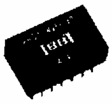
BURR-BROWN®



4341

Low Cost
TRUE RMS-TO-DC CONVERTER

FEATURES

- LOW COST
- HIGH ACCURACY: ±0.2% ±2mV
- VERSATILE: AC and DC Inputs

DESCRIPTION

The 4341 RMS-to-DC converter features low cost without sacrificing performance. The 4341 computes a DC voltage proportional to the true rms value of signals which may be complex waveforms, DC levels, or a combination of both.

The input and output are fully protected against over-voltages and short circuits. Provisions for the external adjustment of gain, offset voltage, DC-reversal error, and frequency response make the 4341 versatile enough to fill the majority of your applications.

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SPECIFICATIONS

ELECTRICAL

T_A = +25°C, V_S = ±15VDC, unless otherwise noted.

PARAMETER	CONDITIONS
TRANSFER FUNCTION	$E_{rms}(t) = \sqrt{\frac{1}{T}\int_0^T [E_{IN}(t)]^2 dt}$
INPUT	
Peak Operating Voltage	±10V
Absolute Maximum Voltage	±Supply
Impedance	5kΩ
OUTPUT	
Voltage	0 to +10V
Current	+5mA, min
Resistance	1Ω, max
BANDWIDTH	
±1% of Theoretical Output	80kHz
–3dB	450kHz
CONVERSION ACCURACY(2)	
Input: 500mVrms to 5.0Vrms Input: DC to 10kHz Sine Wave	±0.5% of Reading, max(1)
Input: 10mVrms to 7Vrms Input: DC to 20kHz	±2mV ±0.2% of Reading
STABILITY	
Accuracy vs Temperature	±0.1mV ±0.01% of Reading/°C
Accuracy vs Supply Voltage	±0.1mV ±0.01% of Reading/% of Supply Voltage Change
TEMPERATURE RANGE	
Operating	–25°C to +85°C
Storage	–40°C to +85°C
POWER REQUIREMENTS	
Rated Voltage	±15VDC
Voltage Range	±14VDC to ±16VDC
Quiescent Current	±12mA, typ, ±24mA, max

NOTES: (1) After standard trim procedure (see below). (2) Model 4341 will convert DC inputs. Lower frequency AC inputs require a large value of averaging capactior to minimize ripple at output. (see Figure 2).

STANDARD TRIM PROCEDURE

If the 4341 is used to measure sine waves or distorted sine waves, only two trims are needed to achieve an accuracy of ±0.5% of reading from 500mVrms to 5Vrms up to 10kHz. Refer to Figure 1.

1. Set E_{IN} = 5.000Vrms ±0.02% and adjust R_1 such that E_O = 5.000VDC ±2mV.
2. Set E_{IN} = 500mVrms ±0.02% and adjust R_2 such that E_O = 500mVDC ±0.2mV.
3. Repeat Step 1.

THEORY OF OPERATION

The true rms value of a time-varying signal E (t) over a time period T is

$$E_{rms}(t) = \sqrt{\frac{1}{T}\int_0^T [E_{IN}(t)]^2 dt}$$

The required operations are squaring, averaging and square rooting. A simplified schematic diagram of the 4341 is shown in Figure 1. The A_1 circuit produces a current, i_1, which is proportional to the rectified input voltage. The A_2 circuit is a logarithmic amplifier which produces a voltage proportional to 2 log E_{IN} or log E_{IN}^2. The logarithmic gain of the A_2 circuit is derived from the inherent exponential characteristics of transistor junctions. By using proprietary

