Low Level, True RMS-to-DC Converter

Data Sheet

AD636

FEATURES

True rms-to-dc conversion
200 mV full scale
Laser-trimmed to high accuracy
   0.5% maximum error (AD636K)
   1.0% maximum error (AD636J)
Wide response capability
   Computes rms of ac and dc signals
   1 MHz, −3 dB bandwidth: V rms > 100 mV
   Signal crest factor of 6 for 0.5% error
dB output with 50 dB range
Low power: 800 µA quiescent current
Single or dual supply operation
Monolithic integrated circuit
Low cost

GENERAL DESCRIPTION

The AD636 is a low power monolithic IC that performs true rms-to-dc conversion on low level signals. It offers performance that is comparable or superior to that of hybrid and modular converters costing much more. The AD636 is specified for a signal range of 0 mV to 200 mV rms. Crest factors up to 6 can be accommodated with less than 0.5% additional error, allowing accurate measurement of complex input waveforms.

The low power supply current requirement of the AD636, typically 800 µA, is ideal for battery-powered portable instruments. It operates from a wide range of dual and single power supplies, from ±2.5 V to ±16.5 V or from +5 V to +24 V. The input and output terminals are fully protected; the input signal can exceed the power supply with no damage to the device (allowing the presence of input signals in the absence of supply voltage), and the output buffer amplifier is short-circuit protected.

The AD636 includes an auxiliary dB output derived from an internal circuit point that represents the logarithm of the rms output. The 0 dB reference level is set by an externally supplied current and can be selected to correspond to any input level from 0 dBm (774.6 mV) to −20 dBm (77.46 mV). Frequency response ranges from 1.2 MHz at 0 dBm to greater than 10 kHz at −50 dBm.

The AD636 is easy to use. The device is factory-trimmed at the wafer level for input and output offset, positive and negative waveform symmetry (dc reversal error), and full-scale accuracy at 200 mV rms. Therefore, no external trims are required to achieve full-rated accuracy.
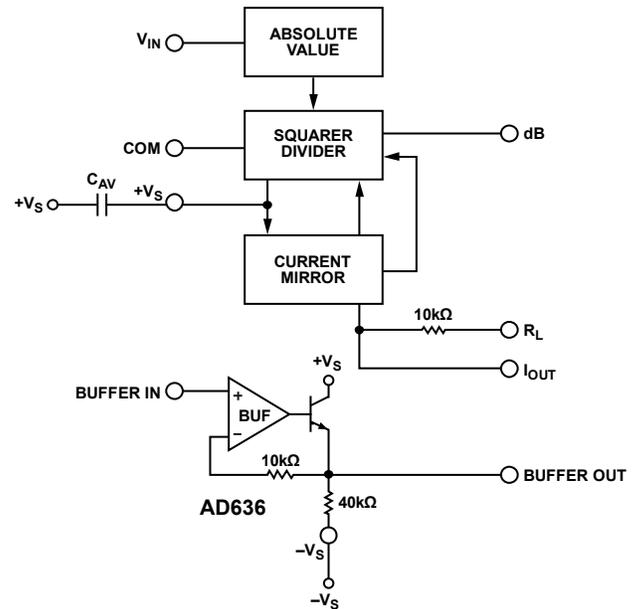
FUNCTIONAL BLOCK DIAGRAM

Figure 1.

The AD636 is available in two accuracy grades. The total error of the J-version is typically less than ±0.5 mV ± 1.0% of reading, while the total error of the AD636K is less than ±0.2 mV to ±0.5% of reading. Both versions are temperature rated for operation between 0°C and 70°C and available in 14-lead SBDIP and 10-lead TO-100 metal can.

The AD636 computes the true root-mean-square of a complex ac (or ac plus dc) input signal and gives an equivalent dc output level. The true rms value of a waveform is a more useful quantity than the average rectified value because it is a measure of the power in the signal. The rms value of an ac-coupled signal is also its standard deviation.

The 200 mV full-scale range of the AD636 is compatible with many popular display-oriented ADCs. The low power supply current requirement permits use in battery-powered hand-held instruments. An averaging capacitor is the only external component required to perform measurements to the fully specified accuracy is. Its value optimizes the trade-off between low frequency accuracy, ripple, and settling time.

An optional on-chip amplifier acts as a buffer for the input or the output signals. Used in the input, it provides accurate performance from standard 10 MΩ input attenuators. As an output buffer, it sources up to 5 mA.

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REVISION HISTORY

SPECIFICATIONS

@ 25°C, +V$_S$ = +3 V, and −V$_S$ = −5 V, unless otherwise noted.[1]

Table 1.

