30. Dual Supply or Negative Supply Blasing



$$I_{SET} \cong \frac{V^+ - 0.6V}{R_{SET}}$$

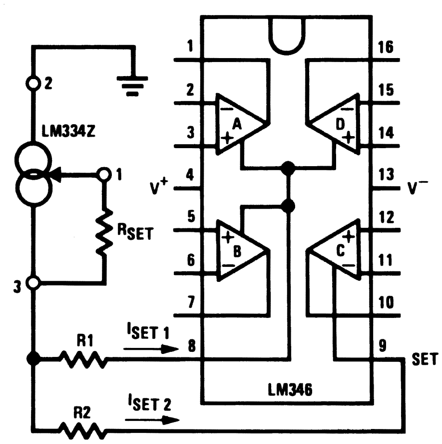
Figure 31. Single (Positive) Supply Biasing



$$I_{SET} = \frac{67.7\ mV}{R_{SET}}$$

• The LM334 provides an I_{SET} directly proportional to absolute temperature. This cancels the slight GBW product Temperature coefficient of the LM346.

Figure 32. Current Source Biasing with Temperature Compensation



$$\frac{I_{SET1}}{I_{SET2}} = \frac{R2}{R1},\ I_{SET1} + I_{SET2} = \frac{67.7\ mV}{R_{SET}}$$

• For $I_{SET1} \approx I_{SET2}$ resistors R1 and R2 are not required if a slight error between the 2 set currents can be tolerated. If not, then use R1 = R2 to create a 100 mV drop across these resistors.

Figure 33. Biasing all 4 Amplifiers with Single Current Source

Active Filters Applications

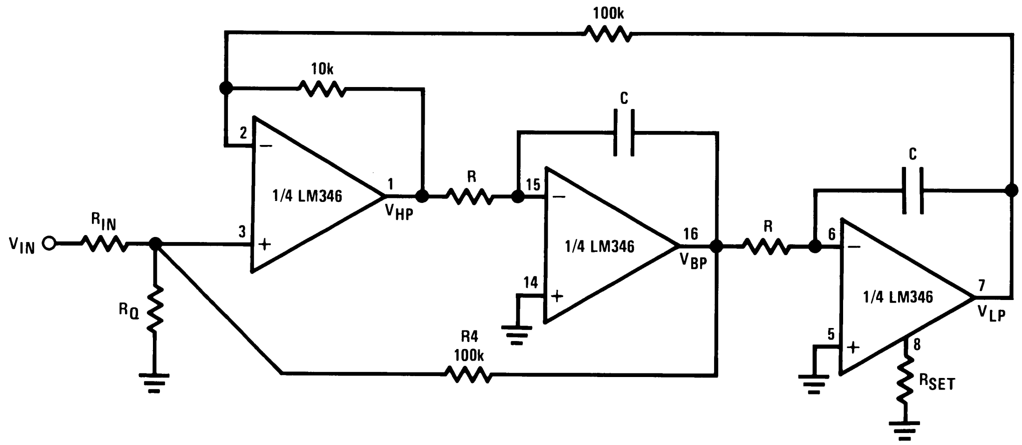


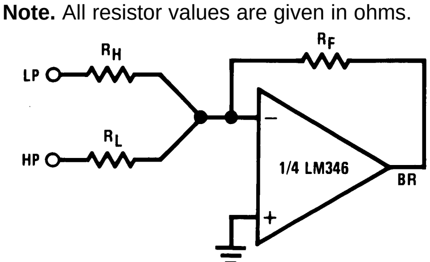
Figure 34. Basic (Non-Inverting "State Variable") Active Filter Building Block

- The LM146 quad programmable op amp is especially suited for active filters because of their adequate GBW product and low power consumption.

  Circuit synthesis equations (for circuit analysis equations, consult with the LM148 data sheet).

