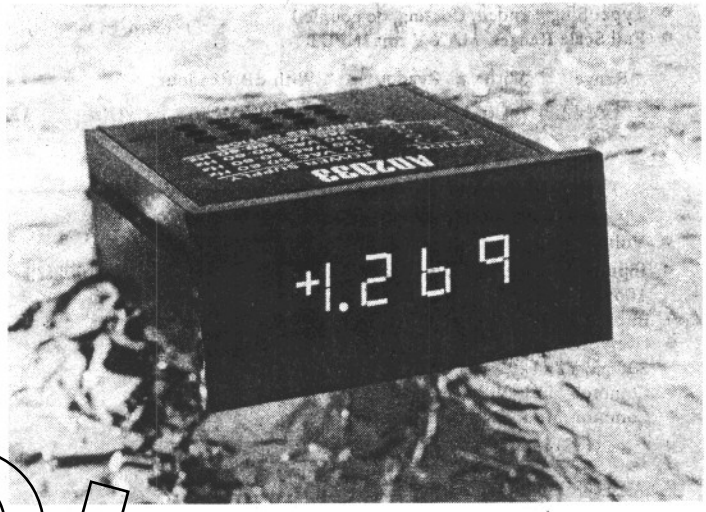
ANALOG DEVICES

True rms/dB Multirange Meter

AD2033

FEATURES
- True rms Measurement
- dB Measurements
- Bipolar dc Measurements
- High Accuracy/Wide Frequency Response
- Full Floating Input Isolation
- Parallel BCD Data Outputs
- Five Input Ranges
- 3½ Digits
- Large 0.5" (13mm) LED Displays
- Line Powered
- Industry Standard Case Design

APPLICATIONS
- Accurate True rms Measurement of Complex ac or ac+dc Waveforms
- Decibel Display of ac or ac+dc Inputs
- For Use in Test Equipment, Power Controllers, Process Control Equipment and Analytical and Scientific Instruments



GENERAL DESCRIPTION

The AD2033 is a 3½ digit, LED display, line-powered digital panel meter (DPM) that measures dc and ac input signals. The AD2033 measures either the true rms value of ac+dc signals or the dB value of the ac+dc inputs.

The input of the AD2033 is dc coupled and therefore accepts ac and/or dc inputs. The input can be ac coupled if it is desired to measure an ac signal riding on a constant dc voltage, as in measuring the ripple of a dc power supply.

TRUE rms MEASUREMENTS

Unlike most ac meters which display rms but measure the rectified average of ac input signals, the AD2033 uses implicit computing techniques to derive the actual rms value of the ac signals. Thus, the accuracy of the AD2033 does not depend on input waveforms. Pulse trains, triangular pulses and SCR chopped sinewaves, even with high crest factors (ratio of peak to rms) and pure sinewaves, are all measured with high accuracy and no recalibration over a wide frequency range.

dB MEASUREMENTS

dB measurements can be made with respect to internal or external references (including standard 1mW/600Ω used in audio measurements). In either case, internal or external, the measurements are made with regard to a voltage level from +5mV to +5V. With internal reference, the voltage can be adjusted via a built-in reference adjust pot. dB measurements can also be made against an arbitrary external reference, either constant or slow varying. The external reference is applied to a pin on the top rear connector, and may be divided down from a higher reference voltage.

FIVE INPUT RANGES

The AD2033 provides five separate inputs: 199.9mV; 1.999V; 19.99V; 199.9V and 600V rms Full Scale (FS). 1000V rms FS input is available upon special request. When reading is dB, these input ranges are extended to 500mV, 5V, 50V, 500V and 625V rms.

Factory calibration provides excellent accuracies on all five ranges, but the standard unit is optimized for the 1.999V rms FS range. Optimized calibration for the other ranges is also available. The floating opto-isolated analog input withstands common mode voltages up to 300V rms, even with digital outputs and control lines connected. This not only facilitates making measurements in various electrical environments, but is essential in making current measurements which are rarely referenced directly to ground.

SECOND GENERATION DPM DESIGN

The use of MOS/LSI (Metal Oxide Semiconductor/Large Scale Integration) integrated circuits in the AD2033 reduces the number of components, cuts power consumption and greatly increases reliability.

