MODEL 2680M1-M7/2680M12-M14/2680M61-67/2681M1-M7/2685M1-M7
AIRBORNE CHARGE AMPLIFIER

INSTRUCTION MANUAL

IM2680

Revision B
Nov 1, 91

ENDEVCO

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SECTION 1:
DESCRIPTION

1. INTRODUCTION

The Endevco® Model 2680 Series of Charge Amplifiers are Solid-State Airborne Devices designed for use with Piezoelectric Transducers. The Charge Amplifiers are epoxy-potted and hermetically sealed units containing a charge converter front end to receive the transducer signal, an optional filter to select the flat frequency response of the charge amplifier, a gain potentiometer to set the desired gain of the charge amplifier, and a voltage amplifier in the output. The charge amplifier produces an output voltage proportional to the charge at the input, thus minimizing the effect of input cable length. The charge amplifier uses hybrid microcircuits to achieve small size, low weight, and low power consumption.

The case of each charge amplifier is completely isolated from the circuit, and an internal electrostatic shield protects from stray pickup. A DC-to-DC Converter installed in specific models isolates power and signal grounds.

The series of charge amplifiers covered by this instruction manual are listed below with a brief description defining each configuration. As noted the difference between the basic charge converter Models (2680 & 2681) is the type of output connectors used and the addition of the DC-to-DC Converter. Table 1-1 provides a further breakdown between the basic models.

Basic Model	Configuration
2680	Viking Connector
2681	Viking Connector, DC-to-DC Converter
2685	Endevco Connector, DC-to-DC Converter Integral Electronic Conditioner with constant current supply

Each basic model consists of a series of modifications ("M series) to provide seven different gain ranges and nine different high frequency responses. The "M" series covered by this Instruction Manual are M1 thru M7, M12 and M14. Table 1-2 lists the "M" series and provides a comparison of their input and output characteristics.

2. ADJUSTABLE GAIN

The Charge Amplifier's case contains a removable screw to permit access to a Gain Potentiometer. The Potentiometer enables the user to adjust the gain to any desire setting within the gain range of the Charge Amplifier.

The Gain-Access Screw is located on the side of the case for Charge Amplifiers without DC-to-DC Converters, and on the connector end of the case for Charge Amplifiers with DC-to-DC Converters. Refer to Table 1-1 for the basic model numbers of Charge Amplifiers containing the DC-to-DC Converters, and to Figures B-2 and B-3 for location of the Gain Adjustment.

The Gain Adjustment is a 12-turn (typical), 500 kΩ (±0,1%) Potentiometer with wiper idles as mechanical stops at the extreme clockwise (CW) and counterclockwise (CCW) positions. Maximum resistance (minimum Charge Amplifier Gain) is obtained in the extreme CW position. Signals are present at both ends of the Potentiometer, but signal changes may not occur during the final two turns.

Charge Amplifiers shipped as a component of an Endevco system (Accelerometer, Cable Assembly and Charge Amplifier) normally have the gain factory-set to a specific gain, and the Gain-Access Screw Solder-Sealed to the case of the Charge Amplifier. The Gain-Access Screw must be sealed to the case with solder, glyptol or epoxy for the Charge Amplifier to meet humidity specifications during operation.

Charge Amplifiers shipped as single items of equipment have the Gain Potentiometer set to the maximum rated gain of the Charge Amplifier, and the Gain-Access Screw temporarily seated in the threaded access hole. Users of the Charge Amplifier are then required to adjust the gain to a desired gain setting prior to application of a Charge Amplifier (see Paragraph 4.2). Table 1-2 lists the gain ranges for each "M" series (M1 thru M7, M12 and M14) of Charge Amplifiers.

					Power Requirements		
						Current	
Basic Model	Input Connector	Output Connector	Accessories	DC-to-DC Conv.	Voltage VDC	M1-M7 mA DC	M12, M14 mA DC
2680	Microdot 51-49 10-32 UNF-2A thread	Viking VR5/4AG15 Endevco P/N EP30 5-Pin connector	Endevco Kit 21997 consisting of: Mating Plug - Viking VP5/4CE6 Hood - Viking VS4/16C5 Potting Sleeve-VikingVS4/16C9 Mounting Hardware - Two #6-32 Captive Screws w/ Lockwashers	No	20-32 V 28 V typ	< 20	< 25
2681	Microdot 51-49 10-32 UNF-2A thread	Viking VR7/4AG15 Endevco P/N EJ277 7-Pin connector	Endevco Kit 23318 consisting of: Mating Plug - Viking VP7/4CE6 Hood - Viking VS4/16C5 Potting Sleeve-VikingVS4/16C9 Mounting Hardware - Two #6-32 Captive Screws w/ Lockwashers	Yes	24-32 V 28 V typ	< 30	< 35
2680	Microdot 51-49 10-32 UNF-2A thread	Viking VR7/4AG15 Endevco P/N EJ277 7-Pin connector	Endevco Kit 21997 consisting of: Mating Plug - Viking VP5/4CE6 Hood - Viking VS4/16C5 Potting Sleeve-VikingVS4/16C9 Mounting Hardware - Two #6-32 Captive Screws w/ Lockwashers	Yes	20-32 V 28 V typ	< 30	< 35

TABLE 1-1: CONNECTORS, ACCESSORIES, AND POWER REQUIREMENT

3. OUTPUTS

Each Charge Amplifier has two outputs, biased and/or unbiased. The outputs can be a combination of a biased and an unbiased, or both outputs can be biased, or both outputs can be unbiased. The "M" number following the model number is the determinant (see "Types of Output" column in Table 1-2). Both outputs are single-ended with one side connected to circuit ground. When both outputs for the M1 through M7 are used simultaneously, the parallel combination of both load resistances must be 10 kΩ or greater to meet all specifications. For the M12 and M14, both outputs can be loaded with 10 k ohms or greater simultaneously and still meet all specifications. Maximum output voltage is approximately 0 to 5 v (±2.5 v pk) depending on the specific Charge Amplifier. The output circuits are short-circuit proof, thus the outputs will withstand an indefinite short without damage.

The biased outputs are direct coupled with an output impedance of less than 50 Ω. With no input, the Charge Amplifier produces +2.5 V dc ±3% at the output. Output voltage will be approximately ±2.5 V pk around this bias level. Clipping will occur slightly about the 0 V level and between +5.0 and +5.3 V. The unbiased outputs are in series with a minimum 16 uF capacitance and have an output impedance of less than 50 Ω. With the addition of the series capacitor and bleed resistor in the output, a 0.00 V bias level is established. The unbiased output is linear from 0 to 4.65 V p-p, or 0 to 5.00 V p-p, depending on the specific Charge Amplifier used.

