

# Precision, Extended Input Range Current Sense Amplifier

## DESCRIPTION

The **RH6105MW** is a micropower, precision current sense amplifier with a very wide input common mode range. The RH6105MW monitors unidirectional current via the voltage across an external sense resistor. The input common mode range extends from  $-0.3\text{V}$  to  $44\text{V}$ , with respect to the negative supply voltage ( $V^-$ ). This allows the RH6105MW to operate as a high side current sense monitor or a low side current sense monitor. It also allows the RH6105MW to monitor current on a negative supply voltage, as well as continuously monitor a battery from full charge to depletion. The inputs of the RH6105MW can withstand differential voltages up to  $\pm 44\text{V}$ , which makes it ideal for monitoring a fuse or MOSFET switch.

Gain is configured with external resistors from  $1\text{V/V}$  to  $100\text{V/V}$ . The input common mode rejection and power supply rejection are in excess of  $100\text{dB}$  and the input offset voltage is less than  $565\mu\text{V}$ . A typical slew rate of  $2\text{V}/\mu\text{s}$  ensures fast response to unexpected current changes.

The RH6105MW can operate from an independent power supply of  $2.85\text{V}$  to  $36\text{V}$  and draws only  $150\mu\text{A}$ . When  $V^+$  is powered down, the sense pins are biased off. This prevents loading of the monitored circuit, irrespective of the sense voltage. The RH6105MW is available in a 10-lead bottom brazed flat pack.

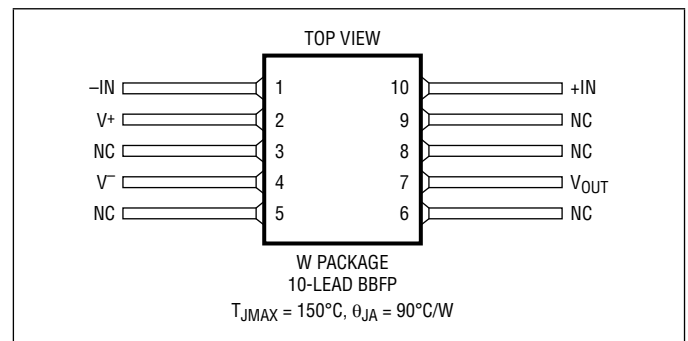
## ABSOLUTE MAXIMUM RATINGS

(Notes 1, 2)

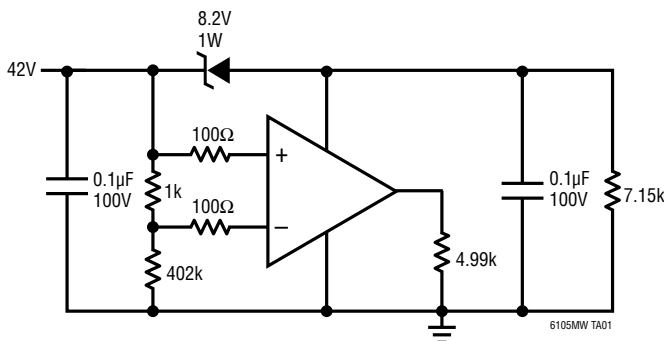
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|--|--|
| Differential Input Voltage (+IN to -IN)            | $\pm 44\text{V}$                           |
| Input Voltage $V(+\text{IN}, -\text{IN})$ to $V^-$ | $-9.5\text{V}$ to $44\text{V}$             |
| Total $V^+$ Supply Voltage from $V^-$              | $36\text{V}$                               |
| Output Voltage                                     | $V^-$ to $(V^+ + 36\text{V})$              |
| Output Short-Circuit Duration (Note 3)             | Indefinite                                 |
| Operating Temperature Range                        | $-55^\circ\text{C}$ to $125^\circ\text{C}$ |
| Maximum Junction Temperature                       | $150^\circ\text{C}$                        |
| Storage Temperature Range                          | $-65^\circ\text{C}$ to $150^\circ\text{C}$ |
| Lead Temperature (Soldering, 10 sec)               | $300^\circ\text{C}$                        |

