12MHz, High Input Impedance Operational Amplifiers

HA-2600/2605 are internally compensated bipolar operational amplifiers that feature very high input impedance (500MΩ, HA-2600) coupled with wideband AC performance. The high resistance of the input stage is complemented by low offset voltage (0.5mV, HA-2600) and low bias and offset current (1nA, HA-2600) to facilitate accurate signal processing. Input offset can be reduced further by means of an external nulling potentiometer. 12MHz unity gain-bandwidth, 7V/μs slew rate and 150kV/V open-loop gain enables HA-2600/2605 to perform high-gain amplification of fast, wideband signals. These dynamic characteristics, coupled with fast settling times, make these amplifiers ideally suited to pulse amplification designs as well as high frequency (e.g. video) applications. The frequency response of the amplifier can be tailored to exact design requirements by means of an external bandwidth control capacitor.

In addition to its application in pulse and video amplifier designs, HA-2600/2605 are particularly suited to other high performance designs such as high-gain low distortion audio amplifiers, high-Q and wideband active filters and high-speed comparators. For more information, please refer to Application Note AN515.

The HA-2600 is offered as /883 Military Grade; product and data sheet are available upon request.

Features
- Bandwidth: 12MHz
- High Input Impedance: 500MΩ
- Low Input Bias Current: 1nA
- Low Input Offset Current: 1nA
- Low Input Offset Voltage: 0.5mV
- High Gain: 150kV/V
- Slew Rate: 7V/μs
- Output Short Circuit Protection
- Unity Gain Stable

Applications
- Video Amplifier
- Pulse Amplifier
- Audio Amplifiers and Filters
- High-Q Active Filters
- High-Speed Comparators
- Low Distortion Oscillators

Pinouts

Ordering Information

<table>
<thead>
<tr>
<th>PART NUMBER</th>
<th>TEMP. RANGE (°C)</th>
<th>PACKAGE</th>
<th>PKG. NO.</th>
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<tbody>
<tr>
<td>HA2-2600-2</td>
<td>-55 to 125</td>
<td>8 Pin Metal Can</td>
<td>T8.C</td>
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<tr>
<td>HA2-2605-5</td>
<td>0 to 75</td>
<td>8 Pin Metal Can</td>
<td>T8.C</td>
</tr>
<tr>
<td>HA3-2605-5</td>
<td>0 to 75</td>
<td>8 Ld PDIP</td>
<td>E8.3</td>
</tr>
</tbody>
</table>

CAUTION: These devices are sensitive to electrostatic discharge; follow proper IC Handling Procedures.
Absolute Maximum Ratings
Supply Voltage Between V+ and V- Terminals .................. 45V
Differential Input Voltage ...............................12V
Peak Output Current .................Full Short Circuit Protection

Operating Conditions
Temperature Range
HA-2600-2 ................................. -55°C to 125°C
HA-2605-5 ................................. 0°C to 75°C

CAUTION: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:
1. $\theta_{JA}$ is measured with the component mounted on an evaluation PC board in free air.

Thermal Information
Thermal Resistance (Typical, Note 1) $\theta_{JA}$ (°C/W) $\theta_{JC}$ (°C/W)
Metal Can Package ..........................165 80
PDIP Package .............................. 96 N/A
Maximum Junction Temperature (Hermetic Package) ..............175°C
Maximum Junction Temperature (Plastic Package) .................150°C
Maximum Storage Temperature Range ................-65°C to 150°C
Maximum Lead Temperature (Soldering 10s) ...............300°C

