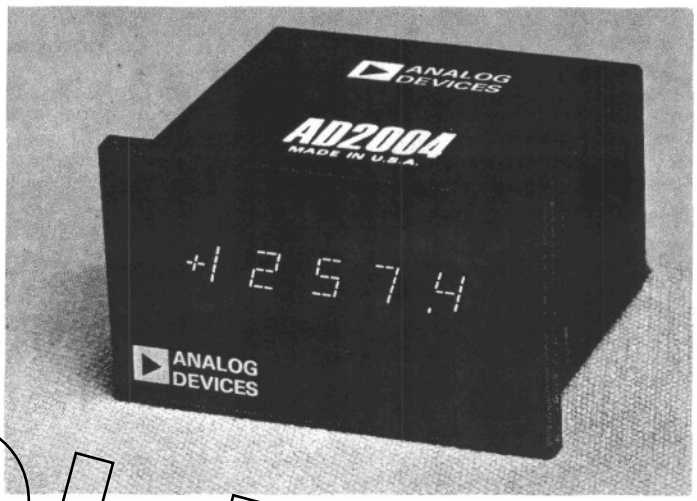
High Performance 4½ Digit DPM For System Applications

AD2004

FEATURES
- Floating Optically Isolated Analog Section
- Excellent Common Mode Rejection: 120dB at ±300V
- High Normal Mode Rejection: 60dB
- 5V dc Powered
- Automatic Zero with Maximum Error: 0.01% ±1 Digit
- LED Display with Latched Digital Outputs
- Small Size: 1.8"H x 3"W x 2.5"D
- Low Price

APPLICATIONS
- Industrial Weighing Systems
- Process Control Monitoring
- Precision Differential Measurement
- Ground Loop Elimination
- Off Ground Signal Measurements
- Analytical and Scientific Instrumentation



GENERAL DESCRIPTION

Analog Devices' model AD2004 is a 4½ Digit, 5V dc powered digital panel meter offering 0.01% ±1 digit accuracy, resolution of 0.1mV, common mode voltage (CMV) of ±300V with a common mode rejection ratio (CMRR) of 120dB.

Using optically coupled isolation techniques for the signal channel, this new design is capable of performing precision measurements of floating differential voltages in noisy environments or under widely varying common mode voltage levels of up to ±300V. The optically isolated design assures ground loop elimination and permits critical measurement of off ground signals such as those found in the nuclear and process control industries.

The AD2004 features a 4½ digit light-emitting-diode (LED) display with a full scale range of 0 to ±1.9999 Volts and latched digital data outputs and control interface signals. Automatic-zero correction circuitry measures and compensates for offset and offset drift errors thereby providing virtually no zero error.

The conversion rate of the AD2004 is normally 4 readings per second. However, an external trigger may be applied to vary the sampling rates from a maximum of 8 readings per second down to an indefinite hold rate. During conversion, the previous reading is held by the latched logic. The numeric readout is available as BCD data. Application of the metering system in a computer or data logging system is made easy with the availability of the "overrange," "polarity," "overload," and "status" signals.

The AD2004 can operate from the users 5V dc system supply, thereby, eliminating the shielding and decoupling needed for line powered units when the ac line must be routed near signal leads.

TYPICAL APPLICATIONS INCLUDE:

- Ground loop elimination between input transducer and output circuit functions.
- High resolution monitoring of small signals impressed on high off-ground voltages of up to ±300V.
- Electronic indicating weighing systems for industrial applications. Numerical output may be interfaced with a digital computer or data logging system.
- Digitally controlled industrial process where analog and digital signal isolation is required.
- Balanced strain gage bridge output measurement for industrial requirements.
- Digital indicating micrometer using a linear variable differential transformer (LVDT). Due to the high normal mode rejection ratio of the AD2004, the ac excitation of the LVDT does not induce errors into the system.
- Analytic and Scientific Instrument displays with isolated numeric readout.