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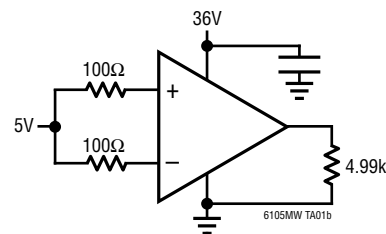
## PACKAGE INFORMATION



## BURN-IN CIRCUIT



## TOTAL DOSE CIRCUIT



## ELECTRICAL CHARACTERISTICS (Pre-Irradiation) $V^+ = 12V$ , $V^- = 0V$ , $V_{S^+} = 12$ , $R_{IN1} = R_{IN2} = 100\Omega$ , $R_{OUT} = 5k$ ( $A_V = 50$ ), $V_{SENSE} = V_{S^+}$ to $V_{S^-}$ , unless otherwise specified. (Note 5)

| SYMBOL                    | PARAMETER                                  | CONDITIONS  | NOTES | $T_A = 25^\circ C$ |      |       | SUB-GROUP | $-55^\circ C \leq T_A \leq 125^\circ C$ |     |       | SUB-GROUP | UNITS            |
|---------------------------|--|---|-------|--------------------|------|-------|-----------|---|-----|-------|-----------|------------------|
|                           |  |   |       | MIN                | TYP  | MAX   |           | MIN                                     | TYP | MAX   |           |                  |
| $V_{S^+}$ , $V_{S^-}$     | Input Voltage Range                        | Guaranteed by CMRR  |       | -0.1               |      | 44    |           | -0.1                                    |     | 44    |           | V                |
| $A_V$ Error               | Voltage Gain Error                         | $V_{SENSE} = 25mV$ to $75mV$ , $V_{S^+} = 12V$                      | 5     | -1                 | -0.1 | 1     |           | -1.5                                    |     | 1.5   |           | %                |
|                           |  | $V_{SENSE} = 25mV$ to $75mV$ , $V_{S^+} = 0V$                       | 5     | -4.25              |      | 2.25  |           | -4.25                                   |     | 2.25  |           | %                |
| $V_{OS}$                  | Input Offset Voltage                       | $V_{SENSE} = 5mV$   |       | -0.565             |      | 0.565 |           | -0.990                                  |     | 0.990 |           | mV               |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = 0V$                                  |       | -1.0               |      | 1.0   |           | -2.3                                    |     | 2.3   |           | mV               |
| $\Delta V_{OS}/\Delta T$  | Temperature Coefficient of $V_{OS}$        |   |       |                    |      |       |           | 1.0                                     |     |       |           | $\mu V/^\circ C$ |
| CMRR                      | Input Common Mode Rejection Ratio          | $V_{SENSE} = 5mV$ , $V_{S^+} = 2.8V$ to $44V$                       |       | 100                |      | 120   |           | 97                                      |     |       |           | dB               |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = -0.1V$ to $44V$                      |       | 85                 |      |       |           | 75                                      |     |       |           | dB               |
| $V^+$                     | Power Supply Voltage Range                 | Guaranteed by PSRR  |       |                    |      |       |           | 2.85                                    |     | 36    |           | V                |
| PSRR                      | Power Supply Rejection Ratio               | $V_{SENSE} = 5mV$ , $V_{S^+} = 12V$ , $V^+ = 2.85V$ to $36V$        |       | 98                 |      | 120   |           | 94                                      |     |       |           | dB               |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = 0V$ , $V^+ = 2.85V$ to $36V$         |       | 85                 |      | 93    |           | 85                                      |     |       |           | dB               |
| $I_{(+IN)}$ , $I_{(-IN)}$ | Input Current                              | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$                                   |       |                    | 14.1 | 20    |           |   |     | 30    |           | $\mu A$          |
