MODEL 35B
GENERAL PURPOSE DIFFERENTIAL AMPLIFIER

LAWSON LABS, INC.
3217 Phoenixville Pike
Malvern, PA 19355

610 725-8800
or
800 321-5355

Rev. D

TABLE OF CONTENTS

INTRODUCTION

The Lawson Labs Model 35B Differential Amplifier, in combination with any Lawson Labs precision A/D card, allows a personal computer to be used as a multi-channel millivoltmeter. Despite the low per channel cost, the Model 35B delivers highly accurate and stable data when properly applied.

The inputs to the Model 35B are protected against transient overvoltages of up to 120 volts or 65 volts continuous.

Four Model 35Bs can be used with one Model 134 or Model 140 A/D card. Two Model 35Bs can be used with one Model 141 A/D card. Systems up to 512 channels can be assembled using Model 66 Expansion modules. Much larger systems are possible. Contact the factory for details.

SECTION 1.   INTERCONNECTIONS

Eight wires will be needed to connect the Model 35B to the A/D card. See the appropriate section in the A/D card's manual for pin locations. The interconnecting wire can be of any general-purpose type. We strongly recommend shielded wire for all connections. Small diameters and long lengths of wire will not interfere with system function except in extreme cases. For example, 250 feet of 26AWG shielded wire will not significantly affect the system. The "+" output should connect to one of the plus input pins on the A/D's connector and the "-" output should connect to the corresponding minus input at the A/D card. The examples in this manual assume the first Model 35B is connected to input #0. If another input is used, the control codes should be adjusted as described in the A/D manual. The GROUND terminal on the Model 35B should be connected to chassis ground at the computer.

WARNING: Use a cover-securing screw (without paint) for chassis ground.

On some portable computers, no metal chassis contact is accessible. In that case, use the center screw of the power outlet as ground. We do not recommend using the ground pin on the A/D card connector instead of chassis ground because it is possible that under certain catastrophic conditions the ground current might be large enough to cause damage to the computer.

The control inputs to the Model 35B should now be connected to the isolated control output lines on the A/D card connector. Input A is connected to output A on the A/D, input B is connected to output B on the A/D, input C is connected to output C on the A/D, and input D is connected to output D on the A/D card. Connect the Guard pin on the A/D card connector to the GUARD terminal on the Model 35B.

FIGURE 1.   INTERCONNECTION DIAGRAM FOR MODEL 35B
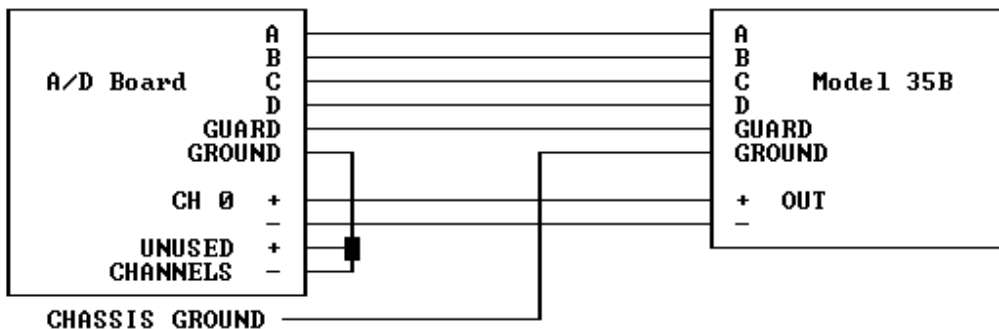
## SECTION 2.   CONNECTING INPUTS

Any type of millivolt source may be used with the Model 35B.

NOTE: No input voltages need be connected to test operation. You

may want to connect one source only and then check its operation
before connecting additional inputs.

