



Gain of 1 Fully Differential Input/Output Amplifier/Driver

July 2003

FEATURES

- Differential Inputs
- Differential Outputs
- Fixed Gain of $1 \pm 0.3\%$ (Max) Gain Error from -40°C to 85°C
- C_{LOAD} Stable from 0pF to 10,000pF
- Adjustable Output Common Mode Voltage
- Output Common Mode Level Independent of Input Common Mode Level
- Low Supply Current 1mA (Max)
- High Output Current 10mA (Min)
- Rail-to-Rail Output Swing
- Specified on a Single 2.7V to $\pm 5\text{V}$ Supply
- DC Offset Voltage $< 2.5\text{mV}$ (Max)
- 8-Lead MSOP Package

APPLICATIONS

- Differential Driver/Receiver
- Differential Amplification
- Single-Ended to Differential Conversion
- Level Shifting

DESCRIPTION

The LTC[®]1992-1 is a fully differential amplifier with a fixed gain of 1. The LTC1992-1 has a separate internal common mode feedback path for better common mode noise rejection, outstanding output gain and phase balancing and reduced second order harmonics. The V_{OCM} pin sets the output common mode level independent of the input common mode level. This feature makes level shifting of signals easy. The integrated precision gain setting resistors ensure gain accuracy without external components.

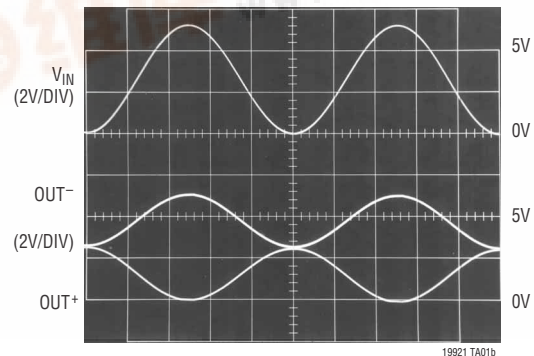
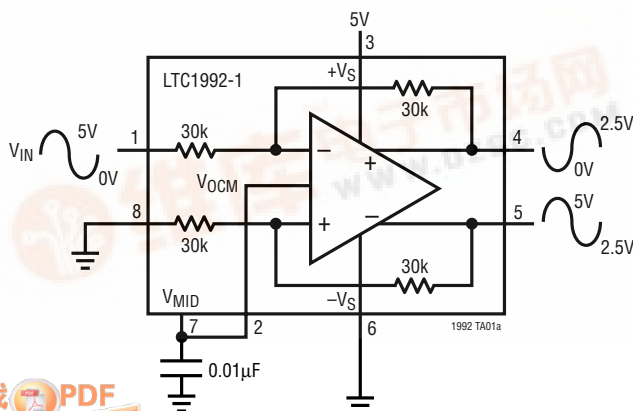
The differential inputs operate with signals ranging from rail-to-rail with a common mode level from the negative supply up to 1.3V from the positive supply. The differential input DC offset is typically $250\mu\text{V}$. The rail-to-rail outputs sink and source 10mA. The LTC1992-1 is stable for all capacitive loads up to 10,000pF.

The LTC1992-1 can be used in single-supply applications with supply voltages as low as 2.7V. It can also be used with dual supplies up to $\pm 5\text{V}$. The LTC1992-1 is available in an 8-pin MSOP package.

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TYPICAL APPLICATION

Single-Supply Single-Ended to Differential Conversion



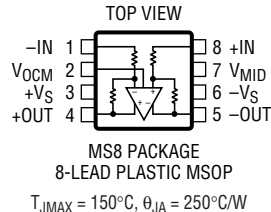
LTC1992-1

ABSOLUTE MAXIMUM RATINGS

(Note 1)

| | |
|--|---|
| Total Supply Voltage (+V _S to -V _S) | 12V |
| Maximum Voltage on any Pin | $(-V_S - 0.3V) \leq V_{PIN} \leq (+V_S + 0.3V)$ |
| Output Short-Circuit Duration (Note 3) | Indefinite |
| Operating Temperature Range (Note 5) | |
| LTC1992-1CMS8 | -40°C to 85°C |
| LTC1992-1IMS8 | -40°C to 85°C |
| LTC1992-1HMS8 | -40°C to 125°C |
| Specified Temperature Range (Note 6) | |
| LTC1992-1CMS8 | -40°C to 85°C |
| LTC1992-1IMS8 | -40°C to 85°C |
| LTC1992-1HMS8 | -40°C to 125°C |
| Storage Temperature Range | -65°C to 150°C |
| Lead Temperature (Soldering, 10 sec) | 300°C |

