Low Cost, Low Power, True RMS-to-DC Converter

AD737

FEATURES

COMPUTES
- True RMS Value
- Average Rectified Value
- Absolute Value

PROVIDES
- 200 mV Full-Scale Input Range
  (Larger Inputs with Input Attenuator)
- Direct Interfacing with 3 1/2 Digit CMOS A/D Converters
- High Input Impedance of $10^{12}\ \Omega$
- Low Input Bias Current: 25 pA max
- High Accuracy: ±0.2 mV ±0.3% of Reading
- RMS Conversion with Signal Crest Factors Up to 5
- Wide Power Supply Range: +2.8 V, −3.2 V to ±16.5 V
- Low Power: 160 µA max Supply Current
- No External Trims Needed for Specified Accuracy
- AD736—A General Purpose, Buffered Voltage Output Version Also Available

PRODUCT DESCRIPTION

The AD737 is a low power, precision, monolithic true rms-to-dc converter. It is laser trimmed to provide a maximum error of ±0.2 mV ±0.3% of reading with sine-wave inputs. Furthermore, it maintains high accuracy while measuring a wide range of input waveforms, including variable duty cycle pulses and triac (phase) controlled sine waves. The low cost and small physical size of this converter make it suitable for upgrading the performance of non-rms “precision rectifiers” in many applications. Compared to these circuits, the AD737 offers higher accuracy at equal or lower cost.

The AD737 can compute the rms value of both ac and dc input voltages. It can also be operated ac coupled by adding one external capacitor. In this mode, the AD737 can resolve input signal levels of 100 µV rms or less, despite variations in temperature or supply voltage. High accuracy is also maintained for input waveforms with crest factors of 1 to 3. In addition, crest factors as high as 5 can be measured (while introducing only 2.5% additional error) at the 200 mV full-scale input level.

The AD737 has no output buffer amplifier, thereby significantly reducing dc offset errors occurring at the output. This allows the device to be highly compatible with high input impedance A/D converters.

Requiring only 160 µA of power supply current, the AD737 is optimized for use in portable multimeters and other battery powered applications. This converter also provides a “power down” feature which reduces the power supply standby current to less than 30 µA.

The AD737 allows the choice of two signal input terminals: a high impedance ($10^{12}\ \Omega$) FET input which will directly interface with high Z input attenuators and a low impedance (8 kΩ) input which allows the measurement of 300 mV input levels, while operating from the minimum power supply voltage of +2.8 V, −3.2 V. The two inputs may be used either singly or differentially.

The AD737 achieves a 1% of reading error bandwidth exceeding 10 kHz for input amplitudes from 20 mV rms to 200 mV rms while consuming only 0.72 mW.

The AD737 is available in four performance grades. The AD737J and AD737K grades are rated over the commercial temperature range of 0°C to +70°C. The AD737A and AD737B grades are rated over the industrial temperature range of −40°C to +85°C.

The AD737 is available in three low-cost, 8-pin packages: plastic mini-DIP, plastic SO and hermetic cerdip.

PRODUCT HIGHLIGHTS

1. The AD737 is capable of computing the average rectified value, absolute value or true rms value of various input signals.
2. Only one external component, an averaging capacitor, is required for the AD737 to perform true rms measurement.
3. The low power consumption of 0.72 mW makes the AD737 suitable for many battery powered applications.
AD737—SPECIFICATIONS  
(@ +25°C, ±5 V supplies, ac coupled with 1 kHz sine-wave input applied unless otherwise noted.)

### TRANSFER FUNCTION

\[
V_{\text{OUT}} = \sqrt{\text{Avg}.(V_{\text{IN}}^2)}
\]