     The input connections for the amplifier are inside the case.
Unplug the power supply and then remove the four screws at the
extreme corners of the cover. Inside the 35B you will find 16
pairs of screw terminals and three ground terminals. For
shipment, the input terminals are connected together and to
ground. The ground wires prevent static discharges, which can be
of extremely high voltage, from damaging the circuitry. You will
find a diagram of the input terminal locations on the circuit
card itself. The terminals labeled 3A are selected with a channel
code of 3. Terminals labeled 3 through 14 are selected using
codes 4 through 15.

**FIGURE 2.   MODEL 35B AMPLIFIER INPUT CONNECTIONS**
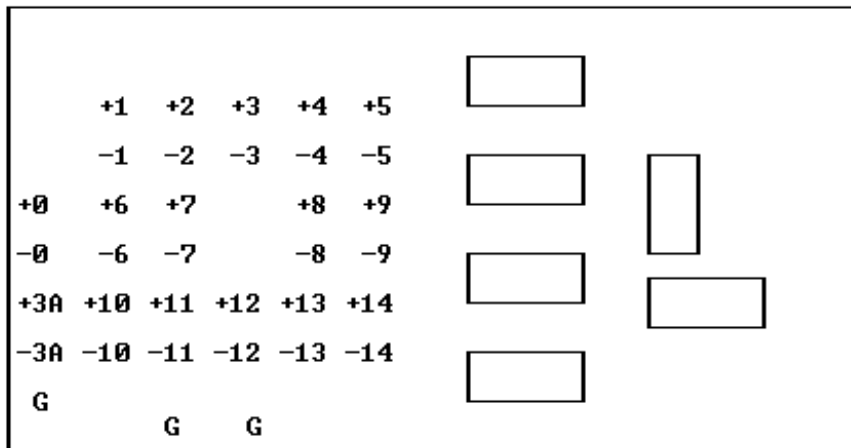
     Run the first input cable through one of the holes in the
case. Remove the grounding wire from terminal pair #1 and connect
the plus wire to the plus terminal and the minus wire to the
minus terminal. If a shield is present, you may want to connect
it to one of the ground terminals (labeled G). Remember that both
the plus and and minus inputs must be within 5 volts of ground
potential for proper operation. If the voltage source is
floating, then the minus input should be connected to ground. If
multiple inputs each have a minus wire connected to a remote
common point, then either the common point should be grounded or
one (and only one) of the minus leads should be jumpered to
ground at the Model 35B. See Figure 3.

CAUTION: Excessive torque can damage the ground terminals.

     Connect any other sources in the same fashion. Holes are
provided at the card's edge for strain relief. Secure the wires
to the card with lacing cord or cable ties for protection against
mechanical failure. Replace the cover and securing screws.

NOTE: If a source is removed from the input terminals, it must be
replaced by a grounding wire.