PACKAGE/ORDER INFORMATION

| | |
|--|---|
|  | ORDER PART NUMBER |
| | LTC1992-1CMS8 LTC1992-1IMS8 LTC1992-1HMS8 |
| | MS8 PART MARKING |
| | LTACJ LTACM LTAZF |

Consult LTC Marketing for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. +V_S = 5V, -V_S = 0V, V_{INCM} = V_{OUTCM} = V_{OCM} = 2.5V, unless otherwise noted. V_{OCM} is the voltage on the V_{OCM} pin. V_{OUTCM} is defined as (V_{+OUT} + V_{-OUT})/2. V_{INCM} is defined as (V_{+IN} + V_{-IN})/2. V_{INDIFF} is defined as (V_{+IN} - V_{-IN}). V_{OUTDIFF} is defined as (V_{+OUT} - V_{-OUT}). Typical values are at T_A = 25°C.

| SYMBOL | PARAMETER | CONDITIONS | | LTC1992-1CMS8 LTC1992-1IMS8 | | | LTC1992-1HMS8 | | | UNITS |
|--------------------------|---|-----------------------------------|---|--------------------------------|---------------|------|---------------|---------------|-------|--------|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| G _{DIFF} | Differential Gain | | ● | | 1 | | | 1 | | V/V |
| | Differential Gain Error | | ● | | ±0.1 | ±0.3 | | ±0.1 | ±0.35 | % |
| | Differential Gain Nonlinearity | | ● | | 50 | | | 50 | | ppm |
| | Differential Gain Temperature Coefficient | | ● | | 35 | | | 35 | | ppm/°C |
| V _{OSDIFF} | Differential Offset Voltage (Amplifier Input Referred)(Note 7) | V _S = 2.7V | ● | | ±0.25 | ±2.5 | | ±0.25 | ±4 | mV |
| | | V _S = 5V | ● | | ±0.25 | ±2.5 | | ±0.25 | ±4 | mV |
| | | V _S = ±5V | ● | | ±0.25 | ±2.5 | | ±0.25 | ±4 | mV |
| ΔV _{OSDIFF} /ΔT | Differential Offset Voltage Drift (Amplifier Input Referred)(Note 7) | V _S = 2.7V | ● | | 10 | | | 10 | | μV/°C |
| | | V _S = 5V | ● | | 10 | | | 10 | | μV/°C |
| | | V _S = ±5V | ● | | 10 | | | 10 | | μV/°C |
| e _n | Input Referred Noise Voltage Density | f = 1kHz | | | 45 | | | 45 | | nV/√Hz |
| R _{IN} | Input Resistance, Single-Ended +IN, -IN Pins | | ● | 22.5 | 30 | 37.5 | 22 | 30 | 38 | kΩ |
| V _{INCMR} | Input Signal Common Mode Range | V _S = 5V | | | -0.1V to 4.9V | | | -0.1V to 4.9V | | V |
| CMRR | Common Mode Rejection Ratio (Amplifier Input Referred)(Note 7) | V _{INCM} = -0.1V to 3.7V | ● | 55 | 60 | | 55 | 60 | | dB |
| PSRR | Power Supply Rejection Ratio (Amplifier Input Referred)(Note 7) | V _S = 2.7V to ±5V | ● | 75 | 80 | | 72 | 80 | | dB |
| G _{CM} | Common Mode Gain(V _{OUTCM} /V _{OCM}) Common Mode Gain Error Output Balance Error(ΔV _{OUTCM} /V _{OUTDIFF}) | | ● | | 1 | | | 1 | | % |
| | | | ● | | ±0.1 | ±0.3 | | ±0.1 | ±0.35 | % |
| | | V _{OUTDIFF} = -2V to +2V | ● | | -85 | -60 | | -85 | -60 | dB |
| V _{OSCM} | Common Mode Offset Voltage (V _{OUTCM} - V _{OCM}) | V _S = 2.7V | ● | | ±0.5 | ±12 | | ±0.5 | ±15 | mV |
| | | V _S = 5V | ● | | ±1 | ±15 | | ±1 | ±17 | mV |
| | | V _S = ±5V | ● | | ±2 | ±18 | | ±2 | ±20 | mV |
| ΔV _{OSCM} /ΔT | Common Mode Offset Voltage Drift | V _S = 2.7V | ● | | 10 | | | 10 | | μV/°C |
| | | V _S = 5V | ● | | 10 | | | 10 | | μV/°C |
| | | V _S = ±5V | ● | | 10 | | | 10 | | μV/°C |

ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $+V_S = 5\text{V}$, $-V_S = 0\text{V}$, $V_{\text{INCM}} = V_{\text{OUTCM}} = V_{\text{OCM}} = 2.5\text{V}$, unless otherwise noted. V_{OCM} is the voltage on the V_{OCM} pin. V_{OUTCM} is defined as $(V_{+\text{OUT}} + V_{-\text{OUT}})/2$. V_{INCM} is defined as $(V_{+\text{IN}} + V_{-\text{IN}})/2$. V_{INDIFF} is defined as $(V_{+\text{IN}} - V_{-\text{IN}})$. V_{OUTDIFF} is defined as $(V_{+\text{OUT}} - V_{-\text{OUT}})$. Typical values are at $T_A = 25^\circ\text{C}$.

| SYMBOL | PARAMETER | CONDITIONS | LTC1992-1CMS8 LTC1992-1IMS8 | | | LTC1992-1HMS8 | | | UNITS |
|---------------------|---|---|--------------------------------|------------------------|-------|------------------------|------------------------|-------|------------------|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_{OUTCMR} | Output Signal Common Mode Range (Voltage Range for the V_{OCM} Pin) | | ● $(-V_S) + 0.5\text{V}$ | $(+V_S) - 1.3\text{V}$ | | $(-V_S) + 0.5\text{V}$ | $(+V_S) - 1.3\text{V}$ | | V |
| R_{INVOCM} | Input Resistance, V_{OCM} Pin | | | 500 | | | 500 | | M Ω |
| I_{BVOCM} | Input Bias Current, V_{OCM} Pin | $V_S = 2.7\text{V}$ to $\pm 5\text{V}$ | | 2 | | | 2 | | pA |
| V_{MID} | Voltage at the V_{MID} Pin | | ● 2.44 | 2.50 | 2.56 | 2.43 | 2.50 | 2.57 | V |
| V_{OUT} | Output Voltage, High (Note 2) | $V_S = 2.7\text{V}$, Load = 10k, 10nF | ● 2.60 | 2.69 | | 2.60 | 2.69 | | V |
| | | $V_S = 2.7\text{V}$, Load = 5mA | ● 2.50 | 2.61 | | 2.50 | 2.61 | | V |
| | | $V_S = 2.7\text{V}$, Load = 10mA | ● 2.29 | 2.52 | | 2.29 | 2.52 | | V |
| | Output Voltage, Low (Note 2) | $V_S = 2.7\text{V}$, Load = 10k, 10nF | ● | 0.02 | 0.10 | | 0.02 | 0.10 | V |
| | | $V_S = 2.7\text{V}$, Load = 5mA | ● | 0.10 | 0.25 | | 0.10 | 0.25 | V |
| | | $V_S = 2.7\text{V}$, Load = 10mA | ● | 0.20 | 0.35 | | 0.20 | 0.41 | V |
| | Output Voltage, High (Note 2) | $V_S = 5\text{V}$, Load = 10k, 10nF | ● 4.90 | 4.99 | | 4.90 | 4.99 | | V |
| | | $V_S = 5\text{V}$, Load = 5mA | ● 4.85 | 4.90 | | 4.80 | 4.90 | | V |
| | | $V_S = 5\text{V}$, Load = 10mA | ● 4.75 | 4.81 | | 4.70 | 4.81 | | V |
| | Output Voltage, Low (Note 2) | $V_S = 5\text{V}$, Load = 10k, 10nF | ● | 0.02 | 0.10 | | 0.02 | 0.10 | V |
| | | $V_S = 5\text{V}$, Load = 5mA | ● | 0.10 | 0.25 | | 0.10 | 0.30 | V |