	AD636J			AD636K			
Model	Min	Typ	Max	Min	Typ	Max	Unit
TRANSFER FUNCTION		$V_{OUT} = \sqrt{avg \times (V_{IN})^2}$			$V_{OUT} = \sqrt{avg \times (V_{IN})^2}$		
CONVERSION ACCURACY							
Total Error, Internal Trim[2, 3]			**±0.5 ± 1.0**			**±0.2 ± 0.5**	mV ± % of reading
vs. Temperature, 0°C to +70°C			±0.1 ± 0.01			±0.1 ± 0.005	mV ± % of reading/°C
vs. Supply Voltage		±0.1 ± 0.01			±0.1 ± 0.01		mV ± % of reading/V
DC Reversal Error at 200 mV		±0.2			±0.1		% of reading
Total Error, External Trim[2]		±0.3 ± 0.3			± 0.1 ± 0.2		mV ± % of reading
ERROR VS. CREST FACTOR[4]							
Crest Factor 1 to 2		Specified Accuracy			Specified Accuracy		
Crest Factor = 3		−0.2			−0.2		% of reading
Crest Factor = 6		−0.5			−0.5		% of reading
AVERAGING TIME CONSTANT		25			25		ms/µF of C$_{AV}$
INPUT CHARACTERISTICS							
Signal Range, All Supplies							
Continuous RMS Level		0 to 200			0 to 200		mV rms
Peak Transient Inputs							
+3 V, −5 V Supply			±2.8			±2.8	V p-p
±2.5 V Supply			±2.0			±2.0	V p-p
±5 V Supply			±5.0			±5.0	V p-p
Maximum Continuous Nondestructive							
Input Level (All Supply Voltages)			±12			±12	V p-p
Input Resistance	5.33	6.67	8	5.33	6.67	8	kΩ
Input Offset Voltage			±0.5			±0.2	mV
FREQUENCY RESPONSE[3, 5]							
Bandwidth for 1% Additional Error (0.09 dB)							
V$_{IN}$ = 10 mV		14			14		kHz
V$_{IN}$ = 100 mV		90			90		kHz
V$_{IN}$ = 200 mV		130			130		kHz
±3 dB Bandwidth							
V$_{IN}$ = 10 mV		100			100		kHz
V$_{IN}$ = 100 mV		900			900		kHz
V$_{IN}$ = 200 mV		1.5			1.5		MHz
OUTPUT CHARACTERISTICS[3]							
Offset Voltage, V$_{IN}$ = COM			**±0.5**			**±0.2**	mV
vs. Temperature		±10			±10		µV/°C
vs. Supply		±0.1			±0.1		mV/V
Voltage Swing							
+3 V, −5 V Supply	0.3	0 to 1.0		0.3	0 to 1.0		V
±5 V to ±16.5 V Supply	0.3	0 to 1.0		0.3	0 to 1.0		V
Output Impedance	8	10	12	8	10	12	kΩ

Model	AD636J			AD636K			Unit
	Min	Typ	Max	Min	Typ	Max	
dB OUTPUT							
Error, V_{IN} = 7 mV to 300 mV rms		±0.3	**±0.5**		±0.1	**±0.2**	dB
Scale Factor		−3.0			−3.0		mV/dB
Scale Factor Temperature Coefficient		0.33			0.33		% of reading/°C
		−0.033			−0.033		dB/°C
I_{REF} for 0 dB = 0.1 V rms	**2**	**4**	**8**	**2**	**4**	**8**	µA
I_{REF} Range	1		50	1		50	µA
I_{OUT} TERMINAL							
I_{OUT} Scale Factor		100			100		µA/V rms
I_{OUT} Scale Factor Tolerance	−20	±10	+20	−20	±10	+20	%
Output Resistance	8	10	12	8	10	12	kΩ
Voltage Compliance		−V_S to (+V_S − 2 V)			−V_S to (+V_S − 2 V)		V
BUFFER AMPLIFIER							
Input and Output Voltage Range	−V_S to (+V_S − 2 V)			−V_S to (+V_S − 2 V)			V
Input Offset Voltage, R_S = 10 kΩ		±0.8	**±2**		±0.5	**±1**	mV
Input Bias Current		100	**300**		100	**300**	nA
Input Resistance		10^8			10^8		Ω
Output Current	(+5 mA, −130 µA)			(+5 mA, −130 µA)			
Short-Circuit Current		20			20		mA
Small Signal Bandwidth		1			1		MHz
Slew Rate[6]		5			5		V/µs
POWER SUPPLY							
Voltage, Rated Performance		+3, −5			+3, −5		V
Dual Supply	+2, −2.5		±16.5	+2, −2.5		±16.5	V
Single Supply	5		24	5		24	V
Quiescent Current[7]		0.80	**1.00**		0.80	**1.00**	mA
TEMPERATURE RANGE							
Rated Performance	0		+70	0		+70	°C
Storage	−55		+150	−55		+150	°C
TRANSISTOR COUNT		62			62		

[1] All minimum and maximum specifications are guaranteed. Specifications shown in **boldface** are tested on all production units at final electrical test and are used to calculate outgoing quality levels.
[2] Accuracy specified for 0 mV to 200 mV rms, dc or 1 kHz sine wave input. Accuracy is degraded at higher rms signal levels.
[3] Measured at Pin 8 of PDIP (I_{OUT}), with Pin 9 tied to common.
[4] Error vs. crest factor is specified as additional error for a 200 mV rms rectangular pulse train, pulse width = 200 µs.
[5] Input voltages are expressed in V rms.
[6] With 10 kΩ pull-down resistor from Pin 6 (BUF OUT) to −V_S.
[7] With BUF IN tied to COMMON.

ABSOLUTE MAXIMUM RATINGS

Table 2.

Parameter	Ratings
Supply Voltage	
Dual Supply	±16.5 V
Single Supply	24 V
Internal Power Dissipation[1]	500 mW
Maximum Input Voltage	±12 V_{PEAK}
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	0°C to 70°C
Lead Temperature Range (Soldering 60 sec)	300°C
ESD Rating	1000 V

[1] 10-Lead TO: θ_{JA} = 150°C/W.
14-Lead PDIP: θ_{JA} = 95°C/W.

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; 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.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.
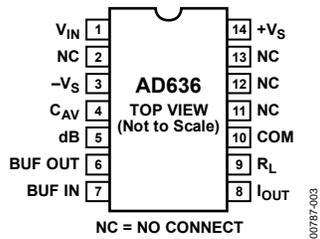
PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

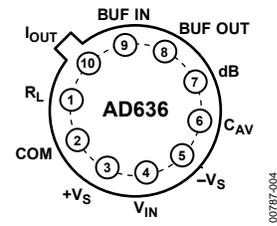Figure 2. 14-Lead SBDIP Pin Configuration

Figure 3. 10-Pin TO-100 Pin Configuration

Table 3. Pin Function Descriptions—14-Lead SBDIP

Pin No.	Mnemonic	Description
1	V_{IN}	Input Voltage.
2	NC	No Connection.
3	$-V_S$	Negative Supply Voltage.
4	C_{AV}	Averaging Capacitor.
5	dB	Log (dB) Value of the RMS Output Voltage.
6	BUF OUT	Buffer Output.
7	BUF IN	Buffer Input.
8	I_{OUT}	RMS Output Current.
9	R_L	Load Resistor.
10	COM	Common.
11, 12, 13	NC	No Connection.
14	$+V_S$	Positive Supply Voltage.