FLOATING DIFFERENTIAL INPUT OFFERS HIGH CMV AND CMR

The AD2004, requiring only 5V dc input power, utilizes a fully floating dual-slope, integrating A-to-D converter. The simplified block diagram shown in Figure 1 illustrates the isolation technique used to achieve high CMV and CMR. Optical coupling is used for the digital control signals and

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SPECIFICATIONS (typical @ +25°C and +5V dc unless otherwise noted)

DISPLAY OUTPUT
- Display consists of five LED's for data digits plus 100% overrange.
- Overload — Four data digits display zeros and flashes when reading exceeds the input range (>1.9999 volts).
- Decimal Points — Selectable at input connector.

INPUT
- Full Scale Range — 0 to ±1.9999 volts
- Automatic Zero
- Automatic Polarity
- Floating
- Bias Current — <1nA max
- Impedance — >100MΩ
- Overvoltage Protection — ±50V sustained without damage.
- Decimal Points (4) — Selectable by Logic "1" or by leaving open. Grounding the input turns decimal points off.

ACCURACY
- 0.01% of Reading ±1 Digit
- Resolution — 0.1mV
- Temperature Range — 0°C to +50°C operating
- Temperature Coefficient — ±15ppm/°C max

NORMAL MODE REJECTION
- 60dB without filter @ 50-60Hz minimum

COMMON MODE REJECTION
- 120dB typical dc-1kHz with 1kΩ unbalance

COMMON MODE VOLTAGE (with digital interface signals connected)
- ±300V dc (600V peak to peak)

DATA PROCESSING SIGNALS

		IN	OUT
• DTL/TTL Compatible	Logic "0"	<0.8V	<0.4V
	Logic "1"	>2.0V	>2.4V

- Inputs

  External Trigger — Operation in the External Trigger mode requires the External Hold input be held at Logic "0" or grounded. A negative going external trigger pulse (Logic "1" or Logic "0" and return) is required to start each conversion. The DPM is reset on the negative transition and a new conversion is triggered on the positive transition. The pulse width must be greater than 100ns. The STATUS signal is set at the negative transition and the actual conversion begins 0—3.3μs (maximum of 1 clock pulse) after the positive transition to allow synchronizing conversion with the internal clock.

  External Hold — When this input is grounded or held at 0.8V max, the last conversion is held and displayed. For a new conversion under internal control, this input must be open or at Logic "1".

- Output

  4BCD Digits (8421 Positive True) - Latched - 3TTL loads

  Overrange — Logic "1" indicates an overrange — Latched — 9TTL loads

  Overload — Logic "1" indicates the input has exceeded the input range — Latched — 9TTL loads

  Status Signal — Logic "0" indicates conversion is complete — 9TTL loads

  Polarity — Logic "1" with positive polarity input — Latched — 7TTL loads

CONVERSION TIME
- 125ms for *Full Scale* Input (145ms for AD2004/E)

SPEED
- External Trigger — 8 conversions per second (6 conversions per second for AD2004/E)
- Internal Conversion — 4 conversions per second
- Hold and Read on Command

SIZE
- 3″W x 1.8″H x 2.5″D (7.62 x 4.57 x 6.35cm) (overall depth for case and connector is 3.3″ (8.38cm))

POWER
- 5V dc ±5% @ 800mA typ, 900mA max

WEIGHT
- 8 oz. (227 gm)

WARM UP TO RATED ACCURACY
- 30 minutes

ORDERING GUIDE
- AD2004 — Standard AD2004 as described above — tuned for peak normal mode rejection at 60Hz and its harmonics.
- AD2004/E — Standard AD2004 as described above — tuned for peak normal mode rejection at 50Hz and its harmonics.

CONNECTOR
- AC1600 6 feet of decade coded wire mated with "3M" Figure 7 Connector (Part No. 3414)

or

AC1601 "3M" mating connector (Part No. 3414) only Figure 7

Specifications subject to change without notice.

