Adjustment Procedure

INTRODUCTION

You can use this procedure to adjust the AP033 Active Differential Probe to meet the warranted specifications. This procedure should only be performed if the instrument fails to meet the Performance Verification tests.

If the probe cannot be adjusted to meet the Performance Verification limits, repair may be necessary.

To ensure instrument accuracy, check the calibration of the AP033 every 1000 hours, or once a year if used infrequently. Before calibration, thoroughly clean and inspect this unit as discussed in the “Cleaning” section.

Completion of each step in the Adjustment Procedure ensures that the differential probe meets specifications. Some of the adjustments interact with other portions of the circuitry. Therefore, it is necessary that all adjustments be performed in the order listed. For best overall instrument performance, make each adjustment to the exact setting, even when adjustment is within the limits stated in the procedure.

Adequate guard bands were designed into the AP033 to ensure that it will meet or exceed published specifications over the entire operating temperature range. To continue to meet the environmental specifications, all adjustments must be performed in a controlled environment with an ambient temperature of 25 ±5 ˚C. The probe must also be at stable operating temperature before performing adjustments.

Caution

The adjustment procedure will require removal of the probe covers. These covers are part of the ESD protection system of the AP033. To protect the probe, you should perform the entire procedure on a static dissipating work surface. Wear an antistatic grounding wrist strap and follow standard static control procedures.

The probe tip housing provides physical rigidity to the input pins of the probe. When the covers are removed, observe extra caution to avoid breaking the probe tip receptacles when mating the probe to the calibration fixture.

TEST EQUIPMENT REQUIRED

The table on the next page lists the test equipment and accessories, or their equivalents, that are required for complete calibration. Specifications given for the test equipment are the minimum necessary for accurate calibration. All test equipment is assumed to be correctly calibrated and operating within the specifications listed. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the test equipment manual if more information is needed.

If alternate test equipment is substituted, control settings or calibration equipment setups may need to be altered. Alternate models of test equipment may have different connector styles requiring adapters not included in the equipment list.

TABLE 4
Test Equipment and Accessories

Description	Minimum Specifications	Test Equipment Examples
Wide Band Oscilloscope *	500 MHz bandwidth 2 mV to 200 mV vertical scale factors ProBus interface equipped* 2% vertical accuracy	LeCroy LT354
Digital Multimeter	0.1% DC volts accuracy at 0.4 V 0.2% AC volts accuracy at 2 V and 1 kHz 5½ digit resolution 0.01 mV AC volts resolution	Agilent Technologies 34401A, Fluke 8842A-09, Keithley 2001
Function Generator	Sine and square wave output 20 V_{p-p} into 1 MΩ 50 Hz to 1 MHz frequency range Sync. or Freq. Reference output	Agilent Technologies 33120A, Stanford Research Model DS340
Fast Rise Pulse Generator	Risetime <2 ns Amplitude >400 mV into 50 Ω Over/Undershoot <6%	Calibrator signal from LeCroy oscilloscope Tegam / Tektronix PG506 with power unit
Sine Wave Generator	Output 250 MHz at 1 V RMS	Agilent Technologies 8648C, with male N to female BNC adapter for the output connector. Tegam SG504 with TM series mainframe.
DC Voltage Source	0 to 1 VDC regulated output, settable to 1 mV resolution	Agilent Technologies 6633A
Termination, BNC	50 Ω through, Male - Female	Pomona 4119-50
Termination, precision	50 Ω ± 0.05%	LeCroy TERM-CF01

TABLE 4
Test Equipment and Accessories

Description	Minimum Specifications	Test Equipment Examples
Calibration Fixture	ProBus Extension Cable	LeCroy PROBUS-CF01
Calibration Fixture	AP033/AP034 Calibration Fixture	LeCroy AP03X-CF01
BNC coaxial cable (2 Required)	male-male BNC, approx. 1 m	Pomona 5697-36
BNC T Adapter	female-male-female	Pomona 3285
Banana Plug Adapter (2 Required)	BNC female to dual male banana plug	Pomona 1269
Shorting Plug	Two 0.025 in. square pins on 0.100 in. centers	Supplied with AP03X-CF01
Adjustment Tool	0.025 in. square tip	Johanson 4192
Low Capacitance Screwdriver		

**** Notes***

If a LeCroy ProBus equipped oscilloscope is not available, you may perform the adjustment procedure with an alternate oscilloscope that meets the other minimum requirements, and the model ADPPS power supply. The input termination of the alternate oscilloscope must be set to 50 Ω, the offset or position must remain at center screen, and the high frequency adjustments must be performed with the ADPPS connected directly to the input of the oscilloscope.

