ANALOG DEVICES

Low Level, True RMS-to-DC Converter

AD636

FEATURES

True rms-to-dc conversion
200 mV full scale
Laser-trimmed to high accuracy
- **0.5% max error (AD636K)**
- **1.0% max 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
Available in chip form

FUNCTIONAL BLOCK DIAGRAM

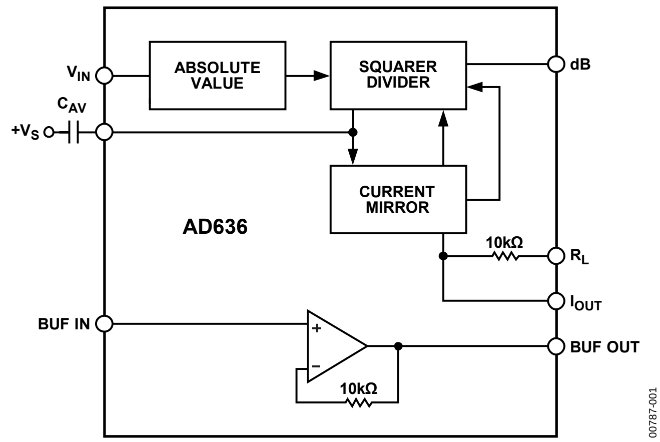

Figure 1.

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, allows it to be used in battery-powered portable instruments. A wide range of power supplies can be used, from ±2.5 V to ±16.5 V or a single +5 V to +24 V supply. 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. This signal is 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 by the user 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 a 0 dBm level to over 10 kHz at −50 dBm.

The AD636 is designed for ease of 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.

The AD636 is available in two accuracy grades; the AD636J total error of ±0.5 mV ± 0.06% of reading, and the AD636K is accurate within ±0.2 mV to ±0.3% of reading. Both versions are specified for the 0°C to 70°C temperature range and are offered in either a 14-lead SBDIP or a 10-lead TO-100 metal can. Chips are also available.

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.

The only external component required to perform measurements to the fully specified accuracy is the averaging capacitor. Its value can be selected to optimize the trade-off between low frequency accuracy, ripple, and settling time.

The on-chip amplifier can be used to buffer either the input or the output. Used in the input it provides accurate performance from standard 10 MΩ input attenuators, and in the output, it can source up to 5 mA.

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Changes to Ordering Guide ... 14

8/99—Rev A to Rev. B

SPECIFICATIONS

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

Table 1.

Model	AD636J			AD636K			
	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		±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 CAV
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[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							
Offset Voltage, V_{IN} = COM			**±0.5**			**±0.2**	mV
vs. Temperature		±10			±10		mV/°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			
	Min	Typ	Max	Min	Typ	Max	Unit
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 trim, 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 N, R	−55°C to +150°C
Operating Temperature Range	
AD636J/AD636K	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. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

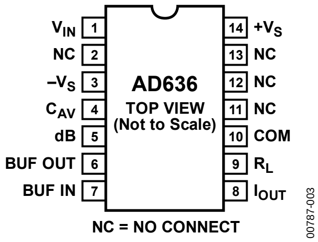


Figure 2. 14-Lead SBDIP Pin Configuration

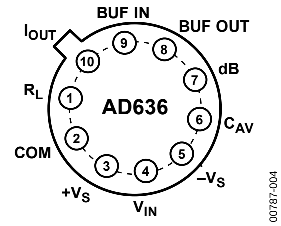


Figure 3. 10-Pin TO-100 Pin Configuration

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	BUFOUT	Buffer Output
7	BUFIN	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	BUFOUT	Buffer Output
9	BUFIN	Buffer Input
10	I_{OUT}	RMS Output Current

APPLYING THE AD636

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 4. 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 8. 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 will be 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 6; 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, as discussed elsewhere in this data sheet.