Table 4. Pin Function Descriptions—10-Pin TO-100

Pin No.	Mnemonic	Description
1	R_L	Load Resistor.
2	COM	Common.
3	$+V_S$	Positive Supply Voltage.
4	V_{IN}	Input Voltage.
5	$-V_S$	Negative Supply Voltage.
6	C_{AV}	Averaging Capacitor.
7	dB	Log (dB) Value of the RMS Output Voltage.
8	BUF OUT	Buffer Output.
9	BUF IN	Buffer Input.
10	I_{OUT}	RMS Output Current.

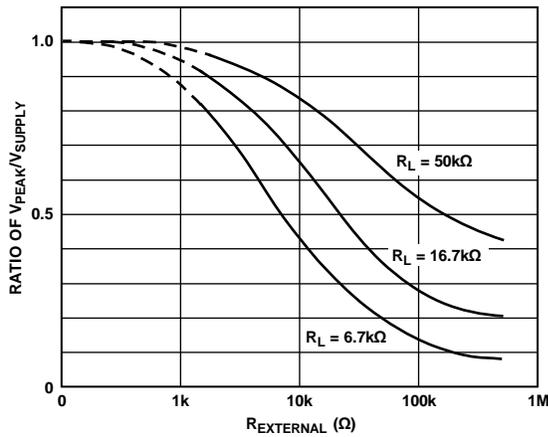# TYPICAL PERFORMANCE CHARACTERISTICS

Figure 4. Ratio of Peak Negative Swing to −V_S vs. $R_{EXTERNAL}$
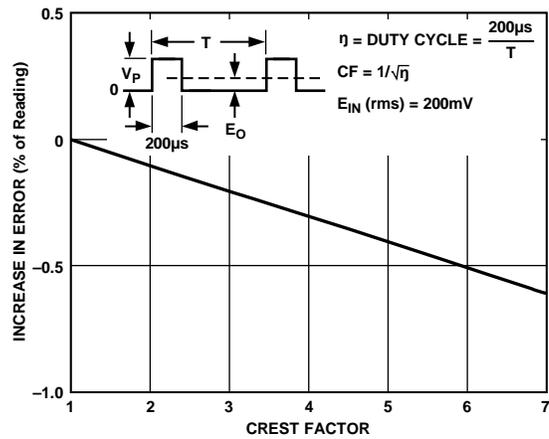for Several Load Resistances

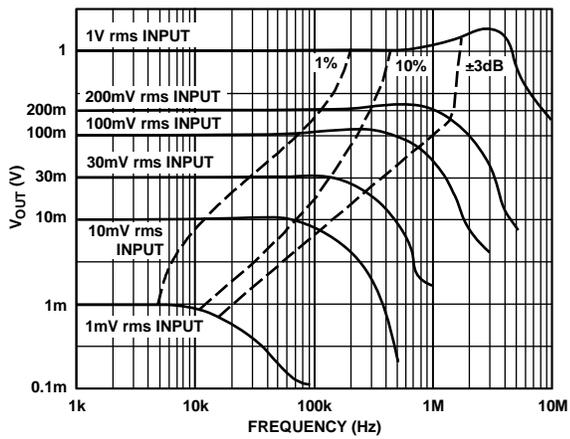Figure 6. Error vs. Crest Factor

Figure 5. AD636 Frequency Response

THEORY OF OPERATION

RMS MEASUREMENTS

The AD636 embodies an implicit solution of the rms equation that overcomes the dynamic range as well as other limitations inherent in a straightforward computation of rms. The actual computation performed by the AD636 follows the equation:

$$V\,rms = Avg \times \left[\frac{V_{IN}^{\,2}}{V\,rms} \right]$$

The AD636 is comprised of four major sections: absolute value circuit (active rectifier), squarer/divider, current mirror, and buffer amplifier (see Figure 7, for a simplified schematic). The input voltage, V_{IN}, which can be ac or dc, is converted to a unipolar current I1, by the active rectifier A1, A2. I1 drives one input of the squarer/divider, which has the transfer function:

$$I4 = \frac{I1^2}{I3}$$

The output current, I4, of the squarer/divider drives the current mirror through a low-pass filter formed by R1 and the externally connected capacitor, C_{AV}. If the R1, C_{AV} time constant is much greater than the longest period of the input signal, then I4 is effectively averaged. The current mirror returns a current I3, which equals Avg. [I4], back to the squarer/divider to complete the implicit rms computation. Therefore,

$$I4 = Avg \times \left[\frac{I2^2}{I4} \right] = I1\,rms$$

The current mirror also produces the output current, I_{OUT}, which equals 2I4. I_{OUT} can be used directly or converted to a voltage with R2 and buffered by A4 to provide a low impedance voltage output. The transfer function of the AD636 thus results

$$V_{OUT} = 2\,R2\,I\,rms = V_{IN}\,rms$$

The dB output is derived from the emitter of Q_3, because the voltage at this point is proportional to $-\log V_{IN}$. Emitter follower, Q5, buffers and level shifts this voltage, so that the dB output voltage is zero when the externally supplied emitter current (I_{REF}) to Q5 approximates I3.
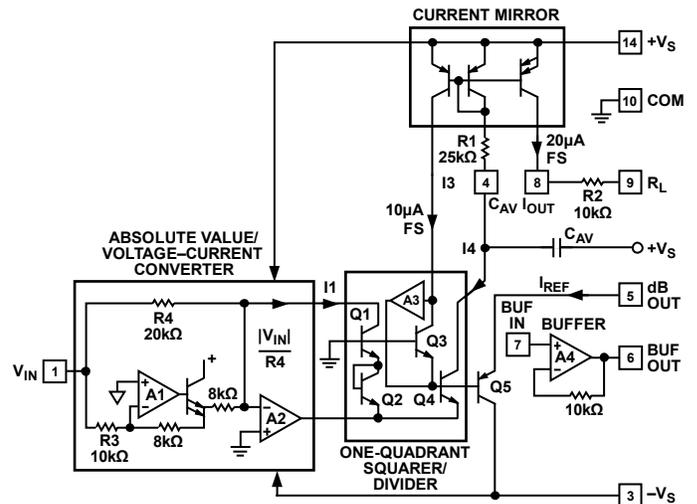

