ANALOG DEVICES

3½ Digit Line Powered Functional DPM

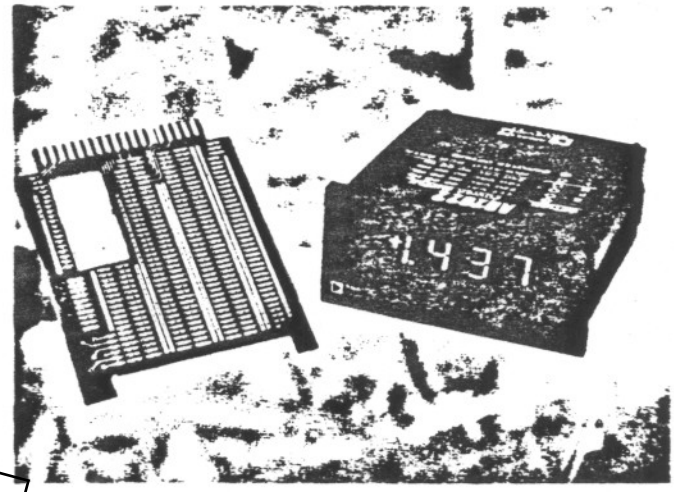
AD2022

FEATURES

- Space and Power for Large 3¾" x 4" (95 x 102mm) Custom Design Printed Circuit Card
- "Second Generation" MOS/LSI Design
- Large 0.5" (13mm) LED Display
- AC Line Powered, Universal Transformer
- ±1.999VDC Full Scale Range
- Auto Zero Correction
- AD2022: Limited Differential Input and Character Serial Data Output
- AD2022/I: Full Floating Input Isolation and Parallel BCD Data Output
- Optional Ratiometric Operation
- Industry Standard Case Design

APPLICATIONS

- Dedicated Transducer Readout for Temperature, Pressure, pH, or Any Other Physical Parameter
- Custom Test and Measurement Equipment with Customer Designed Signal Conditioning, and/or Logic Circuitry on Printed Circuit Board Internal to DPM



GENERAL DESCRIPTION

The AD2022 is a low cost 3½ digit, AC line powered, "functional" DPM. The AD2022 accommodates a large 3.75" x 4" (95 x 102mm) printed circuit board with over 12 square inches (7700mm^2) of usable circuit space for adding extra signal conditioning and/or logic circuitry. For powering additional signal conditioning circuitry, regulated ±12VDC at 20mA is provided. For logic circuitry, +5VDC at 100mA referenced to digital ground is available (30mA if the isolated parallel BCD output option is specified). The special function board is connected to the AD2022 converter board via ribbon cable. The function board also has an external 18 or 36 pin input/output connector with gold plated fingers. A standard breadboarding card is available or special layout printed circuit board (to suit the particular application) can be used.

The AD2022 converter measures bipolar input voltages over the full scale range of ±1.999VDC with an accuracy of ±0.05% reading ±0.025% full scale ±1 digit. The design of special signal conditioning circuitry is simplified by the AD2022 limited differential input (standard) which reduces effects of ground loops and provides common mode noise rejection.

The AD2022 displays readings on large 0.5" (13mm) high LED displays. Both (+) and (-) polarities are indicated. Controls are provided for blanking the display and for selection of any of three decimal points. A fourth decimal point is selectable by internal jumper.

The AD2022 is available for operation at any AC line voltage and frequency required throughout the world. And, since the AD2022 uses a "universal" transformer, simple bridging between solder pads allows for easy selection of AC input voltage. Thus, only minimum stocking for export is required to satisfy widely varying circumstances of AC power.

SECOND GENERATION DESIGN

The use of MOS/LSI (Metal Oxide Semiconductor/Large Scale Integration) integrated circuits in the AD2022 reduces the number of components, cuts power consumption and greatly increases reliability.