| $I_{(+IN)} - I_{(-IN)}$   | Input Offset Current                       | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$                                   |       |                    |      | 0.350 |           |   |     | 3.33  |           | $\mu A$          |
| $I_{(+IN)}$               | Input Current (Power Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       |                    |      | 0.250 |           |   |     | 0.300 |           | $\mu A$          |
| $I_{(-IN)}$               | Input Current (Power Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       |                    |      | 0.250 |           |   |     | 1.550 |           | $\mu A$          |
| $I_{(+IN)} + I_{(-IN)}$   | Input Current (Power-Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       |                    |      | 0.500 |           |   |     | 1.850 |           | $\mu A$          |
| $I_S$                     | $V^+$ Supply Current                       | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$ , $V^+ = 2.85V$                   |       |                    | 154  | 300   |           |   |     | 350   |           | $\mu A$          |
|                           |  | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$ , $V^+ = 36V$                     |       |                    | 185  | 360   |           |   |     | 450   |           | $\mu A$          |
| $V_{O(MIN)}$              | Minimum Output Voltage                     | $V_{SENSE} = 0V$ , $V_{S^+} = 44V$ , $V^+ = 36V$                    |       |                    |      | 25    |           |   |     | 90    |           | mV               |
| $V_{O(MAX)}$              | Output High (Referred to $V^+$ )           | $V_{SENSE} = 120mV$ , $A_V = 100$ , $R_{OUT} = 10k\Omega$           |       |                    |      | 1.285 |           |   |     | 1.7   |           | V                |
| $I_{OUT}$                 | Maximum Output Current                     | Guaranteed by $V_{O(MAX)}$  |       |                    |      |       |           | 1                                       |     |       |           | mA               |
| ISC                       | Short-Circuit Output Current               | $V_{S^+} = 44V$ , $V_{S^-} = 0V$ , $R_{OUT} = 10k\Omega$            |       | 2                  |      |       |           | 1.2                                     |     |       |           | mA               |
| BW                        | -3dB Bandwidth                             | $V_{SENSE} = 500mV$ , $A_V = 10V/V$                                 |       |                    |      | 100   |           |   |     |       |           | kHz              |
| $t_S$                     | Output Settling to 1% of Final Value       | $V_{SENSE} = 5mV$ to $100mV$  |       |                    |      | 5     |           |   |     |       |           | $\mu s$          |
| $t_r$                     | Input Step Response                        | $V_{SENSE} = 5mV$ to $100mV$  | 6     |                    |      | 3     |           |   |     |       |           | $\mu s$          |
| SR                        | Slew Rate                                  | $V_{SENSE} = 5mV$ to $150mV$ , $A_V = 50V/V$ , $R_{IN} = 400\Omega$ | 7     | 2                  |      | 3     |           | 1.5                                     |     |       |           | V/ $\mu s$       |
| $V_{REV}$                 | Reverse Input Voltage (Referred to $V^-$ ) | $I_{(+IN)} + I_{(-IN)} = -5mA$                                      |       |                    | -13  | -12   |           |   |     | -12.5 | -9.5      | V                |

## ELECTRICAL CHARACTERISTICS (Post-Irradiation) $V^+ = 12V$ , $V^- = 0V$ , $V_{S^+} = 12$ , $R_{IN1} = R_{IN2} = 100\Omega$ , $R_{OUT} = 5k$ ( $A_V = 50$ ), $V_{SENSE} = V_{S^+}$ to $V_{S^-}$ , unless otherwise specified. (Note 5)

