



Digitally-Programmed, Dual 2nd-Order Continuous Lowpass Filters

General Description

The MAX270/MAX271 are digitally-programmed, dual second-order continuous-time lowpass filters. Their typical dynamic range of 96dB surpasses most switched capacitor filters which require additional filtering to remove clock noise. The MAX270/MAX271 are ideal for anti-aliasing and DAC smoothing applications and can be cascaded for higher-order responses.

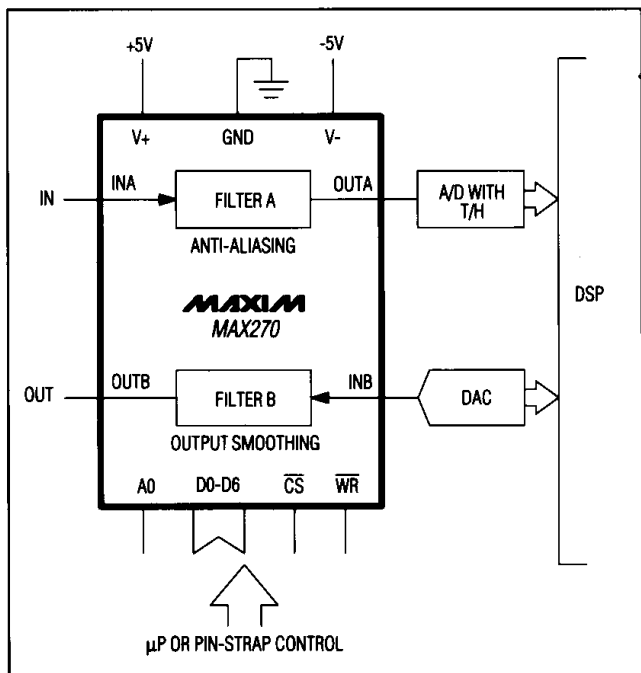
The two filter sections are independently programmable by either microprocessor (μ P) control or pin strapping. Cutoff frequencies in the 1kHz to 25kHz range can be selected.

The MAX270 has an on-board, uncommitted op amp, while the MAX271 has an internal track-and-hold (T/H).

Applications

- Lowpass Filtering
- Anti-Aliasing Filter
- Output Smoothing
- Low-Noise Applications
- Anti-Aliasing and Track-and-Hold (MAX271)

Typical Operating Circuit



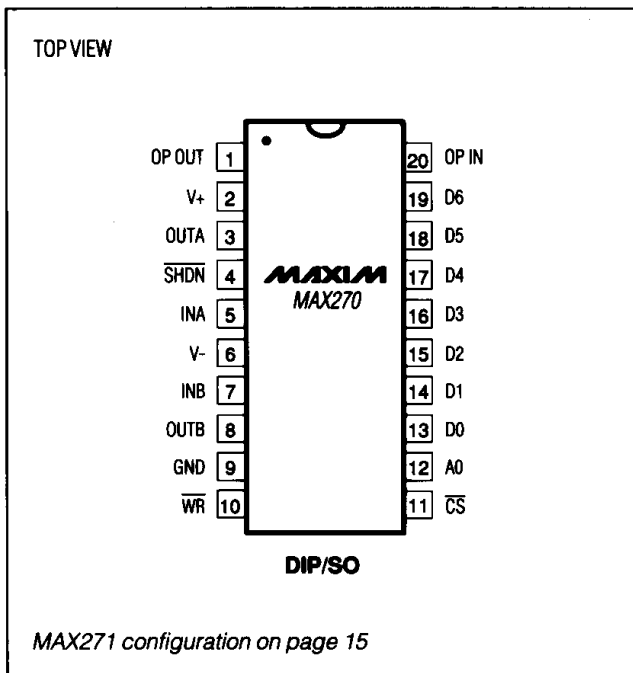
Features

- ◆ Continuous-Time Filtering - No Clock Required
- ◆ Dual 2nd-Order Lowpass Filters
- ◆ Sections Independently Programmable: 1kHz to 25kHz
- ◆ 96dB Dynamic Range
- ◆ No External Components
- ◆ Cascadable for Higher Order
- ◆ Low-Power Shutdown Mode
- ◆ Track-and-Hold (MAX271)

Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE |
|-----------|-----------------|----------------|
| MAX270CPP | 0°C to +70°C | 20 Plastic DIP |
| MAX270CWP | 0°C to +70°C | 20 Wide SO |
| MAX270EPP | -40°C to +85°C | 20 Plastic DIP |
| MAX270EWP | -40°C to +85°C | 20 Wide SO |
| MAX270MJP | -55°C to +125°C | 20 CERDIP |
| MAX271CNG | 0°C to +70°C | 24 Plastic DIP |
| MAX271CWG | 0°C to +70°C | 24 Wide SO |
| MAX271ENG | -40°C to +85°C | 24 Plastic DIP |
| MAX271EWG | -40°C to +85°C | 24 Wide SO |
| MAX271MRG | -55°C to +125°C | 24 CERDIP |

Pin Configurations



MAX271 configuration on page 15



MAX270/MAX271

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ABSOLUTE MAXIMUM RATINGS

| | |
|---|--------------------|
| V+ to V- | -0.3V, +17V |
| V+ to GND | -0.3V, +8.5V |
| V- to GND | +0.3V, -8.5V |
| Input Voltage to GND, Any Input Pin | V- -0.3V, V+ +0.3V |
| Duration of Output Short Circuit to GND | Indefinite |
| Continuous Total Power Dissipation (TA = +70°C) | |
| MAX270: | |
| Plastic DIP (derate 8mW/°C above +70°C) | 640mW |
| Wide SO (derate 10mW/°C above +70°C) | 800mW |
| CERDIP (derate 11.1mW/°C above +70°C) | 889mW |

| | |
|---|-----------------|
| MAX271: | |
| Plastic DIP (derate 8.7mW/°C above +70°C) | 696mW |
| Wide SO (derate 11.7mW/°C above +70°C) | 941mW |
| CERDIP (derate 12.5mW/°C above +70°C) | 1000mW |
| Operating Temperature Ranges: | |
| MAX27_C_ | 0°C to +70°C |
| MAX27_E_ | -40°C to +85°C |
| MAX27_M_ | -55°C to +125°C |
| Storage Temperature Range | -65°C to +165°C |
| Lead Temperature (soldering, 10 sec) | +300°C |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V+ = 5V, V- = -5V; TA = +25°C, unless otherwise noted.)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---------------------------|------|------|-------|
| FILTER CHARACTERISTICS | | | | | |
| Operating Frequency Range | (Note 1) | | 2 | | MHz |
| Programmed Cutoff Frequency (fc) Range | | | 1-25 | | kHz |
| Programmed Cutoff Frequency Error | fc code = 53 (2.536kHz typ) | | ±2.9 | | % |
| | fc code = 127 (25kHz typ) | | ±9.5 | | |
| Filter Gain | fc code = 0 (1kHz typ), TA = TMIN to TMAX | fIN = 1kHz | -3.6 | -2.4 | dB |
| | | fIN = 8kHz | | -33 | |
| | fc code = 127 (25kHz typ), TA = TMIN to TMAX | fIN = 25kHz | -6 | -0.5 | |
| | | fIN = 200kHz | | -34 | |
| Maximum Gain (Peaking) | fc code = 0 (1kHz typ) | | | 0.15 | dB |
| | fc code = 127 (25kHz typ) | | | 0.15 | |
| Wideband Noise | 50Hz to 50kHz Bandwidth | fc code = 0 (1kHz typ) | | 12 | µVRMS |
| | | fc code = 127 (25kHz typ) | | 38 | |
| DC CHARACTERISTICS | | | | | |
| DC Output Signal Swing OUTA, OUTB, OP OUT (MAX270) OUTA, OUTB, T/H OUT (MAX271) | RLOAD = 5kΩ, TA = TMIN to TMAX | -3 | | 3 | V |
| Offset Voltage at Outputs OUTA, OUTB, OP OUT (MAX270) OUTA, OUTB (MAX271) | | -2 | | 2 | mV |
| DC Input Leakage Current INA, INB (MAX270) INA, INB (MAX271) | TA = TMIN to TMAX | -1 | | 1 | µA |