VERSATILITY FOR SIGNAL CONDITIONING

The standard AC2615 function card is laid out for easy breadboarding. Solder pads are provided on 0.100 inch spacing to fit standard dual in-line packages and other components. Special tracks are provided for bussing power to components. Provision exists on the front of the AC2615 to mount two trim pots which can be adjusted from the front of the DPM after removing the snap-on lens. Ribbon cable connects the AC2615 breadboarding card (or same size special layout function card) to the DPM converter card. Regulated ±12VDC and regulated +5VDC are available to power special circuitry. Height clearance allows mounting modules up to 0.65" high. If ratiometric operation is desired, one plated-through hole on the converter board is drilled out, and the reference-in and reference-out connections are made on the function board.

VERSATILITY FOR DATA INTERFACING

The BCD data output of the AD2022 is presented in bit parallel, character serial format compatible with CMOS logic systems. Some applications, such as interfacing with microprocessors, are simplified with this data format. Applications involving line printers or comparators often require parallel BCD data outputs. The AD2022/I is an optional version of the DPM that

(continued on page 3)

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West Coast 213/595-1783 Mid-West 312/894-3300 Texas 214/231-5094

SPECIFICATIONS (typical at +25°C and nominal power supply voltage)

DISPLAY OUTPUT
- Light emitting diode (LED), seven segment display readouts, 0.5" (13mm) high for 3 data digits, 100% overrange and polarity indication. Overload indicated by flashing display, polarity remains valid.
- Decimal points (3) selectable at input connector (DP 4XXX. selectable by internal jumper at Y3)
- Display Blanking

ANALOG INPUT
- Configuration: AD2022 – bipolar, limited differential
  AD2022/I – bipolar, floating
- ±1.999VDC Full Scale Range
- Automatic Polarity
- Auto Zero
- Input Impedance: 100MΩ
- Bias Current: 50pA
- Overvoltage Protection: ±200V peak sustained
- External Reference Voltage Range: +6.1V to +6.7V (For details, see Ratiometric Operation under Applying the AD2022.)

ACCURACY
- ±0.05% Reading ±0.025% Full Scale ±1 Digit[1]
- Resolution: 1mV
- Temperature Range[2]: 0 to +50°C operating; -25°C to +85°C storage
- Temperature Coefficient: Gain: 50ppm/°C
  Zero: Auto Zero
- Warm-Up Time to Rated Accuracy: less than one minute
- Settling Time to Rated Accuracy: 0.5 seconds (-full scale to +full scale)

NORMAL MODE REJECTION
- 40dB at 50–60Hz (converter clock frequency can be trimmed for greater rejection)

COMMON MODE REJECTION
- Limited Differential Mode: 40dB at DC and from 50Hz to 1kHz. 30dB from >DC to <50Hz. CMV, ±200mV peak max.
- Floated on Power Supply[3] or with AD2022/I Input Isolation: 100dB at 300V rms max. CMV, $dV_{cm}/dt < 10^6$ V/sec, 1kΩ imbalance.

CONVERSION RATE
- 5 conversions per second
- Hold and read on command

CONTROL INPUTS

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 (AD2022/I Only; TTL/DTL Compatible, 1 TTL Load). Logic "0" or grounding inhibits updating of latched parallel output data of AD2022/I. 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.

[1] Guaranteed at +25°C
[2] Guaranteed
[3] No control inputs or data outputs can be used when the AD2022 is floated on the power supply transformer at high common mode voltages. Restriction does not apply to AD2022/I.

DATA OUTPUTS (See Applications Section for details on the data outputs)[3]

Bit Parallel, Character Serial BCD Data Outputs (Standard)
4 BCD data bits, positive true logic (CMOS, LPTTL or LP Schottky Compatible, 1 LP Schottky Load)
4 digit strobes (CMOS, TTL Compatible, 1 TTL Load)
Polarity (CMOS, TTL Compatible, 1 TTL Load), Logic "1" indicates positive polarity
Clock Output (CMOS, TTL Compatible, 1 TTL Load)
Status Output (CMOS, TTL Compatible, 1 TTL Load)

Isolated Parallel BCD Outputs (Optional, AD2022/I Only)
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.