| SYMBOL                    | PARAMETER                                  | CONDITIONS  | NOTES | 10kRAD (Si) |       | 20kRAD (Si) |       | 50kRAD (Si) |       | 100kRAD (Si) |       | 200kRAD (Si) |       | UNITS      |
|---------------------------|--|---|-------|-------------|-------|-------------|-------|-------------|-------|--------------|-------|--------------|-------|------------|
|                           |  |   |       | MIN         | MAX   | MIN         | MAX   | MIN         | MAX   | MIN          | MAX   | MIN          | MAX   |            |
| $A_V$ Error               | Voltage Gain Error                         | $V_{SENSE} = 25mV$ to $75mV$ , $V_{S^+} = 12V$                      | 5     | -1.28       | 1.28  | -1.46       | 1.46  | -1.97       | 1.97  | -2.3         | 2.3   | -2.9         | 2.9   | %          |
|                           |  | $V_{SENSE} = 25mV$ to $75mV$ , $V_{S^+} = 0V$                       | 5     | -4.47       | 2.47  | -4.48       | 2.48  | -4.85       | 2.85  | -5.47        | 3.47  | -6.1         | 4.1   | %          |
| $V_{OS}$                  | Input Offset Voltage                       | $V_{SENSE} = 5mV$   |       | -0.625      | 0.625 | -0.685      | 0.685 | -1.045      | 1.045 | -1.600       | 1.600 | -4.600       | 4.600 | mV         |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = 0V$                                  |       | -1.4        | 1.4   | -1.9        | 1.9   | -1.9        | 1.9   | -2.2         | 2.2   | -2.5         | 2.5   | mV         |
| CMRR                      | Input Common Mode                          | $V_{SENSE} = 5mV$ , $V_{S^+} = 2.8V$ to $44V$                       |       | 99.3        |       | 99.2        |       | 96.0        |       | 93.0         |       | 90.0         |       | dB         |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = -0.1V$ to $44V$                      |       | 83.7        |       | 82.9        |       | 82.8        |       | 81.8         |       | 78.0         |       | dB         |
| PSRR                      | Power Supply Rejection Ratio               | $V_{SENSE} = 5mV$ , $V_{S^+} = 12V$ , $V^+ = 2.85V$ to $36V$        |       | 95.1        |       | 95.1        |       | 95.1        |       | 93.0         |       | 85.4         |       | dB         |
|                           |  | $V_{SENSE} = 5mV$ , $V_{S^+} = 0V$ , $V^+ = 2.85V$ to $36V$         |       | 84.2        |       | 83.5        |       | 83.5        |       | 83.2         |       | 83.0         |       | dB         |
| $I_{(+IN)}$ , $I_{(-IN)}$ | Input Current                              | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$                                   |       | 21.5        |       | 22.5        |       | 24.5        |       | 28.5         |       | 30.5         |       | $\mu A$    |
| $I_{(+IN)} - I_{(-IN)}$   | Input Offset Current                       | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$                                   |       | 0.39        |       | 0.39        |       | 0.51        |       | 0.51         |       | 0.51         |       | $\mu A$    |
| $I_{(+IN)}$               | Input Current (Power Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       | 270         |       | 270         |       | 270         |       | 270          |       | 270          |       | nA         |
| $I_{(-IN)}$               | Input Current (Power Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       | 0.46        |       | 0.46        |       | 3.81        |       | 4.95         |       | 5.00         |       | $\mu A$    |
| $I_{(+IN)} + I_{(-IN)}$   | Input Current (Power-Down)                 | $V^+ = 0V$ , $V_{S^+} = 44V$ , $V_{SENSE} = 0V$                     |       | 0.73        |       | 0.73        |       | 4.08        |       | 5.22         |       | 5.27         |       | $\mu A$    |
| IS                        | $V^+$ Supply Current                       | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$ , $V^+ = 2.85V$                   |       | 306         |       | 315         |       | 330         |       | 360          |       | 400          |       | $\mu A$    |
|                           |  | $V_{SENSE} = 0V$ , $V_{S^+} = 3V$ , $V^+ = 36V$                     |       | 370         |       | 370         |       | 375         |       | 380          |       | 420          |       | $\mu A$    |
| $V_{O(MIN)}$              | Minimum Output Voltage                     | $V_{SENSE} = 0V$ , $V_{S^+} = 44V$ , $V^+ = 36V$                    |       | 26          |       | 28          |       | 35          |       | 36           |       | 38           |       | mV         |
| $V_{O(MAX)}$              | Output High (Referred to $V^+$ )           | $V_{SENSE} = 120mV$ , $A_V = 100$ , $R_{OUT} = 10k\Omega$           |       | 1.31        |       | 1.34        |       | 1.37        |       | 1.47         |       | 2.3          |       | V          |
| $I_{SC}$                  | Short-Circuit Output Current               | $V_{S^+} = 44V$ , $V_{S^-} = 0V$ , $R_{OUT} = 10k\Omega$            |       | 1.67        |       | 1.38        |       | 0.72        |       | 0.65         |       | 0.25         |       | mA         |
| SR                        | Slew Rate                                  | $V_{SENSE} = 5mV$ to $150mV$ , $A_V = 50V/V$ , $R_{IN} = 400\Omega$ | 7     | 1.65        |       | 1.45        |       | 0.81        |       | 0.5          |       | 0.25         |       | V/ $\mu s$ |
| $V_{REV}$                 | Reverse Input Voltage (Referred to $V^-$ ) | $I_{(+IN)} + I_{(-IN)} = -5mA$                                      |       | -11.8       |       | -11.7       |       | -11.0       |       | -10.0        |       | -9.5         |       | V          |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Note 2:** ESD (Electrostatic Discharge) sensitive devices. Extensive use of ESD protection devices are used internal to the RH6105MW, however, high electrostatic discharge can damage or degrade the device. Use proper ESD handling precautions.