FIGURE 3.   EXAMPLES OF INPUT SOURCES
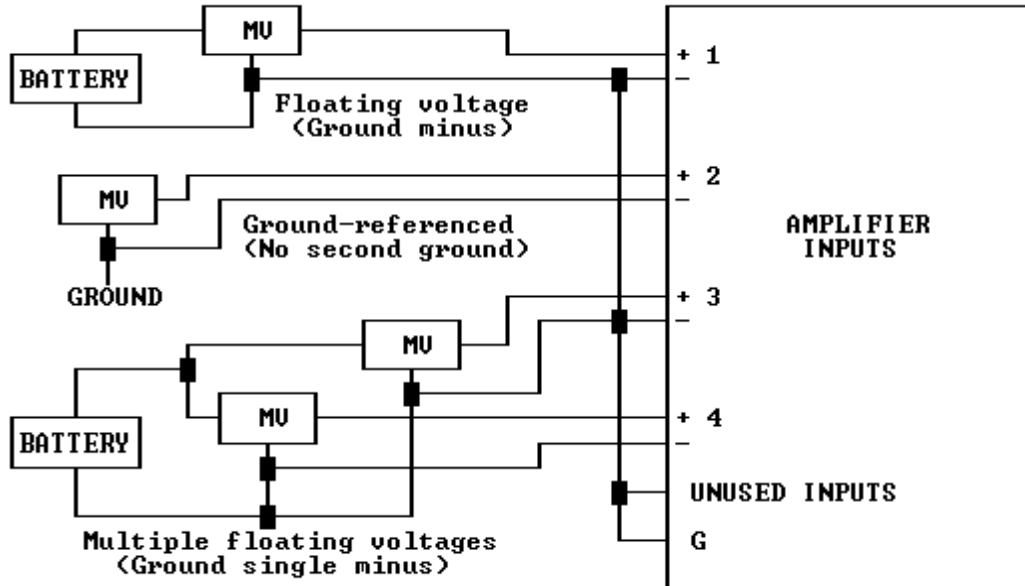
SECTION 3.   OPERATION

After the interconnections have been completed, plug in the power cord and turn on the computer. If you are using the Lawson Labs PC64 Data Logging Software, run the program. Configure the A/D channel to which you have connected the Model 35B as a multiplexer and enter the G factor. You should now see millivolts at the amplifier input displayed on the screen. Amplifiers with gains of 100 or more are scaled to display in microvolts.

The following detailed description is for programmers who want to integrate Model 35B support into their application programs. In the following example, the Model 35B is assumed to be at A/D channel #0. The Model 134 example assumes all switches are OFF. The Model 140 example assumes switch #4 is in the ON position. The Model 141 example assumes switches #1, 4, 5 and 6 are ON and all others are OFF. If your address switches are set differently, see your A/D manual for the correct ADC address.

Enter the following program. Set BOARDCODE in line 2030 to 128 for a Model 141; set it to 0 for a Model 134 or 140. If you are using a Model 141, refer to the A/D board manual and be sure to calibrate the 141 card in bipolar mode before proceeding.

The main program below begins at line 1000. It calls various subroutines to perform the necessary operations. Subroutine 2000 sets the constants for your particular combination of Model 35B and A/D board. PAUSE for the Model 141 should be set to the settling time of the A/D board plus 0.1 second. The settling time is listed in the 141 manual. The 35B itself requires only one millisecond settling time. The 0.1 second pause is needed because of the resolution of the TIMER function. Subroutine 3000 reads and displays the offset from channel #0 of the Model 35B. The format for display may be changed if desired to display fewer digits. Subroutine 7000 provides the necessary delay for the

hardware. Subroutine 8000, which depends on A/D board type, does
the actual reading of the data and the conversion to millivolts.

```
1000 REM Sample program
1010 GOSUB 2000: REM Set constants for your system
1020 ADCHAN = 0: REM Assume A/D board channel #0
1030 GOSUB 3000: REM Read and display offset
1090 END

2000 REM Set constants
2010 PAUSE = 0.1: REM For the 141, enter settling time + 0.1
2020 ADC = [value]: REM Your A/D board address
2030 BOARDCODE = [value]: REM 128 for Model 141, 0 for others
2070 RETURN

3000 REM Read and display offset
3010 OUT ADC, BOARDCODE + ADCHAN * 16
3020 GOSUB 8000
3030 OFFSET = V
3040 PRINT USING "A/D Channel ##"; ADCHAN;
3050 PRINT USING "    Offset #####.#### mv"; OFFSET
3060 RETURN

7000 REM Delay for settling time of PAUSE sec.
7010 IF TIMER > 86395 THEN GOTO 7010
7020 START = TIMER
7030 IF TIMER < START + PAUSE THEN GOTO 7030
7040 RETURN
```

    Include this subroutine if you are using a Model 140.

```
8000 REM Returns Model 140 voltage in millivolts
8010 OUT ADC + 1, 0
8020 IF INP(ADC) AND 128 THEN 8020
8030 X = INP(ADC)
8040 V = X MOD 16 + (INP(ADC + 1) MOD 16) * 10  + (INP( ADC + 2)
     MOD 16) * 100 + (INP(ADC + 3) MOD 16) * 1000
8050 IF X AND 32 THEN V = V + 10000
8060 IF X AND 64 THEN V = −V
8070 V = V * .25
8080 RETURN
```