### CONVERSION ACCURACY

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Error, Internal Trim(^1)</td>
<td>0.2/0.3</td>
<td>0.40/0.5</td>
<td>0.2/0.2</td>
<td>0.2/0.3</td>
<td>±mV/±% of Reading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Grades</td>
<td>0–200 mV rms</td>
<td>200 mV–1 V rms</td>
<td>–1.2</td>
<td>±2.0</td>
<td>–1.2</td>
<td>±2.0</td>
<td></td>
</tr>
<tr>
<td>T(<em>{\text{MIN}})–T(</em>{\text{MAX}})</td>
<td>@ 200 mV rms</td>
<td>0.50/0.7</td>
<td>0.3/0.5</td>
<td>±% of Reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A&amp;B Grades</td>
<td>@ 200 mV rms</td>
<td>0.007</td>
<td>0.007</td>
<td>±% of Reading(^\circ)C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J&amp;K Grades</td>
<td>@ 200 mV rms</td>
<td>0.007</td>
<td>0.007</td>
<td>±% of Reading</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ERROR vs. CREST FACTOR\(^3\)

<table>
<thead>
<tr>
<th>Crest Factor</th>
<th>V(_{\text{AV}}), CF = 100 µF</th>
<th>±3 dB Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 3</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### INPUT CHARACTERISTICS

**High Impedance Input (Pin 2)**

<table>
<thead>
<tr>
<th>Signal Range</th>
<th>Continuous rms Level</th>
<th>Continuous rms Level</th>
<th>Peak Transient Input</th>
<th>Peak Transient Input</th>
<th>Input Resistance</th>
<th>Input Bias Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(_{S}) = ±5 V to ±16.5 V</td>
<td>1</td>
<td>1</td>
<td>±0.9</td>
<td>±0.9</td>
<td>10(^{12})</td>
<td>1</td>
</tr>
<tr>
<td>Peak Transient Input</td>
<td>+2.8 V, –3.2 V</td>
<td>0</td>
<td>200</td>
<td>200</td>
<td>V rms</td>
<td></td>
</tr>
<tr>
<td>V(_{S}) = ±5 V</td>
<td>±2.7</td>
<td>1 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(_{S}) = ±16.5 V</td>
<td>±4.0</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Low Impedance Input (Pin 1)**

<table>
<thead>
<tr>
<th>Signal Range</th>
<th>Continuous rms Level</th>
<th>Continuous rms Level</th>
<th>Peak Transient Input</th>
<th>Peak Transient Input</th>
<th>Input Resistance</th>
<th>Input Bias Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(_{S}) = ±5 V to ±16.5 V</td>
<td>1</td>
<td>1</td>
<td>±1.7</td>
<td>±1.7</td>
<td>6.4</td>
<td>8</td>
</tr>
<tr>
<td>Peak Transient Input</td>
<td>+2.8 V, –3.2 V</td>
<td>±3.8</td>
<td>8.96</td>
<td>±11</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>V(_{S}) = ±16.5 V</td>
<td>±11</td>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### OUTPUT CHARACTERISTICS

<table>
<thead>
<tr>
<th>Output Voltage Swing</th>
<th>V(_{S}) = ±2.8 V, –3.2 V</th>
<th>V(_{S}) = ±5 V</th>
<th>V(_{S}) = ±16.5 V</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Load</td>
<td>0 to –1.6</td>
<td>–1.7</td>
<td>0 to –1.6</td>
<td>–1.7</td>
</tr>
<tr>
<td>No Load</td>
<td>0 to –3.3</td>
<td>–3.4</td>
<td>0 to –3.3</td>
<td>–3.4</td>
</tr>
<tr>
<td>No Load</td>
<td>0 to –4</td>
<td>–5</td>
<td>0 to –4</td>
<td>–5</td>
</tr>
<tr>
<td>Output Resistance</td>
<td>@ dc</td>
<td>6.4</td>
<td>8</td>
<td>9.6</td>
</tr>
</tbody>
</table>

### FREQUENCY RESPONSE

**High Impedance Input (Pin 2)**

<table>
<thead>
<tr>
<th>For 1% Additional Error</th>
<th>V(_{IN}) = 1 mV rms</th>
<th>V(_{IN}) = 10 mV rms</th>
<th>V(_{IN}) = 100 mV rms</th>
<th>V(_{IN}) = 200 mV rms</th>
<th>±3 dB Bandwidth</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(_{IN}) = 1 mV rms</td>
<td>1</td>
<td>1</td>
<td>kHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(_{IN}) = 10 mV rms</td>
<td>6</td>
<td>6</td>
<td>kHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(_{IN}) = 100 mV rms</td>
<td>37</td>
<td>37</td>
<td>kHz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(_{IN}) = 200 mV rms</td>
<td>33</td>
<td>33</td>
<td>kHz</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sine-Wave Input**

| V\(_{IN}\) = 1 mV rms | 5 | 5 | kHz |
| V\(_{IN}\) = 10 mV rms | 55 | 55 | kHz |
| V\(_{IN}\) = 100 mV rms | 170 | 170 | kHz |
| V\(_{IN}\) = 200 mV rms | 190 | 190 | kHz |
## FREQUENCY RESPONSE