  Need to know desired: f_o = center frequency measured at the BP output
  Q_o = quality factor measured at the BP output
  H_o = gain at the output of interest (BP or HP or LP or all of them)
- Relation between different gains: $H_{o(BP)} = 0.316 \times Q_o \times H_{o(LP)}$; $H_{o(LP)} = 10 \times H_{o(HP)}$
- $R \times C = \dfrac{5.033 \times 10^{-2}}{f_o}$ (sec)
- For BP output: $R_Q = \left(\dfrac{3.478\,Q_o - H_{o(BP)}}{10^5} - \dfrac{H_{o(BP)}}{10^5 \times 3.748 \times Q_o}\right)^{-1}$; $R_{IN} = \dfrac{\left(\dfrac{3.478\,Q_o}{H_{o(BP)}} - 1\right)}{\dfrac{1}{RQ} + 10^{-5}}$
- For HP ouput: $R_Q = \dfrac{1.1 \times 10^5}{3.478\,Q_o\,(1.1 - H_{o(HP)}) - H_{o(HP)}}$; $R_{IN} = \dfrac{\dfrac{1.1}{H_{o(HP)}} - 1}{\dfrac{1}{RQ} + 10^{-5}}$
- For LP output: $R_Q = \dfrac{11 \times 10^5}{3.478\,Q_o\,(11 - H_{o(LP)}) - H_{o(LP)}}$; $R_{IN} = \dfrac{\dfrac{11}{H_{o(LP)}} - 1}{\dfrac{1}{RQ} + 10^{-5}}$
- For BR (notch) output: Use the 4th amplifier of the LM146 to sum the LP and HP outputs of the basic filter.

Note. All resistor values are given in ohms.



$$\sqrt{\frac{R_H}{R_L}} = 0.316\,\frac{f_{notch}}{f_o}$$

Determine R_F according to the desired gains: $H_{o(BR)}\Big|_{f<<f_{notch}} = \frac{R_F}{R_L}H_{o(LP)}$, $H_{o(BR)}\Big|_{f>>f_{notch}} = \frac{R_F}{R_H}H_{o(HP)}$

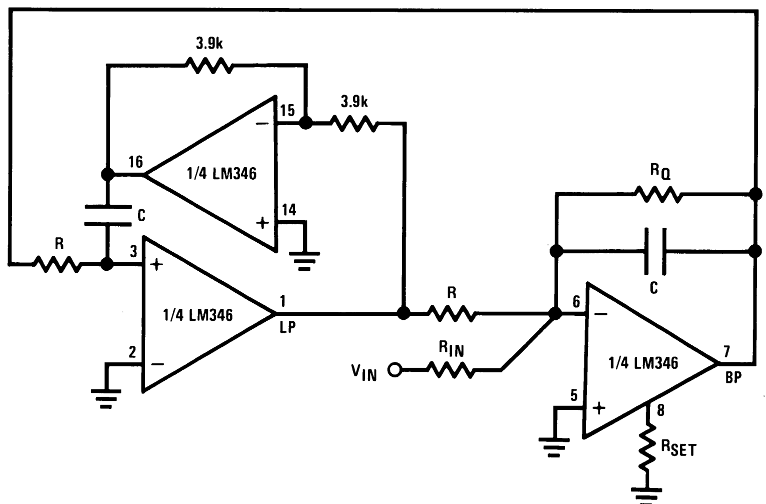
- **Where to use amplifier C:** Examine the above gain relations and determine the dynamics of the filter. Do not allow slew rate limiting in any output (V_{HP}, V_{BP}, V_{LP}), that is:

$$V_{IN(peak)} < 63.66 \times 10^3 \times \frac{I_{SET}}{10\ \mu A} \times \frac{1}{f_o \times H_o}\ \text{(Volts)}$$

If necessary, use amplifier C, biased at higher I_{SET}, where you get the largest output swing.

Deviation from Theoretical Predictions: Due to the finite GBW products of the op amps the f_o, Q_o will be slightly different from the theoretical predictions.

$$f_{real} \cong \frac{f_o}{1 + \frac{2 f_o}{GBW}},\ Q_{real} \cong \frac{Q_o}{1 - \frac{3.2 f_o \times Q_o}{GBW}}$$



- If resistive biasing is used to set the LM346 performance, the Q_o of this filter building block is nearly insensitive to the op amp's GBW product temperature drift; it has also better noise performance than the state variable filter.

