承永資訊科技
CYRUSTEK CO.

ES636

True RMS-to-DC Converters

Features

- True RMS-to-DC Conversion
- Computes RMS of AC and DC Signals
- Wide Response:

  * 1MHz Bandwidth for V_{RMS} > 100mV
- Auxiliary dB Output:

  * 60dB Range
- Single-or Dual-Supply Operation
- Low Cost
- Power-Down Function
- Low Power:

  800 μA typical

Description

The ES636 is a true RMS-to-DC converter. It accepts low-level input signals from 0 to 400 mV $_{RMS}$ complex input waveforms. It can be operated form either a single supply or dual supplies. The device draws less than 1 mA of quiescent supply current, furthermore, an enable pin is provided to turn-off the device, making it ideal for battery-powered applications.

Application

* Digital Multi-Meters
* Battery-Powered Instruments
* Panel Meter

Pin Assignment

SOP 14 Pin Package

Pin Description

Pin No	Symbol	Type	Description
1	Vin	I	Measurement input
2	$\overline{\text{Enable}}$	I	Chip enable, active LOW
3	-Vs	P	Negative supply voltage
4	Cav	IO	Averaging capacitor
5	dB	IO	DB out
6	BUF OUT	O	Buffer output
7	BUF IN	I	Buffer input
8	Iout	O	Rms output
9	R_L	IO	R_L terminal, connected to COMMON in general
10	COMMON	G	Analog ground
11	N.C.		
12	N.C.		
13	N.C		
14	+Vs	P	Positive supply voltage

Absolute Maximum Ratings

Supply Voltage: Dual Supplies ..... ± 10V

Single Supply .....+20V

Input Voltage: ..... ± 10V

Power Dissipation (Package)

SOP.....450mW

Operating Temperature Range .....0℃ to +70℃

Storage Temperature Range.....-55℃ to +150℃

Lead Temperature (Soldering, 10sec).....300℃

Electrical Characteristics-ES636

(T_A= +25℃, Vs = +3V, -Vs = -3V, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Transfer Equation				V_{OUT} = [avg.(V_{IN})2]$^{1/2}$		
Averaging Time Constant	Figure 3			6		ms/ μF C_{AV}
CONVERSION ACCURACY						
Total Error, Internal Trim (Notes 1,2)					±0.5 ±1.0	mV ±% of Reading
Total Error vs. Temperature (0℃ to + 70℃)					±0.1 ±0.01	mV ±% of Reading/℃
Total Error vs. Supply				±0.1 ±0.01		mV ±% of Reading/V
Total Error vs. DC Reversal	VIN=400mV			±0.2		±% of Reading
Total Error, External Trim (Note 1)				±0.3 ±0.1		mV ±% of Reading

Electrical Characteristics-ES636(continued)