PRELIMINARY PROCEDURE

1. Using pliers, carefully remove each of the push buttons from the ProBus interface housing by gently pulling them away from the housing.
2. Remove the two screws that secure the plastic cover on the cable end of the ProBus interface housing. Gently pull on the probe cable to slide the circuit board assembly from the metal housing.

3. Remove the 5/64 in. (2 mm) Allen head cap screw from the small cover on the back of the probe tip. Remove the cover along with the small cover on the opposite side of the probe. Hold the shielded portion of the probe head in one hand and gently slide the larger cover off by pulling it away from the probe tip end.

4. Connect the AP033 Active Differential Probe output to the female end of the ProBus Extension Cable. Be careful to align the ProBus pins with the corresponding connector correctly. Connect the male end of the ProBus Extension Cable to Channel 1 of the oscilloscope.

Note

The Logic board is connected to the Amplifier board by four small 8-pin connectors. There are no additional mechanical fasteners holding the two boards together. A small foam pad mounted on the circuit board ensures that the connectors remain engaged while the assembly is mounted within the ProBus interface housing. Be sure that the connectors between the boards are firmly engaged before applying power to the probe. Operating the probe without the logic board will not damage it. However, to ensure reliable operation, the logic board should only be mated with the Amplifier board with the power removed, and the ProBus connector disengaged.

5. Apply power to the oscilloscope and to the other test instrumentation. Allow at least 30 minute's warm-up time for the AP033 and test equipment before continuing the calibration procedure.

Note

The probe tip cover also serves to thermally stabilize the input circuitry. The differential input stage of the probe utilizes discrete transistors that need to maintain an

approximate match of junction temperatures for correct DC balance. With the covers removed, this circuitry is susceptible to drift caused by air currents flowing over the components. Remove or redirect any fans that may be blowing air currents over the probe tip during adjustment.

Note

The operation of the controls of the AP033 may differ depending on which version of software is in the oscilloscope. You can find out the software version by pushing ***SHOW STATUS****, then selecting the* ***System*** *menu option.*

In version 8.1.0 and higher, the ***OFFSET*** *controls on the front panel of the probe are disabled. Offset is controlled by the* OFFSET *knob in the oscilloscope CHANNEL section. In earlier software versions, probe offset was controlled through one of the knobs in the "COUPLING" menu corresponding to the channel the probe is attached to. In versions 7.8.0 and higher, you have the option of selecting manual or automatic gain control. The oscilloscope defaults to* ***Auto*** *mode. This procedure is best performed with the oscilloscope set to* ***Manual*** *gain control. Gain control can be selected in the* ***COUPLING*** *menu for the channel that the probe is connected to.*

PROCEDURE

A. Adjust Preliminary Probe DC Balance (R36)

1. From the oscilloscope's front panel, select channel **1**, then select the "COUPLING" menu. Set the AP033 Atten/Gain to **Manual**, the Probe Atten to **/10**, and the Probe Gain to **X10**.
2. If necessary, set the probe offset to **0.000 V** by rotating the OFFSET knob in the CHANNEL section of the oscilloscope (or with the **OFFSET** knob linked to the "COUPLING" menu when using older software versions).
3. Connect one end of a BNC cable to the probe end of the ProBus Extension Cable. Attach the precision 50 Ω terminator to the opposite end of the BNC cable.
4. Insert the banana plugs of the precision 50 Ω terminator into the input terminals of the DMM.
5. Insert the two pin shorting plug into the socket on the Logic board. Use the two holes closest to the probe cable. (See Figure 9.)

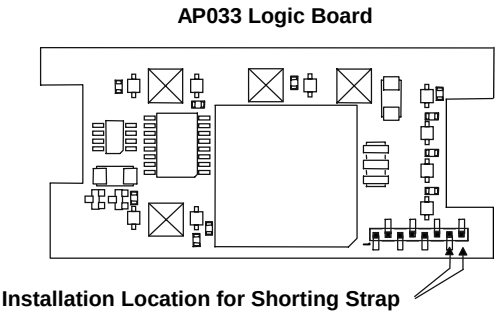

Figure 9

6. To enter the Cal Mode, push any one of the four buttons that protrude through holes in the Logic board. Entry into Cal Mode is confirmed by the absence of an audible "click" when you push the button.
7. Adjust **DC Bal** (R36) on the probe tip (Figure 10) to obtain a DMM reading of 0 V ±10 mV.