POWER INPUT
- AC Line 50–400Hz
- Power Consumption (with DPM supplying max rated function card currents): 6.2 watts at 60Hz; 6.4 watts at 50Hz; 6.0 watts at 400Hz

FUNCTION CARD POWER
- ±12VDC at 20mA (isolated on AD2022/I)
- +5VDC at 100mA (30mA with "I" option)
- Accuracy: ±10%
- Load Regulation: 2% for 0 to 100% load variation
- Line Regulation: 2% for -10 to +10% line variation
- Temperature Coefficient: ±500ppm/°C

CALIBRATION ADJUSTMENTS
- Gain
- Zero: Capability for system zero adjustment; meter is drift corrected
- Recommended recalibration interval: six months

SIZE
- 3.92"W x 1.67"H x 4.48"D (100 x 42 x 114mm)
- Panel Cutout: 3.930" x 1.682" (99.8 x 42.7mm)

WEIGHT
- AD2022 without function card: 15 ounces (425 grams)
- AC2615 breadboarding function card: 1 ounce (30 grams)

OPTIONS – ORDERING GUIDE[4]
- AC Power Inputs (no cost option)
  AD2022 – 117VAC
  AD2022/E – 220VAC
  AD2022/F – 100VAC
  AD2022/H – 240VAC
  } ±10%
- Isolated Parallel BCD (see pricing guide)
  AD2022/I
- Display Lens Options[5]
  Lens 7 – Red with ADI Logo
  Lens 8 – Red without ADI Logo
- Function Card
  AC2615, breadboarding function card with connector (AD2022 includes interconnecting ribbon cable)
- AD2022 Converter Card Connector
  30 pin, 0.156" spacing card edge connector, Viking 2VK150/1-2
  Optional: Order AC1501 at $3.50 each

PRICING
- AD2022: $142 (1–9), all power supply options
- AD2022/I: $183 (1–9)
- AC2615 Function Card: $15 (1–9), connector(s) included

[4] Only one AC power supply input may be specified. The "I" option can be ordered with any power supply input option.
[5] Lens 7 is supplied if no lens option is specified.

Specifications subject to change without notice.

(continued from page 1)

provides isolated character parallel BCD data outputs that are TTL compatible. The parallel data output is fully latched. Use of the isolated parallel BCD output option allows accommodation of up to 300V rms common mode voltage between analog inputs and digital ground.

AD2022 has two "Hold" inputs. The "Converter Hold" stops DPM conversions and inhibits both the display and the data outputs from changing. The "Data Hold" (AD2022/I only) prevents the data outputs from changing, but the DPM continues to convert and update the display.

STANDARD PACKAGING

The AD2022 is packaged in Analog Devices' AC line powered DPM case which uses the same panel cutout as most other AC line powered DPMs from other manufacturers. In addition, the pin connections for the AD2022 converter board are the same as for the AD2009, AD3016 and DPMs available from several other manufacturers.

DESIGNED AND BUILT FOR RELIABILITY

Even beyond the inherent advantages of the LSI IC design and LED displays, the AD2022 has had extreme care taken in its design and manufacture to insure reliability. Manufacturing processes are monitored by continual quality assurance inspections to insure proper workmanship and testing. Automatic equipment is used to test each DPM, both at the board level and at final assembly, to assure fault free performance. And, prior to shipment, each AD2022 must pass one full week of failure-free, +50°C cycled power burn-in.

APPLYING THE AD2022

Function Card Mechanical Considerations

The AD2022 function card capability is designed to accommodate special signal conditioning circuitry for user-designed measurements. A special breadboard card (AC2615, see Figure 1) is available for testing circuit designs and for small quantity production. For larger quantity production, special PCB layouts can be generated. Custom function cards with special layouts should conform to the outline dimensions, hole sizes and hole placements shown in Figure 2. Forbidden component areas and height restrictions for both the AC2615 and custom PCB cards are shown in Figure 3.