- Bias Current[3]: 1nA on all ranges except 200mV (10nA)
- Overvoltage Protection: 625V rms sustained on all ranges except 200mV FS (120V rms)
- Common Mode Voltage: 300V rms max at 60Hz
- Common Mode Rejection at 60Hz:

F.S. Input	CMR
A	100dB
B	80dB
C	75dB
D	60dB
E	40dB

- Temperature Range: Operating 0 to +50°C; Storage -25°C to +85°C
- Settling Time to Rated Accuracy: 2 seconds
- Provisions for external capacitor to extend low frequency response (reference applications section)
- Warm-Up Time: 20 minutes to rated accuracy

CONVERSION RATE

Display Blanking (TTL/DTL Compatible, 1 TTL Load) - Logic "0" or grounding blanks entire display except for decimal points; Logic "1" or open circuit for normal operation. Display blanking has no effect on output data. Display is valid immediately upon removal of blanking input.

Converter Hold (CMOS/TTL/DTL Compatible, 1 LPTTL Load) - Logic "0" or grounding causes DPM to cease conversions and display data from last conversion; Logic "1" or open circuit for normal operation. After "Converter Hold" is removed, one or two conversions are needed before reading and BCD data are valid.

Decimal Points (Not TTL Compatible) - Logic "0" or grounding illuminates desired decimal point. External drive circuitry must sink 25mA peak at a 25% duty cycle, when decimal point is illuminated.

Data Hold (TTL/DTL Compatible, 1 TTL Load) - Logic "0" or grounding inhibits updating of latched parallel output data; Logic "1" or open circuit allows data to be updated after each DPM conversion. This input has no effect on the normal conversion of the DPM and its display.

DATA OUTPUTS

Isolated Parallel BCD Outputs - 3 BCD digits, Overrange, Overload and Data Ready Outputs (TTL compatible, 4 TTL Loads). BCD Data Outputs are latched, positive true logic. Overload output is Logic "0" for inputs greater than full scale range, Logic"1" when other data outputs are valid. Polarity Output (TTL Compatible, 4 TTL Loads Latched) indicates positive polarity when high (Logic "1"). Digital Outputs are fully isolated from input circuitry; all logic levels are referenced to digital ground.

BIPOLAR DC MEASUREMENTS

- Full Scale Input: ±1.999V dc (See AD2022 Data Sheet for complete information)

POWER INPUT

- AC line 50–400Hz
- Power Consumption: 6.8 watts at 60Hz

CALIBRATION ADJUSTMENTS

- Input Offset
- Zero Width
- Gain
- Internal (dB) Reference Adjust
- Recommended Calibration Interval: 6 months

SIZE

- 3.92″W x 1.67″H x 4.48″D (100 x 42 x 114mm)
- Panel Cutout: 3.924″ x 1.682″ (99.8 x 42.7mm)

- AC Power Inputs (no cost option) (50–400Hz)

  AD2033 – 117V ac
  AD2033/E – 220V ac
  AD2033/F – 100V ac
  AD2033/H – 240V ac
  } ±10%

- Display Lens Options[4]
  Lens 7 – Red with ADI Logo
  Lens 8 – Red without ADI Logo
- AD2033 Converter Card Connector P1
  30 pin, 0.156″ spacing card edge connector, Viking 2VK150/1-2
  Optional: Order AC1501
- AD2033 rms/dB Card Connector P2
  36 pin, 0.156″ spacing card edge connector, Viking 2VK18D/1-2
  Optional: Order AC2610

[1] Overrange of 250% of full scale is available for analog only output (pin R) on all ranges except E. For E overrange capability is 4%.
[2] 1000V is optional, contact factory.
[3] Bias Current approximately doubles for each change in ambient temperature of +10°C.
[4] Lens 7 is supplied if no lens option is specified.

Specifications subject to change without notice.