(T_A= +25℃, Vs = +3V, -Vs = -3V, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
ERROR vs. CREST FACTOR						
Additional Error	Crest Factor 1 to 2			Specified Accuracy		±% of Reading
	Crest Factor = 3			-0.2		
	Crest Factor = 6			-0.5		
FREQUENCY RESPONSE (Note 2,4)						
Bandwidth for 1% Additional Error (0.09dB)	V_{IN} =35mV			75		kHz
	V_{IN}=100mV			99		
	V_{IN} =400mV			560		
±3dB Bandwidth	V_{IN} =35mV			1.1		MHz
	V_{IN} =100mV			2.5		
	V_{IN} =400mV			6.5		MHz
INPUT CHARACTERISTICS						
Input Signal range	Continuous RMS, All Supplies			0 to 400		mV_{RMS}
	Peak Transient	+3V, -5V Supplies			±2.8	V_{PK}
		±2.5V Supplies			±2	
		±5V Supplies			±5	
Safe Input	All Supplies				±12	V_{PK}
Input Resistance			5.33	6.7	8	kΩ
Input Offset Voltage					±0.5	mV
OUTPUT CHARACTERISTICS (Note 1)						
Offset Voltage	T_A=+25℃				±0.5	mV
	T_A =T_{MIN} to T_{MAX}			±10		μV/℃
	With Supply Voltage			±0.1		mV/V
Output Voltage Swing	+3V, -3V Supplies		0 to 2			V
	±5V to ±10V Supplies		0 to 1	1.5		
Output Resistance			8	10	12	kΩ
dB OUTPUT						
ERROR	3mV ≦V_{IN} ≦1.5V			±0.3	±0.5	dB
Scale Factor				-3		mV/dB
Scale Factor Tempco						%/℃
						dB/℃
I_{REF}	0dB=0.11V_{RMS}		2	4	8	μA
I_{REF} Range			1		50	μA
I_{OUT} TERMINAL						
I_{OUT} Scale Factor				125		μA/V_{RMS}
I_{OUT} Scale Factor Tolerance			-20	±10	±20	%
Output Resistance			8	10	12	kΩ
Voltage Compliance				-Vs to (+Vs-2.0)		V
BUFFER AMPLIFIER						
Input and Output Voltage Range				-Vs to (+Vs-2.0)		V
Input Offset Voltage	Rs=10kΩ			±0.8	±2	mV
Input Current				100	300	nA
Input Resistance				108		Ω
Output Current	Source		+2			mA
	Sink		-130			μA
Short-Circuit Current				20		mA
Small-Signal Bandwidth				1		MHz
Slew Rate (Note 5)				3		V/μs

Electrical Characteristics-ES636(continued)

(T_A= +25℃, Vs = +3V, -Vs = -3V, unless otherwise noted.)

Power SUPPLY					
Rated Performance		+3/-3			V
Dual Supplies		+2/-2.5		±10	V
Single Supply		+5		+20	V
Quiescent Current (Note 6)			0.8	1	mA

Note 1: Accuracy is specified for 0 to 400mV, DC or 1kHz sine-wave input. Accuracy is degraded at higher RMS signal levels.

Note 2: Measured at pin 8 (I_{OUT}), with pin 9 tied to COMMON.

Note 3: Error vs. crest factor is specified as an additional error for 200mV_{RMS} rectangular pulse input, pulse width = 200 μs.

Note 4: Input voltages are expressed in volts RMS.

Note 5: With 10 kΩ external pull-down resistor from pin 6 (BUF OUT) to – Vs.

Note 6: With BUF input tied to COMMON.

Detailed Description

Figure 1 shows the simplified schematic of ES636. It consists of four major subcircuits: absolute value circuit (rectifier), square/divider, current mirror and buffer amplifier. The actual computation performed by the ES636 follows the equation:

$$V_{RMS} = \text{Avg.}\ [V_{IN}2 / V_{RMS}]$$

The input voltage, V_{IN}, applied to the ES636 is converted to a unipolar current I_1 (Figure 1) by the absolute-value/voltage. This current drives one input of the squarer/divider that produces a current I_4 , which has the transfer function:

$$I_4 = \frac{I_1^2}{I_3}$$

The current I_4 drives the internal current mirror through a low-pass filter formed by R1 and the external capacitor, C_{AV}. As long as the time constant of this filter is greater than the longest period of the input signal, I_4 is averaged. The current mirror returns a current, I_3, to the square/divider to complete the circuit. The current I_4 is then a function of the average of (I_1^2/ I_4), which is equal to I_{1RMS}.

The current mirror also produces a 2 · I_4 output current, I_{OUT}, that can be used directly or converted to a voltage using resistor R2 and the internal buffer to provide a low-impedance voltage output. The transfer function for the ES636 is:

$$V_{OUT}=2 \cdot R2 \cdot I_{RMS}= V_{IN}$$

The dB output is obtained by the voltage at the emitter of Q3, which is proportional to

the -log V_{IN}. The emitter follower Q5 buffers and level shifts this voltage so that the dB output is zero when the externally set emitter current for Q5 approximates I_3.