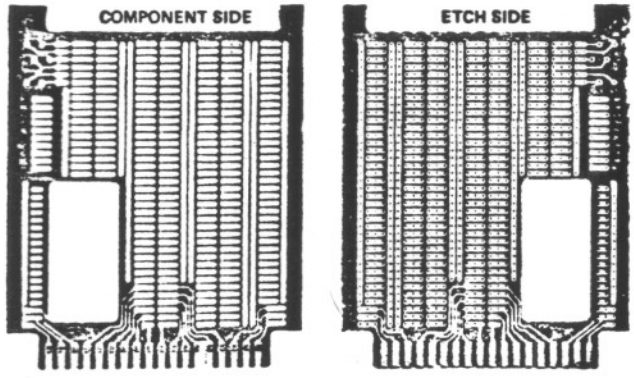

Figure 1. AC2615 Breadboarding Card

Provision is made on the AC2615 breadboard card and in the mechanical layout of the AD2022 to allow mounting two trimpots (for external trim and calibration) on the function card.

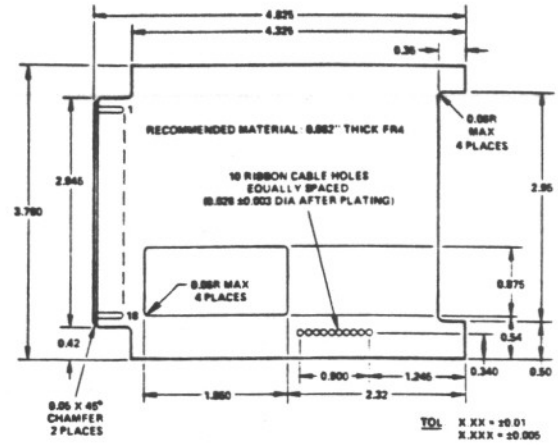

Figure 2. Dimensions of Large Function Card

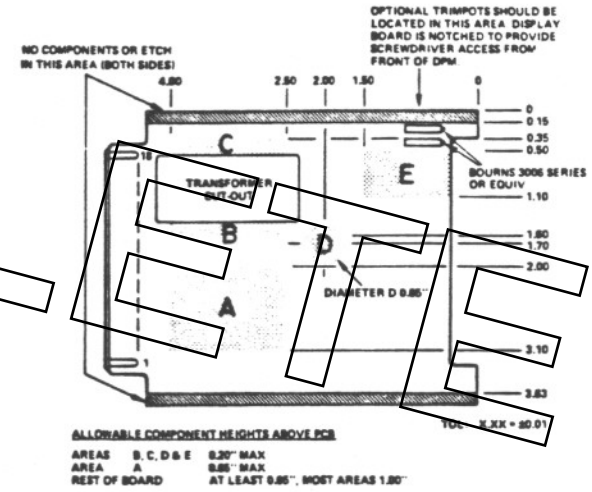

Figure 3. Large Card Forbidden Areas and Height Restrictions

By proper location of these pots, it is possible to have them accessible from the front panel after removing the AD2022 snap-on lens. Refer to Figure 11 for details.

It is also possible to use a small function card (1.10" x 1.43") in place of the large card. This is useful if only a limited amount of signal conditioning circuitry is necessary. Mechanical layout of this card is shown in Figure 4. Interconnection is by standard lead frame on 0.1" spacing.

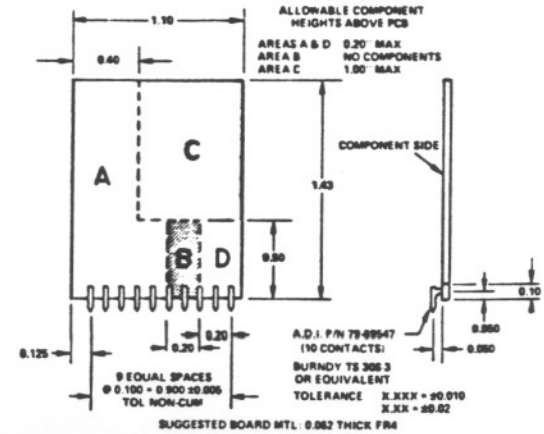

Figure 4. Dimensions of Small Function Card

Function Card Installation and Removal from Case

To install a function card, or to remove a combined converter and function card assembly, it is first necessary to remove the rear plate of the DPM case (Figure 11). This can be accomplished by removing the four Phillips head machine screws which hold the rear plate to the side extrusions. The printed circuit board(s) can then slide out of the slot(s).