Range	199.9mV rms	1.999V rms	19.99V rms	199.9V rms	600V rms
Accuracy	±1.2% RDG	±0.1% RDG	±0.3% RDG	±0.3% RDG	±1.2% RDG
DC or 30Hz to	±0.05% FS	±0.05% FS	±0.05% FS	±0.05% FS	±0.05% FS
3kHz Sinewave	±1 digit	±1 digit	±1 digit	±1 digit	±1 digit
Temperature Coefficient:					
Zero	±20μV/°C	±60μV/°C	±0.6mV/°C	±6mV/°C	±60mV/°C
Gain	±75ppm/°C	±75ppm/°C	±75ppm/°C	±75ppm/°C	±75ppm/°C
Frequency Response: (Sinewave Input)					
±1% RDG ±0.05% FS ±1 digit (max error)	30Hz to 10kHz	30Hz to 10kHz	30Hz to 10kHz	30Hz to 10kHz	30Hz to 5kHz
3dB (max error)	30Hz to 100kHz	30Hz to 100kHz	30Hz to 100kHz	30Hz to 100kHz	30Hz to 30kHz

Table 1. AD2033 rms Specifications

APPLYING THE AD2033

Description Of Operation

The timing and block diagrams are shown in Figures 1 and 2 respectively. The input pin for all ranges except range A is Pin K. Range A input connects to Pin E. The input signal is fed into a buffer amplifier. Range selection is made by connecting the appropriate feedback resistor. The Bias Current Compensate (Pin B), for stabilization of bias current over extended temperatures, should be tied to ground on all

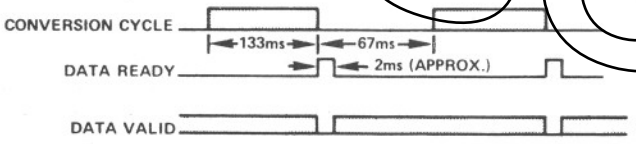


Figure 1. AD2033 Timing Diagram

ranges except Range B. The output of the buffer amplifier drives a True rms to dc converter that combines logarithmic and implicit computing techniques to achieve low overall error and a wide dynamic range, as in the equation:

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T (V_{IN})^2\, dt}$$

For True rms readout, the above is used as the A/D input. It also drives the log ratio circuitry which develops a dB output relative to either internal or external reference voltage. For dD readout, the log ratio output feeds the A/D input.

The A/D conversion is performed via a special technique ("Charge Balancing") that requires interaction between analog and digital processing. The analog processor provides buffering, integration, autozeroing and comparison functions. The digital processor contains control, counting, storage and data multiplexing functions. As can be seen from the block diagram, the two processors are opto and pulse transformer isolated. This isolation increases DPM tolerance to front end noise and high common mode voltage. The output of the digital processor drives the display via a seven segment decoder driver and is also available via the parallel BCD data storage.

True rms Measurements

A typical setup for measuring 1.999V rms FS (Range B) can be accomplished by linking Feedback Range Select (Pin A) to Feedback (Pin F). Connect 1.999V source between Input (Pin K) and Ground (Pins 1-6). Then connect rms/dc fashion in setting up for all other ranges except when using