Refer to Table 1-2 for further output data on specific "M" series Charge Amplifiers.

		Output Characteristics								
					DC Output Voltage		Minimum Linear Output			
							Biased	Unbiased Voltage		
Model M No.	Input Charge Limit (pC)	Adjustable Gain Range mV/pC	Residual Noise (mV rms)	Type Output	Biased (±3%)	Unbiased (+0.50/ -0.00)	Voltage (≥10kΩ Load)	>10kΩ Load	>1MΩ Load	Current (10kΩ Load at Min. Linear Voltage)
M 1	50 000	0.1 to 1.0	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 2	25 000	0.2 to 2.0	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 3	10 000	0.5 to 5.0	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 4	5 000	1.0 to 10	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 5	2 500	2.0 to 20	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 6	1 000	5.0 to 50	1.5	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M 7	500	10 to 100	2.0	Biased/ Unbiased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms	4.25 Vp-p 1.5 Vrms	4.65 Vp-p 1.64 Vrms	0.465 mA p-p 0.164 mA rms
M12 Low Gain	5 000	1.0 to 10	1.5	Biased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms			0.465 mA p-p 0.164 mA rms
High Gain	5 000	10 to 100	7.5	Biased	2.5 V	0.00 V	4.65 Vp-p 1.64 Vrms			0.465 mA p-p 0.164 mA rms
M14 Low Gain	5 000	1.0 to 10	1.5	Unbiased	2.5 V	0.00 V		Limited at 5.00 Vp-p 1.77 Vrms		0.500 mA p-p 0.177 mA rms
High Gain	5 000	10 to 100	7.5	Unbiased	2.5 V	0.00 V		Limited at 5.00 Vp-p 1.77 Vrms		0.500 mA p-p 0.177 mA rms

TABLE 1-2: INPUT/OUTPUT CHARACTERISTICS

4. DC-TO-DC CONVERTER

A DC-to-DC Converter is installed in specific models of the Charge Amplifier (see Table 1-1) to isolate power and signal grounds. The isolation of the grounds is required when power is noisy, or when switching transients are present, or when separate grounds have already been established in a measurement system.

5. INPUT POWER

The Charge Amplifiers operate from a 20 to 32 V dc source (28 V typically). Each model may vary in voltage range and input current requirements, this is dependent on the installation of a DC-to-DC Converter. Refer to Table 1-1 for input voltage and current requirements for each Charge Amplifier model and "M" series.

6. OPTIONAL FILTERS

An optional low-pass filter is factory installed in the Charge Amplifier if specified on the Customer Purchase Order. Optional filters are available in two, four, and six pole low-pass Butterworth configurations that provide the Charge Amplifier with a specific frequency response. If a Charge Amplifier contains an optional filter, the model number will contain a three-digit suffix (dash number) to indicate the filter's 5% frequency in Hz. The first two digits are significant numbers and the third indicates the numbers of zeroes. As an example, the Model 2680M12-101 Charge Amplifier has two-pole low-pass filter installed with a flat response up to 100 Hz. Table 1-3 provides a list of the various filters by dash number and frequency responses of each.

7. ACCESSORIES

Accessories for the series of Charge Amplifiers vary according to the type of output connector installed on the unit. All Charge Amplifiers are shipped with mounting hardware, and those units with output connectors installed will have a mating connector for connecting input power and readout devices.

8. APPLICATION

The Model 2680 Series of Airborne Charge Amplifiers are ideally suited for inflight telemetry applications and other dynamic instrumentation systems using Transducers such as Piezoelectric Accelerometers, Microphones, Force Gages or Pressure Pickups. The small size, light weight, low-power consumption, and the use of long cables to connect Transducers to the Charge Amplifier, enables the unit to be used in ground and laboratory testing, rocket test stands, combined environmental testing, steam turbines and other industrial applications.

Model Dash No.*	Low Frequency -10%/+5% Rolloff (Hz)	High Frequency ±5% Flat Response (Hz)	2-Pole Filter -3 dB Typ. (Hz)	2-Pole Filter -12 dB Typ. (Hz)	4-Pole Filter -3 dB Typ. (Hz)	4-Pole Filter -40 dB Min. (Hz)	6-Pole Filter -3 dB Typ. (Hz)	6-Pole Filter -40 dB Min. (Hz)
None	3 to 5	5 to 20 000						
-101	3 to 5	5 to 100	200	400	150	480	140	325
-201	3 to 5	5 to 200	400	800	300	960	280	650
-501	3 to 5	5 to 500	1 000	2 000	750	2 400	700	1 625
-102	3 to 5	5 to 1 000	2 000	4 000	1 500	4 800	1 400	3 250
-202	3 to 5	5 to 2 000	4 000	8 000	3 000	9 600	2 800	6 500
-502	3 to 5	5 to 5 000	10 000	20 000	7 500	24 000	7 000	16 250
-103	3 to 5	5 to 10 000	20 000	40 000	15 000	48 000	14 000	32 500
-203	3 to 5	5 to 20 000	40 000	80 000	30 000	96 000	28 000	65 000

* Add dash number to Model Number. For example: 2680M12-101 has a 2-pole, low-pass filter which is flat up to 100 Hz. Specify number of poles of filter, if other than 2.

TABLE 1-3: LOW-PASS FILTER FREQUENCY RESPONSE VERSUS MODEL DASH NUMBER

SECTION 2: INSPECTION AND INSTALLATION

1. INSPECTION

The Charge Amplifier is packed in a protective bag and packaged in a shipping carton containing shock-absorbent materials to prevent in-transit damage. However, upon receipt of the units, the customer should make an inspection to be certain that no damage has occurred during shipment. Obvious damage should be reported immediately to the carrier.

Inspect the contents of the shipping carton and verify that the applicable accessories listed in Table 1-1 are included in the shipment with each Charge Amplifier.

2. INSTALLATION

The Charge Amplifier case is drilled with two holes for mounting the unit to the test specimen. The mounting holes vary in size and placement for each Charge Amplifier, thus the user should refer to the appropriate Product Data Sheet or Performance Specification for an outline drawing depicting the mounting holes. The mounting hardware for each Charge Amplifier model is listed in Table 1-1.

To minimize noise pickup, the case of the Charge Amplifier should be grounded to frame ground through the mounting screws which act as grounding lugs. Frame ground is then connected to circuit ground at some single point to prevent ground loops.