Figure 7. Simplified Schematic

THE AD636 BUFFER AMPLIFIER

The buffer amplifier included in the AD636 offers the user additional application flexibility. It is important to understand some of the characteristics of this amplifier to obtain optimum performance. Figure 8 shows a simplified schematic of the buffer.

Because the output of an rms-to-dc converter is always positive, it is not necessary to use a traditional complementary Class AB output stage. In the AD636 buffer, a Class A emitter follower is used instead. In addition to excellent positive output voltage swing, this configuration allows the output to swing fully down to ground in single-supply applications without the problems associated with most IC operational amplifiers.
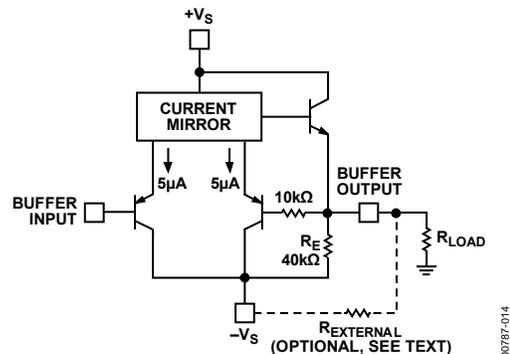

Figure 8. Buffer Amplifier Simplified Schematic

When this amplifier is used in dual-supply applications as an input buffer amplifier driving a load resistance referred to ground, steps must be taken to ensure an adequate negative voltage swing. For negative outputs, current flows from the load resistor through the 40 kΩ emitter resistor, setting up a voltage divider between $-V_S$ and ground. This reduced effective $-V_S$, limits the available negative output swing of the buffer. The addition of an external resistor in parallel with R_E alters this voltage divider such that increased negative swing is possible.

Figure 4 shows the value of $R_{EXTERNAL}$ for a particular ratio of V_{PEAK} to $-V_S$ for several values of R_{LOAD}. The addition of $R_{EXTERNAL}$ increases the quiescent current of the buffer amplifier by an amount equal to $R_{EXT}/-V_S$. Nominal buffer quiescent current with no $R_{EXTERNAL}$ is 30 µA at $-V_S = -5$ V.

FREQUENCY RESPONSE

The AD636 uses a logarithmic circuit to perform the implicit rms computation. As with any log circuit, bandwidth is proportional to signal level. The solid lines in Figure 5 represent the frequency response of the AD636 at input levels from 1 mV to 1 V rms. The dashed lines indicate the upper frequency limits for 1%, 10%, and ±3 dB of reading additional error. For example, note that a 1 V rms signal produces less than 1% of reading additional error up to 220 kHz. A 10 mV signal can be measured with 1% of reading additional error (100 µV) up to 14 kHz.

AC MEASUREMENT ACCURACY AND CREST FACTOR (CF)

Crest factor is often overlooked in determining the accuracy of an ac measurement. Crest factor is defined as the ratio of the peak signal amplitude to the rms value of the signal (CF = V_P/V rms). Most common waveforms, such as sine and triangle waves, have relatively low crest factors (<2). Waveforms that resemble low duty cycle pulse trains, such as those occurring in switching power supplies and SCR circuits, have high crest factors. For example, a rectangular pulse train with a 1% duty cycle has a crest factor of 10 (CF = $1/\sqrt{\eta}$).

Figure 6 is a curve of reading error for the AD636 for a 200 mV rms input signal with crest factors from 1 to 7. A rectangular pulse train (pulse width 200 µs) was used for this test because it is the worst-case waveform for rms measurement (all the energy is contained in the peaks). The duty cycle and peak amplitude were varied to produce crest factors from 1 to 7 while maintaining a constant 200 mV rms input amplitude.

APPLICATIONS

The input and output signal ranges are a function of the supply voltages as detailed in the specifications. The AD636 can also be used in an unbuffered voltage output mode by disconnecting the input to the buffer. The output then appears unbuffered across the 10 kΩ resistor. The buffer amplifier can then be used for other purposes. Further, the AD636 can be used in a current output mode by disconnecting the 10 kΩ resistor from the ground. The output current is available at Pin 8 (Pin 10 on the H package) with a nominal scale of 100 μA per volt rms input, positive out.

STANDARD CONNECTION

The AD636 is simple to connect for the majority of high accuracy rms measurements, requiring only an external capacitor to set the averaging time constant. The standard connection is shown in Figure 9 In this configuration, the AD636 measures the rms of the ac and dc level present at the input but shows an error for low frequency inputs as a function of the filter capacitor, C_{AV}, as shown in Figure 13. Therefore, if a 4 μF capacitor is used, the additional average error at 10 Hz is 0.1%, and at 3 Hz it is 1%. The accuracy at higher frequencies is according to specification. If it is desired to reject the dc input, a capacitor is added in series with the input, as shown in Figure 11; the capacitor must be nonpolar. If the AD636 is driven with power supplies with a considerable amount of high frequency ripple, it is advisable to bypass both supplies to ground with 0.1 μF ceramic discs as near the device as possible. C_F is an optional output ripple filter.
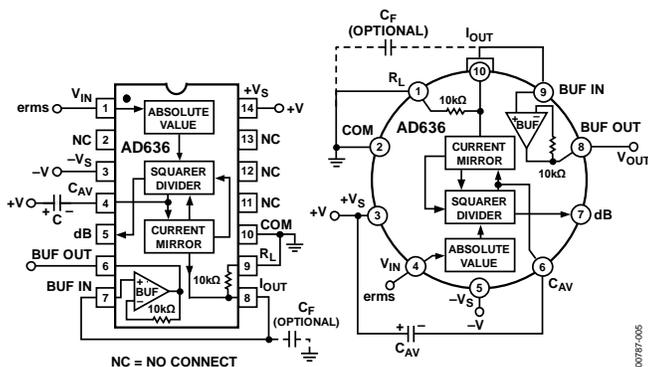