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ELECTRICAL CHARACTERISTICS (continued)

(V+ = 5V, V- = -5V; TA = +25°C, unless otherwise noted.)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|--|-----|-----------------|-----|-------|
| DYNAMIC FILTER CHARACTERISTICS - MAX270 | | | | | |
| Total Harmonic Distortion (THD) | f _C code = 44 (2.01kHz typ), V _{IN} = 3.5V _{p-p} at 390.625Hz (Notes 2, 3) | | | -70 | dB |
| Signal/(Noise + Distortion) (SINAD) | | | 73 | | |
| Spurious-Free Dynamic Range (SFDR) | | 70 | | | |
| UNCOMMITTED AMPLIFIER - MAX270 | | | | | |
| Slew Rate | | | 1.2 | | V/μs |
| Bandwidth | | | 2 | | MHz |
| TRACK-AND-HOLD - MAX271 | | | | | |
| Hold Settling Time | To 0.1% (Note 4) | | 500 | | ns |
| Acquisition Time | To 0.1% (Note 5) | | 1.8 | | μs |
| Hold Step | | | 1 | | mV |
| Droop Rate | TA = TMIN to TMAX | | 30 | | μV/μs |
| Offset Voltage at T/H OUT | Includes filter offset | -6 | | 6 | mV |
| T/H OUT Disabled Output Leakage Current | TA = TMIN to TMAX, T/H = 0V (Track Mode) | -10 | | 10 | μA |
| Total Harmonic Distortion (THD) | f _C code = 44 (2.01kHz typ), V _{IN} = 3.5V _{p-p} at 390.625Hz, Sampling rate = 50kHz (Notes 2, 6, 7) | | | -70 | dB |
| Spurious-Free Dynamic Range (SFDR) | | 70 | | | |
| DIGITAL INPUTS | | | | | |
| Digital Input High Voltage | TA = TMIN to TMAX (Note 8) | 2.4 | | | V |
| Digital Input Low Voltage | | 0.8 | | | |
| Digital Input Current | TA = TMIN to TMAX, Digital input held at ±5V, includes MODE (MAX271) (Note 8) | -1 | | 1 | μA |
| POWER REQUIREMENTS | | | | | |
| Supply Voltage Range | | | ±2.375 to ±8 | | V |
| Supply Current | TA = TMIN to TMAX (Note 9) | | | 6.5 | mA |
| Shutdown Supply Current | TA = TMIN to TMAX (Note 10) | | | 15 | μA |
| Power-Supply Rejection Ratio (PSRR) at 1kHz | f _C code = 0 (1kHz typ), V+ = 5VDC + 100mV _{p-p} at 1kHz | | 30 | | dB |

Note 1: All internal amplifiers limited to 2MHz bandwidth.

Note 2: Only filter A tested for these parameters.

Note 3: Spurious-Free Dynamic Range is the ratio of the fundamental to the largest of any harmonic or noise spur in dB.

Note 4: Includes T/H propagation delays. With 5kΩ, parallel 100pF load.

Note 5: +2V input step settling 0.1% with 5kΩ parallel 100pF load.

Note 6: T/H pin toggled at sampling rate, 50% duty cycle.

Note 7: THD and SFDR specifications for T/H include contributions from filter.

Note 8: Digital pins include SHDN, WR, CS, A0, D0-D6 (MAX270) and SHDN, T/H A/B, WR, T/H EN, CS, A0, A1, D0-D6, T/H (MAX271).

Note 9: Input of uncommitted op amp floating with a 5kΩ feedback resistor from input to output.

Note 10: WR, CS, A0, D0-D6 held at +5V; SHDN = 0V (MAX270). WR, CS, A0, A1, D0-D6, T/H, T/H A/B, T/H, MODE held at +5V; SHDN = 0V (MAX271).

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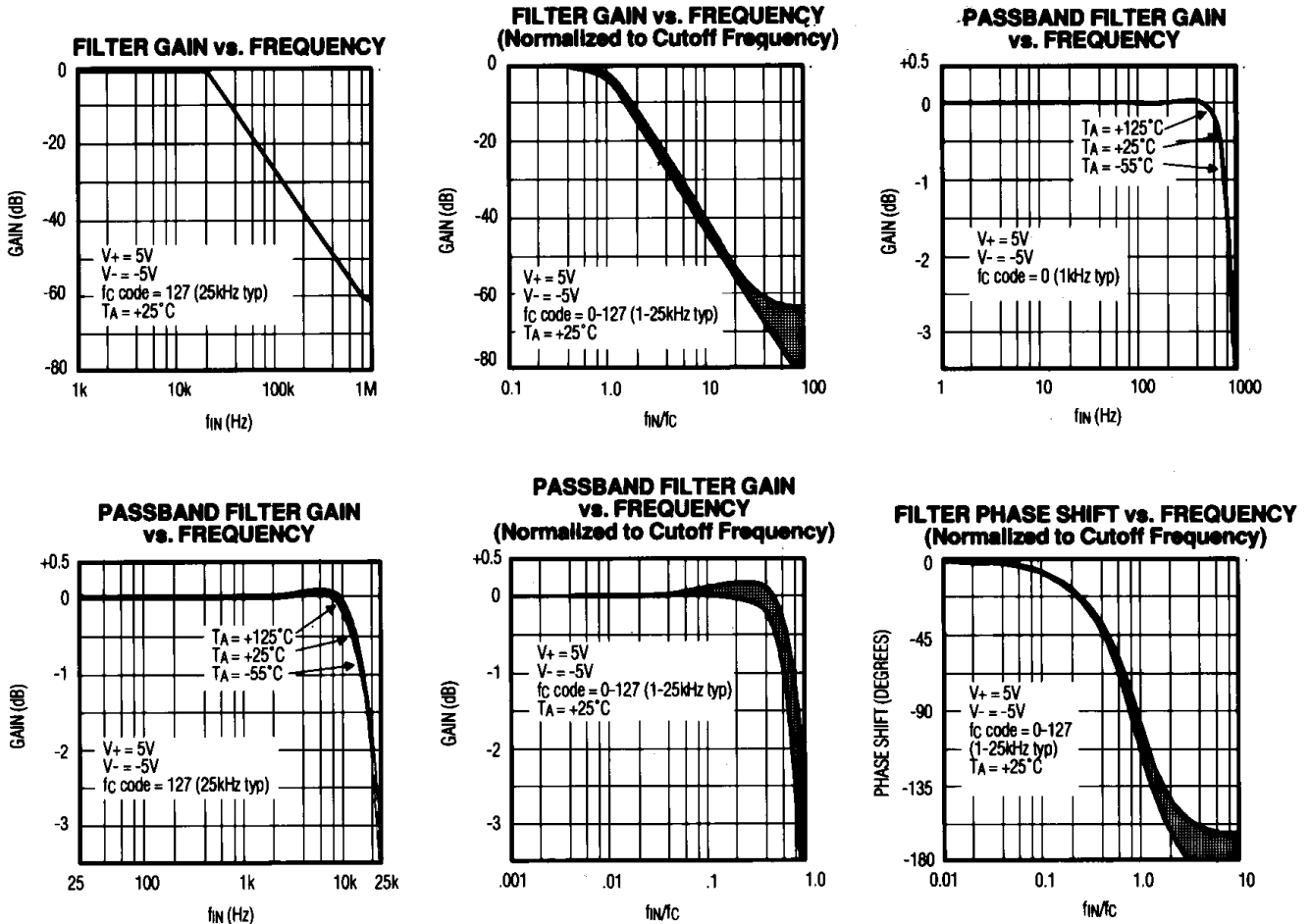
TIMING CHARACTERISTICS (Figure 2)

(V+ = 5V, V- = -5V; TA = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|----------|------------|-----|-----|-----|-------|
| \overline{CS} to \overline{WR} Setup | t_{ws} | | | | 0 | ns |
| \overline{CS} to \overline{WR} Hold | t_{wh} | | | | 0 | ns |
| \overline{WR} Pulse Width | t_{wv} | | 100 | | | ns |
| Address-Setup Time | t_{as} | | 30 | | | ns |
| Address-Hold Time | t_{ah} | | 10 | | | ns |
| Data-Setup Time | t_{ds} | | 30 | | | ns |
| Data-Hold Time | t_{dh} | | 10 | | | ns |

Note 11: All input control signals specified with $t_r = t_f = 5ns$ (10% to 90% of +5V) and timed from a +1.6V voltage level.