Note

This voltage may not be stable because of air currents near the probe. The average voltage should be 0 V ±10 mV.

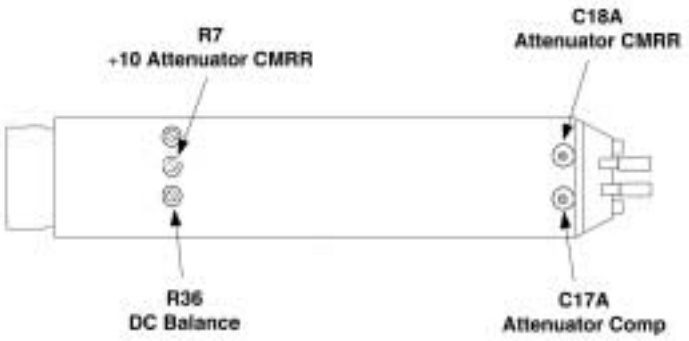

Figure 10. Probe Tip Adjustment Locations

B. Adjust Coarse DC Balance (R226)

1. Remove the shorting plug from the Logic Board.
2. In the Channel 1 “COUPLING” menu, change the **Probe Gain** to **X1**.
3. Reinsert the shorting plug into the two holes near the end of the Logic Board. (See Figure 9.)
4. Reenter Cal Mode by pushing any one of the four buttons that protrude through holes in the Logic board.
5. Adjust **Coarse DC Bal** (R226) on the amplifier board for an output voltage of 0 mV ±10 mV. (See Figure 11 for location.)

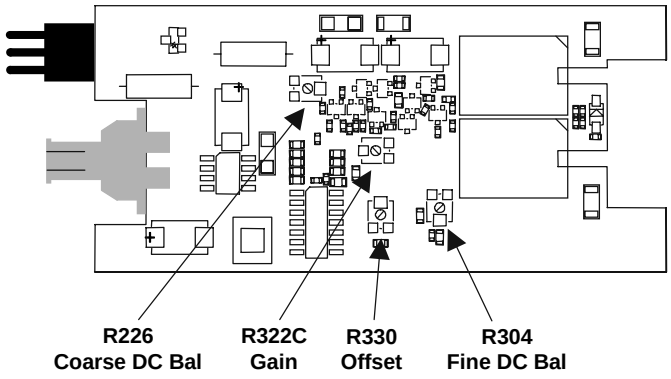

Figure 11. Amplifier Board Adjustment Locations

C. Adjust Fine DC Balance (R304)

1. Remove the shorting plug from the Logic Board.
2. In the Channel 1 “COUPLING” menu, change the **Probe Gain** to **X10**.
3. Reinsert the shorting plug into the two holes near the end of the Logic Board. (See Figure 9.)
4. Reenter Cal Mode by pushing any one of the four buttons that protrude through holes in the Logic board.
5. Remove the BNC cable from the precision 50 Ω terminator attached to the DMM.
6. Short the output BNC connector by reconnecting the cable to the **SHORT** connector on the AP033/AP034 Calibration Fixture. The **SHORT** connector is the only BNC connector on the AP033/AP034 Calibration Fixture that does not have corresponding input pins for the probe tip. It is located on the end of the board beyond the Common Mode Terminated connector.
7. In Cal Mode, the **EFFECTIVE GAIN** indicators serve as an adjustment indicator. The **EFFECTIVE GAIN** indicators are located on the Logic Board (See Figure 12.) It may be necessary to hold the boards in your hands to see the indicators while making the adjustment.