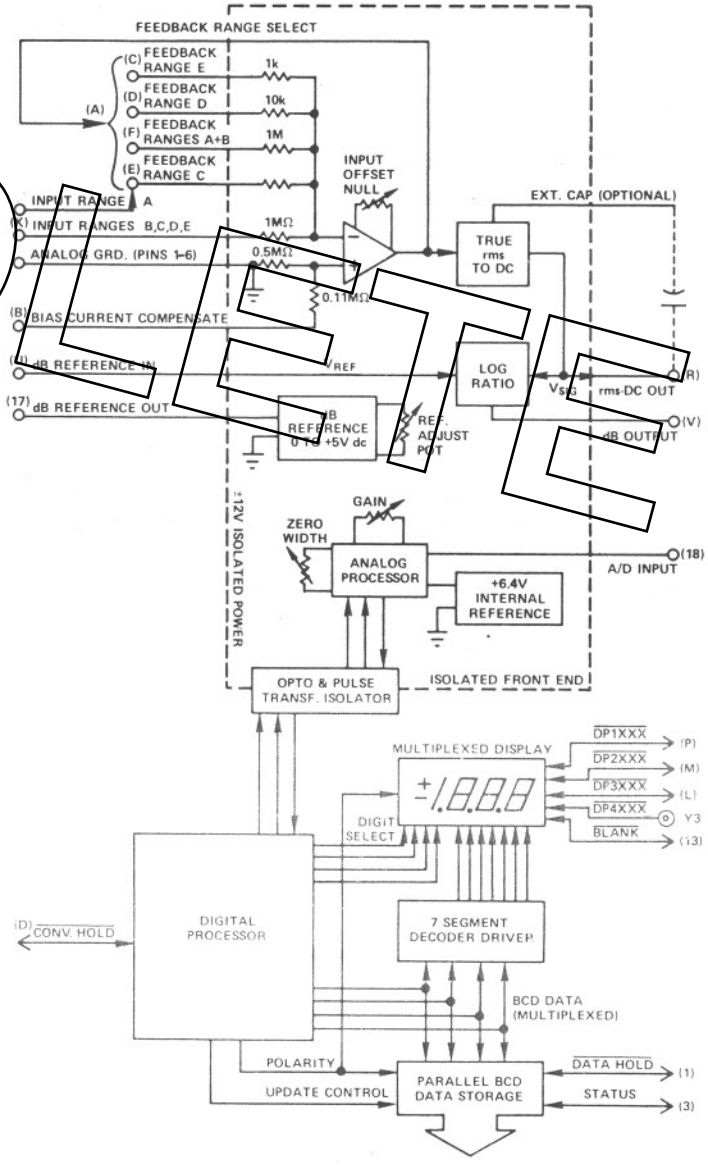
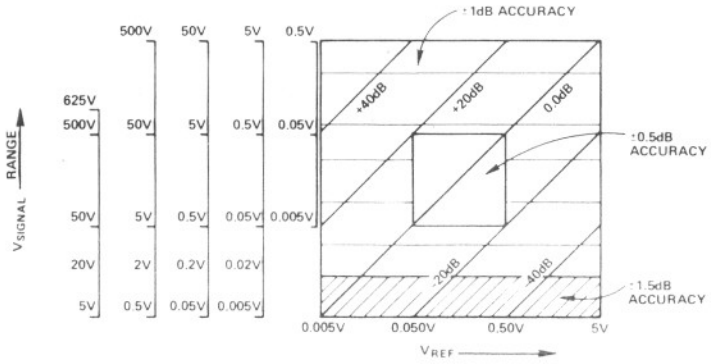


Figure 2. AD2033 Block Diagram

the 199.9mV rms FS range where Pin K *must* be grounded and the input must go to Pin E. The Bias Current Compensate (Pin B) must be connected to Ground on all ranges except the 1.999V rms FS.

As shown in Figure 3, dB readout for a particular V_{SIG} can be varied by controlling V_{REF}, either via the Internal Reference Adjust or by control of an external reference (which can can be divided down from a higher voltage).



NOTE: FIGURE 3 IS SET UP FOR ABSOLUTE VOLTAGES ON THE 5V SCALE. 20dB CORRECTION PER DECADE WOULD BE NEEDED IF V_{REF} REMAINS ABSOLUTE ON OTHER RANGES.

CAUTION: THERE IS NO INPUT OVERLOAD INDICATION IN dB MODE.

Figure 3. dB Readout as a Function of V_{SIG} and V_{REF}

Adjustment of the dB range can also be accomplished by selecting the proper V_{SIG} input range and V_{REF}. The 60dB readout range can be offset anywhere within the total meter range of +60dB to −60dB.

Examples: 1. V_{SIG} = 50V rms on the 50V rms range with V_{REF} = 5V. dB readout = 0.00dB and the full dB readout range is 0.00dB to −60dB.
2. V_{SIG} = 50V rms on the 500V rms range with V_{REF} = 0.5V. dB readout = 0.00dB and the full dB readout range is +20dB to −40dB.

To set up for a full scale of 500mV input range, link Feedback Range Select (Pin A) to Feedback (Pin F). Connect source between 200mV Input (Pin E) and Ground (Pins 1-6). Connect dB Reference In (Pin U) to dB Reference Out (Pin 17) for use of internal reference and then link dB Output (Pin V) to A/D Input (Pin 18). To use external reference, connect source between dB Reference In (Pin U) and Analog Ground (Pins 1-6). Since the input pin for this range is Pin E, the Input Pin (Pin K) for all other ranges must be grounded and the Bias Current Compensate must be linked to Ground (Pins 1-6) on all ranges except the 1.999V rms FS Range. Set up in similar fashion on other ranges.