SECTION 3:
PRE-OPERATION TEST

1. INTRODUCTION

It is sometimes desirable (or required) to test the integrity of a system after installation. A suggested method for performing a pre-operation test is the Voltage Insertion Test. Ideally, a Voltage Insertion Test performed in a calibration laboratory can be used to establish normal response of the system. The test is not only useful to check the Accelerometer/Cable/Amplifier Circuit Continuity, but can also be considered a Calibration Test. If the Accelerometer has an open circuit, the Charge Amplifier's output signal will be less than normal since only the cable capacitance remains in the input circuit. If the accelerometer is shorted, the Charge Amplifier's output will be zero. If a short circuit exists in the Charge Amplifier, the output again will be zero, or considerably lower than normal.

Since the Voltage Insertion Test requires using formulas to obtain data, certain parameters of system components must be known, or established, prior to performing the test. The internal capacitance of the Accelerometer and the capacitance of the cable must be known. These values are obtained from the calibration card shipped with each item. Also, the Charge Amplifier's output voltage must be established. The output voltage established must be less than the Charge Amplifier's full-scale output (maximum 5 V p-p, or 1.77 V rms). As an example, the 2680M1 has a maximum linear biased output of 4.65 V p-p (1.64 V rms) into a 10,000-ohm load. Thus, the output established for a 2680M1 should be less than 4.64 V p-p. Normally, an output voltage is selected which is easily read on the readout device. For example, if an oscilloscope is being used, an output voltage should be selected to provide a full-scale output easily determined by viewing the oscilloscope grid (graticule).

When performing the Voltage Insertion Test, the Accelerometer must be isolated from ground. Total source capacitance should not be more than 10,000 pF for the Charge Amplifier to meet all specifications.

2. EQUIPMENT REQUIRED

The following equipment is required to perform a Voltage Insertion Test:

A. Oscillator capable of operating over the minimum range of 3 Hz to 20 kHz.

B. Power supply, +20 to +32 V dc rated at 50 mA maximum.

C. T-Block containing a 100 Ω, 1/2-watt, ±0.5% resistor.
Endevco T-Junction Calibrator, part number 2944.1 is recommended.

D. Oscilloscope to verify Oscillator and Charge Amplifier Outputs.

E. Digital voltmeter (DVM) to monitor Oscillator and Charge Amplifier Outputs in AC volts, or V rms.

F. Accelerometer isolated mounting studs. Endevco Model 2980 Series isolated Mounting Stud is recommended. Stud is used to isolate Accelerometer from ground.

G. Switch, SPDT (S1)

H. Switch, DPDT (S2)

3. VOLTAGE INSERTION TEST PROCEDURE

A. Connect equipment as shown in Figure 3-1. Ensure Accelerometer is isolated from ground. As shown in Figure 3-1, the Accelerometer acts as a Passive Transducer when driven by the Oscillator.

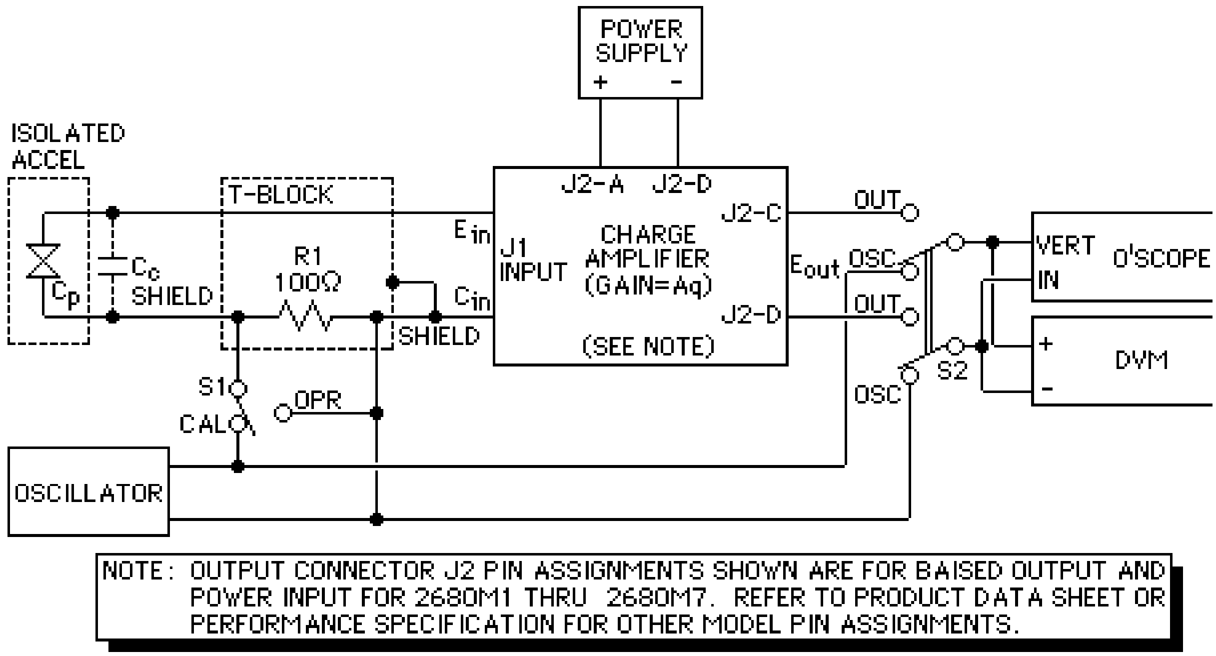


FIGURE 3-1: VOLTAGE INSERTION TEST SETUP

B. Energize equipment and adjust power supply for +28 V dc output. Allow 15 minutes for equipment to temperature stabilize.

C. Review Accelerometer and Cable Assembly Calibration Cards for capacitance of each item. Use the following formula to determine total capacitance (C_{in}) seen at Charge Amplifier's input:

$$C_{in} = C_p + C_c$$

where C_p = Internal Capacitance of Accelerometer
C_c = Cable Capacitance between Accelerometer and T-Block

D. Establish an Output Voltage (E_o) for Charge Amplifier. The Output Voltage should be less than the maximum linear output for applicable Charge Amplifier. See Table 1-2 or Performance Specification. Use the following formula to obtain a voltage input (E_{in}) to T-Block:

$$E_{in} = \frac{E_o \times 10^3}{A_q \times C_{in}}$$

where E_o = Output Voltage in volts
E_{in} = Input Voltage to T-Block form Oscillator in volts

A_q = Charge Amplifier Gain in mV/pC (see paragraph 4.2.)
C_{in} = Input Capacitance in pF. Includes Accelerometer Capacitance (Cp) and Cable Capacitance (Cc) between Accel and T-Block

E. Set switch S2 in Figure 3-1 test setup to OSC position. Readout devices should receive output of Oscillator.

F. Adjust Oscillator for a frequency between 20 and 50 Hz, and for an Output Voltage obtained for E_{in} in Step D. Verify Oscillator frequency on Oscilloscope and Output Voltage on DVM.