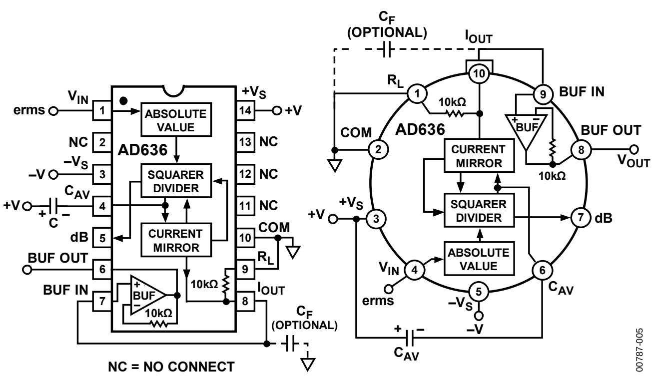


Figure 4. Standard RMS Connection

OPTIONAL TRIMS FOR HIGH ACCURACY

If it is desired to improve the accuracy of the AD636, the external trims shown in Figure 5 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.

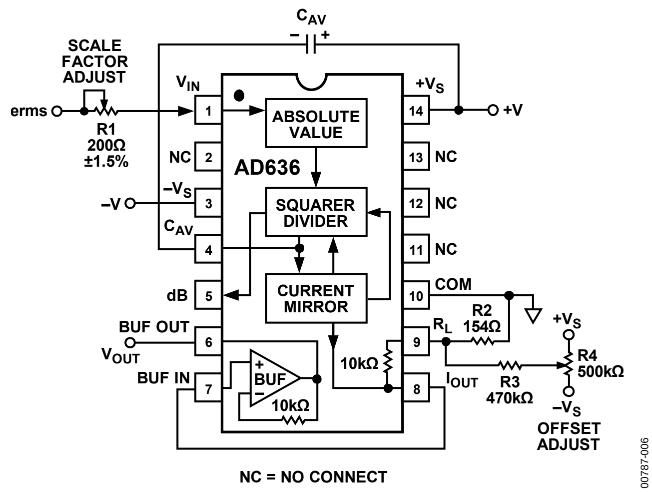


Figure 5. Optional External Gain and Output Offset Trims

SINGLE-SUPPLY CONNECTION

The applications in Figure 4 and Figure 5 assume the use of dual power supplies. The AD636 can also be used with only a single positive supply down to 5 V, as shown in Figure 6. Figure 6 is optimized for use with a 9 V battery. The major limitation of this connection is that only ac signals can be measured because the input stage must be biased off ground for proper operation. This biasing is done at Pin 10; therefore, it is critical that no extraneous signals be coupled into this point. Biasing can be accomplished by using a resistive divider between $+V_S$ and ground. The values of the resistors can be increased in the interest of lowered power consumption, because only 1 µA of 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 as 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.

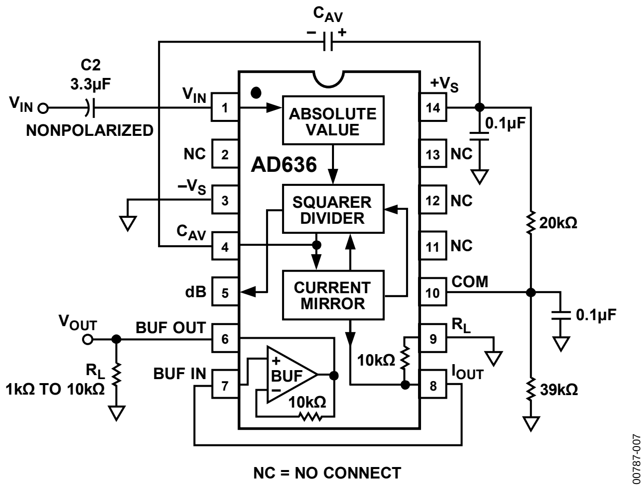


Figure 6. Single-Supply Connection

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 7.

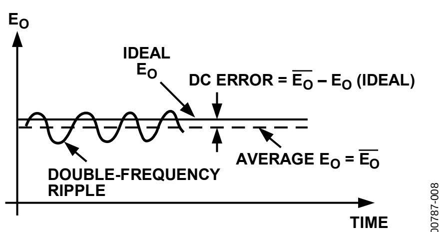


Figure 7. Typical Output Waveform for Sinusoidal Input

The dc error is dependent on the input signal frequency and the value of C_{AV}. Figure 8 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).