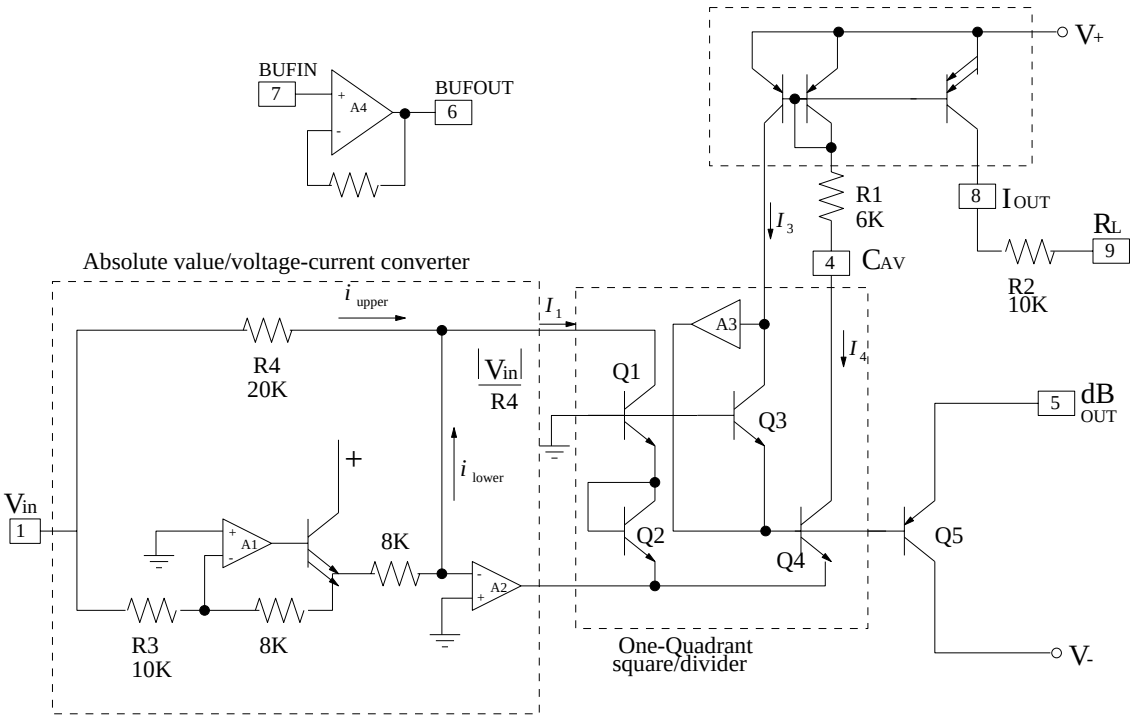


Figure 1. ES636 Simplified Schematic

Standard Connection (Figure 2)

The standard RMS connection requires only one external component, C_{AV}. In this configuration the ES636 measures the RMS of the AC and DC levels present at the input, but shows an error for low-frequency inputs as a function of the C_{AV} filter capacitor. Figure 3 gives practical values of C_{AV} for various values of averaging error over frequency for the standard RMS connections (no post filtering). If a 3uF capacitor is chosen, the additional error at 30Hz will be 1%. If the DC error can be rejected, a capacitor should be connected in series with the input, as would typically be the case in single-supply operation.

The input and output signal ranges are a function of the supply voltages. Refer to the electrical characteristics for guaranteed performance. The buffer amplifier can be used either for lowering the output impedance of the circuit, or for other applications such as buffering high-impedance input signals. The ES636 can be used in current output mode by disconnecting the internal load resistor, RL, from ground. The current output is available at pin 8 with a nominal scale of 100 μA/ V_{RMS} input for the ES636. The output is positive.