Typical Operating Characteristics

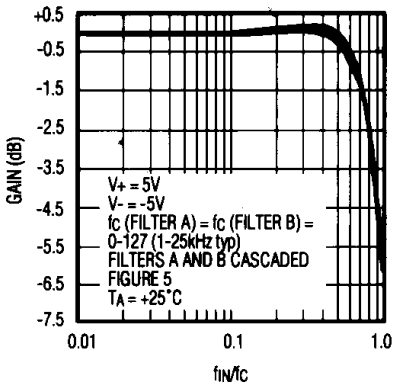


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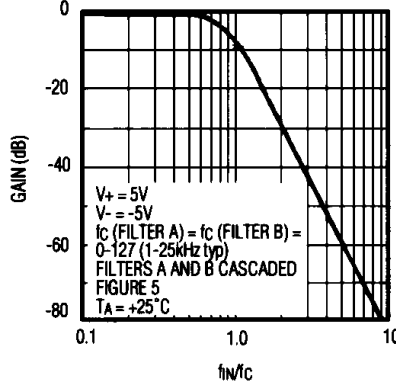
Typical Operating Characteristics (continued)

MAX270/MAX271

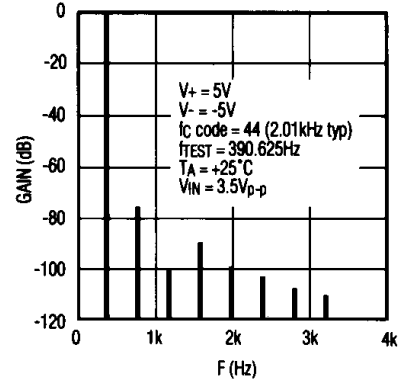
CASCADED FILTER GAIN vs. FREQUENCY (Normalized to Cutoff Frequency)



CASCADED FILTER GAIN vs. FREQUENCY (Normalized to Cutoff Frequency)



FILTER HARMONIC DISTORTION

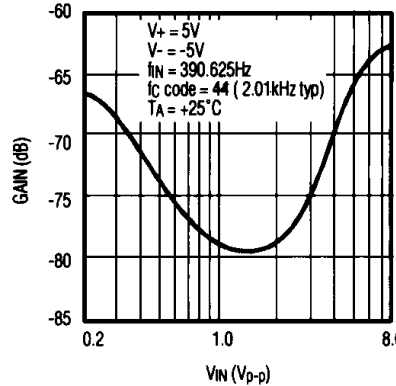


FILTER TOTAL HARMONIC DISTORTION + NOISE vs. INPUT FREQUENCY

| f_{IN} (Hz) | f_c Code | f_c (Hz) (Typ) | THD + NOISE (dB) |
|---------------|------------|------------------|------------------|
| 190 | 0 | 1k | -78 |
| 390 | 44 | 2.01k | -73 |
| 1367 | 100 | 7.01k | -67 |
| 4875 | 127 | 25k | -66 |

$V_+ = 5V$, $V_- = -5V$; $V_{IN} = 3.5V_{p-p}$; $T_A = +25^\circ C$

FILTER TOTAL HARMONIC DISTORTION + NOISE vs. INPUT AMPLITUDE

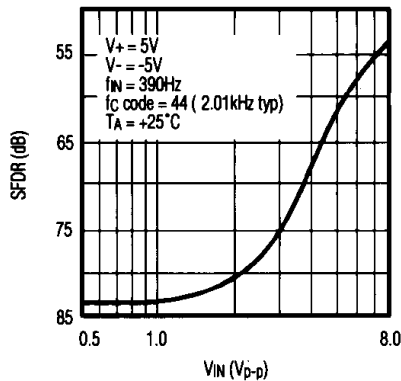


MAX271 FILTER + TRACK-AND-HOLD SPURIOUS-FREE DYNAMIC RANGE vs. INPUT FREQUENCY

| f_{IN} (Hz) | f_c Code | f_c (Hz) (Typ) | SFDR (dB) |
|---------------|------------|------------------|-----------|
| 195 | 0 | 1k | 73.5 |
| 781 | 72 | 4.01k | 69.5 |
| 1562.5 | 105 | 8.08k | 66 |
| 3906 | 124 | 19.4k | 61.5 |

$V_+ = 5V$, $V_- = -5V$; $V_{IN} = 3.5V_{p-p}$;
 \bar{T}/H SWITCHED AT 50kHz, 50% DUTY CYCLE;
 $T_A = +25^\circ C$

MAX271 FILTER + TRACK-AND-HOLD SPURIOUS-FREE DYNAMIC RANGE vs. INPUT AMPLITUDE



MAX271 FILTER + TRACK-AND-HOLD SPURIOUS-FREE DYNAMIC RANGE vs. SAMPLING FREQUENCY

| F_{SAMPLE} (Hz) | f_{IN} (Hz) | f_c Code | f_c (Hz) | SFDR (dB) |
|-------------------|---------------|------------|------------|-----------|
| 100k | 781 | 72 | 4.01k | 72 |
| 200k | 1562 | 105 | 8.08k | 72 |
| 500k | 3906 | 124 | 19.4k | 64 |

$V_+ = 5V$, $V_- = -5V$; $V_{IN} = 3.5V_{p-p}$;
 \bar{T}/H SWITCHED AT 50% DUTY CYCLE;
 $T_A = +25^\circ C$

Digitally-Programmed, Dual 2nd-Order Continuous Lowpass Filters

Detailed Description

Figures 1a, 1b, and 1c show the MAX270/MAX271 functional diagrams. Both the MAX270 and MAX271 contain two independent, second-order, Sallen-Key, lowpass filter sections, A and B, to provide a frequency vs. gain rolloff of approximately 40dB/decade. These are not switched-capacitor filters, but have a continuous-time design similar to discrete active filters built around op amps. The MAX270/MAX271 eliminate clock noise and aliasing problems which limit low-noise performance of switched-capacitor filters; resulting dynamic range is over 96dB.

Each filter section contains two banks of programmable capacitors, controlled by an internal 7-bit memory, which set filter cutoff frequencies (f_c) from 1kHz to 25kHz. The filters provide two program modes. In μP mode, cutoff frequencies are programmed by writing 7-bit data to one of two memory addresses (one for each filter section). Alternately, a pin-strap programming mode programs both filter sections simultaneously. In this mode, both memory latches are transparent (not addressable), and data pins D0-D6 may be pin strapped (hardwired) to set a common f_c for both filter sections.

The filters are trimmed at the wafer level, setting Q for a maximum of 0.15dB passband peaking for f_c programmed to 1kHz. Maximum passband peaking at other codes is typically less than 0.15dB. Filter Q is not user-programmable.

The MAX270 includes an uncommitted op amp (non-inverting input grounded); the MAX271 has an on-chip T/H that tracks and holds the output of either filter section (selectable). The held output is provided at T/H OUT. T/H functions are controlled by writing control bits to internal registers (in μP mode) or by control pins directly (in pin-strap mode).

The MAX270 and MAX271 provide a low quiescent current shutdown mode controlled by the SHDN pin, which turns off internal amplifiers and floats all outputs, reducing quiescent operating current to less than 15 μA . When the MAX271 is in μP mode, shutdown mode is selected by writing control bits to memory (the SHDN pin is disabled).

Pin Descriptions

MAX270

| PIN # | NAME | FUNCTION |
|-------|--------|--|
| 1 | OP OUT | Uncommitted Op-Amp Output |
| 2 | V+ | Positive Supply Voltage |
| 3 | OUTA | Filter A Output |
| 4 | SHDN | SHUTDOWN Control. Low level floats OUTA, OUTB, and OP OUT and places device into shutdown mode. |
| 5 | INA | Filter A Input |
| 6 | V- | Negative Supply Voltage |
| 7 | INB | Filter B Input |
| 8 | OUTB | Filter B Output |
| 9 | GND | Ground |
| 10 | WR | WRITE Control Input. A low level writes data D0-D6 to program memory addressed by A0. High level latches data. |
| 11 | CS | CHIP SELECT Input. Must be low for WR input to be recognized. |
| 12 | A0 | Three-Level Address Input— logic high: addresses filter A logic low: addresses filter B connect to V-: pin-strap mode |
| 13-19 | D0-D6 | 7-Bit Data Inputs. Allows programming of 128 cutoff frequencies in a 1kHz to 25kHz range. |
| 20 | OP IN | Uncommitted Op-Amp Input |

Note: All digital input levels are TTL and CMOS compatible, unless otherwise stated.