8. Adjust **Fine DC Balance** (R304) until the **÷10 EFFECTIVE GAIN** indicator lights. (See Figure 11.)

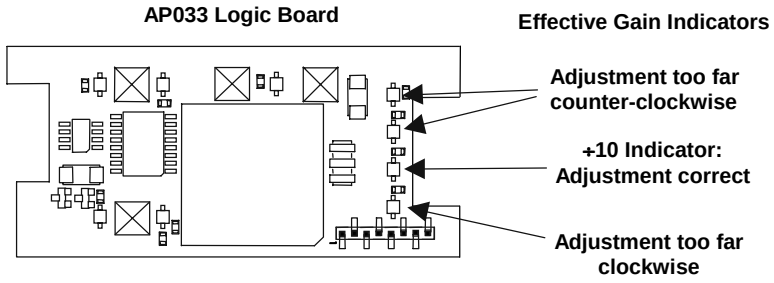

Figure 12. ÷10 Effective Gain Indicator

9. Disconnect the BNC cable from the short connector. Remove the shorting plug from the logic board.

D. Adjust ÷10 Attenuator CMRR (R7)

1. Keep the BNC cable attached to the probe end of the ProBus extension cable. Attach a 50Ω BNC Through Terminator on the other end of the BNC cable. Attach the male end of the 50Ω terminator to channel 3 on the oscilloscope. The oscilloscope end of the ProBus extension cable should remain connected to channel 1 of the oscilloscope although there is no signal cable attached.
2. In the Channel 1 "COUPLING" menu, set AP033 Atten/Gain to **Manual**, Probe Atten to **/10** and Probe Gain to **X10**.
3. Connect a BNC cable from the output of the Function Generator to the Channel 2 input of the oscilloscope.
4. Connect a second BNC cable from the Function Generator **SYNC OUT** to the external trigger input of the oscilloscope.
5. Set the Function Generator waveform to **Sine** and the frequency to **70 Hz**.

6. Set the oscilloscope as follows:

Display:	Channel 2
Channel 1 VOLTS/DIV:	2 mV/div
Channel 2 VOLTS/DIV:	5 V/div
Channel 3 VOLTS/DIV:	2 mV/div
Channel 2 Coupling:	DC1MΩ
Channel 3 Coupling:	AC 1MΩ
Trigger on:	EXT10
cplg EXT10:	DC
TIME/DIV:	10 ms/div
Acquisition Mode:	NORMAL

7. Adjust the trigger level for a stable display.
8. Set the Function Generator output voltage to 20 V_{p-p} as displayed on the oscilloscope.
9. Disconnect the output cable of the function generator from the channel 2 input of the oscilloscope and reconnect it to the **Common Mode Drive No Termination** connector of the AP033/AP034 Calibration Fixture.
10. Carefully align the four pins that correspond to the **Common Mode Drive No Termination** portion of the AP033/AP034 Calibration Fixture with the input receptacles in the AP033 probe head. Press the probe into the fixture to fully engage the pins.
11. Set the oscilloscope to display channel **3**. The waveform is the common mode signal. Turn the offset as necessary to keep the trace on screen. Turn on Math Channel A. Press **MATH SETUP**, then **REDEFINE A**. Set the **A Math** type to **Average**, **Avg Type** to **Continuous**, **with 1:15 weighting**, **of** channel **3**. Turn off the trace 3 display. Use the Math Zoom and Position controls as necessary to view the waveform.
12. Adjust **÷10 CMRR** (R7) for minimum amplitude. (See Figure 10 for location.)
13. Remove the BNC cable from the output of the Function Generator and the calibration fixture. Leave the BNC cable

from the SYNC output to the oscilloscope external trigger input in place. Remove the BNC cable and 50Ω terminator from channel 3.

E. Adjust OFFSET (R330)

1. In the oscilloscope channel 1 “COUPLING” menu, set AP033 Atten/Gain to **Manual**, Probe Atten to **/1** and Probe Gain to **X1**. Set the channel 1 scale factor to 2 mV/div, and the acquisition mode to Auto. Set the BW**L** to **20** or **25 MHz**. Adjust the OFFSET to **0.0 mV**.
2. Carefully move the AP033 probe tip from the **Common Mode Drive No Termination** position of the AP033/AP034 Calibration Fixture to the **Differential Drive No Termination** position. Press the probe into the fixture to fully engage the pins.
3. Attach the female BNC to dual male banana plug adapters to each end of the BNC cable. Plug one end into the output of the DC voltage source, making sure that the plug corresponding to the BNC shield (marked “Ground”) is connected to the voltage source – output (or common for dual supplies) connector, and the other pin on the **+** output connector.
4. Connect the other end of the cable to the DMM input, making sure that the plug corresponding to the BNC shield (marked “Ground”) is connected to the LO or COM input.
5. Set the DC Voltage Source to read as close as possible to **+0.4000 V** on the DMM.
6. Autobalance the AP033 by pressing the **AUTOBALANCE** menu button located in the “COUPLING” menu twice, or by pressing and holding both probe offset buttons for at least two seconds.
7. Disconnect the BNC cable from the female BNC-to-dual male banana plug adapter on the DMM.
8. Reconnect the BNC cable from the DC Voltage Source to the **Differential Drive No Termination** connector on the AP033/AP034 Calibration Fixture.