Electrical Specifications $V_{SUPPLY} = \pm 15V$, Unless Otherwise Specified

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TEMP. (°C)</th>
<th>HA-2600-2</th>
<th>HA-2605-5</th>
<th>UNITS</th>
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<tr>
<td>INPUT CHARACTERISTICS</td>
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<tr>
<td>Offset Voltage</td>
<td>25</td>
<td>-</td>
<td>0.5</td>
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<tr>
<td></td>
<td>Full</td>
<td>-</td>
<td>2</td>
<td>6</td>
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<tr>
<td>Average Offset Voltage Drift</td>
<td>Full</td>
<td>-</td>
<td>5</td>
<td>-</td>
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<tr>
<td>Bias Current</td>
<td>25</td>
<td>-</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>-</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Offset Current</td>
<td>25</td>
<td>-</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>-</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Differential Input Resistance (Note 12)</td>
<td>25</td>
<td>100</td>
<td>500</td>
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<tr>
<td>Input Noise Voltage Density ($f = 1kHz$)</td>
<td>25</td>
<td>-</td>
<td>11</td>
<td>-</td>
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<tr>
<td>Input Noise Current Density ($f = 1kHz$)</td>
<td>25</td>
<td>-</td>
<td>0.16</td>
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<tr>
<td>Common Mode Range</td>
<td>Full</td>
<td>±11</td>
<td>±12</td>
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<td>TRANSFER CHARACTERISTICS</td>
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<tr>
<td>Large Signal Voltage Gain (Notes 3, 6)</td>
<td>25</td>
<td>100</td>
<td>150</td>
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<tr>
<td></td>
<td>Full</td>
<td>70</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Common Mode Rejection Ratio (Note 4)</td>
<td>Full</td>
<td>80</td>
<td>100</td>
<td>-</td>
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<tr>
<td>Minimum Stable Gain</td>
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<td>-</td>
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<td>Gain Bandwidth Product (Note 5)</td>
<td>25</td>
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<td>12</td>
<td>-</td>
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<td>OUTPUT CHARACTERISTICS</td>
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<tr>
<td>Output Voltage Swing (Note 3)</td>
<td>Full</td>
<td>±10</td>
<td>±12</td>
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<tr>
<td>Output Current (Note 6)</td>
<td>25</td>
<td>±15</td>
<td>±22</td>
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<tr>
<td>Full Power Bandwidth (Notes 6, 13)</td>
<td>25</td>
<td>50</td>
<td>75</td>
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<tr>
<td>TRANSIENT RESPONSE (Note 10)</td>
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<tr>
<td>Rise Time (Notes 3, 7, 8, 9)</td>
<td>25</td>
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<td>30</td>
<td>60</td>
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<tr>
<td>Overshoot (Notes 3, 7, 8, 9)</td>
<td>25</td>
<td>-</td>
<td>25</td>
<td>40</td>
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<tr>
<td>Slew Rate (Notes 3, 7, 9, 14)</td>
<td>25</td>
<td>±4</td>
<td>±7</td>
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<tr>
<td>Settling Time (Notes 3, 7, 15)</td>
<td>25</td>
<td>-</td>
<td>1.5</td>
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## Electrical Specifications

<table>
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<tr>
<th>PARAMETER</th>
<th>TEMP. (°C)</th>
<th>HA-2600-2</th>
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<th>HA-2605-2</th>
<th></th>
<th></th>
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<th>UNITS</th>
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<tbody>
<tr>
<td>Supply Current</td>
<td>25</td>
<td>-</td>
<td>3</td>
<td>3.7</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>mA</td>
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<tr>
<td>Power Supply Rejection Ratio (Note 11)</td>
<td>Full</td>
<td>80</td>
<td>90</td>
<td>-</td>
<td>74</td>
<td>90</td>
<td>-</td>
<td>dB</td>
</tr>
</tbody>
</table>

**NOTES:**

2. Typical and minimum specifications for -9 are identical to those of -5. All maximum specifications for -9 are identical to those of -5 except for Full Temperature Bias and Offset Currents, which are 70nA Max.

3. $R_L = 2k\Omega$.

4. $V_{CM} = \pm 10V$.

5. $V_{OUT} < 90mV$.

6. $V_{OUT} = \pm 10V$.

7. $C_L = 100pF$.

8. $V_{OUT} = \pm 200mV$.


10. See Transient Response Test Circuits and Waveforms.

11. $\Delta V_S = \pm 5V$.

12. This parameter value guaranteed by design calculations.

13. Full Power Bandwidth guaranteed by slew rate measurement: $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$.

14. $V_{OUT} = \pm 5V$.

15. Settling time is characterized at $A_V = -1$ to 0.1% of a 10V step.

### Test Circuits and Waveforms

**FIGURE 1. TRANSIENT RESPONSE**

**FIGURE 2. SLEW RATE**

**FIGURE 3. SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT**

**FIGURE 4. SUGGESTED $V_{OS}$ ADJUSTMENT AND COMPENSATION HOOK UP**

NOTE: Tested offset adjustment range is $|V_{OS} + 1mV|$ minimum referred to output. Typical ranges are $\pm 10mV$ with $R_T = 100k\Omega$. 

NOTE: Measured on both positive and negative transitions from 0V to $+200mV$ and 0V to $-200mV$ at the output.
### Schematic Diagram

A detailed schematic diagram of the circuit with various components and their connections is shown. The diagram includes transistors, capacitors, resistors, and other electronic components typically used in electronic circuits.