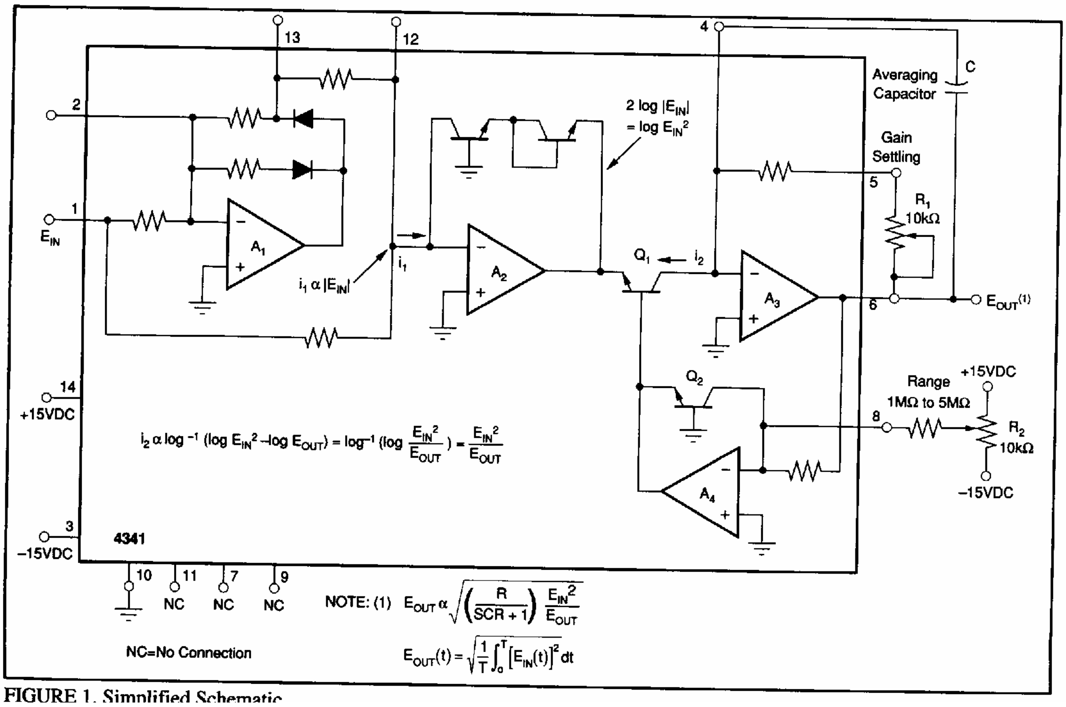

FIGURE 1. Simplified Schematic

monolithic components, the circuit provides an accurate log function over many decades which is relatively insensitive to temperature variations. Amplifier A_4 uses the same techniques as A_2 to generate log E_{OUT}.

Transistor Q_1 produces a collector current, i_2, proportional to the antilog of its base-emitter voltage such that

$$i_2 \;\alpha\; \log^{-1}\left(\log E_{IN}{}^2 - \log E_{OUT}\right)$$

$$= \log^{-1}\left(\log E_{IN}{}^2 / E_{OUT}\right) = E_{IN}{}^2 / E_{OUT}$$

The A_3 circuit, which contains the external capacitor, takes the time average of the i_2 signal and produces E_{OUT}, which is directly proportional to the rms value of E_{IN}.

Figures 2 and 3 show the effects of the external filter capacitor on ripple magnitude and response time. As the frequency of the input approaches DC, the 4341 begins to act like a full wave rectifier such that the output is the absolute value of the input. While the 4341 will accurately convert DC input voltages, the averaging capacitor must be made very large to minimize ripple at low frequencies.

CHOOSING THE AVERAGING CAPACITOR

A single-pole low-pass RC filter provides the averaging function. The time constant is 1/2 RC where R is 10kΩ when the 4341 is adjusted for unity gain. To select the best value of C, make a tradeoff between output ripple and response time. Figure 2 shows the ripple magnitude vs frequency for several typical values of capacitor. Response time vs capacitor value is shown in Figure 3. (Note that rise times and fall times are different for the same value of capacitor).

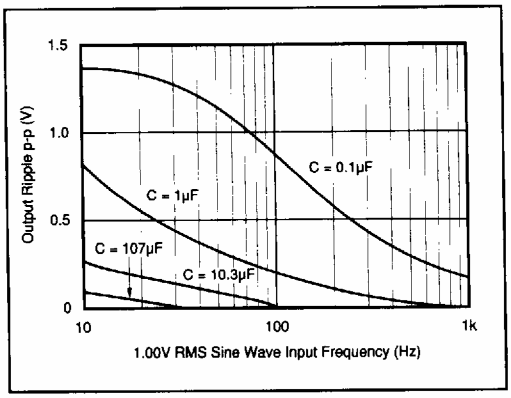

FIGURE 2. Output Ripple Magnitude vs Input Signal Frequency.