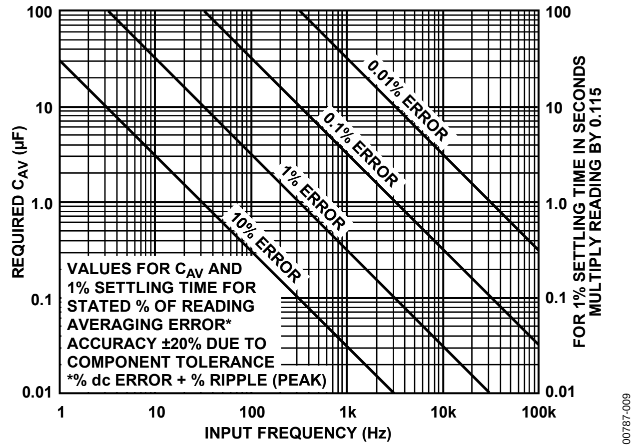


Figure 8. Error/Settling Time Graph for Use with the Standard RMS Connection

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 8 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 8 are for decreasing signals). Settling time also increases for low signal levels, as shown in Figure 9.

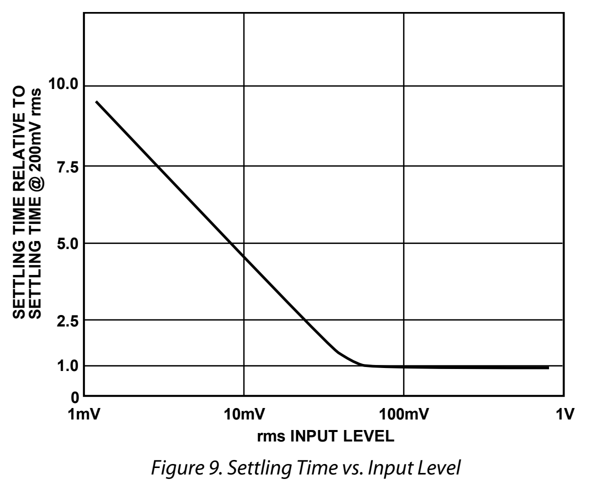


Figure 9. Settling Time vs. Input Level

A better method for reducing output ripple is the use of a post-filter. Figure 10 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 11, 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*.

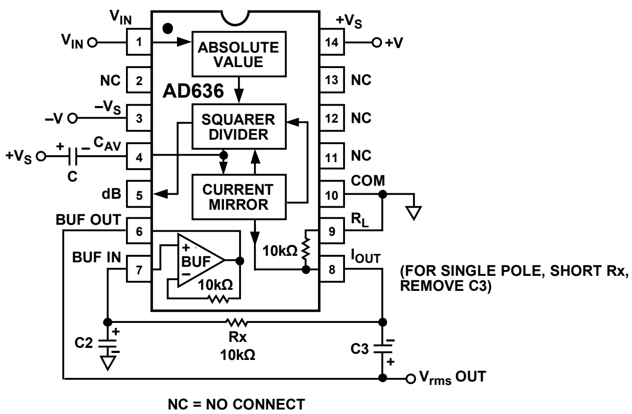


Figure 10. 2-Pole Post Filter

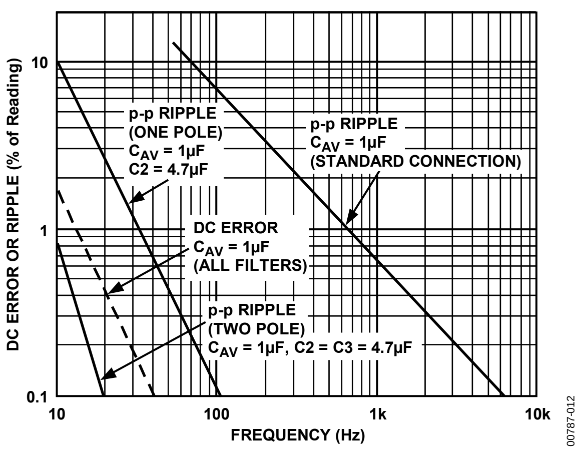


Figure 11. Performance Features of Various Filter Types

RMS MEASUREMENTS

AD636 Principle of Operation

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:

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

Figure 12 is a simplified schematic of the AD636; it is subdivided into four major sections: absolute value circuit (active rectifier), squarer/divider, current mirror, and buffer amplifier. 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.