To add the AC2615 or same size special layout board, start with the converter card laid down with the component side up. Place the function card, component side down, over the converter card so that the transformer can be seen through the cutout. A 10 conductor flat ribbon cable is factory assembled at one end to the converter card. Insert the pins of the free end of the ribbon cable into the outside ten holes of the function card and solder into place. Clean soldered joints with isopropyl alcohol.

A small function card (Figure 4) is installed on the converter card in place of the ribbon cable, components facing inward.

For installation in the case, slide the board(s) into the slot(s) until the assembly is fully forward. With the case right side up (AD2022 model identification on top) the converter card should be in the lower slot. Re-install the rear plate with four #4 machine screws.

Interconnections Between Boards

As described above, the AC2615 or same size special layout board connects directly to the AD2022 converter card via a 10 conductor flat ribbon cable. The combined assembly, out of the case, can be laid flat on a workbench for ease in troubleshooting and modifying circuitry (Figure 5).

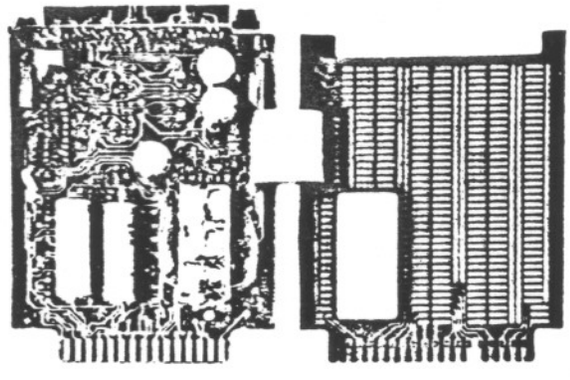

Figure 5. Converter/Function Assembly Laid Flat

IMPORTANT NOTE: There is AC line voltage on the primary of the AD2022 transformer. This can be very dangerous if proper care is not exercised. Working surfaces should be clean. Avoid touching PC tracks and components in the power supply area.

Whether large card with ribbon cable or small card mounted directly on the converter board, the electrical connections available between boards are as follows:

PIN	FUNCTION
1	Reference Source, internal +6.1V to +6.7V with respect to Analog Ground
2	Reference Input, +6.1V to +6.7V (drill out hole X16 to use external reference)
3	+5VDC ±10%, referenced to Digital Ground
4	+12VDC ±10% referenced to Analog Ground
5	Analog Ground ⏚
6	-12VDC ±10%, referenced to Analog Ground
7	Analog Input to A/D converter
8	Spare (hole Y7 on converter board)
9	Digital Ground ▽
10	Analog Input of DPM (pin 2 on AD2022 I/O connector)

The AD2022 Block Diagram (Figure 6) also shows these connections and how they relate to the AD2022 converter.

Function Card Input/Output Connections

With a large size function card, there are two ways of making signal connections. The AC2615 breadboard card has its own 18 pin card edge connector for inputs and outputs. Customer designed boards can have 18 or 36 pin card edge connectors. Thus, if desired, the converter card edge connector (P1, Figures 9 and 10) can be used exclusively for power and data outputs, and the function card connector can be used for signal inputs and special function outputs. Alternatively, where there are only limited input and output connections required, external connections to the function card can be made via the P1 connector and the interconnecting ribbon cable. In this fashion, signals can be brought in via P1 on Pins 2 (Signal Input), 10 (Analog Ground), A (Spare, hole Y4) and B(Spare, hole Y5). If this latter method is used, it may be necessary to remove R10 (input protection and filter resistor) and possibly C1 (input filter capacitor) in order to prevent undesired circuit