### Low Impedance Input (Pin 1)

For 1% Additional Error Sine-Wave Input

- **VIN = 1 mV rms**
  - Min: 1 kHz
  - Typ: 1 kHz
  - Max: 1 kHz
- **VIN = 10 mV rms**
  - Min: 6 kHz
  - Typ: 6 kHz
  - Max: 6 kHz
- **VIN = 100 mV rms**
  - Min: 90 kHz
  - Typ: 90 kHz
  - Max: 90 kHz
- **VIN = 200 mV rms**
  - Min: 90 kHz
  - Typ: 90 kHz
  - Max: 90 kHz

±3 dB Bandwidth Sine-Wave Input

- **VIN = 1 mV rms**
  - Min: 5 kHz
  - Typ: 5 kHz
  - Max: 5 kHz
- **VIN = 10 mV rms**
  - Min: 55 kHz
  - Typ: 55 kHz
  - Max: 55 kHz
- **VIN = 100 mV rms**
  - Min: 350 kHz
  - Typ: 350 kHz
  - Max: 350 kHz
- **VIN = 200 mV rms**
  - Min: 460 kHz
  - Typ: 460 kHz
  - Max: 460 kHz

## POWER SUPPLY

### Operating Voltage Range

- +2.8 V to –3.2 V
- ±5 V
- ±16.5 V

### Quiescent Current

- Zero Signal
  - 120 µA
  - 160 µA
- VIN = 200 mV rms, No Load Sine-Wave Input
  - 170 µA
  - 210 µA
- Power Down Mode Current
  - Pin 3 Tied to +V
  - 25 µA
  - 40 µA

## TEMPERATURE RANGE

### Operating, Rated Performance

- **Commercial (0°C to +70°C)**
  - AD737J
  - AD737K
- **Industrial (–40°C to +85°C)**
  - AD737A
  - AD737B

### NOTES

1. Accuracy is specified with the AD737 connected as shown in Figure 16 with capacitor Cc.
2. Nonlinearity is defined as the maximum deviation (in percent error) from a straight line connecting the readings at 0 and 200 mV rms.
3. Error vs. Crest Factor is specified as additional error for a 200 mV rms signal. C.F. = VPEAK/V rms.
4. DC offset does not limit ac resolution.

Specifications are subject to change without notice.
Specifications shown in **boldface** are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels.

### ABSOLUTE MAXIMUM RATINGS1

- **Supply Voltage**
  - ±16.5 V
- **Internal Power Dissipation**
  - 200 mW
- **Input Voltage**
  - ±VS
- **Output Short-Circuit Duration**
  - Indefinite
- **Differential Input Voltage**
  - +VS and –VS
- **Storage Temperature Range (Q)**
  - –65°C to +150°C
- **Storage Temperature Range (N, R)**
  - –65°C to +125°C
- **Operating Temperature Range**
  - **AD737J/K**
    - 0°C to +70°C
  - **AD737A/B**
    - –40°C to +85°C
- **Lead Temperature Range (Soldering 60 sec)**
  - +300°C
- **ESD Rating**
  - 500 V