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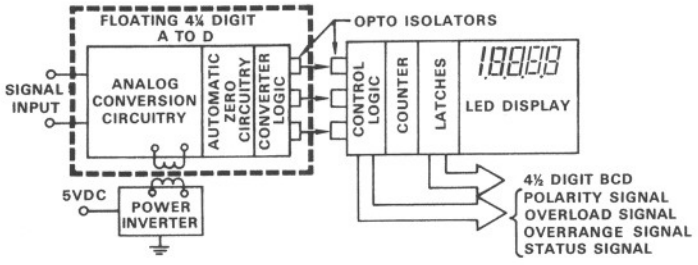


Figure 1. Simplified Block Diagram

transformer coupling in the dc to dc converter section to transmit operating power to the floating converter. The use of these techniques provides high quality isolation between the analog input signals and the display and BCD output registers. Troublesome ground loops are eliminated and excellent CMRR of 120dB over the common mode voltage range of ±300V is achieved.

IMPROVED NOISE IMMUNITY, ACCURACY AND ZERO STABILITY

Dual-slope integration, as described in the theory of operation section offers several design benefits.

- Conversion accuracy for example, is independent of both the timing capacitor value and the clock frequency, since they affect in the same way the up ramp and down ramp integration period. Linearity is also improved because the analog conversion as shown in Figure 3 is free from discontinuities.
- Normal mode noise at line frequencies or its harmonics is rejected since the average value of this noise is zero over the integration period.
- To achieve zero stability, a time interval during each conversion is provided to allow the automatic-zero correction circuitry to measure and compensate for offset and offset drift errors, thereby, providing virtually no zero error.

5VDC OPERATION PROVIDES REDUCED NOISE PICKUP, IMPROVED RELIABILITY

A DPM designed for 5V dc operation offers the user many advantages over ac line powered devices. These benefits include:

- REDUCED NOISE PICKUP AND SUSCEPTIBILITY. Since line voltages are not required for operation, signal leads and internal circuitry need not be exposed to this source of noise, thereby, reducing power-frequency interference. A separate 5V dc power supply also provides additional isolation from line transients. Shielding and decoupling of the DPM circuits can also be eliminated. The DPM may be used as a component without danger of shock hazards to operational personnel or nearby circuitry.
- IMPROVED RELIABILITY. Meters without power supplies generally require less space and generate less heat. The result is improved reliability while achieving lower cost. The smaller package size provides greater packaging flexibility and requires less ventilation behind the panel.

LED's GIVES LONG LIFE, SHARP DISPLAY

The numeric outputs are displayed using 0.27" high, 7 segment, red LEDs. The LEDs provide the physical ruggedness typical of ICs, with a life expectancy in excess of 100,000 hours. The displayed numerals are sharp and easily readable at distances of up to 8 feet. The clean uncluttered look of the lens and case design further enhance the visual attractiveness of the display.

Optical features of the display include: a minimum photometric brightness of 200 foot-lamberts, and a 6300 angstrom, wavelength at peak emission (red). Other display features include programmable decimal points, automatic zero, 4 readings per second display rate with trigger and hold feature for externally programmed 0 to 8 readings per second, and flashing-zeros overload indication.

COMPACT DESIGN FEATURES EASY SNAP-IN INSTALLATION

The AD2004 is housed in an aluminum case providing light weight, structural strength, optimum heat dissipation and shielding against external noise. As shown in Figure 5, no tools are required for installation. You simply snap in the case, then snap on the filter and lens. Its light weight makes AD2004 ideal for applications in hinged panel equipment.

THEORY OF OPERATION

The AD2004 (Block and Timing Diagrams – Figures 2 and 3) uses a dual-slope integrating A/D conversion scheme. When an input signal is applied to the DPM, it is applied to an integrator at the same time a counter is started, counting clock pulses. After a predetermined number of counts (a fixed interval of time, T), the polarity of the input signal is strobed and a reference voltage having opposite polarity is applied to the integrator. At that instant, the accumulated charge on the integrating capacitor, C, is proportional to the average value of the input over the interval T. The integral of the reference is an opposite-going ramp having a slope V_{REF}/RC. At the same time, the counter is again counting from zero. When the integrator output reaches zero, the count is stopped, and the analog circuitry is reset. Since the charge gained is proportional to $V_{IN}T$, and the equal amount of charge lost is proportional to $V_{REF}\triangle t$, then the number of counts relative to the full count is proportional to $\triangle t/T$, or V_{IN}/V_{REF}. The output of the counter is a BCD number, which is decoded and displayed as the digital representation of the input.