Figure 35. A Simple-to-Design BP, LP Filter Building Block

Circuit Synthesis Equations

$$H_{o(BP)} = Q_o H_{o(LP)};\ R \times C = \frac{0.159}{f_o};\ R_Q = Q_o \times R;\ R_{IN} = \frac{R_Q}{H_{o(BP)}} = \frac{R}{H_{o(LP)}}$$

•For the eventual use of amplifier C, see comments above. (2)

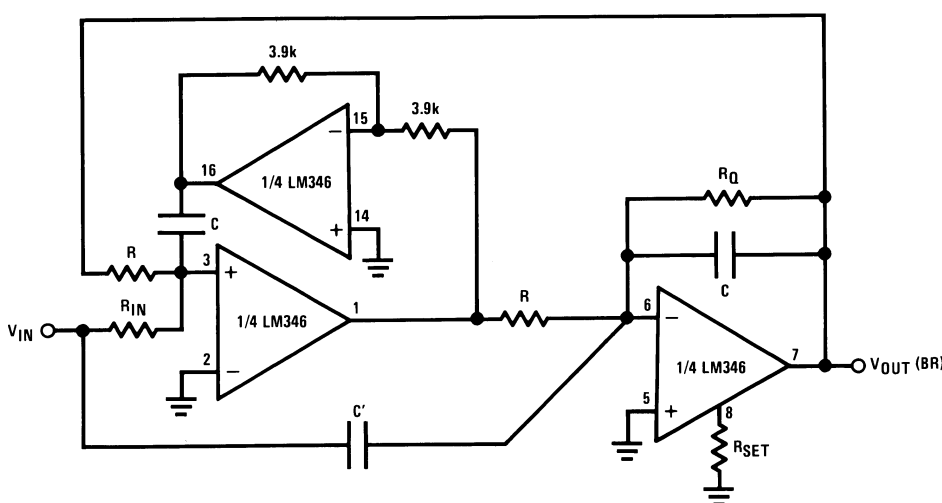


Figure 36. A 3-Amplifier Notch Filter (or Elliptic Filter Building Block)

Circuit Synthesis Equations

$$R \times C = \frac{0.159}{f_o};\ R_o = Q_o \times R;\ R_{IN} = \frac{0.159 \times f_o}{C' \times f^2_{notch}}$$

$$H_{o(BR)}\Big|_{f << f_{notch}} = \frac{R}{R_{IN}}\ H_{o(BR)}\Big|_{f >> f_{notch}} = \frac{C'}{C}$$

•For nothing but a notch output: R_{IN}=R, C′=C. (3)