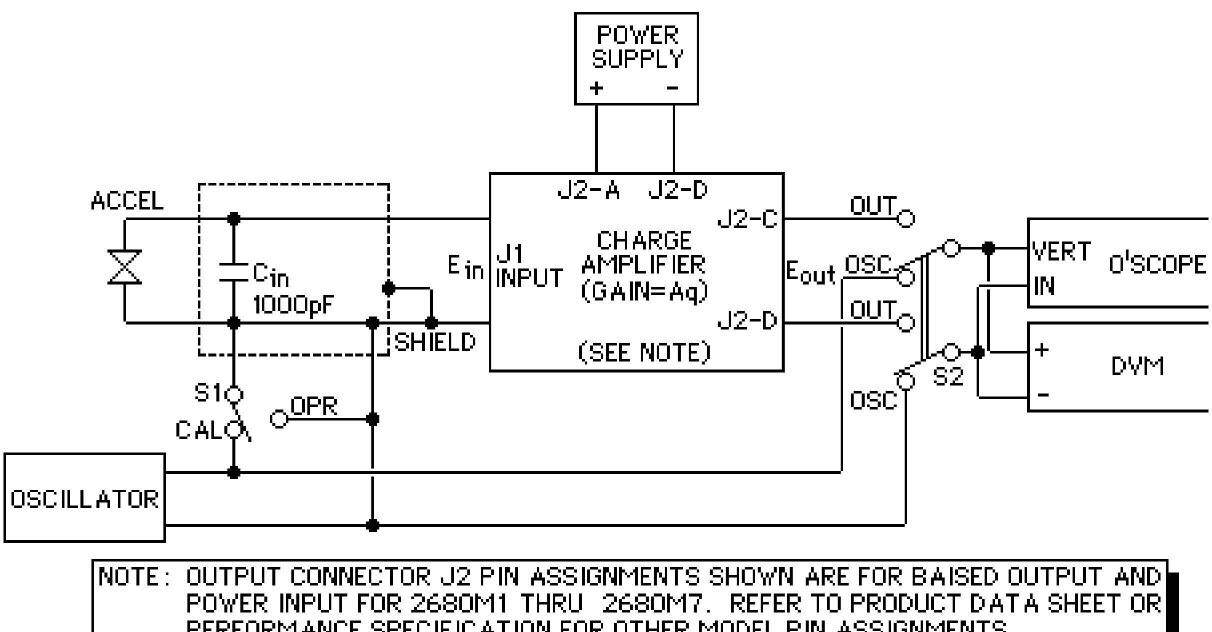
G. Set switch S2 to OUT position and ensure switch S1 is in CAL position. DVM should indicate the value of voltage established for Charge Amplifier's Output (E_o) in Step D. This is accomplished by setting the oscillator's output to E_{in}, and applying this voltage to the input of the T-Block.

H. Since both an input (E_{in}) and output (E_o) has been established and verified, the Voltage Insertion Test can now be used to verify system integrity anytime the system is suspected of being faulty, or assurance that the system is performing to specification.

I. Set switch S1 to OPR (operate) position and S2 to OUT position for normal system operation.

4. ALTERNATE TEST METHOD

An Alternate Test Method (charge insertion) can be performed to the system. The alternate method permits no check of the Accelerometer for an open, but does indicate a short by lack of amplifier output. The test does provide "in-place" calibration of the Charge Amplifier. The advantage of this test is that the Oscillator Output Voltage (E_{in}) can be inserted anywhere between Accelerometer and Charge Amplifier without affecting System Test.



NOTE: OUTPUT CONNECTOR J2 PIN ASSIGNMENTS SHOWN ARE FOR BAISED OUTPUT AND POWER INPUT FOR 2680M1 THRU 2680M7. REFER TO PRODUCT DATA SHEET OR PERFORMANCE SPECIFICATION FOR OTHER MODEL PIN ASSIGNMENTS.

FIGURE 3-2: ALTERNATE CHARGE INSERTION TEST SETUP

A. Connect equipment as shown in Figure 3-2.

B. Energize equipment and adjust power supply for +28 V dc output.

C. Allow 15 minutes for equipment to temperature stabilize.

D. Establish an Output Voltage (E_o) for the Charge Amplifier. The Output Voltage should be less than the maximum Linear Output for the applicable Charge Amplifier.

E. Again, the formula for input versus output is:

$$E_{in} = \frac{E_o \times 10^3}{A_q \times C_{in}}$$

where
E_o = Output Voltage in volts
E_{in} = Input Voltage to T-Block form Oscillator in volts
A_q = Charge Amplifier Gain in mV/pC (see paragraph 4.2.)
C_{in} = Input Capacitance in pF. Includes Accelerometer Capacitance (Cp) and Cable Capacitance (Cc) between Accel and T-Block

F. Repeat steps 3.3.E through 3.3.I to establish a Charge Insertion Test for checking Accelerometer Shorts and Charge Amplifier Integrity.

SECTION 4:
OPERATIONAL CHECKOUT PROCEDURE

1. USING THE CHARGE AMPLIFIER

The 2680 series of Charge Amplifiers are designed to operate with Piezoelectric Accelerometers and other Transducers. In all cases the Transducer and Connecting Cable must form the equivalent of a capacitive input device. Total source capacitance for the input should not be more than 10,000 pF, or as specified on the Product Data Sheet, or Performance Specification.

A simple block diagram of a system using the Charge Amplifier is shown in Figure 4-1. To prevent ground loops and excessive noise, the Transducer should be mounted on an insulated stud. The Charge Amplifier case should also be grounded somewhere in the system to prevent stray pickup. Coaxial cable is to be used between Transducer and Charge Amplifier. The sensitivity of this system is not appreciably affected by the cable capacity.

Readout devices such as Oscilloscopes, Oscillographs (for hard-copy print-outs), Digital Voltmeters, etc., can be used to analyze the Shock and Vibration Data. These instruments are selected according to user preference and requirements.

At 1000 Hz, the biased and unbiased outputs of the M1 through M7 series of Charge Amplifiers (2680M1 through 2680M7, 2681M1 through 2681M7, etc.) are in phase with the input. The 1-10 mV/pC low -gain outputs of the M12 and M14 are in phase with the input signal, while the 10-100 mV/pC high-gain outputs of the M12 and M14 are 180° out-of-phase with the input.