9. Set the probe offset to **–0.4000 V** by rotating the OFFSET knob in the CHANNEL section of the oscilloscope (or with the **OFFSET** knob linked to the “COUPLING” menu when using the older software.)
10. Allow 10 seconds for the AP033 to stabilize.
11. Adjust **Offset** (R330) to bring the trace back to exactly center screen. (See Figure 11.)
12. Remove the dual banana plug adapter from the output of the DC voltage source and reconnect it, with the pins reversed. (The plug corresponding to the BNC shield (marked “Ground”) should now be connected to the **+ Output** connector.)
13. In the CHANNEL section of the oscilloscope, set the probe offset to **+0.4000 V** by rotating the OFFSET knob (or with the **OFFSET** knob linked to the COUPLING menu when using the older software.)
14. Allow 10 seconds for the AP033 to stabilize.
15. Note the amplitude of the trace from center screen.
16. Adjust **Offset Cal** (R330) to position the trace to approximately ½ the amplitude from center screen noted in the previous step. This amplitude should be within ±10 mV of center screen. Note this value.
17. Again, remove the dual banana plug adapter from the output of the DC voltage source and reconnect it, with the pins reversed. The plug corresponding to the BNC shield (marked “Ground”) should now be connected to the **–** (Common) Output connector.
18. In the CHANNEL section of the oscilloscope, set the probe offset to **–0.4000 V** by rotating the OFFSET knob (or with the **OFFSET** knob linked to the “COUPLING” menu when using the older software.)
19. Allow 10 seconds for the AP033 to stabilize.
20. The trace should be offset from the center line by the same amplitude but opposite polarity of the value noted in step 16.

21. Repeat steps E-12 through E-20 as necessary until the errors at +0.4 V and at –0.4 V are approximately equal and within 10 mV of center scale. Reverse the polarity of the dual banana plug adapter at the output of the DC voltage source, and the corresponding probe offset value with each repetition.
22. Disconnect the cable from the DC Voltage Source. Keep the AP033/AP034 Calibration Fixture connected to the AP033 for the next step.

F. Adjust GAIN (R322C)

1. Set the AP033 offset to **0.000 V** by rotating the OFFSET knob in the CHANNEL section of the oscilloscope (or with the **OFFSET** knob linked to the "COUPLING" menu when using the older software versions). Make sure the probe is still set to **/1 Atten** and **X1 Gain**.
2. Disconnect the BNC cable from the oscilloscope end of the ProBus extender cable. Reconnect the end of the cable to the precision 50 Ω termination.
3. Connect one end of a second BNC cable to the output of the Function Generator. Attach the BNC to dual male banana plug adapter to the free end of the BNC cable. Insert the banana plugs of the adapter into the input terminals of the Digital Multimeter (DMM).
4. Set the DMM to measure AC Volts.
5. Set the mode of the Function Generator to **Sine Wave**, the frequency to approximately **1 kHz**, and the output amplitude to read approximately **190 mV** on the DMM.
6. Record the DMM reading. Be careful not to alter the output amplitude of the generator after the measured value has been recorded.
7. Remove the banana plug adapter and connect the free end of the cable to the **Differential Drive no Termination** connector on the calibration fixture.
8. Connect the AP033 Output cable with 50 Ω precision termination to the DMM.

9. Adjust **GAIN** (R322C) so that the DMM reading is within ±1 mV (0.5%) of the reading recorded in step F-6. (See Figure 11.)
10. In the Channel 1 "COUPLING" menu, set AP033 Atten/Gain to **Manual**, Probe Gain to **X10**, and Probe Atten to **/10**.
11. Verify that the DMM reads within 1 mV of the reading recorded in step F-6. If the error exceeds 1 mV, readjust **GAIN** (R322C) for an error amplitude of ½ of the value before making the readjustment. Compromise as necessary to center the error voltage in both gain/attenuation combinations, making sure that the final errors are less than 1 mV.
12. Disconnect the Function Generator, DMM, calibration fixture, and precision 50 Ω terminator.

G. Adjust Final Attenuator Compensation (C17)

Note

The calibrator signal from a LeCroy oscilloscope is the recommended signal source for this adjustment. If another oscilloscope is being used for this procedure, make sure that the square wave source has adequate flatness (minimum overshoot and undershoot.)