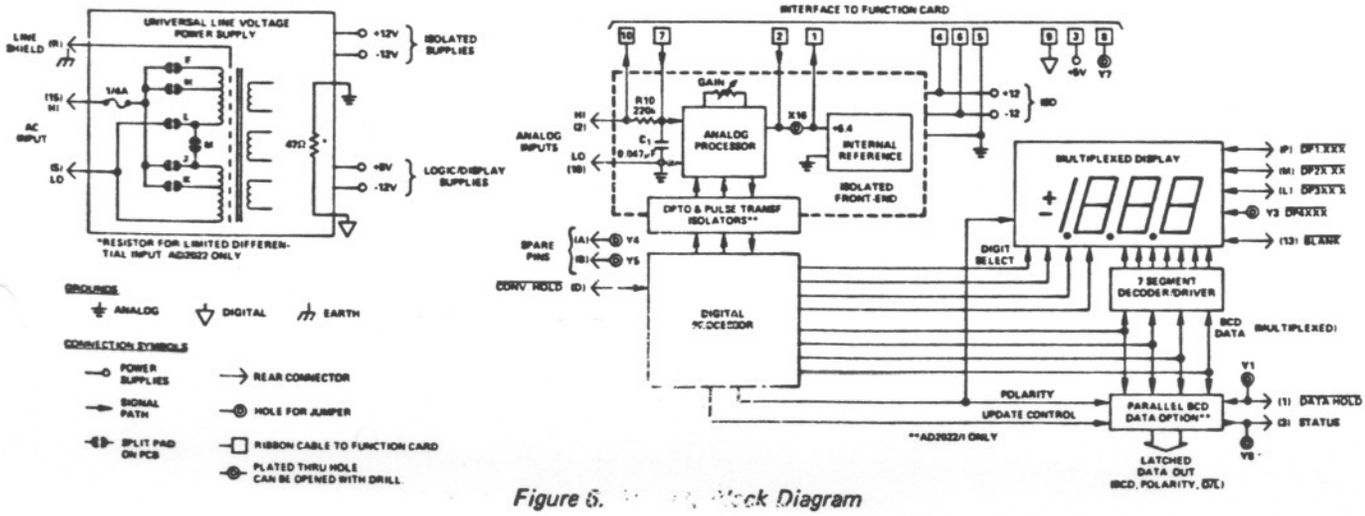

Figure 6. [illegible] Block Diagram

interactions. Locations of C1 and R10 can be found in Figure 7. When small function cards are used, P1 is the only method of access.

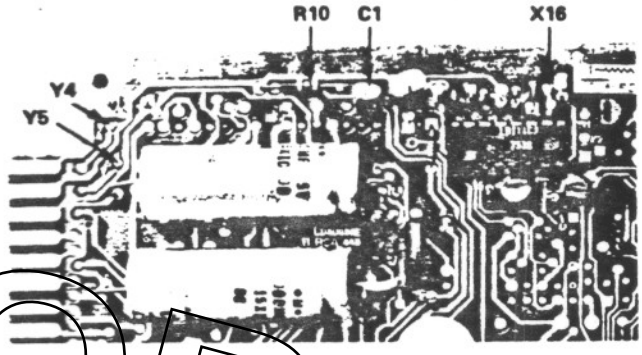

Figure 7. Locations of R10, C1, X16, Y4 and Y5.

Power Available for Custom Circuitry

Power is available for both analog and digital circuits on the function card. The ±12V power will deliver up to 20mA. This analog power is referenced to analog ground ⏚. The +5V power will supply 100mA on AD2022 models (30mA on AD2022/I versions with isolated parallel BCD outputs). +5V is referenced to digital ground ▽. With AD2022 limited differential or AD2022/I isolated input, it is important that power connections and signal inputs be referred to the appropriate ground.

Ratiometric Operation

The AD2022 normally makes conversions referenced to a stable +6.4V internal reference. If ratiometric measurements are desired (such as with bridge transducers), it is necessary to drill out (drill size #65, 0.035" dia.) the plated through hole labeled X16 (Figure 7). The internal reference (Pin 1 on ribbon interconnect cable) will then be disconnected from the A/D converter and a reference voltage input (Pin 2 on the cable) will be available to accept stable external reference voltages in the range of +6.1V to +6.7V. In a ratiometric mode, the DPM will convert with the transfer function:

$$\text{Display} \approx 6400 \frac{E_{IN}}{E_{REF}}$$

The front panel converter gain adjustment is still usable in the ratiometric mode, with an adjustment range of approximately ±5%.