2. GAIN ADJUSTMENT

Each Charge Amplifier provides two outputs, and Gain Potentiometer is common to both outputs. Those Charge Amplifiers (M12 and M14) with dual biased or dual unbiased outputs have a 10:1 ratio maintained between both outputs by the common Gain Potentiometer.

A. Connect equipment per Figure 4-1. Ensure J2 pin assignments conform to Charge Amplifier being tested. See Note in Figure 4-1.

B. Energize equipment and allow 15 minutes to temperature stabilize.

C. Adjust power supply for +28 V dc output.

D. Adjust Oscillator Frequency to 100 Hz and an Output Amplitude of 50 mV rms.

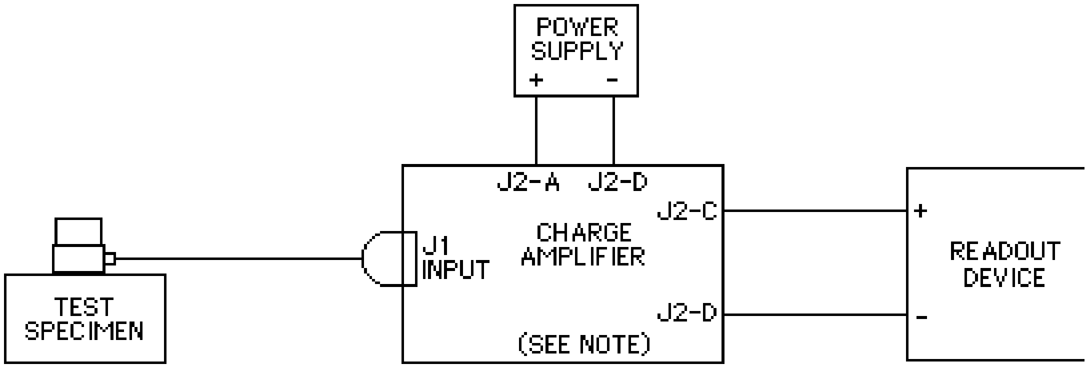
E. Set Voltage Divider Potentiometer to its maximum output (fully CW).

F. Set test setup switch S1 to OUT position.

NOTE: A Charge Amplifier's Gain is not electrically continuous at extreme ends of the Gain Potentiometer. The output could be erratic (minimal, or no change) at both ends.

G. Adjust Charge Amplifier's Gain Potentiometer through its complete range and monitor DVM for change in Charge Amplifier's output. Each "M" series Charge Amplifier's output should vary according to limits listed in Adjustable Gain Range column in Table 1-2, or as specified in Performance Specification.

H. Remove test setup lead from Charge Amplifier's connector pin J2-C and connect to J2-B. Repeat step G for Charge Amplifier's second output.



NOTE: OUTPUT CONNECTOR J2 PIN ASSIGNMENTS SHOWN ARE FOR BAISED OUTPUT AND POWER INPUT FOR 2680M1 THRU 2680M7. REFER TO PRODUCT DATA SHEET OR PERFORMANCE SPECIFICATION FOR OTHER MODEL PIN ASSIGNMENTS.

FIGURE 4-1A: TYPICAL SYSTEM CONNECTIONS WITH CHARGE AMPLIFIER

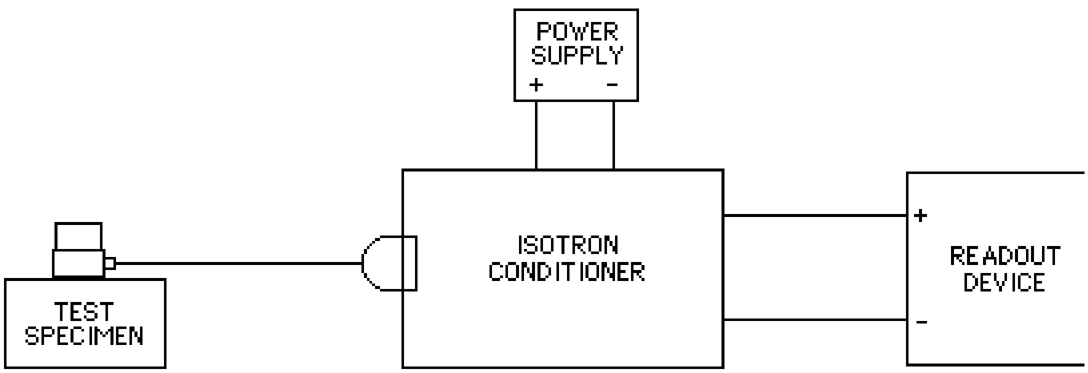


FIGURE 4-1B: TYPICAL SYSTEM CONNECTIONS WITH ISOTRON CONDITIONER

3. AMPLITUDE LINEARITY

A. Connect equipment per Figure 4-1. Ensure J2 pin assignment conforms to Charge Amplifier being tested. See Note in Figure 4-1.

B. Energize equipment and allow 15 minutes to temperature stabilize.

C. Adjust power supply for +28 V dc output.

D. Set Voltage Divider Potentiometer to its maximum output (fully CW).

E. Adjust Oscillator Frequency for 100 Hz, and set test setup switch S1 to OUT position, and then adjust Oscillator Output Amplitude until Charge Amplifier's output is 100 mV below clip level on Oscilloscope (note DVM for mV rms indication).

F. Decrease Oscillator Output Amplitude in 10% steps until Charge Amplifier's output has been reduced to 0.17 V rms on DVM.

G. Non-linearity through this range should be less than 0.5% of best straight line. Refer to Product Data sheet, or paragraph 2.3.4 in Performance Specification for Amplitude Linearity limits of Charge Amplifier under test.

4. FREQUENCY RESPONSE

A. Connect equipment per Figure 4-1. Ensure J2 pin assignments conform to Charge Amplifier being tested. See Note in Figure 4-1A.

B. Energize equipment and allow 15 minutes to temperature stabilize.

C. Adjust power supply or +28 V dc output.

D. Adjust Oscillator Frequency for 100 Hz, and adjust Output Amplitude for 1.0 V rms output. Oscillator output can be verified by setting test setting switch S1 to 1N position. The 1.0 V rms must be checked prior to each reading of Charge Amplifier's Output in step 1.