### Typical Applications

**FIGURE 5. PHOTO CURRENT TO VOLTAGE CONVERTER**

A small load capacitance is recommended in all applications where practical to prevent possible high frequency oscillations resulting from external wiring parasitics. Capacitance up to 100pF has negligible effect on the bandwidth or slew rate.

**FIGURE 6. SAMPLE AND HOLD**

- **FEATURES:**
  1. Constant cell voltage.
  2. Minimum bias current error.

- **NOTE:** A small load capacitance is recommended in all applications where practical to prevent possible high frequency oscillations resulting from external wiring parasitics. Capacitance up to 100pF has negligible effect on the bandwidth or slew rate.

**DRIFT RATE = \( \frac{I_{\text{BIAS}}}{C} \)**

If \( C = 1000\text{pF} \), then \( \text{DRIFT} = 0.01\text{V/µs} \) (Max)

---

4

**HA-2600, HA-2605**
**Typical Applications** (Continued)

![Diagram of HA-2600, HA-2605](image)

**FEATURES:**
1. Minimum bias current in reference cell.
2. Short Circuit Protection.

**NOTE:** A small load capacitance is recommended in all applications where practical to prevent possible high frequency oscillations resulting from external wiring parasitics. Capacitance up to 100pF has negligible effect on the bandwidth or slew rate.

**FIGURE 7. REFERENCE VOLTAGE AMPLIFIER**

**FIGURE 8. VOLTAGE FOLLOWER**

**Typical Performance Curves** \( V_S = \pm 15V, T_A = 25^\circ C \), Unless Otherwise Specified

![Graph 1](image)

- **OFFSET**
- **BIAS**
- **CURRENT (nA)**
- **TEMPERATURE (°C)**

**FIGURE 9. INPUT BIAS CURRENT AND OFFSET CURRENT vs TEMPERATURE**

![Graph 2](image)

- **CURRENT (µV)**
- **TEMPERATURE (°C)**

**FIGURE 10. BROADBAND NOISE CHARACTERISTICS**

![Graph 3](image)

- **EQUIVALENT INPUT NOISE vs BANDWIDTH**
- **10kΩ SOURCE RESISTANCE**
- **0Ω SOURCE RESISTANCE**
- **THERMAL NOISE OF 10K RESISTOR**
- **UPPER 3dB FREQUENCY** (LOWER 3dB FREQUENCY = 10Hz)
- **100Hz 1kHz 10kHz 100kHz 1MHz 10MHz**

**FIGURE 11. OPEN LOOP FREQUENCY RESPONSE**

![Graph 4](image)

- **GAIN**
- **PHASE**

**FIGURE 12. INPUT IMPEDANCE vs TEMPERATURE (100Hz)**

![Graph 5](image)

- **IMPEDANCE (MΩ)**
- **TEMPERATURE (°C)**
- **-55 -35 -15 5 25 45 65 85 105 125**
Typical Performance Curves  \( V_S = \pm 15V, T_A = 25^\circ C, \) Unless Otherwise Specified  

(Continued)

**FIGURE 13. OUTPUT VOLTAGE SWING vs FREQUENCY**

**FIGURE 14. OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM COMPENSATION PIN TO GROUND**

NOTE: External compensation components are not required for stability, but may be added to reduce bandwidth if desired. If External Compensation is used, also connect 100pF capacitor from output to ground.

**FIGURE 15. COMMON MODE VOLTAGE RANGE vs SUPPLY VOLTAGE**

**FIGURE 16. OPEN LOOP VOLTAGE GAIN vs TEMPERATURE**

**FIGURE 17. COMMON MODE REJECTION RATIO vs FREQUENCY**

**FIGURE 18. NOISE DENSITY vs FREQUENCY**
Die Characteristics

DIE DIMENSIONS:
69 mils x 56 mils x 19 mils
1750µm x 1420µm x 483µm

METALLIZATION:
Type: Al, 1% Cu
Thickness: 16k Å ±2k Å

SUBSTRATE POTENTIAL (Powered Up):
Unbiased

PASSIVATION:
Type: Nitride (Si₃N₄) over Silox (SiO₂, 5% Phos.)
Silox Thickness: 12kÅ ±2kÅ
Nitride Thickness: 3.5kÅ ±1.5kÅ

TRANSISTOR COUNT:
140

PROCESS:
Bipolar Dielectric Isolation

Metallization Mask Layout

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