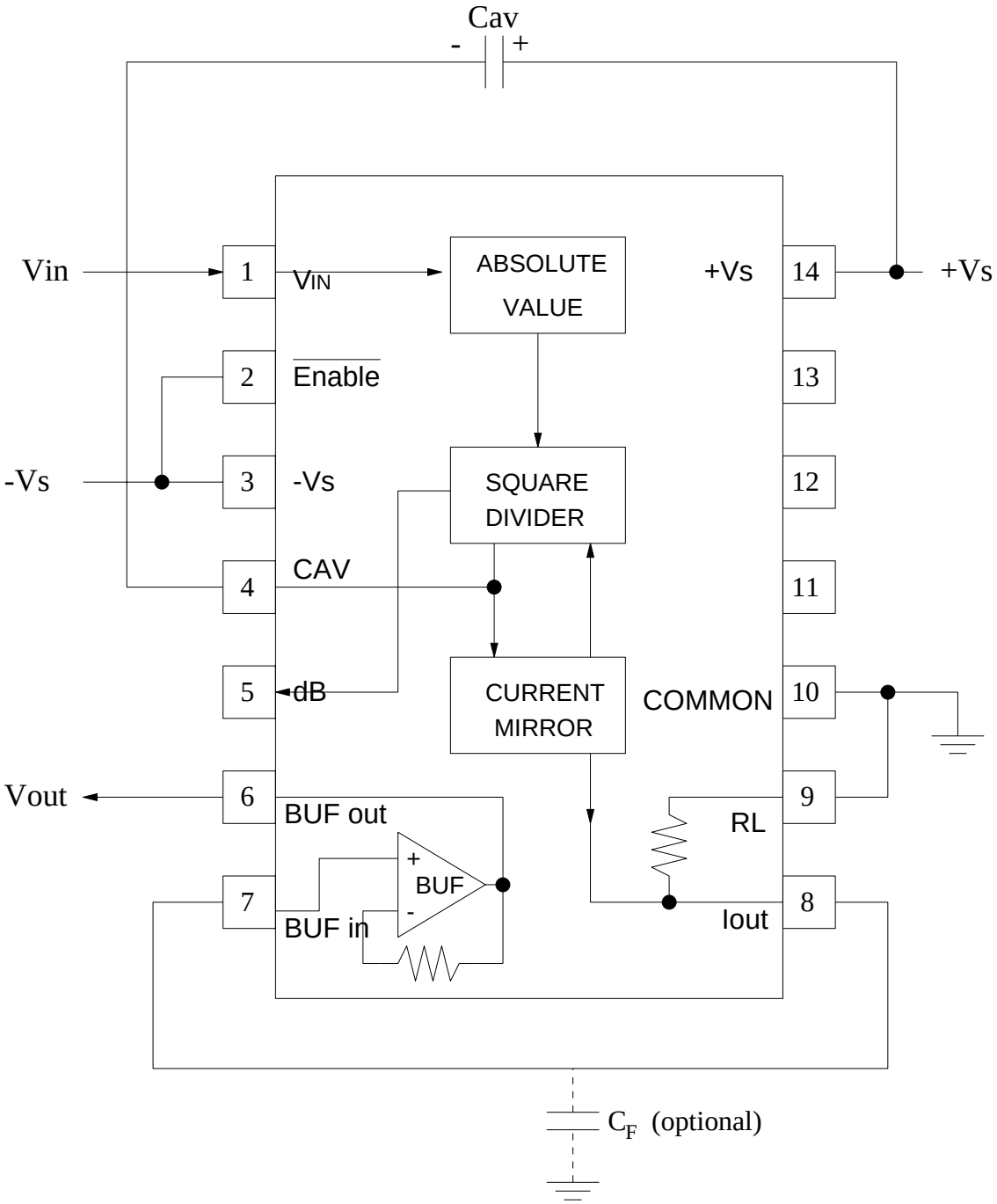


Figure 2. Standard connection for ES636.

- **High-Accuracy Adjustments**

The accuracy of the ES636 can be further improved by the external trimming scheme as shown in Figure 4. The input should be grounded and R4 adjusted to give zero output from pin 6. R1 and R2 are trimmed to give the correct value for a calibrated signal.