Figure 9. Standard RMS Connection

OPTIONAL TRIMS FOR HIGH ACCURACY

If it is desired to improve the accuracy of the AD636, the external trims shown in Figure 10 can be added. R4 is used to trim the offset. The scale factor is trimmed by using R1 as shown. The insertion of R2 allows R1 to either increase or decrease the scale factor by ±1.5%.

The trimming procedure is as follows:

- Ground the input signal, V_{IN}, and adjust R4 to give 0 V output from Pin 6. Alternatively, R4 can be adjusted to give the correct output with the lowest expected value of V_{IN}.

- Connect the desired full-scale input level to V_{IN}, either dc or a calibrated ac signal (1 kHz is the optimum frequency); then trim R1 to give the correct output from Pin 6, that is, 200 mV dc input should give 200 mV dc output. Of course, a ±200 mV peak-to-peak sine wave should give a 141.4 mV dc output. The remaining errors, as given in the specifications, are due to the nonlinearity.
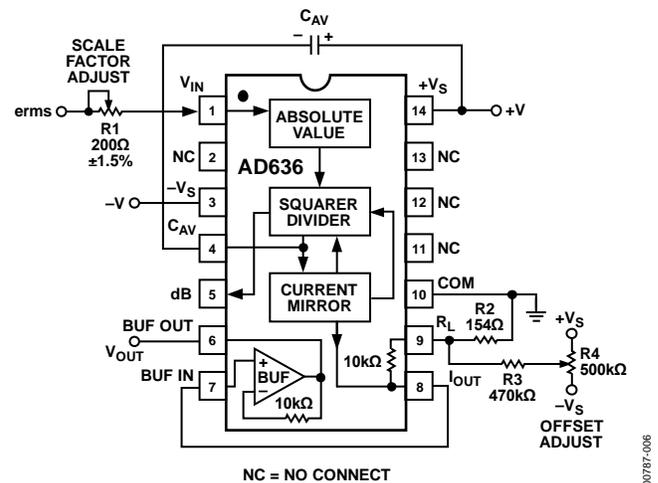

Figure 10. Optional External Gain and Output Offset Trims

SINGLE-SUPPLY CONNECTION

Although the applications illustrated in Figure 9 and Figure 10 assume the use of dual power supplies, three external bias components connected to the COM pin enable powering the AD636 with unipolar supplies as low as 5 V. The two resistors and capacitor network shown connected to Pin 10 in Figure 11 are satisfactory over the same range of voltages permissible with dual supply operation. Any external bias voltage applied to Pin 10 is internally reflected to the VIN pin, rendering the same ac operation as with a dual supply. DC or ac + dc conversion is impractical, due to the resultant dc level shift at the input. The capacitor insures that no extraneous signals are coupled into the COM pin. The values of the resistors are relatively high to minimize power consumption because only 1 μA of bias current flows into Pin 10 (Pin 2 on the H package).

Alternately, the COM pin of some CMOS ADCs provides a suitable artificial ground for the AD636. AC input coupling requires only Capacitor C2 as shown; a dc return is not necessary because it is provided internally. C2 is selected for the proper low frequency break point with the input resistance of 6.7 kΩ; for a cut-off at 10 Hz, C2 should be 3.3 μF. The signal ranges in this connection are

slightly more restricted than in the dual supply connection. The load resistor, R_L, is necessary to provide current sinking capability.
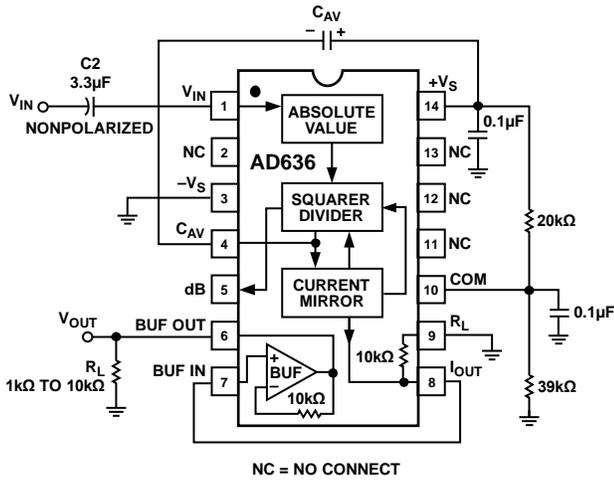

Figure 11. Single-Supply Connection (See Text)

CHOOSING THE AVERAGING TIME CONSTANT

The AD636 computes the rms of both ac and dc signals. If the input is a slowly varying dc voltage, the output of the AD636 tracks the input exactly. At higher frequencies, the average output of the AD636 approaches the rms value of the input signal. The actual output of the AD636 differs from the ideal output by a dc (or average) error and some amount of ripple, as demonstrated in Figure 12.
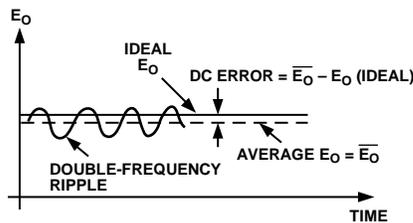

Figure 12. Typical Output Waveform for Sinusoidal Input

The dc error is dependent on the input signal frequency and the value of C_{AV}. Figure 13 can be used to determine the minimum value of C_{AV}, which yields a given % dc error above a given frequency using the standard rms connection.