1. Press the UTILITIES button, then select the **CAL BNC Setup** menu. Set the Mode to **CAL signal**, the Shape to **Square**, the Amplitude to **1 V** into 1 M Ω, and the Frequency to **1 kHz**.
2. In the Channel 1 "COUPLING" menu, set AP033 Atten/Gain to **Manual**, Probe Atten to **/10**, and Probe Gain to **X10**.
3. Reconnect the free end of the ProBus Extender BNC cable to the oscilloscope end of the extender located on channel 1.

4. Connect a BNC cable from the CAL output BNC connector to the **Differential Drive 50 ohm Termination** connector on the AP033/AP034 Calibration Fixture.
5. Carefully attach the **Differential Drive 50 ohm Termination** portion of the AP033/AP034 Calibration Fixture to the probe tip. Press the probe into the fixture to fully engage the pins.
6. Set the oscilloscope's channel **1** vertical scale factor to **50 mV/div**, and the horizontal scale to 1 µs/div. Set the trigger source to channel **1**, and Slope to **Positive**. Adjust the oscilloscope trigger level as necessary for a stable display.
7. Using the OFFSET knob move the trace down until the top portion of the waveform is centered.
8. Adjust **Attenuator Comp** (C17A) for a flattop waveform. See Figure 10 for adjustment location.

H. Adjust Final Attenuator CMRR (C18A)

1. Carefully move the AP033 probe head from the **Differential Drive 50 ohm Termination** portion of the AP033/AP034 Calibration Fixture to the **Common Mode Drive 50 ohm Termination** portion.
2. Remove the BNC cable from the **Differential Drive 50 ohm Termination** connector of the AP033/AP034 Calibration Fixture. Connect one end of the BNC cable to the **Common Mode Drive 50 ohm Termination** connector of the AP033/AP034 Calibration fixture. Connect the other end of the cable to the female end of a BNC T adapter. Plug the male connector of the BNC T adapter into the channel 4 input of the oscilloscope. Connect a second BNC cable to the remaining female connector of the BNC T adapter. Connect the other end of the second BNC cable to the CAL output BNC connector.
3. Set the oscilloscope display to channel **4**, coupling to **DC1MΩ** vertical scale factor to **200 mV/div** and the trigger source to channel **4**. Adjust the oscilloscope trigger level as necessary for a stable display.

4. Set the oscilloscope to display channel **1**, and vertical scale factor to **10 mV/div**. Set the **OFFSET** to **0.0 mV**
5. Adjust **Attenuator CMRR** (capacitor C18A) for minimum amplitude shift of the displayed waveform at the trigger point in time. See Figure 10 for adjustment location.
6. Remove all cables, the Calibration Fixture, and the ProBus extender from the AP033 probe.

I. Assemble Probe and Amplifier

1. Carefully slide the large probe tip cover over the probe tip, being careful to engage the input pins.
2. Snap the small probe cover with the threaded brass insert onto the bottom of the probe. Engage the probe cable strain relief into the mating area of the cover. Carefully dress the wires entering the cable to clear the area above the brass insert.
3. Place the lip on the large end of the remaining cover under the mating surface near the probe tip. Gently press the cover into place. If the cover appears to not close completely, remove it and again check for adequate clearance between the brass insert and the cable wires.
4. Replace the 5/64” Allen cap screw and tighten.
5. Hold the Logic Board / Amplifier Board assembly in one hand with the Logic board facing up. Hold the ProBus Interface housing in the other hand with the control side (side with holes for the buttons) facing up.
6. Align the edges of the Amplifier board with the slots in the center of the inside of the housing. (The amplifier board is the thicker circuit board and has the BNC connector soldered to it.) Slide the boards into the housing being careful to align the screw holes in the end cover with the corresponding channels in the corners of the housing.
7. Insert and tighten the two screws which secure the end panel to the ProBus interface housing. Avoid over tightening the screws as the cover may warp.
8. Replace the four push button caps, pressing each fully to seat the cap on the button shaft

J. Attenuator Matching and Final Check

1. Repeat the Performance Verification procedure to ensure compliance with the warranted specifications.
2. Perform the Attenuator Matching Procedure listed on page 16. Apply calibration seals in accordance with your quality procedures.

This concludes the Adjustment Procedure. Repeat the Performance Verification procedure to complete the calibration of the AP033.

# # #