| | | $V_S = 5\text{V}$, Load = 10mA | ● | 0.20 | 0.35 | | 0.20 | 0.42 | V |
| | Output Voltage, High (Note 2) | $V_S = \pm 5\text{V}$, Load = 10k, 10nF | ● 4.90 | 4.99 | | 4.85 | 4.99 | | V |
| | | $V_S = \pm 5\text{V}$, Load = 5mA | ● 4.85 | 4.89 | | 4.80 | 4.89 | | V |
| | | $V_S = \pm 5\text{V}$, Load = 10mA | ● 4.65 | 4.80 | | 4.60 | 4.80 | | V |
| | Output Voltage, Low (Note 2) | $V_S = \pm 5\text{V}$, Load = 10k, 10nF | ● | -4.98 | -4.90 | | 4.98 | -4.85 | V |
| | | $V_S = \pm 5\text{V}$, Load = 5mA | ● | -4.90 | -4.75 | | 4.90 | -4.75 | V |
| | | $V_S = \pm 5\text{V}$, Load = 10mA | ● | -4.80 | -4.65 | | 4.80 | -4.55 | V |
| I_{SC} | Output Short-Circuit Current Sourcing (Notes 2,3) | $V_S = 2.7\text{V}$, $V_{\text{OUT}} = 1.35\text{V}$ | ● 20 | 30 | | 20 | 30 | | mA |
| | | $V_S = 5\text{V}$, $V_{\text{OUT}} = 2.5\text{V}$ | ● 20 | 30 | | 20 | 30 | | mA |
| | | $V_S = \pm 5\text{V}$, $V_{\text{OUT}} = 0\text{V}$ | ● 20 | 30 | | 20 | 30 | | mA |
| | Output Short-Circuit Current Sinking (Notes 2,3) | $V_S = 2.7\text{V}$, $V_{\text{OUT}} = 1.35\text{V}$ | ● 13 | 30 | | 13 | 30 | | mA |
| | | $V_S = 5\text{V}$, $V_{\text{OUT}} = 2.5\text{V}$ | ● 13 | 30 | | 13 | 30 | | mA |
| | | $V_S = \pm 5\text{V}$, $V_{\text{OUT}} = 0\text{V}$ | ● 13 | 30 | | 13 | 30 | | mA |
| SR | Slew Rate (Note 4) | | ● 0.25 | 0.75 | | 0.25 | 0.75 | | V/ μs |
| GBW | Gain-Bandwidth Product | $f_{\text{TEST}} = 180\text{kHz}$ | | 3 | | | 3 | | MHz |
| V_S | Supply Voltage Range | | ● 2.7 | | 11 | 2.7 | | 11 | V |
| I_S | Supply Current | $V_S = 2.7\text{V}$ to 5V | ● | 0.65 | 1.0 | | 0.65 | 1 | mA |
| | | | ● | 0.75 | 1.2 | | 0.8 | 1.5 | mA |
| | | $V_S = \pm 5\text{V}$ | ● | 0.70 | 1.2 | | 0.7 | 1.2 | mA |
| | | | ● | 0.80 | 1.5 | | 0.9 | 1.8 | mA |

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: Output load is connected to the midpoint of the $+V_S$ and $-V_S$ potentials. Measurement is taken single-ended, one output loaded at a time.

Note 3: A heat sink may be required to keep the junction temperature below the absolute maximum when the output is shorted indefinitely.

Note 4: Slew Rate is measured single-ended. The numbers listed are also single-ended and the differential slew rate would double the listed numbers.

Note 5: The LTC1992-1CMS8, LTC1992-1IMS8 and LTC1992-1HMS8 are guaranteed functional over the extended operating temperature range of -40°C to 125°C .