MAX271 Pin Description on next page

Digitally-Programmed, Dual 2nd-Order Continuous Lowpass Filters

Pin Descriptions (continued)

MAX271

MAX270/MAX271

| PIN # | NAME | FUNCTION, μ P MODE (MODE = GND OR V-) | FUNCTION, PIN-STRAP MODE (MODE = V+) |
|--------|------------------------------|--|--|
| 1 | T/H OUT | Track-and-Hold Output | |
| 2 | V+ | Positive Supply Voltage | |
| 3 | OUTA | Filter A Signal Output | |
| 4 | $\overline{\text{SHDN}}$ | X | SHUTDOWN Control. A low level floats outputs and places device into shutdown mode. |
| 5 | INA | Filter A Signal Input | |
| 6 | V- | Negative Supply Voltage | |
| 7 | INB | Filter B Signal Input | |
| 8 | MODE | Selects μ P mode when tied to GND or V- and pin-strap mode when connected to V+. | |
| 9 | OUTB | Filter B Signal Output | |
| 10 | GND | Ground | |
| 11 | T/H A/ $\overline{\text{B}}$ | X | Track-and-Hold Input Control. A high/low level internally connects OUTA/OUTB to input of Track-and-Hold. |
| 12 | $\overline{\text{WR}}$ | WRITE Control Input. A low level writes data D0-D6 to program memory addressed by A1, A0 (or performs function as described for address inputs). High level latches data. | X |
| 13 | T/H EN | X | Track-and-Hold Output Control. Low level floats T/H OUT. Connect pin high for normal operation. |
| 14 | $\overline{\text{CS}}$ | CHIP SELECT Input. Must be low for $\overline{\text{WR}}$ input to be recognized. | X |
| 15, 16 | A1, A0 | Address and μ P Control Inputs. 0, 0 Programs f_c , filter A. 0, 1 Programs f_c , filter B. 1, 0 Controls T/H functions: D0 performs T/H EN pin function. D1 performs T/H A/ $\overline{\text{B}}$ pin function. 1, 1 Controls device shutdown: D0 performs SHDN pin function. Note: The $\overline{\text{WR}}$ pin must be strobed low to initiate a program/function (Figure 2). | X |
| 17-23 | D0-D6 | 7-bit Data Inputs. Allows programming of 128 cutoff frequencies (also performs control functions as described above). | 7-bit Data Inputs. Program memory latches are transparent in this mode. Connect pins high or low to program filters A and B simultaneously to the same f_c . |
| 24 | T/H | Track-and-Hold Control. Low level causes T/H OUT to track selected filter output. Filter output level held at T/H OUT synchronous with T/H rising transition. | |

X = Pin has no function in this mode.

Note: All digital input levels are TTL and CMOS compatible, unless otherwise stated.

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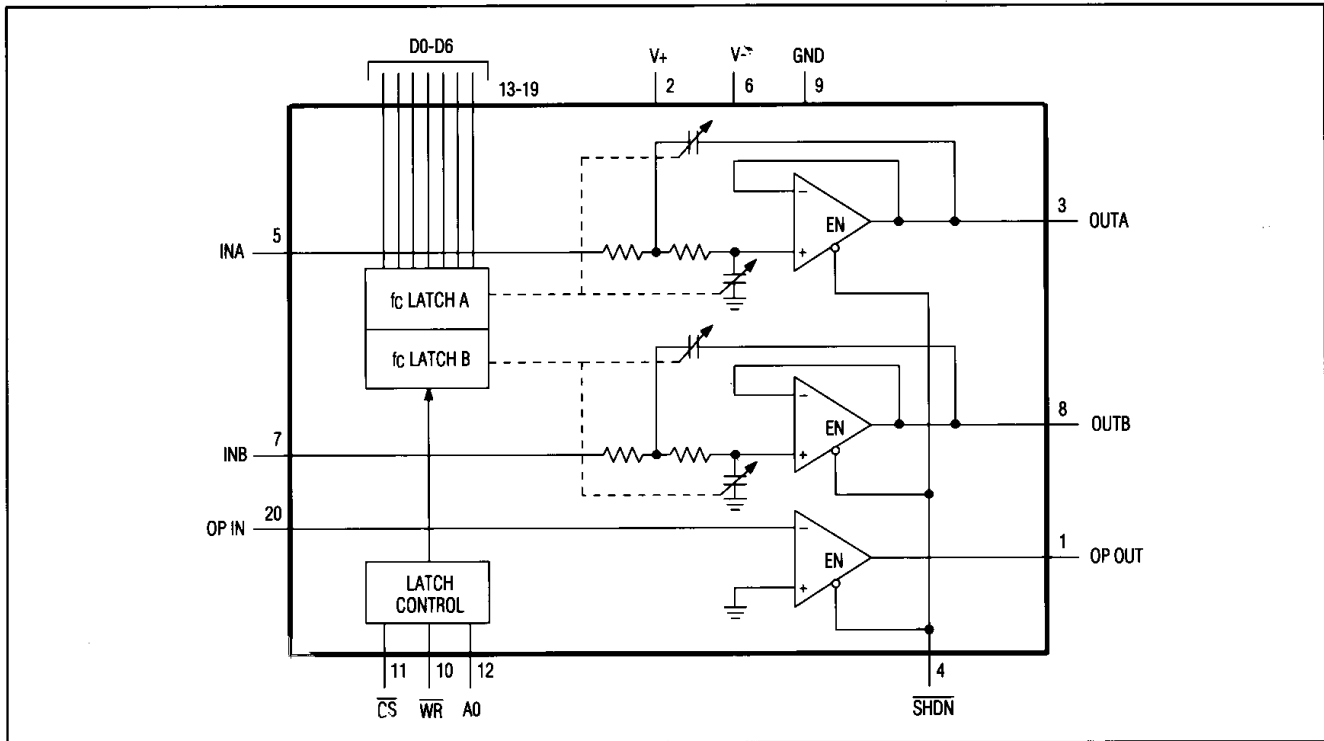