        Include this subroutine if you are using a Model 134. In
line 8030, you may set AVERAGE anywhere from 1 to 255. Larger
numbers reduce noise while smaller numbers increase speed.

```
8000 REM Returns Model 134 voltage in millivolts
8010 GOSUB 7000
8020 X = INP(ADC)
8030 TOTAL = 0: AVERAGE = 20
8040 FOR X = 1 TO AVERAGE
8050 IF INP(ADC − 1) AND 2 THEN 8050
8060 V = INP(ADC + 1) * 256! + INP(ADC)
8070 TOTAL = TOTAL + V
8080 NEXT X
8090 TOTAL = TOTAL / AVERAGE: V = (TOTAL − 32768) * .152588
8100 RETURN
```

        Include this subroutine if you are using a Model 141.

```
8000 REM Returns Model 141 voltage in millivolts
```

```
8010 GOSUB 7000
8020 OUT ADC + 1, 1
8030 H = (INP(ADC + 2) AND &H0F)
8040 M = INP(ADC + 1)
8050 L = INP(ADC)
8060 OUT ADC + 1, 0
8070 COUNT = L + M * 256 + H * 65536
8080 V = COUNT * 9.536743E-03 - 5000
8090 RETURN
```

RUN the program. The offset voltage from the 35B is displayed on the screen. The value of the offset for the amplifier should be close to zero volts. If the short-term variation exceeds a millivolt, check for loose connections or improper grounding. Note that to read the offset at channel 0 on the Model 35B, both input terminals must be connected together and to ground.

Add the following lines to your program. LASTCHAN in line 2060 is the number of millivolt sources attached to your Model 35B assuming the first source is connected to channel 1. The voltage at the input terminals will be printed at line 5090.

```
1050 FOR MUXCHAN = 1 TO LASTCHAN
1060 GOSUB 5000: REM Read and display input
1070 NEXT MUXCHAN

2050 G = [value]: REM from Model 35B case
2060 LASTCHAN = [value]: REM number of sources attached

5000 REM Read and display input
5010 M35BCHAN = MUXCHAN
5030 OUT ADC, BOARDCODE + ADCHAN * 16 +  M35BCHAN
5040 GOSUB 8000
5050 V = (V - OFFSET) * G / 100
5070 PRINT USING "A/D Channel ##"; ADCHAN;
5080 PRINT USING "    35B Channel ##"; M35BCHAN;
5090 PRINT USING "    ###.###### mv"; V
5100 RETURN
```

SECTION 4.   USING MULTIPLE MODEL 35Bs

It is possible to connect two, three, or four Model 35Bs. When multiple Model 35Bs are connected, all must be powered for the system to function properly.