Note 6: The LTC1992-1CMS8 is guaranteed to meet the specified performance limits over the 0°C to 70°C temperature range and is designed, characterized and expected to meet the specified performance from -40°C to 85°C but is not tested or QA sampled at these temperatures. LTC1992-1IMS8 is guaranteed to meet specified performance limits over the -40°C to 85°C temperature range. The LTC1992-1HMS8 is guaranteed to meet the specified performance limits over the -40°C to 125°C temperature range.

Note 7: Differential Offset Voltage, Differential Offset Voltage Drift, CMRR and PSRR are referred to the internal amplifier's input to allow for direct comparison with discrete amplifiers. The LTC1992-1 is an inverting topology with a gain of one. The output referred offset is two times the amplifiers input offset.

PIN FUNCTIONS

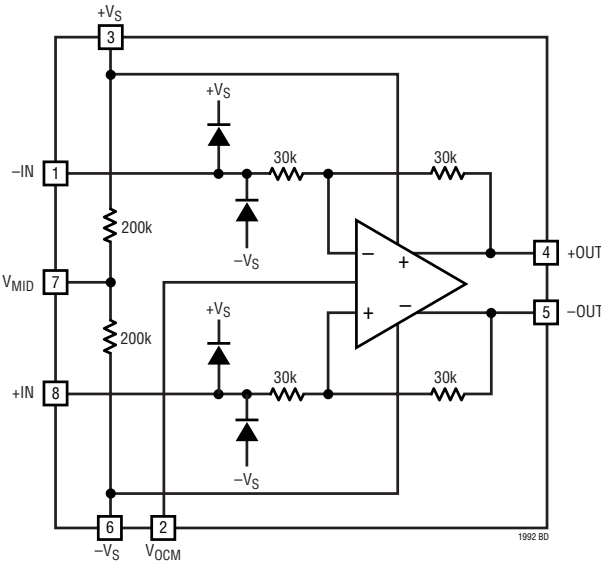
- IN, +IN (Pins 1, 8):** Inverting and Noninverting Inputs of the Amplifier. These pins are connected to on-chip gain setting resistors. The input resistors are nominally 30k.

V_{OCM} (Pin 2): Output Common Mode Voltage Set Pin. The voltage on this pin sets the output signal's common voltage level. The output common mode level is set independent of the input common mode level. This is a high impedance input and must be connected to a known and controlled voltage. It must never be left floating.

+V_S, –V_S (Pins 3, 6): The +V_S and –V_S power supply pins should be bypassed with 0.1μF capacitors to an adequate analog ground or ground plane. The bypass capacitors should be located as closely as possible to the supply pins.
- +OUT, –OUT (Pins 4, 5):** The Positive and Negative Outputs of the Amplifier. These rail-to-rail outputs are designed to drive capacitive loads up to 10,000pF.

V_{MID} (Pin 7): Mid-Supply Reference. This pin is connected to an on-chip resistive voltage divider (two 200k ±25% resistors) to provide a mid-supply reference. This provides a convenient way to set the output common mode voltage level at half-supply. If used for this purpose, the pin should be bypassed with a 0.1μF capacitor to ground and connected to V_{OCM} (Pin 2). If this reference voltage is not used, leave the pin floating.

BLOCK DIAGRAM



RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|-------------|---|--|
| LTC1565-31 | 650kHz Continuous Time, Linear Phase Lowpass Filter | 7th Order Lowpass Filter, Differential Inputs/Output |
| LTC1566-1 | Low Noise 2.3MHz Continuous Time Lowpass Filter | 7th Order Lowpass Filter, Differential Inputs/Output |
| LTC1992 | Fully Differential Input/Output Amplifier/Driver | Low Power, Adjustable Gain |
| LTC1992-2 | Fully Differential Input/Output Amplifier/Driver | Gain = 2 |
| LT6600-10 | Very Low Noise, Differential Amplifier and 10MHz Lowpass Filter | Fully Differential Amplifier with 4th Order Lowpass Filter |
| LT6600-20 | Very Low Noise, Differential Amplifier and 20MHz Lowpass Filter | Fully Differential Amplifier with 4th Order Lowpass Filter |