INTERFACING THE DPM

The latched digital data outputs and control interface signals are available on a "3M" receptacle at the rear of the AD2004. The signals may be interfaced with the system using either the AC1600 or the AC1601 (Figure 7) connector schemes. Signal and pin designations are shown in Figure 6.

The AD2004 requires 900mA maximum input current at +5V dc for power. To minimize voltage drops on the connecting cable assembly, two lines for +5V and two lines for power supply ground are provided. It is recommended that all 4 lines be used, especially with long connecting cables (Figure 8).

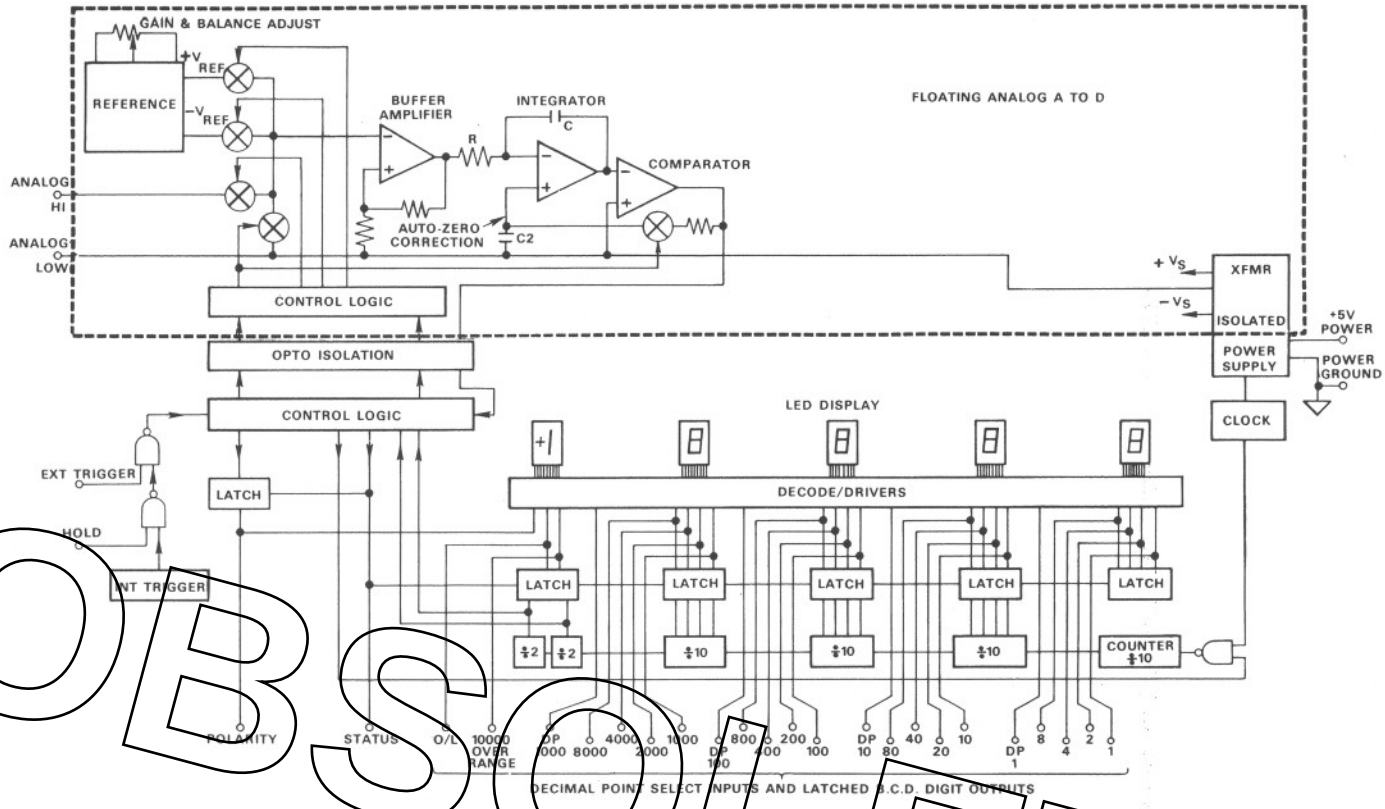


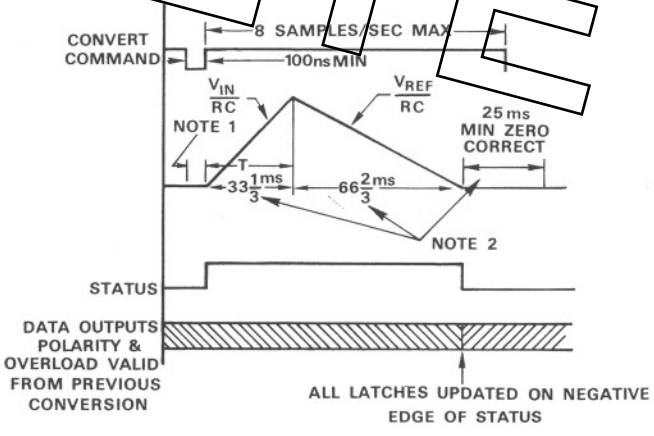
Figure 2. AD2004 Block Diagram

SCALING INPUTS

The AD2004 is designed to measure inputs over a full scale range of 0 to ±1.999 volts. If inputs in other ranges need to be measured, scaling of inputs can easily be done by amplifying low level voltages or attenuating large voltage inputs. If a low level signal must be amplified to be measured by the AD2004, the amplifier chosen must be a high grade instrumentation amplifier or chopper amplifier with performance on a par with the DPM. Attenuators, likewise, must be chosen with the DPM in mind. Attenuator resistors should have tempcos of less than 15ppm and be selected for tracking characteristics. Since the bias current of the AD2004 will change with temperature, keeping the source impedance below 100kΩ will prevent a zero level shift with changes in temperature.

Whenever scaling inputs is necessary, remember to make the signal being transmitted to the DPM as large as possible. Amplification should be done close to the source, attenuation close to the DPM. This will minimize the effects of EMI in noisy environments.

The floating input of the AD2004 makes current measurements easy, by allowing measurements to be made at very high common mode voltages. Shunt resistors should be chosen with wattage ratings sufficient to prevent measurement degradation by heating. For very large currents, a four-terminal meter shunt can be used, but the tempco of the shunt should be carefully checked.



NOTE:

1. Maximum Delay of One Clock Pulse 3.3μs to Synchronize with Clock.
2. AD2004E (50Hz Model) Timing.
   Ramp up 40ms
   Ramp down 80ms
   Zero correct 25ms