FIGURE 4.   INTERCONNECTION DIAGRAM FOR MULTIPLE MODEL 35Bs
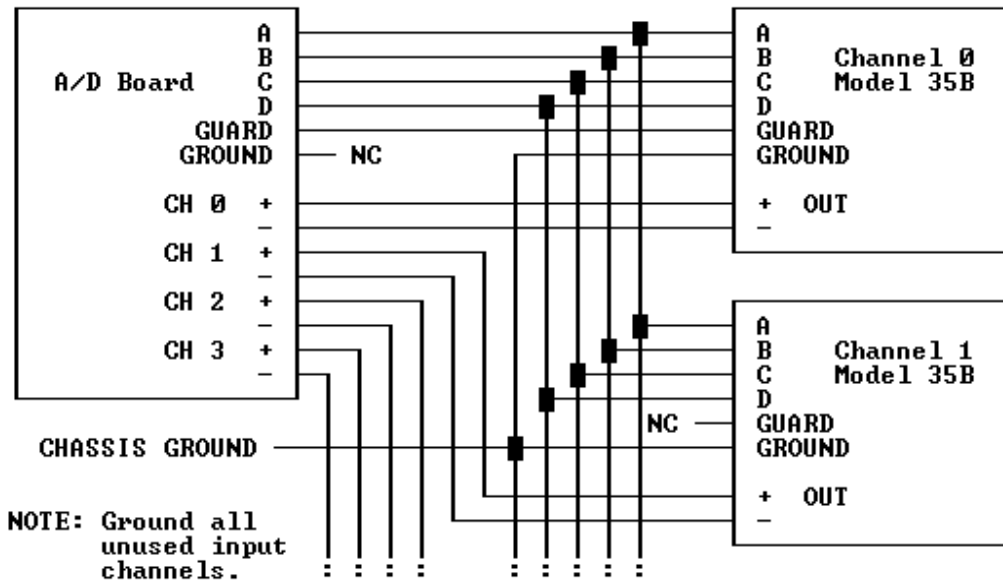
        For multiple amplifier operation, add or change the
following lines marked by asterisks in the program. MAXCHAN is
the highest A/D channel number which has a Model 35B connected to
it. Insert all the applicable G constants identified by their
channel numbers.

```
  1000 REM Sample program
  1010 GOSUB 2000: REM Set constants for your system
* 1020 FOR ADCHAN = 0 TO MAXCHAN
  1030 GOSUB 3000: REM Read and display offset
* 1050 FOR MUXCHAN = 1 TO LASTCHAN(ADCHAN)
  1060 GOSUB 5000: REM Read and display input
  1070 NEXT MUXCHAN
* 1080 NEXT ADCHAN
  1090 END

  2000 REM Set constants
  2010 PAUSE = 0.1: REM For the 141, enter settling time + 0.1
  2020 ADC = [value]: REM Your A/D board address
  2030 BOARDCODE = [value]: REM 128 for Model 141, 0 for others
* 2050 G(0) = [value]: G(1) = [value]: REM etc.
* 2060 LASTCHAN(0) = [value]: LASTCHAN(1) = [value]: REM etc.
  2070 RETURN

  3000 REM Read and display offset
  3010 OUT ADC, BOARDCODE + ADCHAN * 16
  3020 GOSUB 8000
  3030 OFFSET = V
  3040 PRINT USING "A/D Channel ##"; ADCHAN;
  3050 PRINT USING "    Offset #####.#### mv"; OFFSET
  3060 RETURN

  5000 REM Read and display input
  5010 M35BCHAN = MUXCHAN
  5030 OUT ADC, BOARDCODE + ADCHAN * 16 + M35BCHAN
  5040 GOSUB 8000
* 5050 V = (V - OFFSET) * G(ADCHAN) / 100
  5070 PRINT USING "A/D Channel ##"; ADCHAN;
```

```
5080 PRINT USING "    M35B Channel ##"; M35BCHAN;
5090 PRINT USING "    ###.###### mv"; V
5100 RETURN
```

     RUN the program again. The voltages for all A/D channels and
Model 35B channels will be displayed.

SECTION 5.   TROUBLESHOOTING

GENERAL: If problems occur, first short the input terminals of
the amplifier. If that channel then reads near zero volts, then
the problem is probably with the source or its connections.

A. If the voltage reads near zero when you think it shouldn't,
check that the cord is plugged in and that the outlet is live.
Either the amplifier input or output could be short-circuited.
Double-check that guard on the A/D card is connected to GUARD on
the amplifier.

B. If the polarity is reversed, reverse the input leads.

C. If the voltage readings seem random, check for a broken wire.
Check that unused input terminals are grounded. Also make sure
that the correct input channel is being selected.