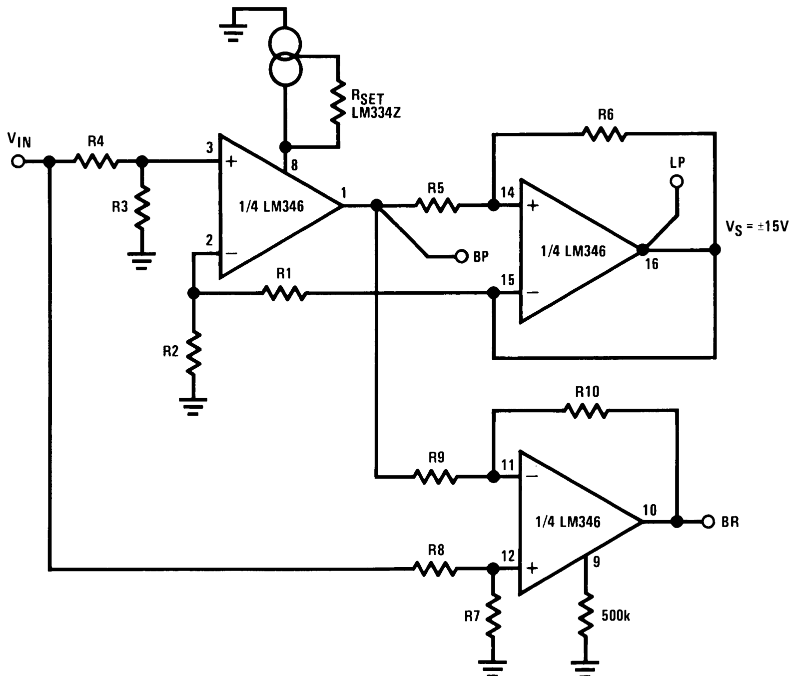


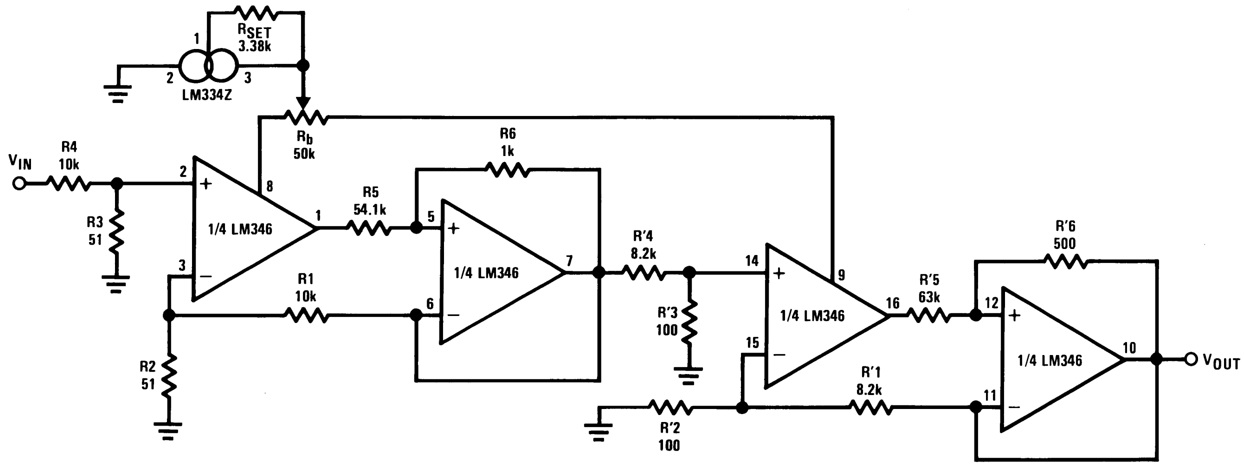
Figure 37. Capacitorless Active Filters (Basic Circuit)

- This is a BP, LP, BR filter. The filter characteristics are created by using the tunable frequency response of the LM346.
- **Limitations:** $Q_o < 10$, $f_o \times Q_o < 1.5$ MHz, output voltage should not exceed Vpeak(out) $\leq \frac{63.66 \times 10^3}{f_o} \times \frac{I_{SET}(\mu A)}{10\ \mu A}$ (V)
- Design equations: $a = \frac{R6 + R5}{R6}$, $b = \frac{R2}{R1 + R2}$, $c = \frac{R3}{R3 + R4}$, $d = \frac{R7}{R8 + R7}$, $e = \frac{R10}{R9 + R10}$, $f_{o(BP)} = f_u\sqrt{\frac{b}{a}}$, $H_{o(BP)} = a \times c$, $H_{o(LP)} = \frac{c}{b}$, $Q_o = \sqrt{a \times b}$

$f_{o(BR)} = f_{o(BP)}$, $\left(1 - \frac{c}{b}\right) \cong f_{o(BP)}$ (C << 1) provided that $d = H_{o(BP)} \times e$, $H_{o(BR)} = \frac{R10}{R9}$.

- Advantage: f_oQ_o, H_o can be independently adjusted; that is, the filter is extremely easy to tune.
- Tuning procedure (ex. BP tuning)

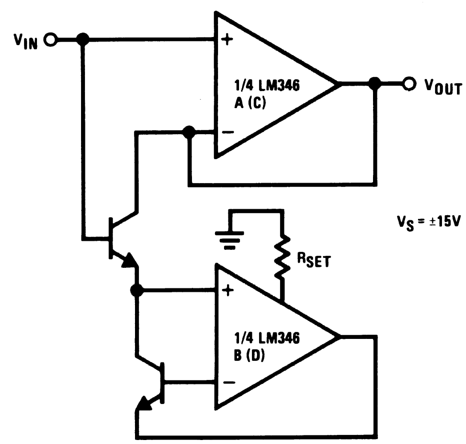
1. Pick up a convenient value for b; (b < 1)
2. Adjust Q_o through R5
3. Adjust $H_{o(BP)}$ through R4
4. Adjust f_o through R_{SET}. This adjusts the unity gain frequency (f_u) of the op amp.