   Maximum Trigger Rate 6ms

Figure 3. AD2004 Timing Diagram

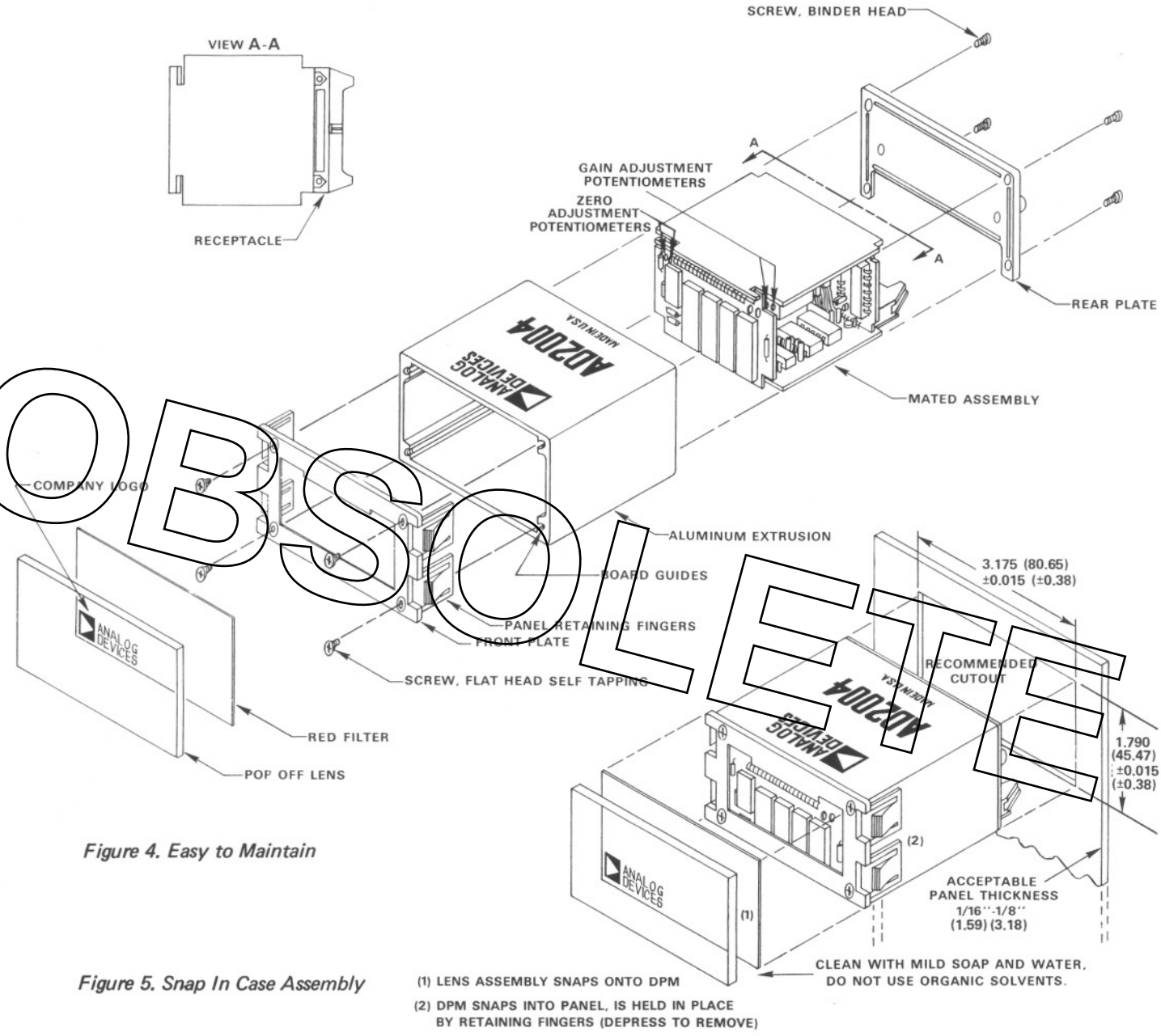


Figure 4. Easy to Maintain

Figure 5. Snap In Case Assembly

AD2004 CALIBRATION PROCEDURES

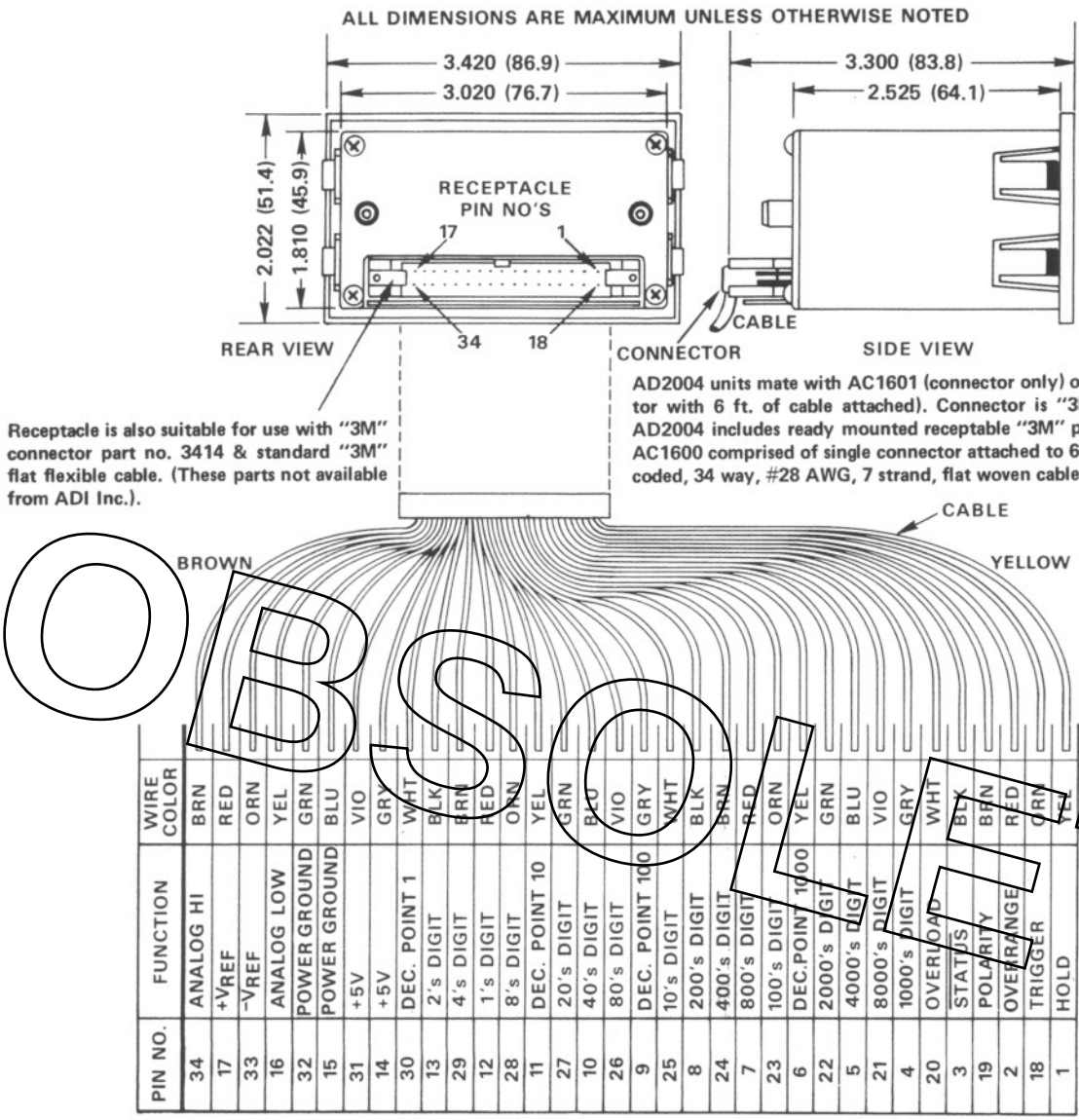
Design modifications in the AD2004 have changed the calibration procedures. Procedure #1 is for models having a gain and balance adjustment only. Procedure #2 is for units with gain and zero adjustment for both polarities. Location of adjustment pots for Procedure #2 is given in Figure 4.

Procedure #1. Apply an input of 1.9V ±15μV from a precision voltage reference source. Switch polarity and see if the meter reads the same at both polarities. (The AD2004 may not read 19000 exactly, if gain adjustment is needed.) If not adjust the balance until the reading is the same at either polarity. Using the gain adjustment, set the DPM to read exactly 19000 (turning the pot counterclockwise will increase the reading). This is a bipolar adjustment, and calibration is complete for both positive and negative inputs.

Procedure #2. Zero and gain adjustments are provided for both (+) and (–) inputs. Although the AD2004 has an automatic zero correction circuitry, the zero adjustment is provided to compensate for non-linearities at very low input signal levels. This zero adjustment is fully calibrated in final testing and it normally will not need adjustment.