Bipolar dc Measurements

By bypassing the rms/dB front end, it is possible to use the AD2033 to measure and display a bipolar dc value on the 1.999V FS. The input pin for this measurement would be the A/D Input Pin (Pin 18 of P2). Connect low side to Ground (Pins 1-6). A shunt capacitor (0.047μF) at the A/D Input is needed to limit input impedance.

Ac Coupling Input of AD2033

For measurements of ac voltages superimposed upon dc DC voltage, put the following dc blocking capacitors at DPM M input:

Range	Capacitor (Rated Accuracy at 45Hz)
200mV	1μF
All Others	0.1μF

Measurement of Very Low Frequencies

If the input signal to be measured has a frequency of dc to about 30Hz, the AD2033 will "track" the input signal and extend the low frequency response of the AD2033, two pins are provided at the connector of P2 to allow an external capacitor to be attached. Table 2 will aid in choosing the proper value of averaging capacitance.

Frequency	Averaging Capacitor Value	Settling Time to Rated Accuracy
25Hz	15μF	6 Seconds
10Hz	100μF	30 Seconds

Table 2. External Capacitor Selection

Interfacing Data Outputs - Parallel BCD

The AD2033 has data outputs in a full parallel BCD format. The output data is latched and is valid except for a 2ms period at the end of conversion, when the "Data Ready" output is high (See Figure 1). As described above, the "Data Hold" input can be used to inhibit updating of the parallel data outputs without affecting DPM conversions or the DPM display.

Extended True rms ac Range Measurements

Although the full scale display range of the AD2033 is 1999 counts, and the display flashes to indicate overrange beyond this point, measurements are actually made up to approximately 3000 counts. Since it is impossible to display "2" in the most significant digit of the AD2033, overrange from 2000 to 2999 counts produces a flashing display of the 3 least significant digits only (a reading of 2.300mV displays as "300" flashing). Overrange beyond 2999 counts is indicated by a constant number flashing. Thus, one can use the extra range measurements as a guide to reducing the input to the normal range. The parallel BCD outputs of the AD2033 beyond 1999 counts go to Logic "0" on all BCD lines, as does the Overload Output.

KEY

PIN	FUNCTION
1	DATA HOLD
2	
3	DATA READY
4	POLARITY
5	BCD 8
6	BCD 2
7	BCD 80
8	BCD 20
9	BCD 800
10	
11	BCD 400
12	BCD 200
13	DISPLAY BLANK
14	OVERRANGE
15	ac LINE HIGH

KEY

PIN	FUNCTION
A	N/C
B	N/C
C	OVERLOAD
D	CONVERTER HOLD
E	BCD 1
F	BCD 4
H	BCD 10
J	BCD 40
K	BCD 100
L	DP3 XX.X
M	DP2 X.XX
N	DIGITAL GROUND
P	DP1 .XXX
R	SHIELD (EARTH GROUND)
S	ac LINE LOW

Figure 4. AD2033 Connector P1

KEY

PIN	FUNCTION
1	ANALOG LOW
2	ANALOG LOW
3	ANALOG LOW
4	ANALOG LOW
5	ANALOG LOW
6	ANALOG LOW
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	dB REF OUT (0 TO +5V)
18	A/D INPUT ±1.999V FS

KEY

PIN	FUNCTION
A	RANGE SELECT (CONNECT TO C,D,E,F)
B	BIAS CURRENT COMPENSATE
C	RANGE E FEEDBACK
D	RANGE D FEEDBACK
E	RANGE C
F	RANGE A AND B
H	
J	
K	INPUT (EXCEPT 200mV)
L	
M	
N	
R	rms OUT ±1.999V FS/EXT CAP (+)
S	EXT CAP (-)
T	dB REF IN (OPTIONAL)
U	dB REF IN (+5mV ≤ V_{REF} ≤ +5V)
V	dB OUT (200mV/DECADE)

Figure 5. AD2033 Connector P2