Ex: f_c = 20 kHz, H_o (gain of the filter) = 1, Q_{01} = 0.541, Q_{o2} = 1.306.
•Since for this filter the GBW product of all 4 amplifiers has been designed to be the same (~1 MHz) only one current source can be used to bias the circuit. Fine tuning can be further accomplished through R_b.

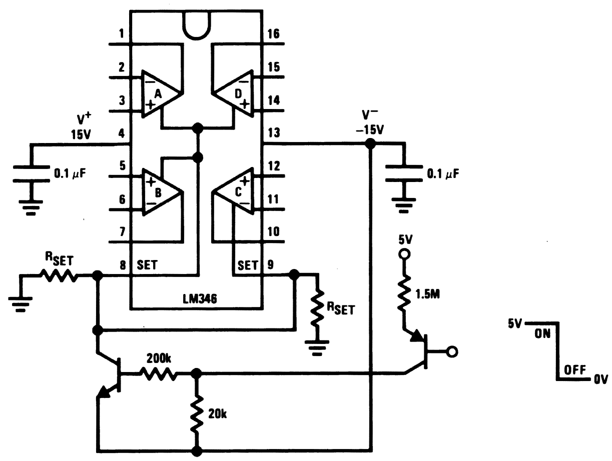
Figure 38. A 4th Order Butterworth Low Pass Capacitorless Filter

Miscellaneous Applications



• For better performance, use a matched NPN pair.

Figure 39. A Unity Gain Follower with Bias Current Reduction



• By pulling the SET pin(s) to V⁻ the op amp(s) shuts down and its output goes to a high impedance state. According to this property, the LM346 can be used as a very low speed analog switch.

Figure 40. Circuit Shutdown

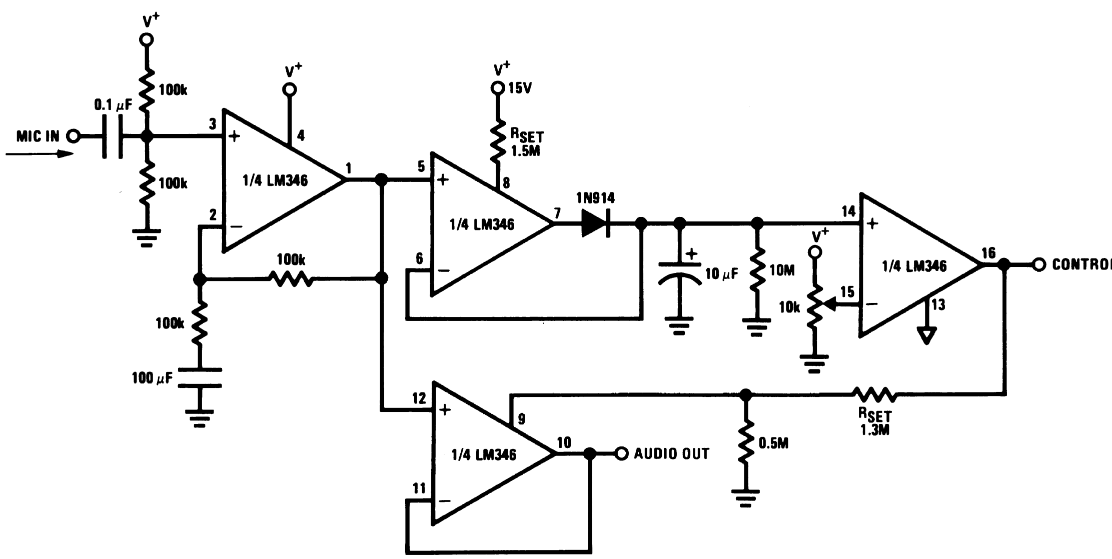
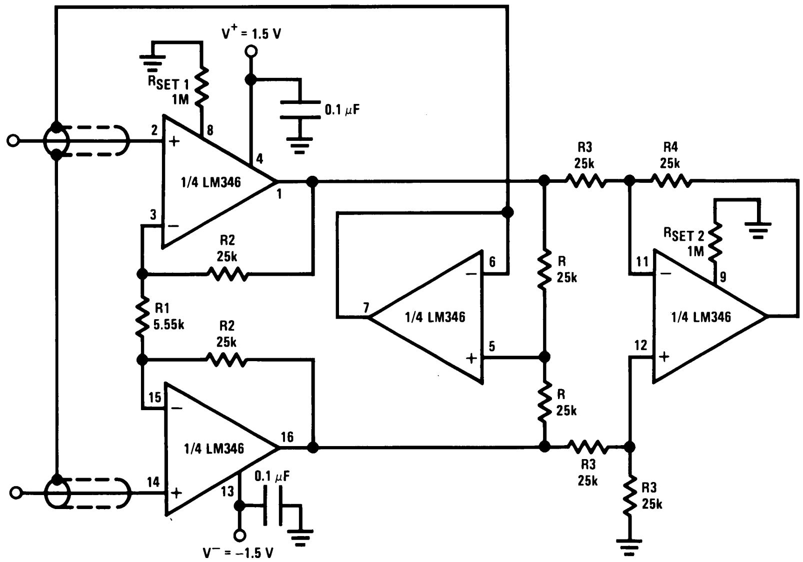