The ac component of the output signal is the ripple. There are two ways to reduce the ripple. The first method involves using a large value of C_{AV}. Because the ripple is inversely proportional to C_{AV}, a tenfold increase in this capacitance effects a tenfold reduction in ripple. When measuring waveforms with high crest factors (such as low duty cycle pulse trains), the averaging time constant should be at least ten times the signal period. For example, a 100 Hz pulse rate requires a 100 ms time constant, which corresponds to a 4 μF capacitor (time constant = 25 ms per μF).
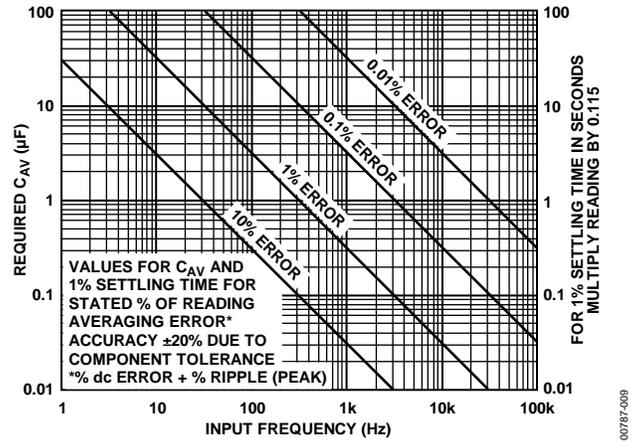

Figure 13. Error/Settling Time Graph for Use with the Standard RMS Connection

The primary disadvantage in using a large C_{AV} to remove ripple is that the settling time for a step change in input level is increased proportionately. Figure 13 shows the relationship between C_{AV} and 1% settling time is 115 ms for each microfarad of C_{AV}. The settling time is twice as great for decreasing signals as for increasing signals (the values in Figure 13 are for decreasing signals). Settling time also increases for low signal levels, as shown in Figure 14.
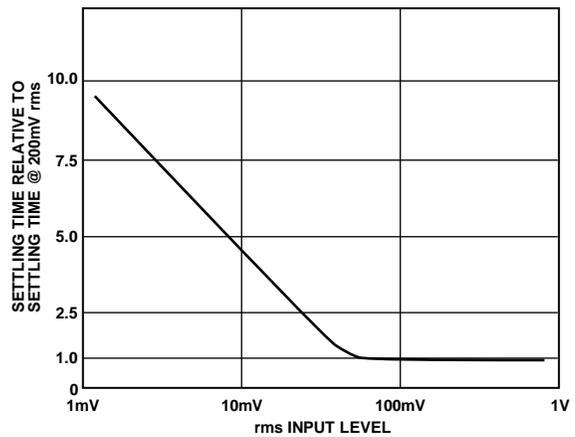

Figure 14. Settling Time vs. Input Level

A better method for reducing output ripple is the use of a post-filter. Figure 15 shows a suggested circuit. If a single-pole filter is used (C3 removed, R_X shorted), and C2 is approximately 5 times the value of C_{AV}, the ripple is reduced, as shown in Figure 16, and the settling time is increased. For example, with C_{AV} = 1 μF and C2 = 4.7 μF, the ripple for a 60 Hz input is reduced from 10% of reading to approximately 0.3% of reading. The settling time, however, is increased by approximately a factor of 3. The values of C_{AV} and C2 can therefore be reduced to permit faster settling times while still providing substantial ripple reduction.

The 2-pole post filter uses an active filter stage to provide even greater ripple reduction without substantially increasing the settling times over a circuit with a 1-pole filter. The values of C_{AV}, C2, and C3 can then be reduced to allow extremely fast settling times for a constant amount of ripple. Caution should be exercised in choosing the value of C_{AV}, because the dc error is dependent upon this value and is independent of the post filter. For a more detailed explanation of these topics, refer to the *RMS-to-DC Conversion Application Guide, 2nd Edition*.
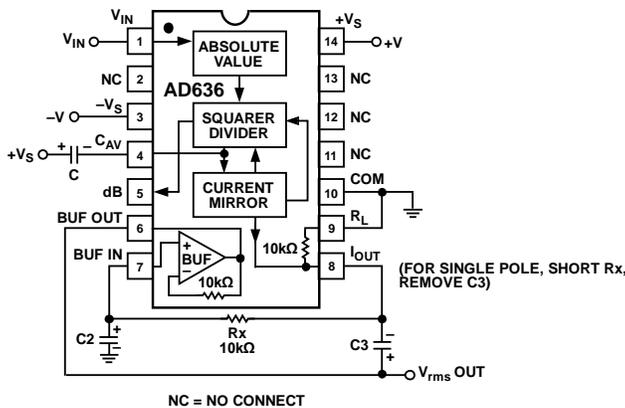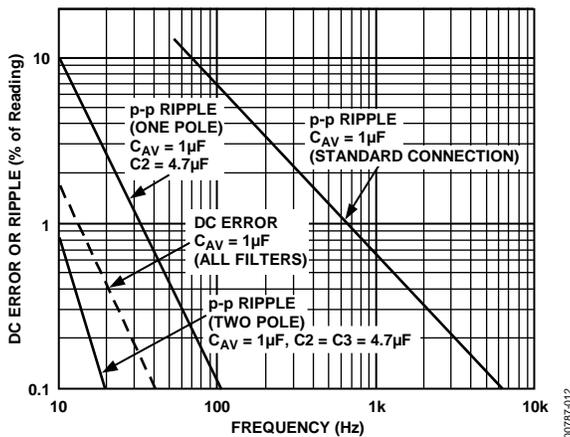

Figure 15. 2-Pole Post Filter

Figure 16. Performance Features of Various Filter Types

A COMPLETE AC DIGITAL VOLTMETER

Figure 17 shows a design for a complete low power ac digital voltmeter circuit based on the AD636. The 10 MΩ input attenuator allows full-scale ranges of 200 mV, 2 V, 20 V, and 200 V rms. Signals are capacitively coupled to the AD636 buffer amplifier, which is connected in an ac bootstrapped configuration to minimize loading. The buffer then drives the 6.7 kΩ input impedance of the AD636. The COM terminal of the ADC provides the false ground required by the AD636 for single-supply operation. An AD589 1.2 V reference diode is used to provide a stable 100 mV reference for the ADC in the linear rms mode; in the dB mode, a 1N4148 diode is inserted in series to provide correction for the temperature coefficient of the dB scale factor. Adjust R13 to calibrate the meter for an accurate readout at full scale.