**Note 3:** A heat sink may be required to keep the junction temperature below absolute maximum ratings.

**Note 4:** The RH6105MW is guaranteed to meet specified performance from  $-55^\circ C$  to  $125^\circ C$ .

**Note 5:** 0.01% tolerance external resistors are used.

**Note 6:**  $t_r$  is measured from the input to the 2.5V point on the 5V output.

**Note 7:** Slew rate is measured on the output between 1V and 5V.

**ELECTRICAL CHARACTERISTICS: BURN-IN DELTA PARAMETERS**Specifications are at  $T_A = 25^\circ\text{C}$ .

| SYMBOL          | PARAMETER            | CONDITIONS   | END POINT LIMITS |     | DELTA LIMITS |      | UNITS         |
|-----------------|----------------------|--|------------------|-----|--------------|------|---------------|
|                 |                      |  | MIN              | MAX | MIN          | MAX  |               |
| $A_V$ Error     | Voltage Gain Error   | $V_{\text{SENSE}} = 25\text{mV to } 75\text{mV}, V_{S^+} = 12\text{V}$ | -1               | 1   | -0.15        | 0.15 | %             |
| $V_{\text{OS}}$ | Input Offset Voltage | $V_{\text{SENSE}} = 5\text{mV}$  | -565             | 565 | -150         | 150  | $\mu\text{V}$ |
| $I_S$           | $V^+$ Supply Current | $V_{\text{SENSE}} = 0\text{mV}, V_{S^+} = 3\text{V}, V_T = 36\text{V}$ |                  | 360 | -8           | 8    | $\mu\text{A}$ |

**ELECTRICAL TEST REQUIREMENTS** Processed to MIL-PRF-38535 QMLV screening except as noted below.

| MIL-PRF-38535 TEST REQUIREMENTS         | SUBGROUPS (IN ACCORDANCE WITH MIL-PRF-38535 TABLE III) |
|---|--|
| Interim Electrical Parameters           | 1  |
| Final Electrical Parameters             | 1, 2, 3*   |
| Group A Test Requirements               | 1, 2, 3  |
| Group C End-Point Electrical Parameters | 1, 2, 3  |
| Group D End-Point Electrical Parameters | 1  |
| Group E End-Point Electrical Parameters | 1**  |

\*PDA applies to Subgroup 1 only along with any delta failures.

\*\*Dry ice is used based on location of test vs radiation source.