E. Remove positive (+) lead of DVM from test setup and connect lead to wiper of Voltage Divider Potentiometer.

F. Adjust Voltage Divider for a 1.0 V rms indication on DVM. This is an indication of Oscillator Output in step D. This setting on Voltage Divider Potentiometer must be changed during tests.

G. Remove DVM positive (+) lead from wiper of Voltage Divider and reconnect as shown in Figure 4-1 test setup.

H. Set test setup switch S1 to 1N position. Verify Oscillator Output Amplitude is still 1.0 V rms and then set switch to OUT position.

NOTE: A Charge Amplifier's frequency range of interest depends on type of filter used. Refer to Table 1-3 for Model versus Frequency Range

I. Vary Oscillator Frequency over Charge Amplifier's range of interest and observe Oscilloscope and DVM for Gain versus Frequency Response. The Charge Amplifier's Output Level must fall within limits listed in Table 1-3, or paragraph 2.3.2 in Performance Specification.

5. DC-TO-DC CONVERTER

This test is performed only on Charge Amplifiers containing a DC-to-DC Converter (2681M1-M7). The test checks the isolation between power ground and signal ground.

A. Place a Shorting Cap on J1 INPUT Connector.

B. Connect a magnetometer between Power-Ground Pin and Signal-Ground Pin on J2 OUTPUT Connector. Refer to Product Data Sheet on drawing in Performance Specification for correct J2 pin assignment. As an example, J2 pin F is Power Ground and J2 pin D is Signal Ground for 2681M1 through 2681M7.

C. With magnetometer set to 50 V dc, the isolation between Power Ground and Signal Ground shall be as specified in Product Data Sheet, or Power Supply isolation paragraph in Performance Specification for Charge Amplifier under test. As an example, Charge Amplifiers 2681M1-XXX through 2681M7-XXX shall have as isolation between both grounds of 50 MΩ or greater.

APPENDIX A:
THEORY OF OPERATION

1. INTRODUCTION

The Model 2680 series of Airborne Charge Amplifiers are designed for use with Piezoelectric Transducers, and Piezoelectric Transducers are self-generating devices requiring no electrical excitation. The electrical charge generated by the Transducer is proportional to the stress on the Piezoelectric Crystal. In an Accelerometer, the output is proportional to acceleration; in a Pressure Transducer, the output is proportional to pressure, etc. For any Transducer, the charge generated is independent of the amount of external capacitance attached to the Transducer.

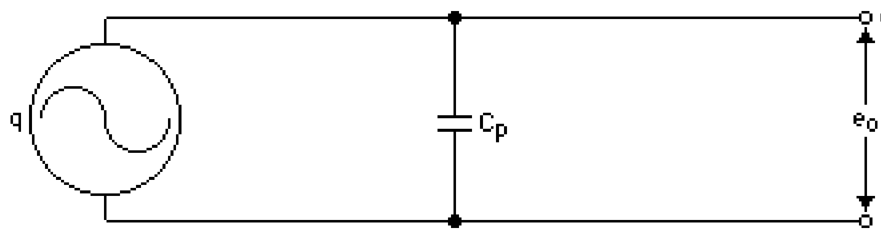


FIGURE A-1: PIEZOELECTRIC TRANSDUCER EQUIVALENT CIRCUIT

A simplified equivalent circuit of a Piezoelectric or Capacitive Transducer is shown in Figure A-1. The open-circuit voltage (E_o) is equal to the charge (q) divided by the Transducer Capacitance (C_p) as noted in the following formula:

$$E_o = \frac{q}{C_p}$$

where E_o is expressed in V
q is expressed in pC
C_p is expressed in pF

If the Open-Circuit Voltage is known, the Transducer charge can be calculated by $q = E_o C_p$.

As an example, suppose a system consisting of an Endevco Model 2680 Series Charge Amplifier (which has a 2.5 V pk, or 2500 mV pk full-scale output) and an Endevco Model 2272 Accelerometer is used as a system to measure ±50 g full scale pk. The formula used to determine the desired system sensitivity in mV/g is:

$$A_s = \frac{E_o \text{ (in mV pk)}}{\text{Desired FS (g pk)}}$$

= /F (25mV, 50 g)

= 50 mV/g pk

With the Charge Sensitivity (Sq) of the Accelerometer given as 13 pC/g, the Gain Setting of the Charge Amplifier is:

$$A_s = \frac{A_s}{S_q}$$

$$= \frac{2500\ \text{mV}}{50}$$

$$= 50\ \text{mV/g pk}$$

If a rms full-scale level is used for calibration, adequate gain margin should be included for the anticipated crest factor.

All Endevco Transducers are provided with a calibration certificate which specifies the Charge Sensitivity expressed in pC per unit measurand. For an Accelerometer the sensitivity is given in pC/g where:

$$Q_s = \frac{pC}{C_p} = \frac{pC\ pk}{g\ pk} = \frac{pC\ rms}{g\ rms}$$

For Transducer sensitivities given only in terms of voltage, the Charge Sensitivity can be calculated from:

$$Q_s = \frac{E_{cal}\,(C_p + C_{cal})}{1000}$$

where Q_s = charge sensitivity in pC/g
E_{cal} = factory supplied voltage sensitivity in mV/g
C_{cal} = external cable and amplifier capacitance when calibrated, in pF

The values of E_{cal}, C_p, and C_{cal} are usually listed on the calibration certificate. Since the Charge Sensitivity is not affected by capacitance connected external to the Transducer, no additional calculations are necessary.

For example, the typical voltage sensitivity (E_{cal}) of the Endevco Model 2272 Accelerometer is 4.0 mV/g, typical capacitance is 2700 pF, and the Accelerometer is calibrated with 300 pF of external capacitance. Thus, the typical Charge Sensitivity is:

$$Q_s = \frac{4\ (2700 + 300)}{1000}$$

$$= 12\ \text{pC/g}$$

2. CHARGE CONVERTER

A functional block diagram of a basic Airborne Charge Amplifier is shown in Figure A-2. The Input Circuit consists of a Charge Converter (the heart of the Charge Amplifier) which accepts the electrical charge from the Transducer and converts it to a voltage proportional to the Input Charge. The Charge Converter is essentially a high-gain Voltage Amplifier with negative capacitive feedback. In operation, the Output Voltage which occurs as a result of the Charge Input Signal is fed back through the feedback capacitor C_f in such a direction as to maintain the voltage at the input at, or very close to, zero. Thus, the Input Charge is stored in the Feedback Capacitor, producing a voltage across it which is equal to the Input Charge divided by the capacitance of the Feedback Capacitor.