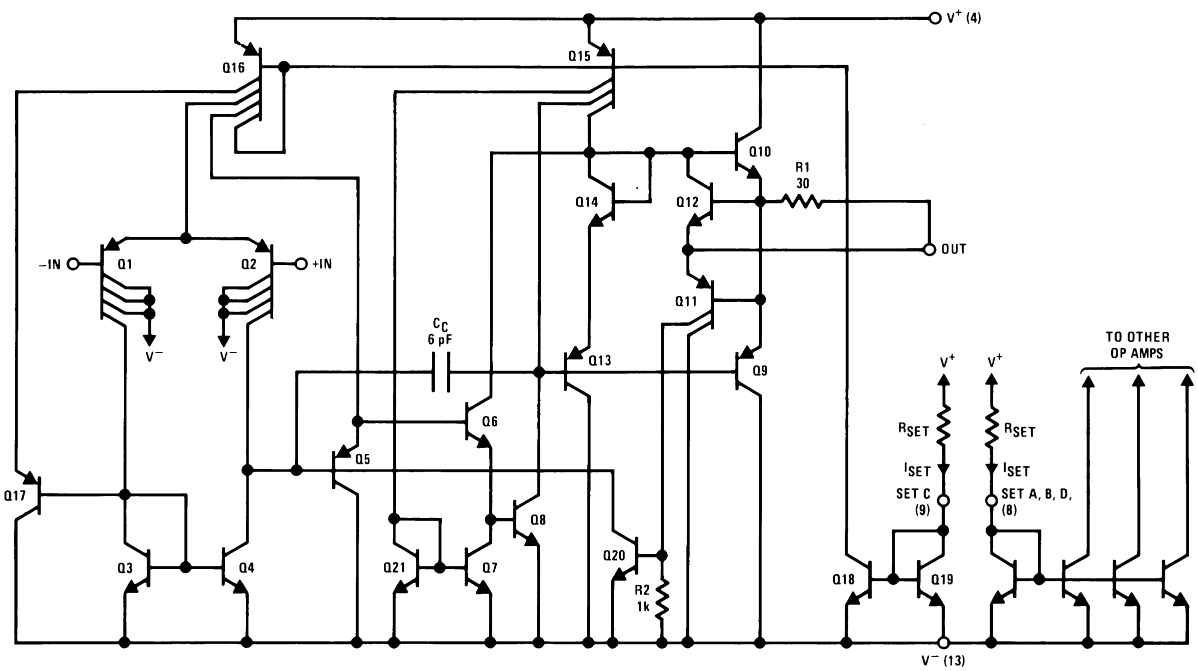
Figure 41. Voice Activated Switch and Amplifier