D. If the voltage readings are consistent but wrong, check for
redundant signal grounds.

E. If the readings show excessive scatter, check for loose
connections. Make sure the GROUND terminal on the amplifier is
connected to chassis ground at the computer and that ungrounded
sources have a connection from minus in to G in the Model 35B.
Perhaps shielding for the amplifier output wires is needed.

F. If more than one device is connected to the output port, all
must be turned on for any to work properly.

G. If a particular source is reading erratically in a multiple
35B system, check the like-numbered sources on the other boxes.

H. Erratic readings can be caused by ground loops or missing
grounds. Try removing redundant ground wires or adding a
connection from the minus input terminal to ground.

I. Erratic readings can also be caused by an extremely fast
computer over-running the settling ability of the Model 35B. Try
adding a longer pause in the program after the channel selection
but before the A/D conversion is initiated.

SECTION 6.   INPUT CODE SUMMARY

| CODE | BINARY | | | | AMPLIFIER |
	D	C	B	A	TERMINALS
0	0	0	0	0	INPUT #0
1	0	0	0	1	INPUT #1
2	0	0	1	0	INPUT #2
3	0	0	1	1	INPUT #3A
4	0	1	0	0	INPUT #3

```
 5        0    1    0    1              INPUT #4
 6        0    1    1    0              INPUT #5
 7        0    1    1    1              INPUT #6
 8        1    0    0    0              INPUT #7
 9        1    0    0    1              INPUT #8
10        1    0    1    0              INPUT #9
11        1    0    1    1              INPUT #10
12        1    1    0    0              INPUT #11
13        1    1    0    1              INPUT #12
14        1    1    1    0              INPUT #13
15        1    1    1    1              INPUT #14
```

NOTE: Although there are input terminals on channel #0 of the Model 35B, that channel is normally used for software offset correction. To read the offset at any channel, both input terminals for that channel must be connected together and to ground.

SECTION 7.   INTERNAL ADJUSTMENT & CALIBRATION

The only trim adjustment inside the Model 35B is an offset trim. It is normally set at the factory to 0.0 volts for the amplifier. The output is usually set with input code #0 selected. The offset will change slightly with temperature but the effects are cancelled in software and the drift will not cause errors. With the offset at 0.0 volts the Model 35B has approximately equal range in the positive and negative directions. If more range is needed in either direction, the offset can be moved away from zero by rotating the shaft of the trimpot with a small screwdriver.

There is no hardware gain adjustment. If you want to fine tune the gain, adjust the G factor to match a known input voltage. If you wish to have the calibration checked, contact Lawson Labs for details.

SECTION 8.   SPECIFICATIONS

INPUTS: 16 fully differential channels

INPUT OVERVOLTAGE
PROTECTION: 120 volts transient
                        65 volts continuous

INPUT IMPEDANCE: 1000 megohms typical

LINEARITY: 0.05% of full scale

SETTLING TIME: 400 microseconds

DIFFERENTIAL MODE
INPUT RANGE: +/- 100 mv nominal with amplifier
                         gain of 50

COMMON MODE
INPUT RANGE: +/- 4 volts

CONTROL INPUTS: 6 volt logic, negative true. Compatible
                         with all Lawson Labs A/D cards.

```
POWER
REQUIREMENT:           105-135 VAC, 50-60HZ, 6 Watts

SIZE:                  6.25 x 3.75 x 2 inches

OPTIONS:               Premium low-noise amplifier
                       Custom gain setting (x2 to x400)
                       DC powered, panel mounting
```

LIMITED WARRANTY

All Lawson Labs, Inc. products are guaranteed against defects in materials and workmanship for a period of one year from the date of delivery. Products must be returned to Lawson Labs for warranty service. Contact Lawson Labs, Inc. at 800 321-5355 for return authorization before returning anything for service. The above warranty is in lieu of all warranties express or implied. Lawson Labs will not be liable for indirect or consequential damages caused by any defect in this product. Some states do not allow the limitation of consequential damages, so the above exclusion may not apply to you.