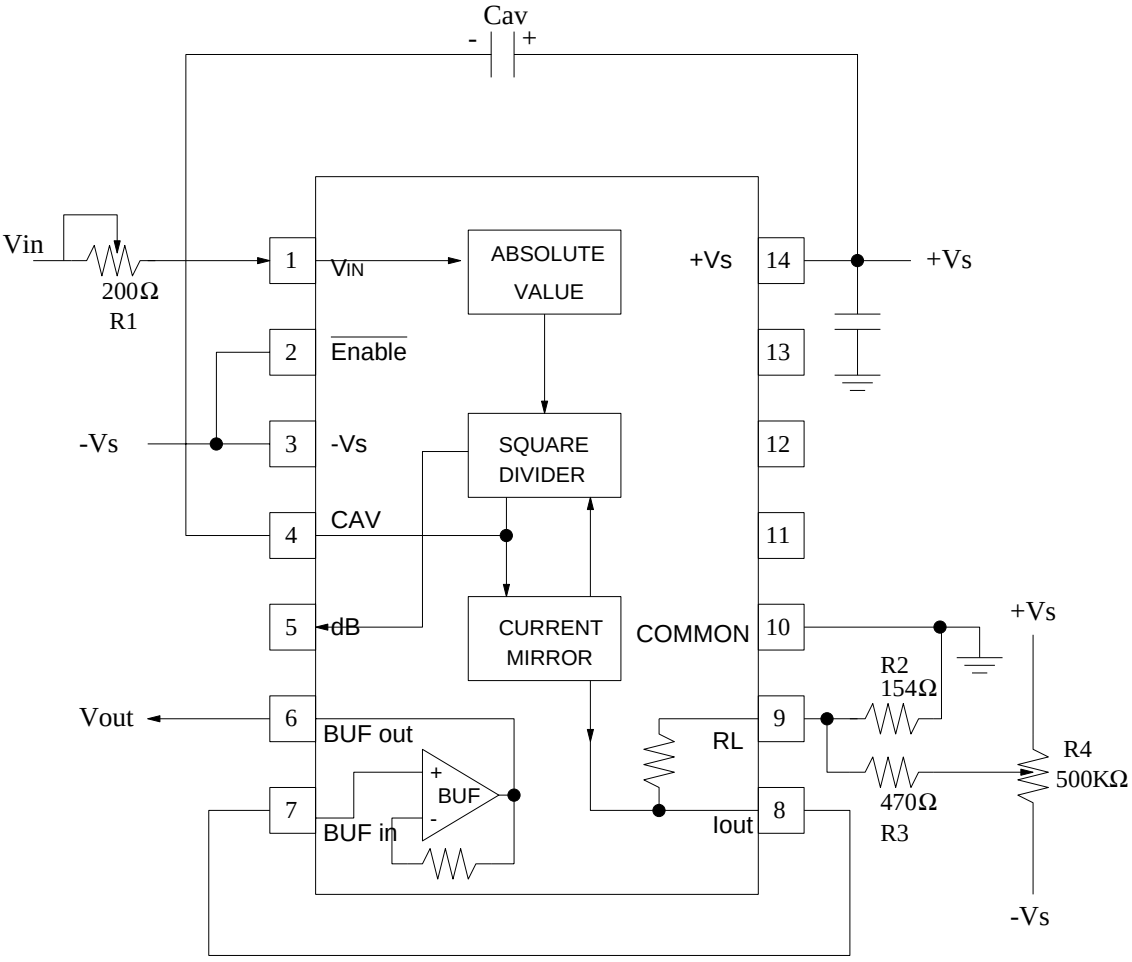


Figure 3. External Gain and Offset Trimming Circuit.

Power-Down Function

The ES636 provides a chip-enable pin (Pin 2). To enable the device, this pin must be connected to –Vs. If it is connected to V+, the device will enter power-down mode. The current it draws at this mode is less than 1uA.