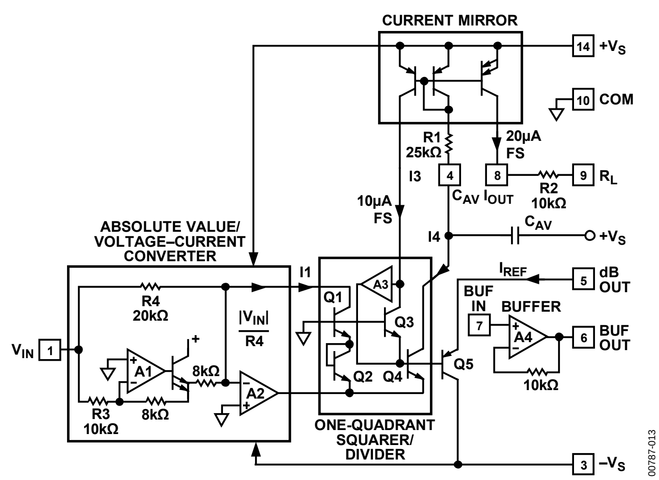


Figure 12. Simplified Schematic

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 13 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.

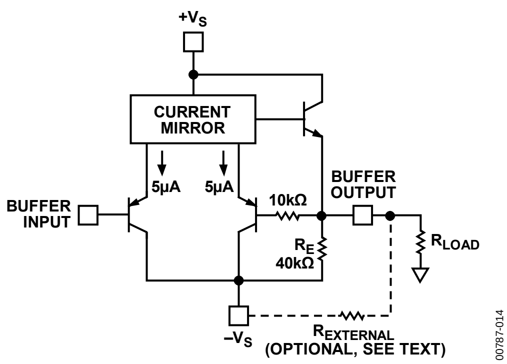


Figure 13. AD636 Buffer Amplifier Simplified Schematic

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. Addition of an external resistor in parallel with R_E alters this voltage divider such that increased negative swing is possible.

Figure 14 shows the value of $R_{EXTERNAL}$ for a particular ratio of V_{PEAK} to $-V_S$ for several values of R_{LOAD}. 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.

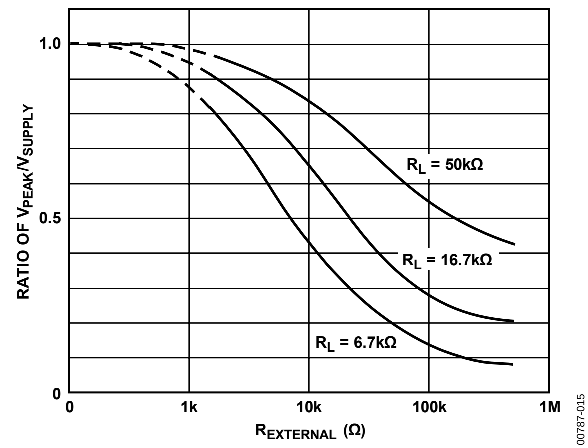


Figure 14. Ratio of Peak Negative Swing to $-V_S$ vs. $R_{EXTERNAL}$ for Several/Load Resistances

FREQUENCY RESPONSE

The AD636 uses a logarithmic circuit in performing the implicit rms computation. As with any log circuit, bandwidth is proportional to signal level. The solid lines in the graph below 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.

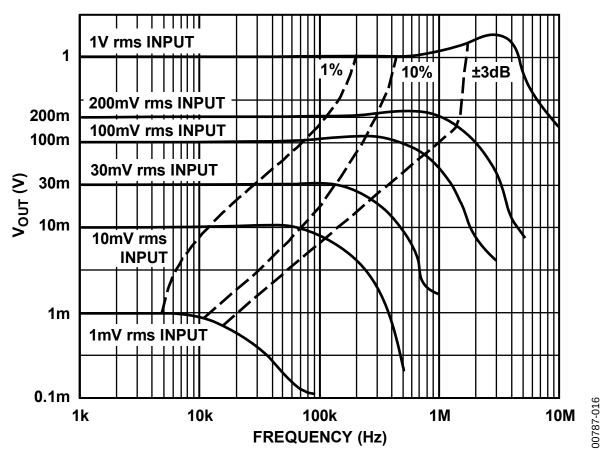


Figure 15. AD636 Frequency Response

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 16 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.