• CMRR: 100 dB (typ)
• Power dissipation: 0.4 mW

Figure 42. x10 Micropower Instrumentation Amplifier with Buffered Input Guarding

Schematic Diagram



PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM346M/NOPB	LIFEBUY	SOIC	D	16	48	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM346M	
LM346MX/NOPB	LIFEBUY	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	0 to 70	LM346M	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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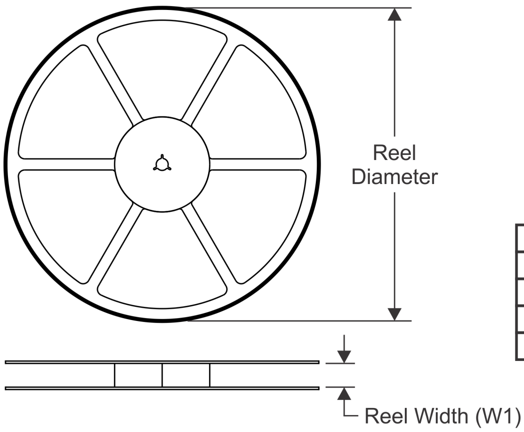
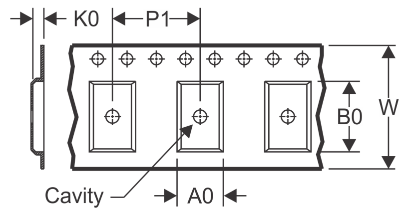
TAPE AND REEL INFORMATION

REEL DIMENSIONS

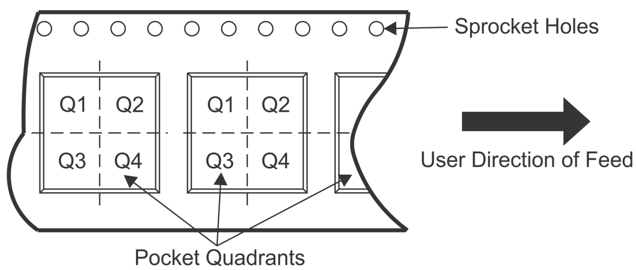


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

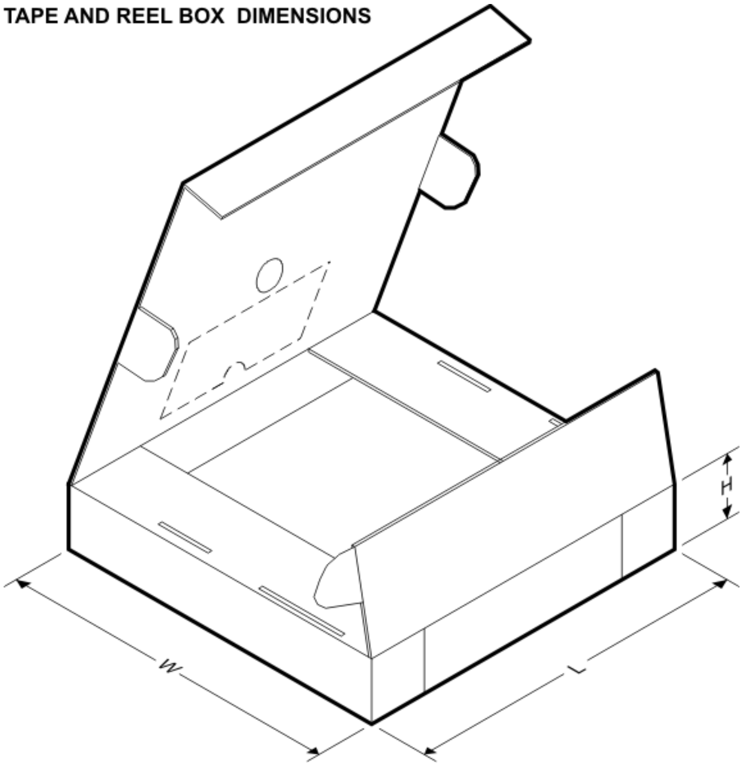
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM346MX/NOPB	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.3	8.0	16.0	Q1