Figure 1a. MAX270 Block Diagram

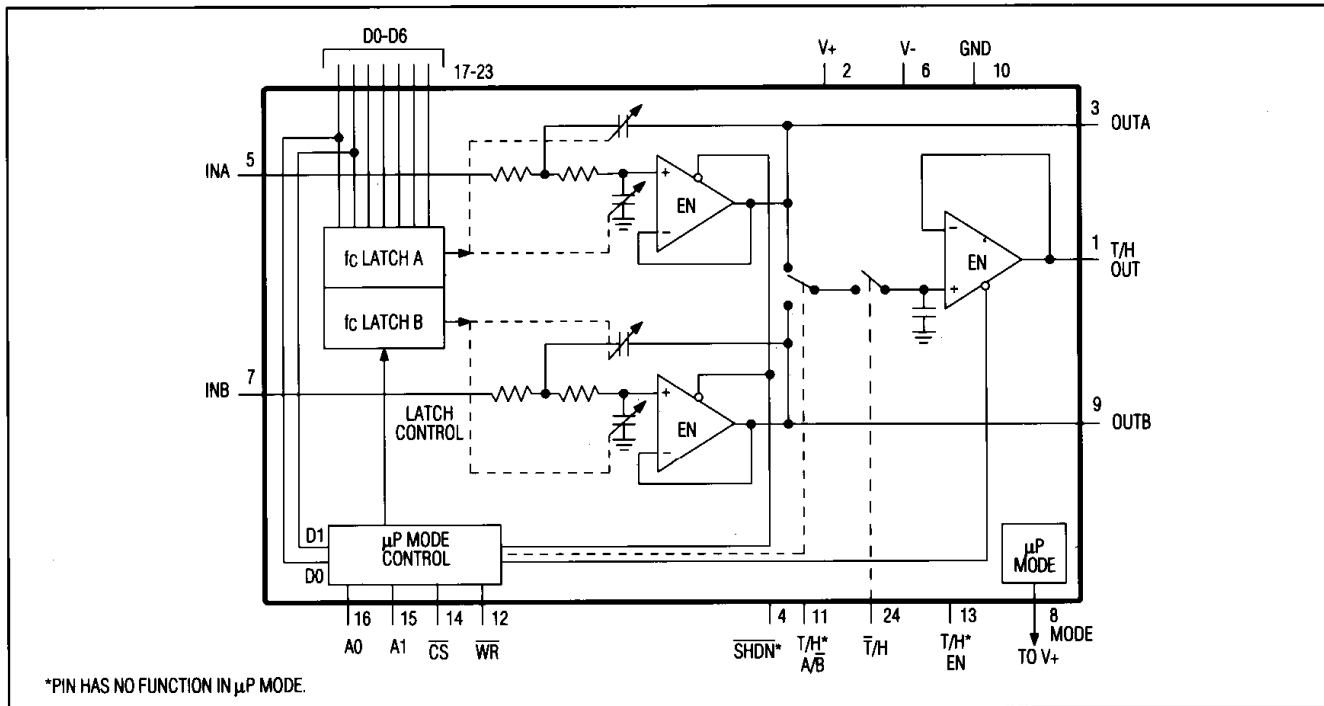


Figure 1b. MAX271 Block Diagram - μP Mode

Digitally-Programmed, Dual 2nd-Order Continuous Lowpass Filters

MAX270/MAX271

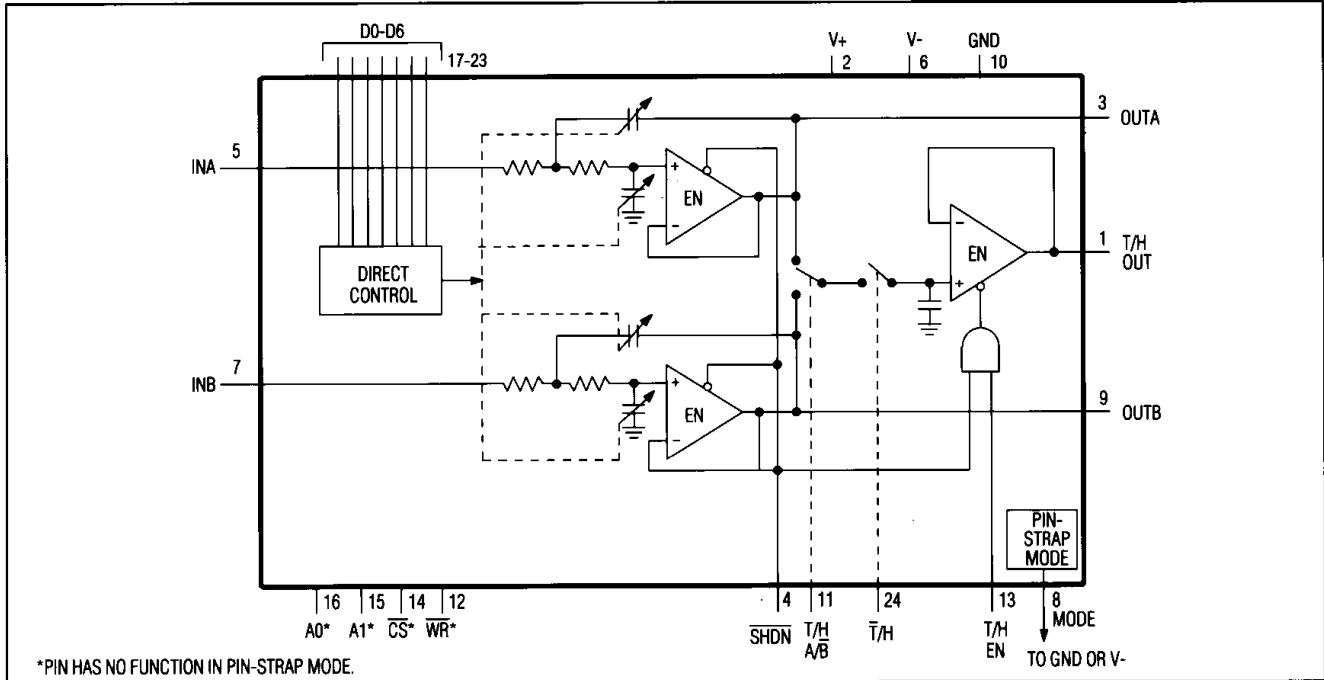


Figure 1c. MAX271 Block Diagram - Pin-Strap Mode

Filter Programming

Cutoff Frequency

f_c is the frequency of 3dB attenuation in the filter response.

Table 1 shows how data pins D0-D6 allow programming of 128 cutoff frequencies from 1kHz to 25kHz.

The equations for calculating f_c from the programmed code are as follows:

$$f_c = \frac{87.5}{87.5 - \text{CODE}} \times 1\text{kHz} \quad \text{for codes 0-63} \quad (f_c = 1\text{kHz to } 3.57\text{kHz})$$

$$f_c = \frac{262.5}{137.5 - \text{CODE}} \times 1\text{kHz} \quad \text{for codes 64-127} \quad (f_c = 3.57\text{kHz to } 25\text{kHz})$$

where CODE is the data on pins D0-D6 (0-127). D6 is the most significant bit (MSB).

Actual cutoff frequencies are subject to some error for each programmed code. Highest accuracy occurs at CODE = 0 where filters are trimmed for a 1kHz cutoff frequency. At higher codes, CODE vs. f_c errors increase; the frequency error at CODE = 127 (highest code) remains typically within $\pm 9.5\%$. This means that the actual filter cutoff frequency, when programmed to CODE = 127, falls between 22.63kHz and 27.38kHz.

Digitally-Programmed, Dual 2nd-Order Continuous Lowpass Filters

Table 1. Programmed Cutoff Frequency Codes (Typ)

| PROGRAMMED CODE | fc (kHz) | PROGRAMMED CODE | fc (kHz) | PROGRAMMED CODE | fc (kHz) | PROGRAMMED CODE | fc (kHz) |
|-----------------|----------|-----------------|----------|-----------------|----------|-----------------|----------|
| 0 | 1.000 | 32 | 1.576 | 64 | 3.571 | 96 | 6.325 |
| 1 | 1.011 | 33 | 1.605 | 65 | 3.620 | 97 | 6.481 |
| 2 | 1.023 | 34 | 1.635 | 66 | 3.671 | 98 | 6.645 |
| 3 | 1.035 | 35 | 1.666 | 67 | 3.723 | 99 | 6.818 |
| 4 | 1.047 | 36 | 1.699 | 68 | 3.777 | 100 | 7.008 |
| 5 | 1.060 | 37 | 1.732 | 69 | 3.832 | 101 | 7.191 |
| 6 | 1.073 | 38 | 1.767 | 70 | 3.888 | 102 | 7.394 |
| 7 | 1.087 | 39 | 1.804 | 71 | 3.947 | 103 | 7.608 |
| 8 | 1.100 | 40 | 1.842 | 72 | 4.007 | 104 | 7.835 |
| 9 | 1.114 | 41 | 1.881 | 73 | 4.069 | 105 | 8.076 |
| 10 | 1.129 | 42 | 1.923 | 74 | 4.133 | 106 | 8.333 |
| 11 | 1.143 | 43 | 1.966 | 75 | 4.200 | 107 | 8.606 |
| 12 | 1.158 | 44 | 2.011 | 76 | 4.268 | 108 | 8.898 |
| 13 | 1.174 | 45 | 2.058 | 77 | 4.338 | 109 | 9.210 |
| 14 | 1.190 | 46 | 2.108 | 78 | 4.411 | 110 | 9.545 |
| 15 | 1.206 | 47 | 2.160 | 79 | 4.487 | 111 | 9.905 |
| 16 | 1.223 | 48 | 2.215 | 80 | 4.565 | 112 | 10.294 |
| 17 | 1.241 | 49 | 2.272 | 81 | 4.646 | 113 | 10.714 |
| 18 | 1.259 | 50 | 2.333 | 82 | 4.729 | 114 | 11.170 |
| 19 | 1.277 | 51 | 2.397 | 83 | 4.816 | 115 | 11.666 |
| 20 | 1.296 | 52 | 2.464 | 84 | 4.906 | 116 | 12.209 |
| 21 | 1.315 | 53 | 2.536 | 85 | 5.000 | 117 | 12.804 |
| 22 | 1.335 | 54 | 2.611 | 86 | 5.097 | 118 | 13.461 |
| 23 | 1.356 | 55 | 2.692 | 87 | 5.198 | 119 | 14.189 |
| 24 | 1.378 | 56 | 2.777 | 88 | 5.303 | 120 | 15.000 |
| 25 | 1.400 | 57 | 2.868 | 89 | 5.412 | 121 | 15.909 |
| 26 | 1.422 | 58 | 2.966 | 90 | 5.526 | 122 | 16.935 |
| 27 | 1.446 | 59 | 3.070 | 91 | 5.645 | 123 | 18.103 |
| 28 | 1.470 | 60 | 3.181 | 92 | 5.769 | 124 | 19.444 |
| 29 | 1.495 | 61 | 3.301 | 93 | 5.898 | 125 | 21.000 |
| 30 | 1.521 | 62 | 3.431 | 94 | 6.034 | 126 | 22.826 |
| 31 | 1.548 | 63 | 3.571 | 95 | 6.176 | 127 | 25.000 |