### NOTES

1. Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Temperature Range</th>
<th>Package Description</th>
<th>Package Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD737JN</td>
<td>0°C to +70°C</td>
<td>Plastic Mini-DIP</td>
<td>N-8</td>
</tr>
<tr>
<td>AD737KN</td>
<td>0°C to +70°C</td>
<td>Plastic Mini-DIP</td>
<td>N-8</td>
</tr>
<tr>
<td>AD737JR</td>
<td>0°C to +70°C</td>
<td>SOIC</td>
<td>R-8</td>
</tr>
<tr>
<td>AD737KR</td>
<td>0°C to +70°C</td>
<td>SOIC</td>
<td>R-8</td>
</tr>
<tr>
<td>AD737AQ</td>
<td>–40°C to +85°C</td>
<td>Cerdip</td>
<td>Q-8</td>
</tr>
<tr>
<td>AD737BQ</td>
<td>–40°C to +85°C</td>
<td>Cerdip</td>
<td>Q-8</td>
</tr>
<tr>
<td>AD737JR-Reel</td>
<td>–40°C to +85°C</td>
<td>SOIC</td>
<td>R-8</td>
</tr>
<tr>
<td>AD737KR-Reel</td>
<td>–40°C to +85°C</td>
<td>SOIC</td>
<td>R-8</td>
</tr>
</tbody>
</table>

### PIN CONFIGURATIONS

8-Pin Mini-DIP (N-8), 8-Pin SOIC (R-8), 8-Pin Cerdip (Q-8)
AD737—Typical Characteristics

Figure 1. Additional Error vs. Supply Voltage
Figure 2. Maximum Input Level vs. Supply Voltage
Figure 3. Power Down Current vs. Supply Voltage
Figure 4. Frequency Response Driving Pin 1
Figure 5. Frequency Response Driving Pin 2
Figure 6. Additional Error vs. Crest Factor vs. CAV
Figure 7. Additional Error vs. Temperature
Figure 8. DC Supply Current vs. RMS Input Level
Figure 9. 23 dB Frequency vs. RMS Input Level (Pin 2)
CALCULATING SETTLING TIME USING FIGURE 14
The graph of Figure 14 may be used to closely approximate the time required for the AD737 to settle when its input level is reduced in amplitude. The net time required for the rms converter to settle will be the difference between two times extracted from the graph – the initial time minus the final settling time. As an example, consider the following conditions: a 33 µF averaging capacitor, an initial rms input level of 100 mV and a final (reduced) input level of 1 mV. From Figure 14, the initial settling time (where the 100 mV line intersects the 33 µF line) is around 80 ms. The settling time corresponding to the new or final input level of 1 mV is approximately 8 seconds. Therefore, the net time for the circuit to settle to its new value will be 8 seconds minus 80 ms which is 7.92 seconds. Note that, because of the smooth decay characteristic inherent with a capacitor/diode combination, this is the total settling time to the final value (i.e., not the settling time to 1%, 0.1%, etc., of final value). Also, this graph provides the worst case settling time, since the AD737 will settle very quickly with increasing input levels.

TYPES OF AC MEASUREMENT
The AD737 is capable of measuring ac signals by operating as either an average responding or a true rms-to-de converter. As its name implies, an average responding converter computes the average absolute value of an ac (or ac and dc) voltage or current by full wave rectifying and low-pass filtering the input signal; this will approximate the average. The resulting output, a dc "average" level, is then scaled by adding (or reducing) gain; this scale factor converts the dc average reading to an rms equivalent value for the waveform being measured. For example, the average absolute value of a sine-wave voltage is 0.636 that of V PEAK; the corresponding rms value is 0.707 times V PEAK. Therefore, for sine-wave voltages, the required scale factor is 1.11 (0.707 divided by 0.636).

In contrast to measuring the "average" value, true rms measurement is a "universal language" among waveforms, allowing the magnitudes of all types of voltage (or current) waveforms to be compared to one another and to dc. RMS is a direct measure of the power or heating value of an ac voltage compared to that of dc: an ac signal of 1 volt rms will produce the same amount of heat in a resistor as a 1 volt dc signal.
Waveform Type 1 Volt Peak Amplitude Crest Factor \((V_{PEAK}/V_{rms})\) True rms Value Average Responding Circuit Calibrated to Read rms Value of Sine Waves Will Read % of Reading Error* Using Average Responding Circuit