The transfer characteristic (conversion gain in mV/pC) of the Charge Converter depends primarily on the value of the Feedback Capacitor. When the Amplifier is operated within specification limits, the equation for conversion gain simplifies to the relationship:

$$\frac{E_o}{q} = \frac{1}{C_f}$$

In effect, a Charge Converter is a circuit which appears to have a capacitive input impedance so large that the effect of varying Input Transducer Cable Capacitance is insignificant. Thus, large variation of source capacitance is possible without any appreciable change in overall system sensitivity.

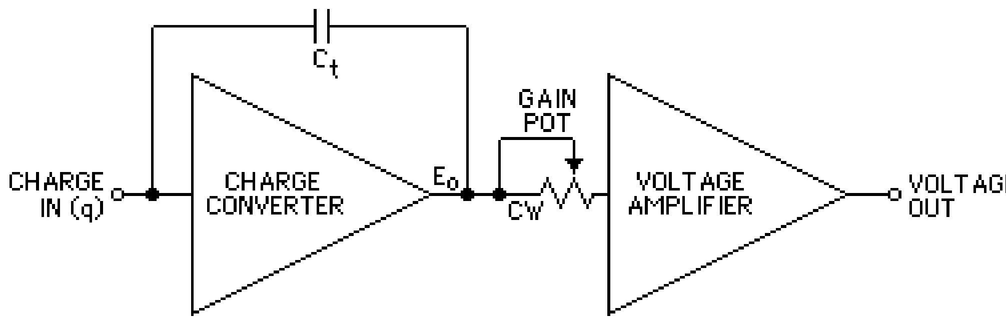


FIGURE A-2: BASIC AIRBORNE CHARGE AMPLIFIER FUNCTIONAL BLOCK DIAGRAM

3. GAIN POTENTIOMETER

Each "M" series (M1 through M12 and M14) of the series of Charge Amplifiers has a specific Gain Range (see Table 2-1). The Gain of each Charge Amplifier is set by a 10-turn Potentiometer to any desired setting within the Gain Range. The Gain is externally adjusted after removal of an Access Screw. Both the Charge Converter and Voltage Amplifier Gains are fixed for optimum stability.

4. VOLTAGE AMPLIFIER

The final stage of the Charge Amplifier is a Voltage Amplifier. Because of its low output impedance and 0.5 mA minimum output current the Charge Amplifier is capable of driving tape recorders directly. The outputs are both biased, or unbiased, or a combination of each. Biased outputs are directly coupled, and unbiased are capacitively coupled.

5. TRANSFER CHARACTERISTICS

The transfer characteristic of any amplifier is the relationship between the output and the input and is generally given by the ratio of the electrical output divided by the electrical input. If both input and output are expressed in volts, this ratio is nondimensional and is called the Voltage Gain (or gain) of the Amplifier. With the unique properties of Charge Amplifiers, however, it is more convenient to express the transfer characteristics as the ratio of the voltage out to the charge in. This quantity is called the Charge Gain of the Amplifier and is expressed in "mV out/pC in".

A typical system (Accelerometer/Cable/Charge Amplifier) equivalent circuit is shown in Figure A-3. Note that Charge Gain is independent of Source Capacitance. In the circuit shown, C_p is the Transducer Capacitance; C_f is the total external shunt (cable) capacitance; and $C_p + C_f$ is the total source capacitance for the Charge Amplifier.

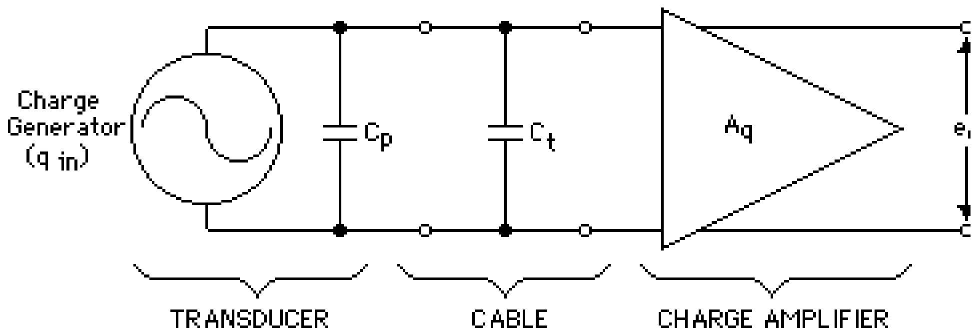


FIGURE A-3: TYPICAL SYSTEM EQUIVALENT CIRCUIT

The Charge Gain in mV/pC of the system is defined by the formula:

$$A_q = \frac{E_o}{q_{in}}$$

where A_q = Charge Gain of Charge Amplifier in mV/pC
E_o = Charge Amplifier output in mV
q_{in} = Charge Amplifier input = Transducer Output in pC

APPENDIX B: GAIN ADJUSTMENT

1. THEORETICAL GAIN ADJUSTMENT

Gain is limited by the full-scale output requirement. The gain setting along with the sensitivity of the Transducer will determine the overall sensitivity of a system (Accelerometer/Cable/Charge/Amplifier).

A measurement system incorporating a 2680 Series Charge Amplifier and a Transducer has a maximum sensitivity (A_S) determined by the formula:

$$A_S = \frac{E_O}{\text{Desired FS}}$$

where
A_S = Peak system sensitivity in mV/g pk
E_O = Charge amplifier's peak full-scale output in mV pk
FS = Charge amplifier's desired peak full scale output in g pk

The Amplifier's Charge Gain Setting (A_q) is computed by:

$$A_q = \frac{A_S}{S_q}$$

where
A_q = Amplifier's Charge Gain setting in mV/pC
S_q = Transducer's Charge Sensitivity in pC/g

As an example, suppose a system consisting of an Endevco Model 2680 Series Charge Amplifier (which has a 2.5 V pk, or 2500 mV pk full-scale output) and an Endevco Model 2271 Accelerometer is used as a system to measure ±50 g full scale pk. The formula used to determine the desired system sensitivity in mV/g is:

$$A_S = \frac{E_O \text{ (in mV pk)}}{\text{Desired FS (g pk)}}$$

= /F (25mV, 50 g)