Programmed code is the data on pins D0-D6 (0-127). D6 is the MSB.

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MAX270/MAX271

MAX270 Control Interface

The A0 pin is a three-level input that selects the memory addresses for updating cutoff frequency data in μ P mode:

| A0 | SELECTS |
|------------|----------|
| Logic Low | Filter B |
| Logic High | Filter A |

Figure 2 shows μ P-mode interface timing.

Connecting A0 to the negative supply selects pin-strap mode. Pin-strap mode allows filter programming with no timing requirements. Internal memory latches are disabled, permitting filters A and B to be programmed directly to f_c data strapped on D0-D6. This mode disables \overline{CS} and \overline{WR} controls, and filters A and B are programmed to the same f_c .

A low level on the \overline{SHDN} pin shuts down all amplifiers and floats OUTA, OUTB, and OP OUT. Current consumption drops to less than 15 μ A in this mode.

MAX271 Control Interface

Connecting the MODE pin to GND or V- selects the μ P mode. In this mode, addressable program memory controls filter cutoff frequency programming and all T/H functions, except $\overline{T/H}$. Refer to Figure 2 for timing characteristics. Table 2 describes available functions:

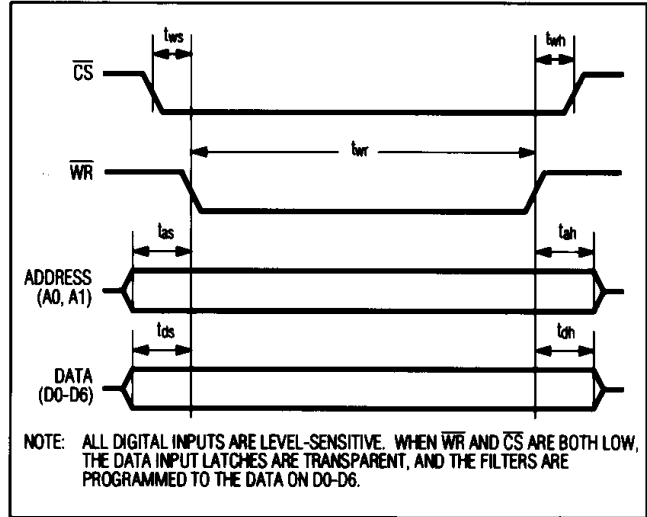


Figure 2. MAX270/MAX271 Digital Timing Diagram

In μ P mode, \overline{SHDN} , T/H A/B, and T/H EN pins are disabled. $\overline{T/H}$ remains enabled and performs the T/H tracking/holding function.

Tying MODE to V+ selects pin-strap mode. In this mode, both memory latches are transparent, and data on D0-D6 controls the f_c of filters A and B directly (filters A and B are programmed to the same f_c). Pin strap D0-D6 for operation without μ P. A0, A1, \overline{CS} , and \overline{WR} are disabled.

Table 2. MAX271 μ P-Mode Interface

| A1 | A0 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | FUNCTION |
|----|----|------------------|----|----|----|----|----|----|--|
| 0 | 0 | 7-bit f_c data | | | | | | | Selects filter A |
| 0 | 1 | 7-bit f_c data | | | | | | | Selects filter B |
| 1 | 0 | X | X | X | X | X | X | 0 | T/H OUT disabled |
| 1 | 0 | X | X | X | X | X | X | 1 | T/H OUT enabled |
| 1 | 0 | X | X | X | X | X | 0 | X | Selects OUTB as input to T/H |
| 1 | 0 | X | X | X | X | X | 1 | X | Selects OUTA as input to T/H |
| 1 | 1 | X | X | X | X | X | X | 0 | Filter shutdown mode. All outputs floated, 15 μ A max supply current |
| 1 | 1 | X | X | X | X | X | X | 1 | Removes filter from shutdown mode |

X = Don't care

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Digital Threshold Levels

All digital inputs are TTL and CMOS compatible, unless otherwise stated. Inputs are CMOS gates with less than 1 μ A leakage current and 8pF capacitance loading. Typical logic voltage thresholds are a function of the V+ supply voltage as shown below (voltages are referenced to GND).

| V+ (V) | LOGIC THRESHOLD VOLTAGE (V) |
|--------|-----------------------------|
| 8 | +2.4 |
| 7 | +2.3 |
| 6 | +2.0 |
| 5 | +1.75 |
| 4 | +1.5 |
| 2.5 | +1.0 |

NOTE: For +5V single-supply operation, where incoming logic signals are referenced to V-, typical logic thresholds are +3.5V. Therefore, a CMOS (rail-to-rail) logic interface is recommended.

Filter Performance

All MAX270/MAX271 internal amplifier and output stages for filter sections, uncommitted op amp, and T/H are identical. The outputs are designed to drive 5k Ω in parallel with a maximum capacitance of 100pF. At higher load levels, the output swing becomes asymmetric. All outputs can be short circuited to GND for an indefinite duration.

The MAX270/MAX271 operating frequency range is limited to approximately 2MHz by the bandwidth of the internal amplifiers.

Filter Noise

Wideband filter noise over a 50kHz bandwidth is 12 μ V_{RMS} and 38 μ V_{RMS} per section for f_C programmed to 1kHz and 25kHz, respectively. A dynamic range of over 96dB results.

Filter Input Impedance

At DC, the input impedance at INA and INB is equal to the DC input impedance of the amplifier, which is about 5M Ω . At higher frequencies, internal capacitors contribute to an effective input impedance that may fall as low as 100k Ω at 25kHz.

MAX271 Track-and-Hold

The MAX271 T/H is functionally equivalent to a switched 200pF capacitor buffered by a unity-gain amplifier (Figures 1b, 1c). When the T/H pin is driven low, the output of filter A or filter B (whichever is selected via control interface) internally connects to the amplifier, and T/H OUT follows the filter output. The offset at T/H OUT (\pm 6mV max) is the combined offset of the filter amplifier and the T/H buffer. When T/H is pulled high, the switch disconnects the filter signal from the T/H. The T/H capacitor holds the stored charge, and that voltage is buffered at T/H OUT.

A low level at T/HEN floats T/H OUT, enabling multiplexed operation (Figure 3). T/H A/B selects between OUTA and OUTB as the T/H input. In μ P mode, the T/H EN and T/H OUT functions are controlled by writing control bits to program memory, with T/H EN and T/H OUT pins disabled.

See Typical Operating Characteristics graphs for T/H dynamic accuracy.

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Applications Information

Power-Supply Configurations

MAX270/MAX271 power supplies must be properly bypassed. Best performance is achieved if V+ and V- are bypassed to GND with 4.7μF electrolytic (tantalum is preferred) and 0.1μF ceramic capacitors in parallel. These should be as close as possible to the chip supply pins.