Zero Adjustment: Using a calibrated reference source, apply an input of +100μV ±15μV, and adjust the (+) zero pot until the meter reads +0001. Repeat the procedure for –100μV ±15μV, adjusting the (–) zero pot.

Gain: Apply an input of +1.9V ±15μV. Adjust the (+) gain pot so that the DPM reads +19000. Turning the pot clockwise increases the reading. Repeat for an input of –1.9V ±15μV, adjusting the (–) gain pot.



PIN NO.	FUNCTION	WIRE COLOR
34	ANALOG HI	BRN
17	+VREF	RED
33	-VREF	ORN
16	ANALOG LOW	YEL
32	POWER GROUND	GRN
15	POWER GROUND	BLU
31	+5V	VIO
14	+5V	GRY
30	DEC. POINT 1	WHT
13	2's DIGIT	BLK
29	4's DIGIT	BRN
12	1's DIGIT	RED
28	8's DIGIT	ORN
11	DEC. POINT 10	YEL
27	20's DIGIT	GRN
10	40's DIGIT	BLU
26	80's DIGIT	VIO
9	DEC. POINT 100	GRY
25	10's DIGIT	WHT
8	200's DIGIT	BLK
24	400's DIGIT	BRN
7	800's DIGIT	RED
23	100's DIGIT	ORN
6	DEC.POINT 1000	YEL
22	2000's DIGIT	GRN
5	4000's DIGIT	BLU
21	8000's DIGIT	VIO
4	1000's DIGIT	GRY
20	OVERLOAD	WHT
3	STATUS	BLK
19	POLARITY	BRN
2	OVERRANGE	RED
18	TRIGGER	ORN
1	HOLD	YEL

6. AD2004 Signal & Pin Designations

NOTE: FOR UNIT DRIVING EXTERNAL WIRING
When not using "External Trigger" & "Hold" these two lines (Pin 1 Yellow & Pin 18 Orange) should be connected to +5V dc through a 1kΩ resistor in order to prevent random noise pick up. Failure to do this will casue erratic readings

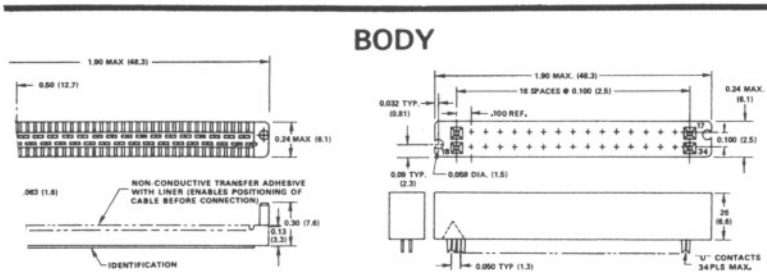


Figure 7. Connector Options

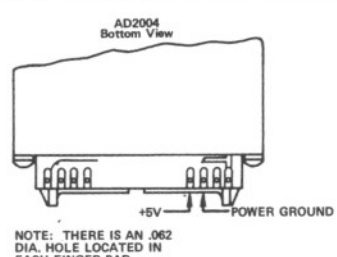


Figure 8.

ROPERTIES OF AC1601

Terminations
re Type Connections

34
Glass Filled Nylon
Beryllium Copper
: Gold Over Nickel
I: Fits Wire on 0.050" Centers

ELECTRICAL
Temperature Rating: +105°C
Contact Rating: 1 Amp
Withstand Voltage: 500VDC (Sea Level)
WIRE RECOMMENDATIONS
#28 AWG Solid
#28 AWG Stranded (7 Strand)
#30 AWG Solid
Maximum O.D. of Ins. Wire: 0.038"
Insulation: (Most Acceptable) – PVC, Non-Irradiated

AC1600 CABLE AND CONNECTOR

The AC1600 ((for the full six feet 12 feet (2 wires) round trip including return)) has 1Ω of resistance. This can result in variations in meter power which must be held to specified 5V dc ±5%. Where possible, provide power via separate wires connected to pin out pads on underside of meter (see above).