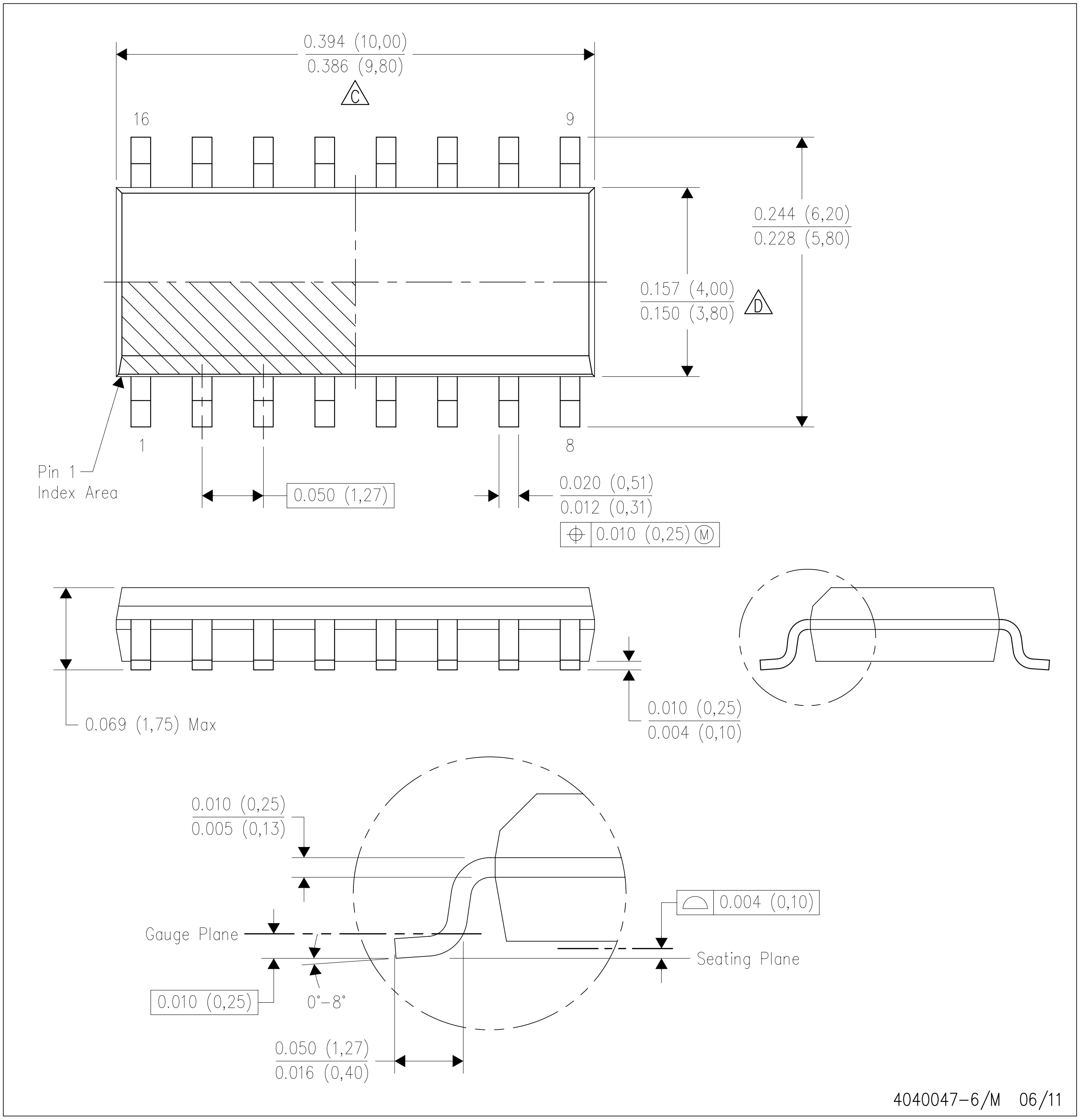
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM346MX/NOPB	SOIC	D	16	2500	367.0	367.0	35.0

D (R–PDSO–G16) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AC.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265