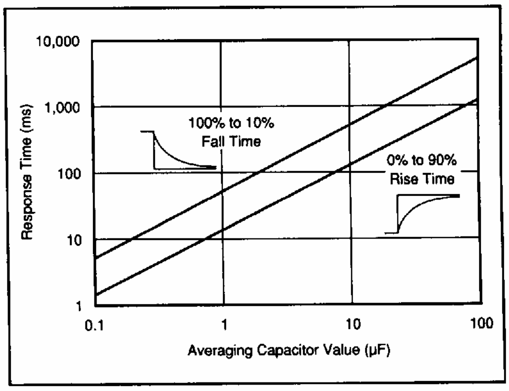

FIGURE 3. Response Time vs Value of Averaging Capacitor.

While the ripple magnitude for signals other than sine waves can be analytically determined, it is tedious. The fastest method of choosing C is to apply a representative input signal and observe the output for various values of C. C can be 100s of microfarads, but should have a leakage current less than 0.1μA to minimize gain errors. With very large values of C, the input signals with frequencies approaching DC level could be averaged. Since the output is always a positive voltage, C can be a polar capacitor.

EXPANDED TRIM PROCEDURE FOR GREATER ACCURACY

If the 4341 is used in applications to measure complex waveforms, the following expanded trim procedure is recommended. (Refer to Figure 4).

First, set all potentiometers at mid turn position.

1. DC Reversal Error — Apply +10.000V ±1mV and -10.000V ±1mV to E_{IN} alternatively, adjust R_5 such that E_O readings are the same ±2mV.
2. Gain Adjustment — Apply E_{IN} = +10.000VDC ±1mV, adjust R_1 such that E_O = +10.000VDC ±1mV.
3. Input Offset — Apply +10.0mV ±0.1mV and -10.0mV ±0.1mV to E_{IN}, adjust R_4 such that E_O readings are the same ±0.1mV.
4. Offset — Ground E_{IN}, adjust R_3 such that E_O = 0 ±0.1mV. Repeat Step (3).
5. Low Level Accuracy — Apply E_{IN} = +10.0mV ±0.1mV, adjust R_2 such that E_O = +10.0mV ±0.1mV.

NONUNITY GAINS

Gain values greater than unity can be achieved by inserting resistor R_X between pin 5 and pin 6. $R_X \approx (A^2 - 1)$ X 10k + 2k where A is the desired value of gain ($1 < A \leq 10$). (R_X is in Ω).

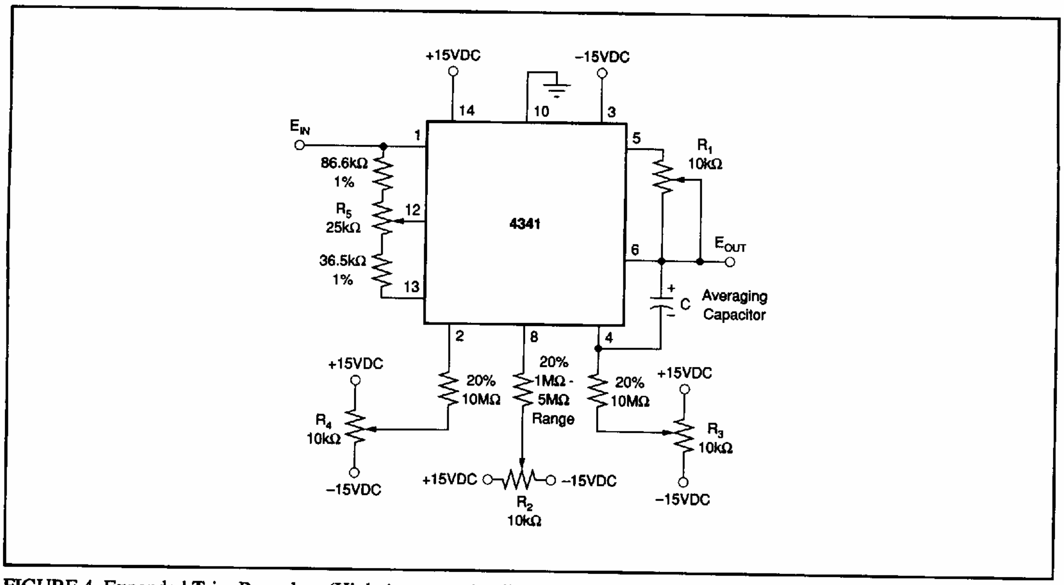

FIGURE 4. Expanded Trim Procedure (High Accuracy Applications).