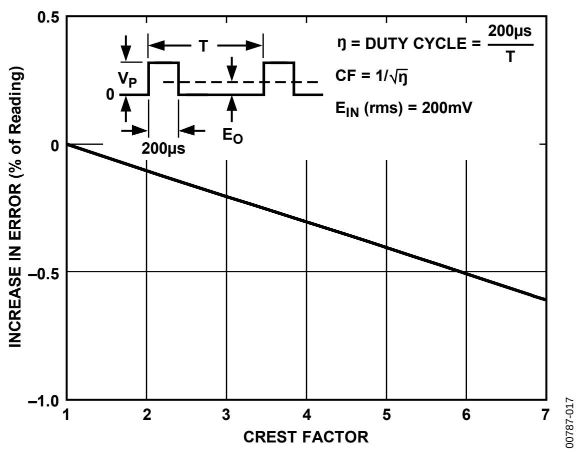


Figure 16. Error vs. Crest Factor

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 chip 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. Calibration of the meter is done by first adjusting offset pot R17 for a proper zero reading, then adjusting the R13 for an accurate readout at full scale.

Calibration of the dB range is accomplished by adjusting R9 for the desired 0 dB reference point, 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

Introduction

The portable dB meter circuit featured here combines the functions of the AD636 rms converter, the AD589 voltage reference, and a μA776 low power operational amplifier. 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}
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} cal 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.