Single supplies in the range of 4.75V to 16V may be used to power the MAX270/MAX271 as shown in Figure 4. Digital logic may be referenced to V- (system ground), but will not maintain TTL compatibility. CMOS (rail-to-rail) logic is recommended. For μP-mode operation with a single supply, the MAX270 A0 pin must be configured with a voltage divider (Figure 4).

Lowest quiescent current in shutdown mode is achieved when A0 is either at V+ or V-.

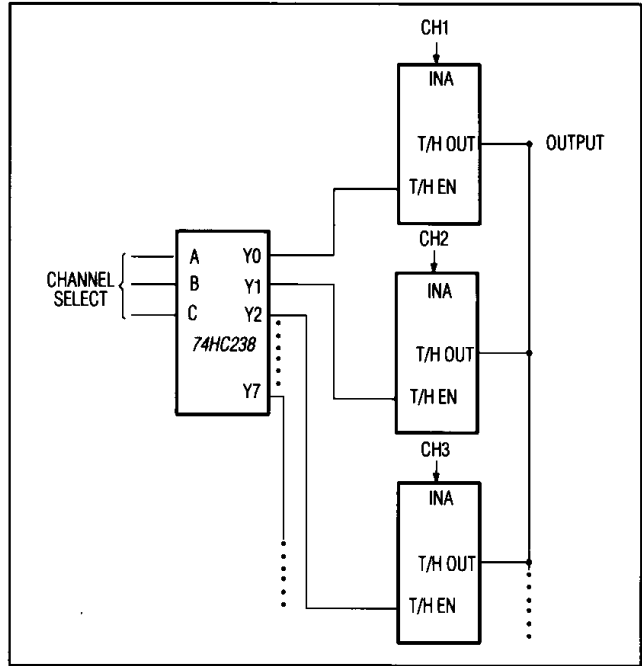


Figure 3. MAX271 Multiplexed Operation

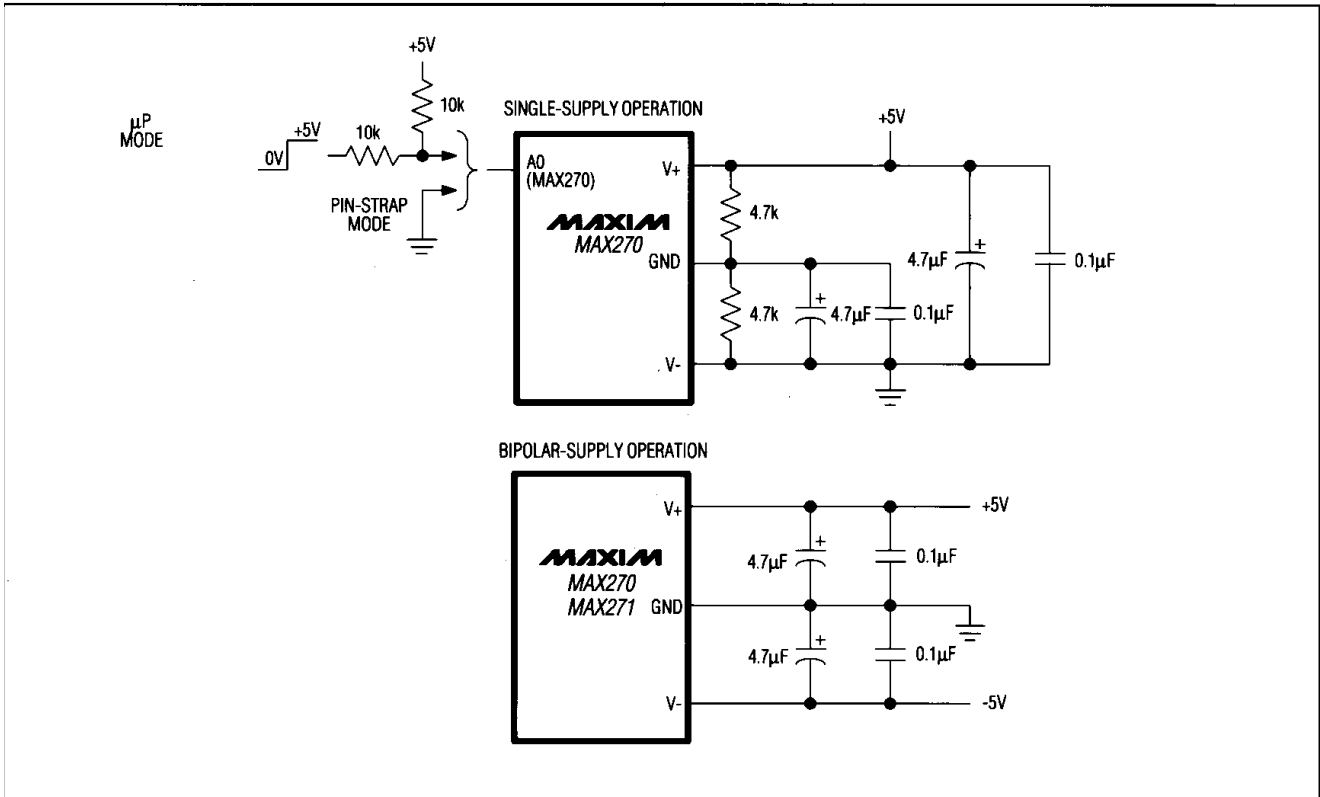


Figure 4. Power-Supply Configurations

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Independent f_c Programming Without a μP

Figure 6 shows how filter sections A and B may be programmed to different cutoff frequencies without the use of a μP . The MAX690 μP supervisory circuit provides the proper programming sequence when the circuit is powered up by controlling the 74HC373 data buffer and the MAX270 addressing pin to load independent f_c data for filters A and B.