Calibration of the dB range is accomplished by adjusting R9 for the desired 0 dB reference point, and then adjusting R14 for the desired dB scale factor (a scale of 10 counts per dB is convenient).

Total power supply current for this circuit is typically 2.8 mA using a 7106-type ADC.

A LOW POWER, HIGH INPUT, IMPEDANCE dB METER

The portable dB meter circuit combines the functions of the AD636 rms converter, the AD589 voltage reference, and a μA776 low power operational amplifier (see Figure 18). This meter offers excellent bandwidth and superior high and low level accuracy while consuming minimal power from a standard 9 V transistor radio battery.

In this circuit, the built-in buffer amplifier of the AD636 is used as a bootstrapped input stage increasing the normal 6.7 kΩ input Z to an input impedance of approximately 10^{10} Ω.

Circuit Description

The input voltage, V_{IN}, is ac-coupled by C4 while R8, together with D1 and D2, provide high input voltage protection.

The buffer's output, Pin 6, is ac-coupled to the rms converter's input (Pin 1) by capacitor C2. Resistor R9 is connected between the buffer's output, a Class A output stage, and the negative output swing. Resistor R1 is the amplifier's bootstrapping resistor.

With this circuit, single-supply operation is made possible by setting ground at a point between the positive and negative sides of the battery. This is accomplished by sending 250 μA from the positive battery terminal through R2, then through the 1.2 V AD589 band gap reference, and finally back to the negative side of the battery via R10. This sets ground at 1.2 V + 3.18 V (250 μA × 12.7 kΩ) = 4.4 V below the positive battery terminal and 5.0 V (250 μA × 20 kΩ) above the negative battery terminal. Bypass capacitors, C3 and C5, keep both sides of the battery at a low ac impedance to ground. The AD589 band gap reference establishes the 1.2 V regulated reference voltage, which together with R3 and trimming Potentiometer R4, sets the 0 dB reference current, I_{REF}.

Performance Data

0 dB Reference Range = 0 dBm (770 mV) to −20 dBm (77 mV) rms
0 dBm = 1 mW in 600 Ω
Input Range (at I_{REF} = 770 mV) = 50 dBm
Input Impedance = approximately 10^{10} Ω
V_{SUPPLY} Operating Range = +5 V dc to +20 V dc
$I_{QUIESCENT}$ = 1. 8 mA typical
Accuracy with 1 kHz sine wave and 9 V dc supply:

   0 dB to −40 dBm ± 0.1 dBm
   0 dBm to −50 dBm ± 0.15 dBm
   +10 dBm to −50 dBm ± 0.5 dBm

Frequency Response ±3 dBm

Input

0 dBm = 5 Hz to 380 kHz
−10 dBm = 5 Hz to 370 kHz
−20 dBm = 5 Hz to 240 kHz
−30 dBm = 5 Hz to 100 kHz
−40 dBm = 5 Hz to 45 kHz
−50 dBm = 5 Hz to 17 kHz

Calibration

First, calibrate the 0 dB reference level by applying a 1 kHz sine wave from an audio oscillator at the desired 0 dB amplitude.

This can be anywhere from 0 dBm (770 mV rms – 2.2 V p-p) to −20 dBm (77 mV rms – 220 mV p-p). Adjust the I_{REF} calibration trimmer for a zero indication on the analog meter.

Then, calibrate the meter scale factor or gain. Apply an input signal −40 dB below the set 0 dB reference and adjust the scale factor calibration trimmer for a 40 μA reading on the analog meter.