It is important to remember that the reference is with respect to analog ground ⏚, not digital ▽ or earth ground ⏚. If the AD2022's internal reference voltage is used for external circuitry, an op amp buffer should be used to assure sufficient drive current capability (internal reference can source up to 100μA without buffering).

Decimal Points

Grounding or Logic "0" applied to the appropriate pin will illuminate the desired decimal point. External drive circuitry, if used, must sink 25mA peak at a 25% duty cycle when the decimal point is turned on.

Display Blanking

Grounding or Logic "0" blanks the entire AD2022 display with the exception of the decimal points on the tens and hundreds digit. The display is valid immediately upon removal of a blanking signal. Display blanking has no effect on the BCD data output (remains valid during display blanking).

Converter Hold

Grounding or Logic "0" causes the DPM to cease conversions and display the data from the last conversion. After a "Converter Hold" is removed, the auto zero circuitry requires one or two conversions before the display and data outputs are again valid.

Data Hold (AD2022/I Only)

Grounding or Logic "0" on this input inhibits updating of the parallel BCD outputs of the AD2022/I. If the parallel data is interfaced to a printer, comparator, computer or other equipment requiring the data to be held stable for proper operation, the Data Hold input should be used to prevent data updating. The DPM itself will continue making conversions and displaying results. After a Data Hold is removed, the BCD data output is updated with valid data on the next completion of a conversion cycle.

Extended Range Measurements

Although the full scale range of the AD2022 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 AD2022, 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. BCD outputs on the standard AD2022 are valid (with appropriate decoding) up through the 3000 count range. The parallel BCD outputs of the AD2022/I beyond 1999 counts go to Logic "0" on all BCD lines as does the Overload Output.

Interfacing Data Outputs – Character Serial BCD

The BCD data outputs on the standard AD2022 are presented in bit parallel character serial format. There are four BCD bit outputs (1, 2, 4, 8) and four digit outputs (10^0, 10^1, 10^2, 10^3, called D1, D2, D3 and D4 respectively). The four bits representing each digit are gated onto the BCD output lines in the continuously repeated sequence D1, D3, D2, D4. At any given time, the BCD output is valid for the digit whose digit line is high (Logic "1"). This serial output data is valid except when it is being updated, which occurs within 2 milliseconds after the Status Line goes low, indicating the end of a conversion (see Figure 8).

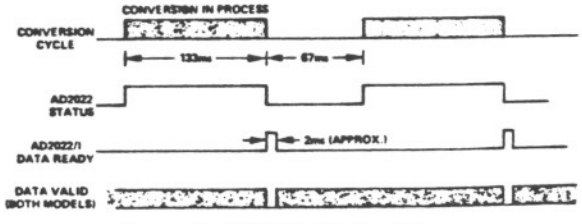

Figure 8. AD2022 Timing Diagram

Interfacing Data Outputs – Parallel BCD

The AD2022/I 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 8). As described on the preceding page, the "Data Hold" input can be used to inhibit updating of the parallel data outputs without affecting DPM conversions or the DPM display.

Converter Calibration Procedure

A precision voltage reference is required. The location of the calibration potentiometers is shown in Figure 11. Always adjust the zero offset before the gain if zero adjustment is necessary.

Zero Adjustment: Short the signal inputs (Pins 2 and 10) and adjust the zero offset potentiometer until the meter reads 000.

Gain Adjustment: Apply an input of +1.800V and adjust the gain potentiometer until the meter reads 1800 exactly.

This calibration procedure refers to the AD2022 converter section only. Calibration of any signal conditioning circuitry on the function card is, of course, not considered.