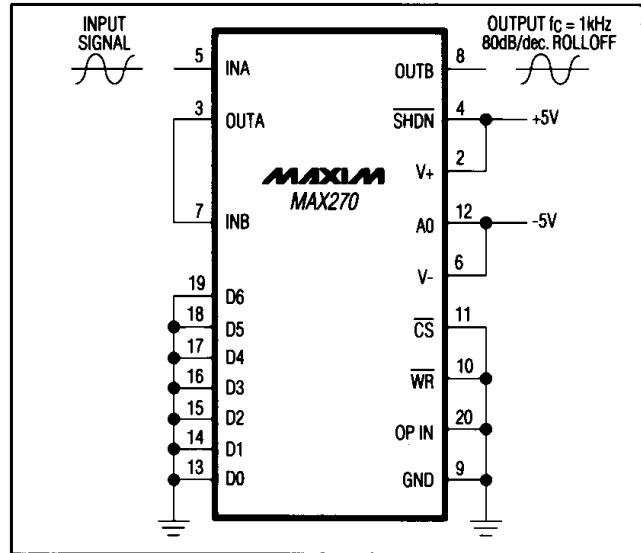


Figure 5. Cascading Filter Sections

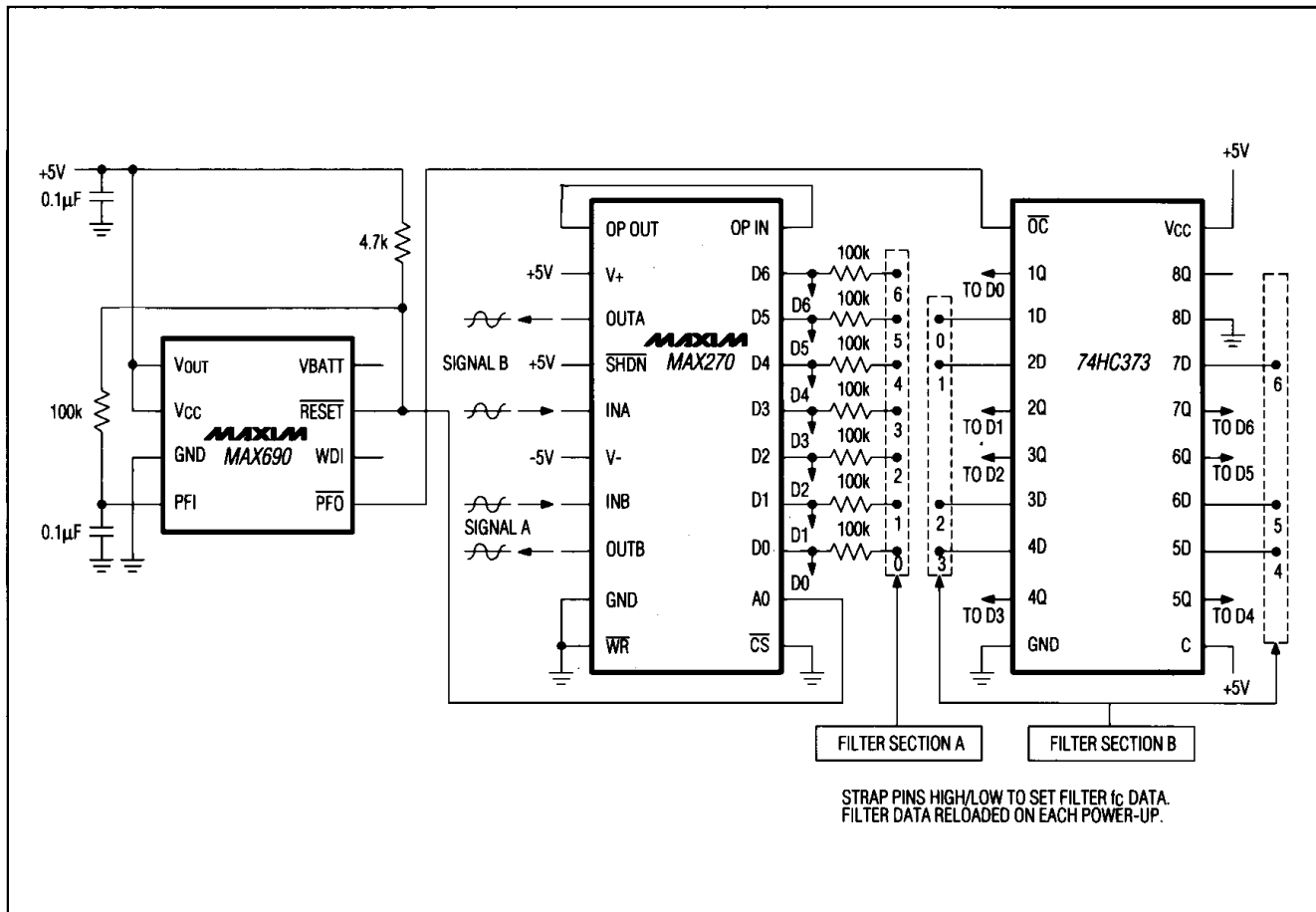
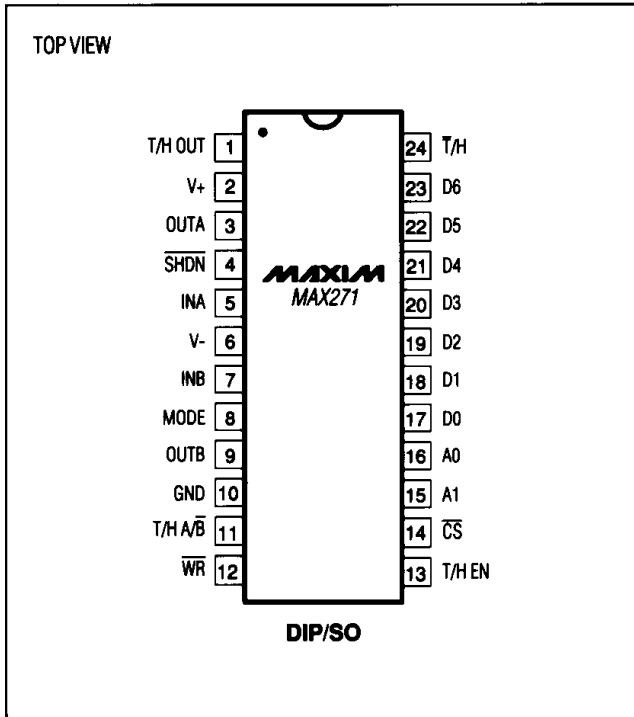


Figure 6. Independent f_c Programming Without a μP

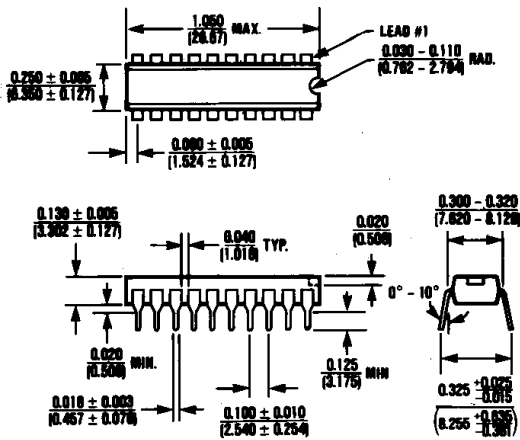
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Pin Configurations (continued)

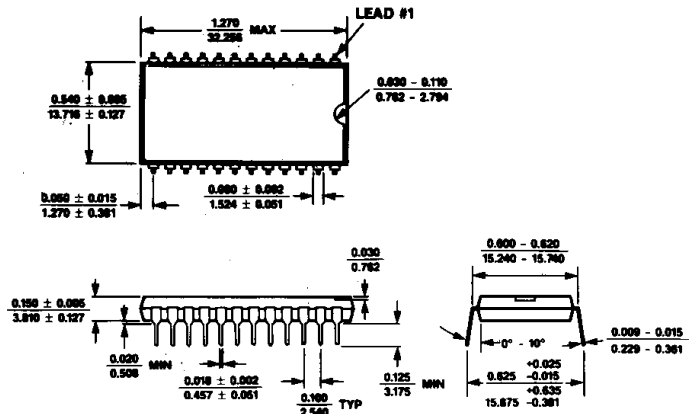


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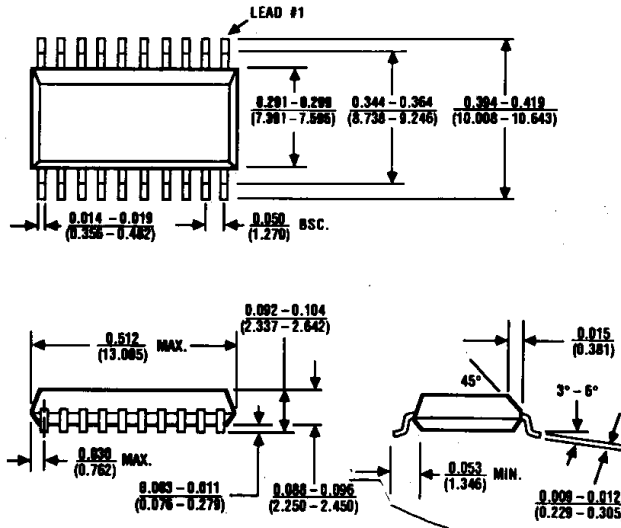
20 Lead Plastic DIP

$\theta_{JA} = 125^{\circ}\text{C/W}$
 $\theta_{JC} = 60^{\circ}\text{C/W}$



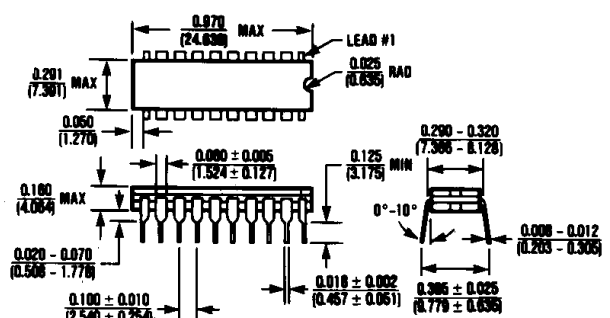
24 Lead Plastic DIP

$\theta_{JA} = 110^{\circ}\text{C/W}$
 $\theta_{JC} = 50^{\circ}\text{C/W}$



20 Lead Small Outline, Wide

$\theta_{JA} = 100^{\circ}\text{C/W}$
 $\theta_{JC} = 50^{\circ}\text{C/W}$



20 Lead Cerdip

$\theta_{JA} = 90^{\circ}\text{C/W}$
 $\theta_{JC} = 40^{\circ}\text{C/W}$

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