<table>
<thead>
<tr>
<th>Waveform Type</th>
<th>Crest Factor ((V_{PEAK}/V_{rms}))</th>
<th>True rms Value</th>
<th>Average Responding Circuit Calibrated to Read rms Value of Sine Waves Will Read</th>
<th>% of Reading Error* Using Average Responding Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undistorted Sine Wave</td>
<td>1.414</td>
<td>0.707 V</td>
<td>0.707 V</td>
<td>0%</td>
</tr>
<tr>
<td>Symmetrical Square Wave</td>
<td>1.00</td>
<td>1.00 V</td>
<td>1.11 V</td>
<td>+11.0%</td>
</tr>
<tr>
<td>Undistorted Triangle Wave</td>
<td>1.73</td>
<td>0.577 V</td>
<td>0.555 V</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Gaussian Noise (98% of Peaks &lt;1 V)</td>
<td>3</td>
<td>0.333 V</td>
<td>0.295 V</td>
<td>-11.4%</td>
</tr>
<tr>
<td>Rectangular Pulse Train</td>
<td>2</td>
<td>0.5 V</td>
<td>0.278 V</td>
<td>-44%</td>
</tr>
<tr>
<td>SCR Waveforms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% Duty Cycle</td>
<td>2</td>
<td>0.495 V</td>
<td>0.354 V</td>
<td>-28%</td>
</tr>
<tr>
<td>25% Duty Cycle</td>
<td>4.7</td>
<td>0.212 V</td>
<td>0.150 V</td>
<td>-30%</td>
</tr>
</tbody>
</table>

Mathematically, the rms value of a voltage is defined (using a simplified equation) as:

\[ V_{rms} = \sqrt{\text{Avg} \cdot (V^2)} \]

This involves squaring the signal, taking the average, and then obtaining the square root. True rms converters are “smart rectifiers”: they provide an accurate rms reading regardless of the type of waveform being measured. However, average responding converters can exhibit very high errors when their input signals deviate from their precalibrated waveform; the magnitude of the error will depend upon the type of waveform being measured. As an example, if an average responding converter is calibrated to measure the rms value of sine-wave voltages, and then is used to measure either symmetrical square waves or dc voltages, the converter will have a computational error 11% (of reading) higher than the true rms value (see Table I).

**AD737 THEORY OF OPERATION**

As shown by Figure 16, the AD737 has four functional subsections: input amplifier, full-wave rectifier, rms core and bias sections. The FET input amplifier allows both a high impedance, buffered input (Pin 2) or a low impedance, wide-dynamic-range input (Pin 1). The high impedance input, with its low input bias current, is well suited for use with high impedance input attenuators. The input signal may be either dc or ac coupled to the input amplifier. Unlike other rms converters, the AD737 permits both direct and indirect ac coupling of the inputs. AC coupling is provided by placing a series capacitor between the input signal and Pin 2 (or Pin 1) for direct coupling and between Pin 1 and ground (while driving Pin 2) for indirect coupling.

The output of the input amplifier drives a full-wave precision rectifier, which in turn, drives the rms core. It is in the core that the essential rms operations of squaring, averaging and square rooting are performed, using an external averaging capacitor, \(C_{AV}\). Without \(C_{AV}\), the rectified input signal travels through the core unprocessed, as is done with the average responding connection (Figure 17).

A final subsection, the bias section, permits a “power down” function. This reduces the idle current of the AD737 from 160 µA down to a mere 30 µA. This feature is selected by tying Pin 3 to the +Vs terminal. In the average responding connection, all of the averaging is carried out by an RC post filter consisting of an 8 kΩ internal scale-factor resistor connected between Pins 6 and 8 and an external averaging capacitor, \(C_F\). In the rms circuit, this additional filtering stage helps reduce any output ripple which was not removed by the averaging capacitor, \(C_{AV}\).

**RMS MEASUREMENT – CHOOSING THE OPTIMUM VALUE FOR \(C_{AV}\)**

Since the external averaging capacitor, \(C_{AV}\), “holds” the rectified input signal during rms computation, its value directly affects the accuracy of the rms measurement, especially at low frequencies. Furthermore, because the averaging capacitor appears across a diode in the rms core, the averaging time constant will increase exponentially as the input signal is reduced. This means that as the input level decreases, errors due to nonideal averaging will reduce while the time it takes for the circuit to settle to the new rms level will increase. Therefore, lower input levels allow the circuit to perform better (due to increased averaging) but increase the waiting time between measurements. Obviously, when selecting \(C_{AV}\), a trade-off between computational accuracy and settling time is required.