Choosing the Averaging Time Constant

The ES636 computes the RMS value of AC and DC signals. At low frequencies and DC, the output tracks the input exactly; at higher frequencies, the average output approaches the RMS value of the input signal. The actual output differs from the ideal by an average (or DC) error plus some amount of ripple.

The DC error term is a function of the value of C_{AV} and the input signal frequency. The output ripple is inversely proportional to the value of C_{AV}. Waveforms with high crest factors, such as a pulse train with low duty cycle, should have an average time constant chosen to be at least ten times the signal period.

Using a large value of C_{AV} to remove the output ripple increases the setting time for a step change in the input signal level. Figure 3 shows the relationship between C_{AV} and 1 % settling time, where 110ms settling equals 4uF of C_{AV}. The settling time, or time for the RMS converter to settle to within a given percent of the change in RMS level, is set by the averaging time constant, which varies approximately 2:1 between decreasing and increasing input signals. In addition, the settling time also varies with input signal levels, increasing as the input signal is reduced, and decreasing as the input is increased.

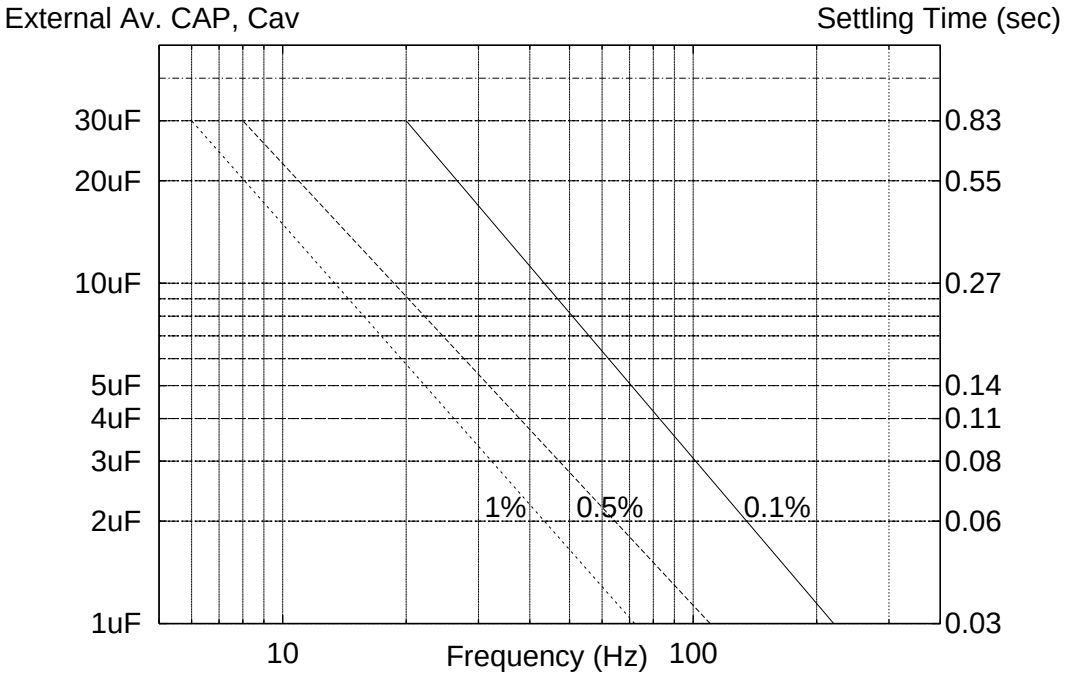


Figure 4. Errors/Settling Time Graph for Standard Connection

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. A better method to reduce the settling time and ripple is to use a post filter. Two suggested circuits are

shown in Figure 4 and Figure 5. A post filter allows a smaller C_{AV}. With post filter, the value of C_{AV} should be just large enough to give the maximum dc error at the lowest frequency of interest. And the output ripple will be removed by the post filter.