PIN DESIGNATIONS

PIN REF	PIN FUNCTION
1	NC
2	SIGNAL INPUT
3	STATUS (PRINT)
4	POLARITY
5	NC
6	D4
7	BCD 2¹
8	BCD 2¹
9	CLOCK OUTPUT
10	ANALOG GROUND
11	NC
12	D3
13	DISPLAY BLANK
14	NC
15	AC LINE HIGH

KEY

PIN REF	PIN FUNCTION
A	NC (HOLE Y4)
B	NC (HOLE Y5)
C	NC
D	CONVERTER HOLD
E	D2
F	NC
H	BCD 2⁰
J	BCD 2²
K	D1
L	DP3 XX.X
M	DP2 X.XX
N	DIGITAL GROUND
P	DP1 .XXX
R	SHIELD (EARTH GROUND)
S	AC LINE LOW

(INC = NO CONNECTION)

Figure 9. AD2022 Connector P1

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

KEY

PIN REF	PIN FUNCTION
A	NC (HOLE Y4)
B	NC (HOLE Y5)
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 10. AD2022/I Connector P1

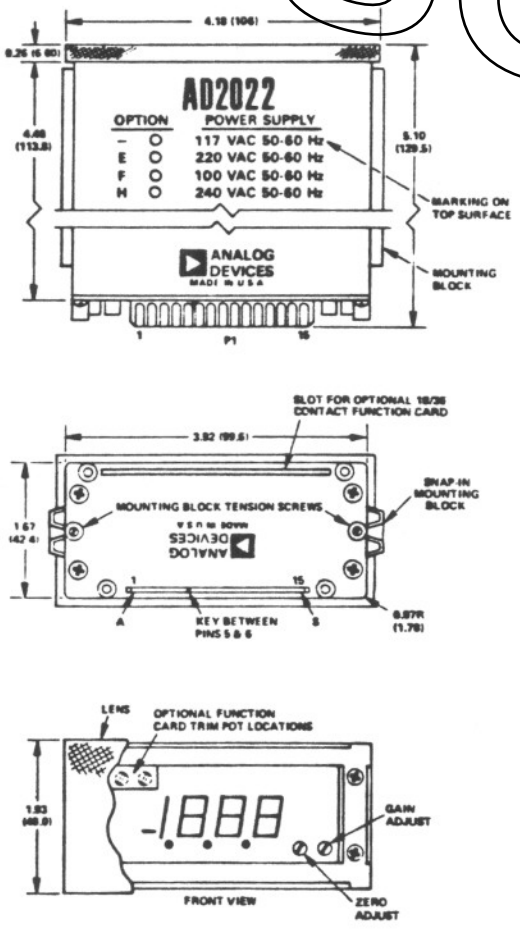

Figure 11. AD2022 Mechanical Outline (Dimensions shown in inches and (mm))

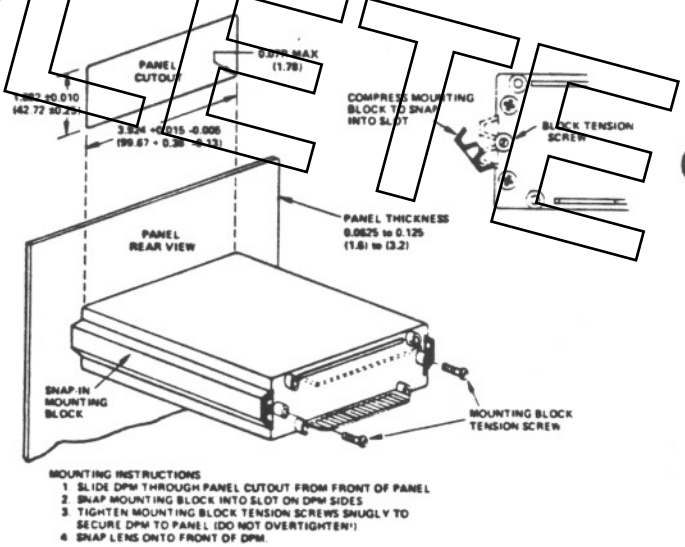

Figure 12. AD2022 Mounting Instructions (Dimensions shown in inches and (mm))