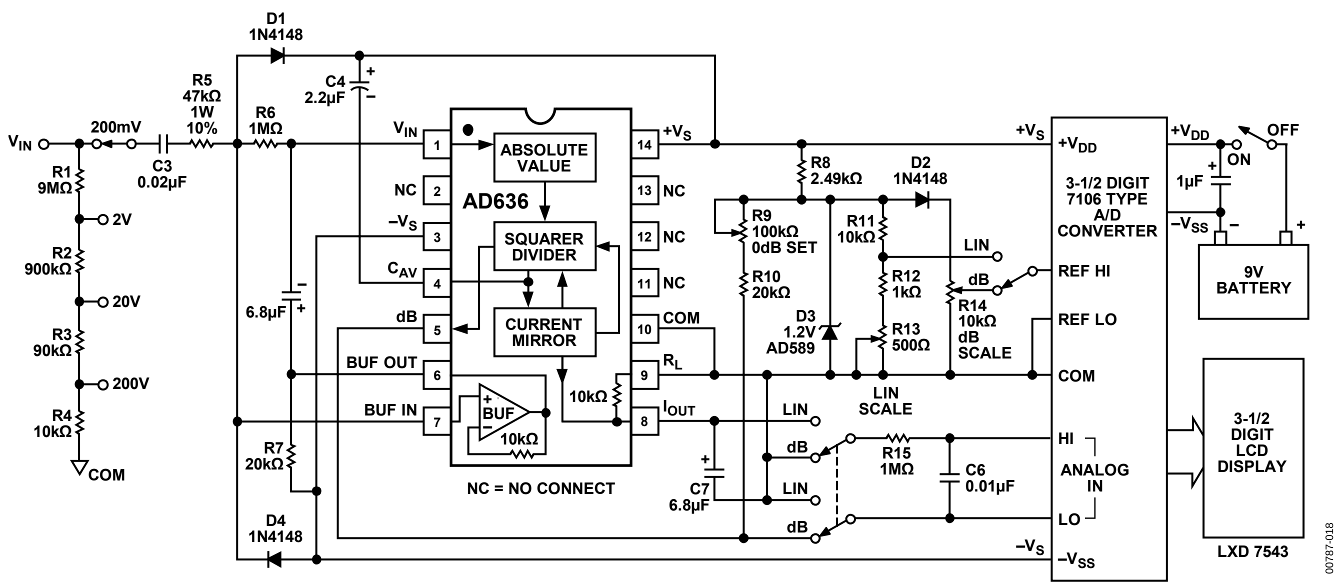


Figure 17. A Portable, High-Z Input, RMS DPM and dB Meter Circuit

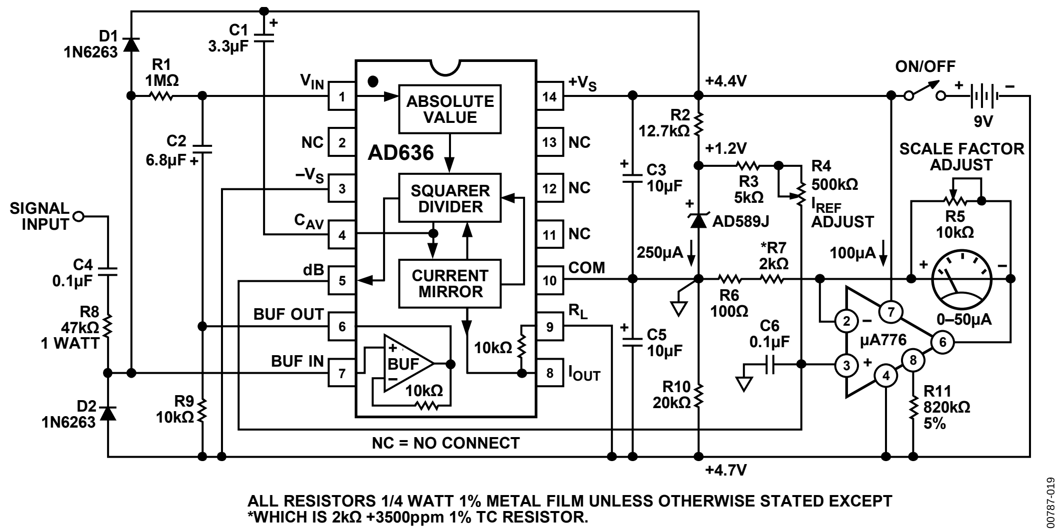
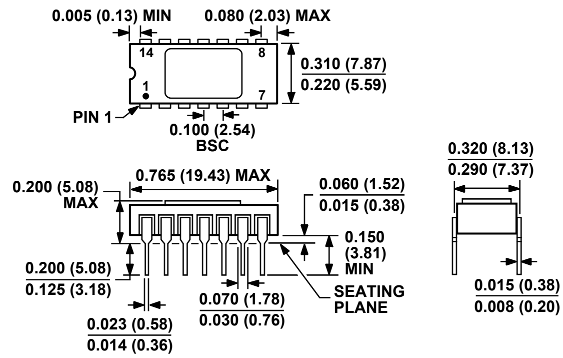


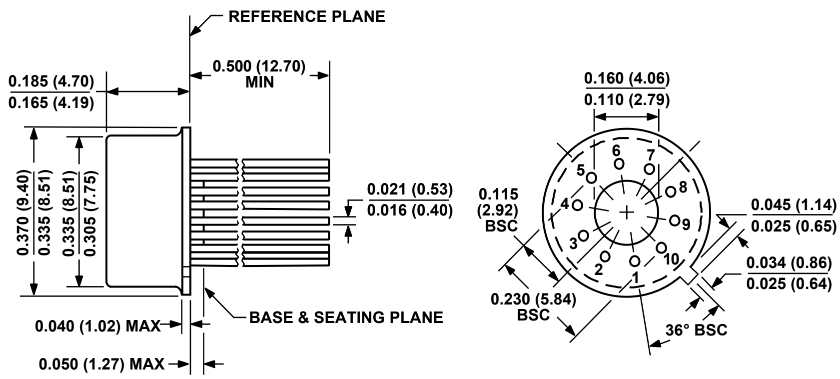
Figure 18. A Low Power, High Input Impedance dB Meter

OUTLINE DIMENSIONS



CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

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



DIMENSIONS PER JEDEC STANDARDS MO-006-AF
CONTROLLING DIMENSIONS ARE IN INCHES; MILLIMETER DIMENSIONS (IN PARENTHESES) ARE ROUNDED-OFF INCH EQUIVALENTS FOR REFERENCE ONLY AND ARE NOT APPROPRIATE FOR USE IN DESIGN.

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

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
AD636JD	0°C to +70°C	14-Lead SBDIP	D-14
AD636KD	0°C to +70°C	14-Lead SBDIP	D-14
AD636JH	0°C to +70°C	10-Pin TO-100	H-10
AD636KH	0°C to +70°C	10-Pin TO-100	H-10

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