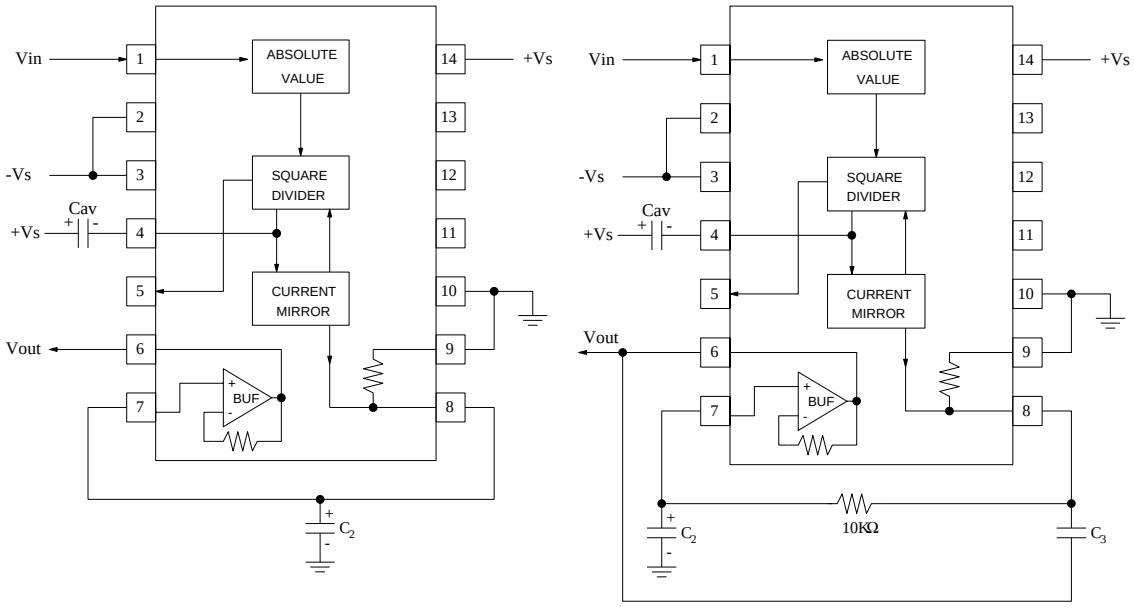


Figure 5(a). ES636 with a One-Pole Filter (b) with a Two-Pole Filter

Decibel Output (dB)

The dB output of the ES636 originates in the squarer/divider section and works well over a 60dB range. The dB output has a temperature drift of 0.03dB/℃.

Frequency Response

ES636 utilizes a logarithmic circuit in performing the RMS computation of the input signal. The bandwidth of the RMS converters is proportional to signal level. Figure 11 represent the frequency response of the converters from 35mV to 1V for ES636.

The dashed lines indicate the upper frequency limits for 1%, 10%, and ± 3dB of reading additional error. Caution must be used when designing RMS measuring systems so that overload does not occur. The input clipping level for ES636 is ± 10V.

A $3V_{RMS}$ signal with a crest factor of 3 has a peak input of 9V.