The temperature compensation resistors for this circuit can be purchased from Micro-Ohm Corporation, 1088 Hamilton Rd., Duarte, CA 91010, Part #Type 401F, 2 kΩ ,1% + 3500 ppm/°C.
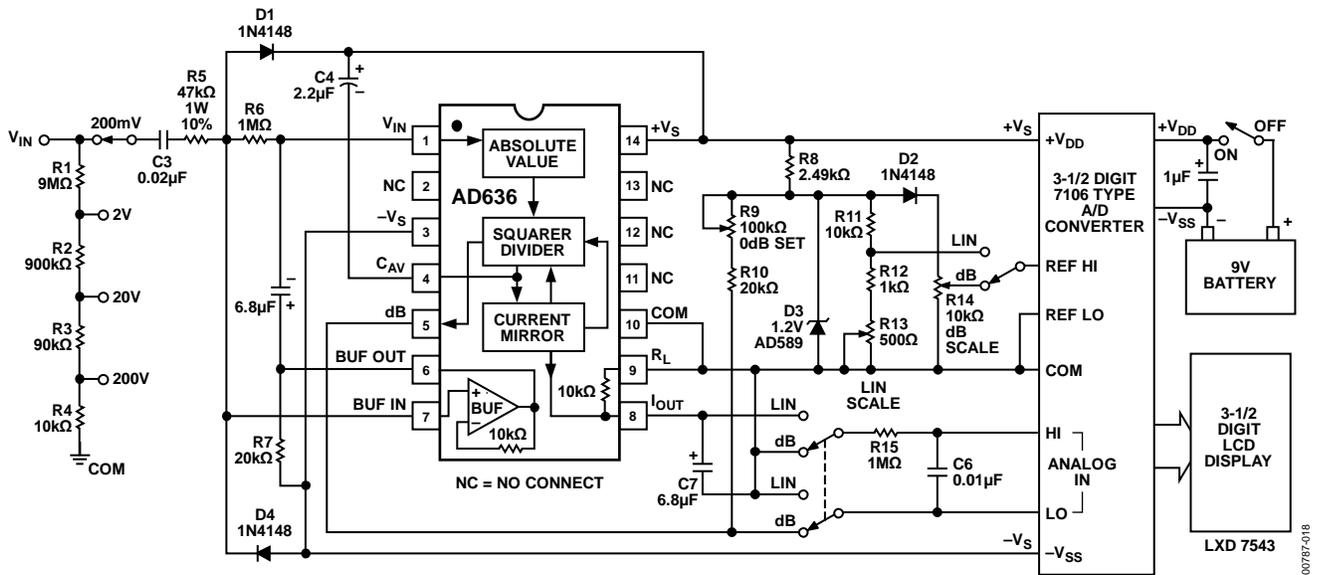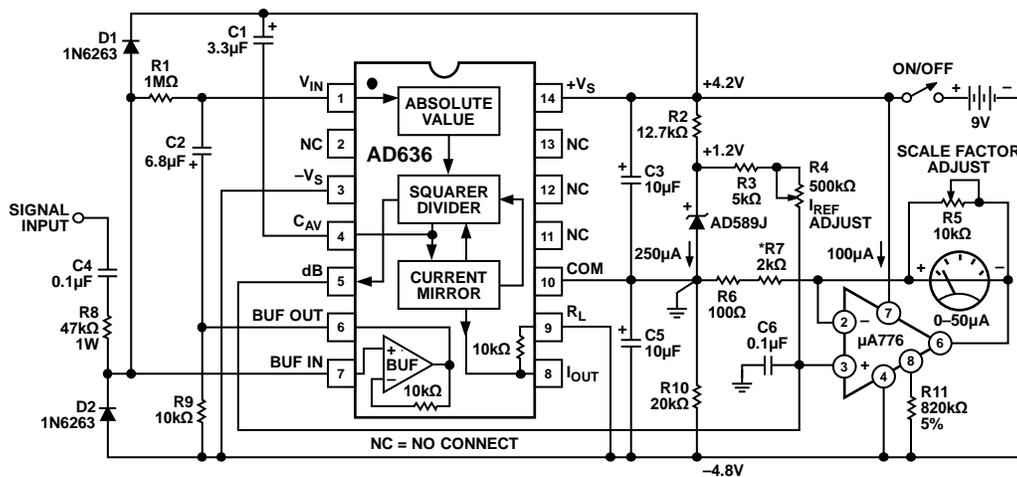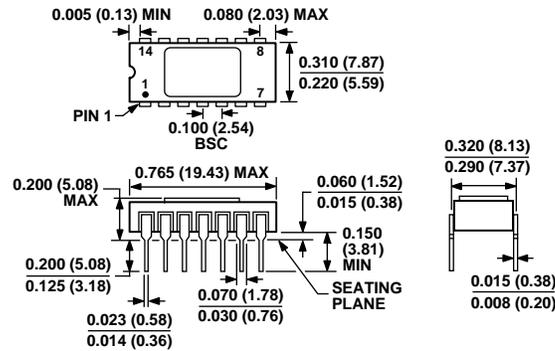

Figure 17. Portable, High-Z Input, RMS DPM and dB Meter Circuit

ALL RESISTORS 1/4W 1% METAL FILM UNLESS OTHERWISE STATED EXCEPT
*WHICH IS 2kΩ +3500ppm 1% TC RESISTOR.
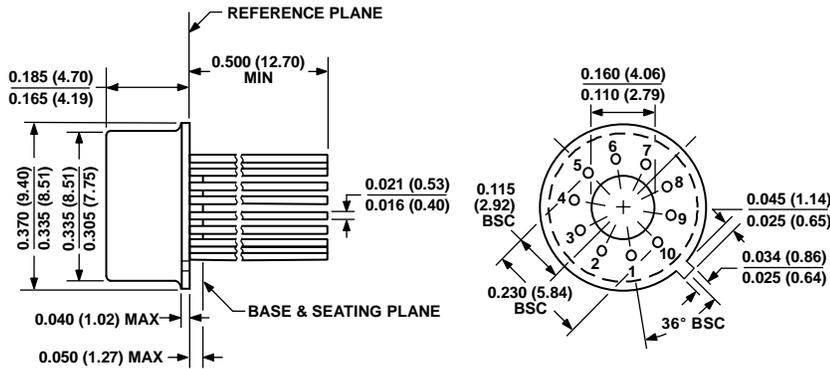
Figure 18. Low Power, High Input Impedance dB Meter

OUTLINE DIMENSIONS

Figure 19. 14-Lead Side-Brazed Ceramic Dual In-Line Package [SBDIP]
(D-14)
Dimensions shown in inches and (millimeters)

Figure 20. 10-Pin Metal Header Package [TO-100]
(H-10)
Dimensions shown in inches and (millimeters)

ORDERING GUIDE

Model[1]	Temperature Range	Package Description	Package Option
AD636JDZ	0°C to +70°C	14-Lead SBDIP	D-14
AD636KDZ	0°C to +70°C	14-Lead SBDIP	D-14
AD636JH	0°C to +70°C	10-Pin TO-100	H-10
AD636JHZ	0°C to +70°C	10-Pin TO-100	H-10
AD636KH	0°C to +70°C	10-Pin TO-100	H-10
AD636KHZ	0°C to +70°C	10-Pin TO-100	H-10

[1] Z = RoHS-Compliant Part.

NOTES

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www.analog.com