![Figure 16. AD737 True RMS Circuit](image-url)
AC MEASUREMENT ACCURACY AND CREST FACTOR

The crest factor of the input waveform is often overlooked when determining the accuracy of an ac measurement. Crest factor is defined as the ratio of the peak signal amplitude to the rms amplitude (C.F. = \frac{V_{\text{peak}}}{V_{\text{rms}}}). Many common waveforms, such as sine and triangle waves, have relatively low crest factors (≥2). Other waveforms, such as low duty cycle pulse trains and SCR waveforms, have high crest factors. These types of waveforms require a long averaging time constant (to average out the long time periods between pulses). Figure 6 shows the additional error vs. crest factor of the AD737 for various values of \(C_{\text{AV}}\).

SELECTING PRACTICAL VALUES FOR INPUT COUPLING (\(C_C\)), AVERAGING (\(C_{\text{AV}}\)) AND FILTERING (\(C_F\)) CAPACITORS

Table II provides practical values of \(C_{\text{AV}}\) and \(C_F\) for several common applications.

<table>
<thead>
<tr>
<th>Application</th>
<th>rms Input Level</th>
<th>Low Frequency Cutoff (&lt;3 dB)</th>
<th>Max Crest Factor</th>
<th>(C_{\text{AV}})</th>
<th>(C_F)</th>
<th>Settling Time* to 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose</td>
<td>0–1 V</td>
<td>20 Hz</td>
<td>5</td>
<td>150 (\mu \text{F})</td>
<td>10 (\mu \text{F})</td>
<td>360 ms</td>
</tr>
<tr>
<td>rms Computation</td>
<td>0–200 mV</td>
<td>20 Hz</td>
<td>5</td>
<td>33 (\mu \text{F})</td>
<td>10 (\mu \text{F})</td>
<td>360 ms</td>
</tr>
<tr>
<td>Average Responding</td>
<td>0–1 V</td>
<td>20 Hz</td>
<td>None</td>
<td>33 (\mu \text{F})</td>
<td>1.2 sec</td>
<td>120 ms</td>
</tr>
<tr>
<td>SCR Waveform Measurement</td>
<td>0–200 mV</td>
<td>50 Hz</td>
<td>5</td>
<td>100 (\mu \text{F})</td>
<td>33 (\mu \text{F})</td>
<td>1.2 sec</td>
</tr>
<tr>
<td>Audio Applications</td>
<td>0–200 mV</td>
<td>300 Hz</td>
<td>3</td>
<td>1.5 (\mu \text{F})</td>
<td>0.5 (\mu \text{F})</td>
<td>18 ms</td>
</tr>
<tr>
<td>Speech</td>
<td>0–200 mV</td>
<td>20 Hz</td>
<td>10</td>
<td>100 (\mu \text{F})</td>
<td>68 (\mu \text{F})</td>
<td>2.4 sec</td>
</tr>
</tbody>
</table>

* Settling time is specified over the stated rms input level with the input signal increasing from zero. Settling times will be greater for decreasing amplitude input signals.

The input coupling capacitor, \(C_C\), in conjunction with the 8 kΩ internal input scaling resistor, determine the \(-3 \text{ dB}\) low frequency rolloff. This frequency, \(F_L\), is equal to:

\[
F_L = \frac{1}{2\pi(8,000)(\text{The Value of } C_C \text{ in Farads})}
\]

Note that at \(F_L\), the amplitude error will be approximately ~30% (~3 dB) of reading. To reduce this error to 0.5% of reading, choose a value of \(C_C\) that sets \(F_L\) at one tenth the lowest frequency to be measured.

In addition, if the input voltage has more than 100 mV of dc offset, then the ac coupling network at Pin 2 should be used in addition to capacitor \(C_C\).
AD737—Applications Circuits

Figure 19. 3 1/2 Digit DVM Circuit

Figure 20. Battery Powered Operation for 200 mV max RMS Full-Scale Input

Figure 21. External Scale Factor Trim

Figure 22. dB Output Connection

Figure 23. DC Coupled V<sub>OS</sub> and Scale Factor Trims

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

Plastic Small Outline (R) Package

Mini-DIP (N) Package

Cerdip (Q) Package