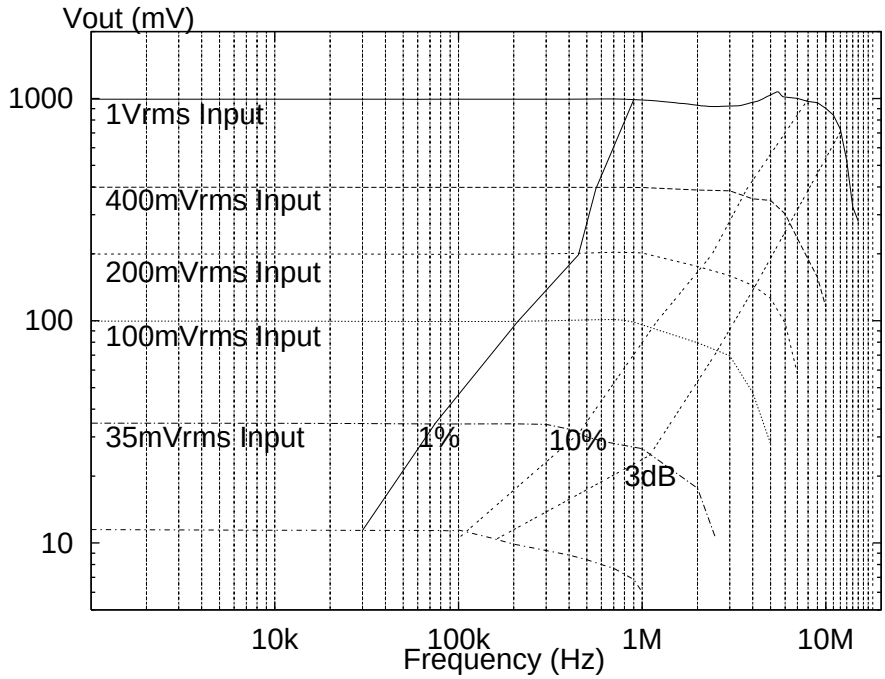
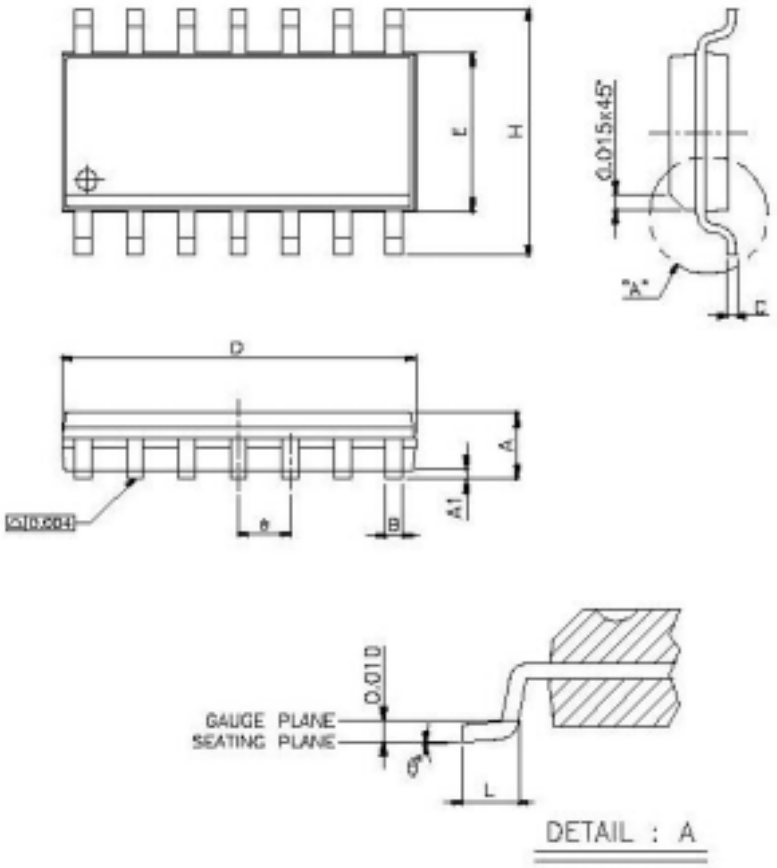


Figure 6. Frequency Response for ES636

Packaging

1.14 Pin SOP Package



2. Dimension Paramenters

SYMBOLS	MIN.	NOM.	MAX.
A	0.058	0.064	0.068
A1	0.004	–	0.010
B	0.013	0.016	0.020
C	0.0075	0.008	0.0098
D	0.336	0.341	0.344
E	0.150	0.154	0.157
e	–	0.050	–
H	0.228	0.236	0.244
L	0.015	0.025	0.050
θ°	0°	–	8°

UNIT : INCH

NOTES:
1.JEDEC OUTLINE : MS-012 AB
2.DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3.DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.