= 50 mV/g pk

With the Charge Sensitivity (S_q) of the Accelerometer given as 13 pC/g, the Gain Setting of the Charge Amplifier is:

$$A_S = \frac{A_S}{S_q}$$

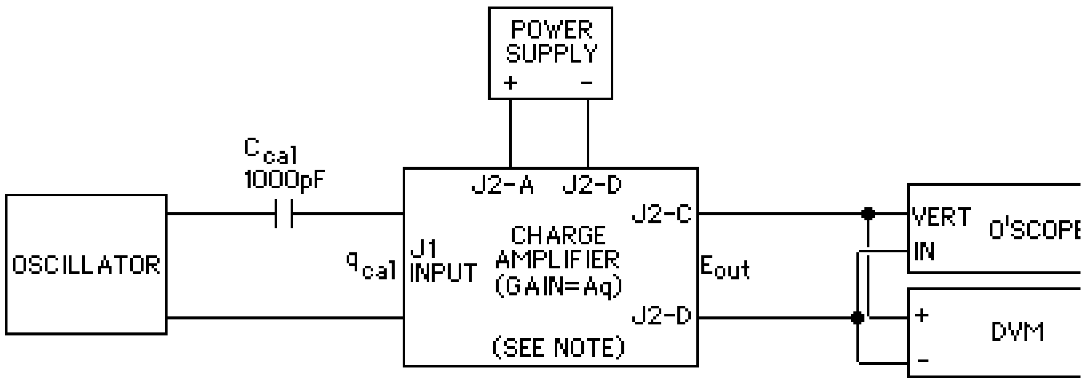
$$= \frac{2500 \text{ mV}}{50}$$

= 50 mV/g pk

If a rms full-scale level is used for calibration, adequate gain margin should be included for the anticipated crest factor.

2. PRACTICAL GAIN ADJUSTMENT

To apply the Theoretical Gain Data in a practical situation, adjust the Gain of the Charge Amplifier with a known source capacitance and input voltage during calibration. Figure B-1 is a typical test setup used for Gain Calibration.



NOTE: OUTPUT CONNECTOR J2 PIN ASSIGNMENTS SHOWN ARE FOR BAISED OUTPUT AND POWER INPUT FOR 2680M1 THRU 2680M7. REFER TO PRODUCT DATA SHEET OR PERFORMANCE SPECIFICATION FOR OTHER MODEL PIN ASSIGNMENTS.

FIGURE B-1: TYPICAL CALIBRATION TEST SETUP

To charge applied to the input of Charge Amplifier in Figure B-1 is determined by:

$$q_{cal} = E_{cal}\, C_{cal}$$

where
E_{cal} = Oscillator output in V
C_{cal} = Series calibration capacitor in pF
q_{cal} = Charge applied to the Charge Amplifier in pC

The Charge Gain of the Amplifier (A_q) is determined by:

$$A_q = \frac{E_{out}}{q_{cal}} \qquad A_q = \frac{A_s}{C_{cal}}$$

where
E_{out} = Charge Amplifier output in V
A_q = Charge Gain of Charge Amplifier in mV/pC

Transposing formula (4) we find that:

$$E_{out} = A_q\, E_{cal}\, C_{cal}$$

Therefore, if C_{cal} in Figure B-1 is exactly 100 pF, then:

$$E_{out} = A_q E_{cal}$$

If C_{cal} is other than exactly 100pF, use the following formula:

$$E_{out} = A_q E_{cal} \frac{C\ cal}{1000}$$

Adjusted to 3.85 mV/pC, as determined by formula. To calibrate the Charge Amplifier in a practical application, set the Oscillator output (figure A-2) to some convenient value, e.g., E_{cal} = 200 mV rms. Assuming that series capacitor C_{cal} is exactly 1000 pf, the Gain of the Charge Amplifier is adjusted until its output is:

$$\begin{aligned} A_{out} &= A_q E_{cal} \\ &= 3.85 \text{ X } 200 \\ &= 700 \text{ mV rms} \end{aligned}$$

During Gain calibration the Oscilloscope must be monitored to ensure the Output Signal is not clipped or distorted.

3. REMOVAL AND RESEALING GAIN-ACCESS SCREWS

Charge Amplifiers used in calibrated airborne systems have the Gain-Access Screw Solder-sealed to the case for operating in abnormal environments. The instructions provided in paragraphs 4.3.2 and 4.3.3 are to be used when removing and resealing the access screw. Endevco recommends only new screws be installed in Charge Amplifiers. Access Screws can be procured from Endevco under part number 1103 (see Table B-1).

Table B-1 lists the equipment required to remove and seal the Gain-Access Screw, and to adjust the Gain of the Charge Amplifier as defined.

ITEM	PURPOSE
Power supply, +20 to ±32 V dc, 50 mA max.	Source supply for Charge Amplifier
Oscillator, 3 Hz to 20 kHz	Input signal to Charge Amplifier
Oscilloscope, DC to 5 MHz	Monitor Charge Amplifier output signal clipping
Digital voltmeter (DVM)	Monitor Charge Amplifier voltage output
Capacitor, 1000 pF ±1%, shielded	Provide input capacitance to Charge Amplifier. Endevco Model 2947 recommended
Soldering iron, Narrow Tip, 200 W	To solder-seal access screws to case
Rosin core solder, 63-37	To seal access screws to case
Oven, temperature minimum of +100°C	To preheat Charge Amplifier
Accessory Kit consisting of:	
Allen Wrench, 5/64, with handle	Remove access screw. Endevco P/N EHM453
Allen Wrench, 0.05	Adjust gain Pot. Endevco P/N EHM35
Access Screws (two)	Seal gain-access hole. Endevco P/N 11003

TABLE B-1: **EQUIPMENT REQUIRED**

4. REMOVING ACCESS SCREWS

A. Preheat oven to +100°C.

B. Place Charge Amplifier in preheated oven for a period of time sufficient for Charge Amplifier to stabilize at +100°C.

C. Remove Charge Amplifier from oven.

D. Insert Allen wrench (with isolated handle) in Access Screw to be removed (see appropriate Figure B-2 or B-3, and place soldering iron adjacent to Access Screw as shown in the diagram.

CAUTION: When removing access screw, care should be observed to prevent molten solder from entering Charge Amplifier interior.

E. Apply torque CW to Allen wrench and remove the access screw when the solder seal is molten.

5. SEALING ACCESS SCREWS

New Access Screws should always be used to seal the gain adjust hold. Installing used Access Screws could prevent the Charge Amplifier from meeting humidity specifications.

A. Install a new Access Screw in gain adjust hold.

B. Preheat oven to a temperature of +100°C.

C. Place Charge Amplifier in preheated oven for a period of time sufficient for Charge Amplifier to stabilize at +100°C.

D. Remove Charge Amplifier from oven.

E. Apply a small amount of Rosin Core Solder 63-37 to recessed area around Access Screw to form a Solder Seal. See Figure B-2 of B-3 and use figure appropriate to Charge Amplifier.

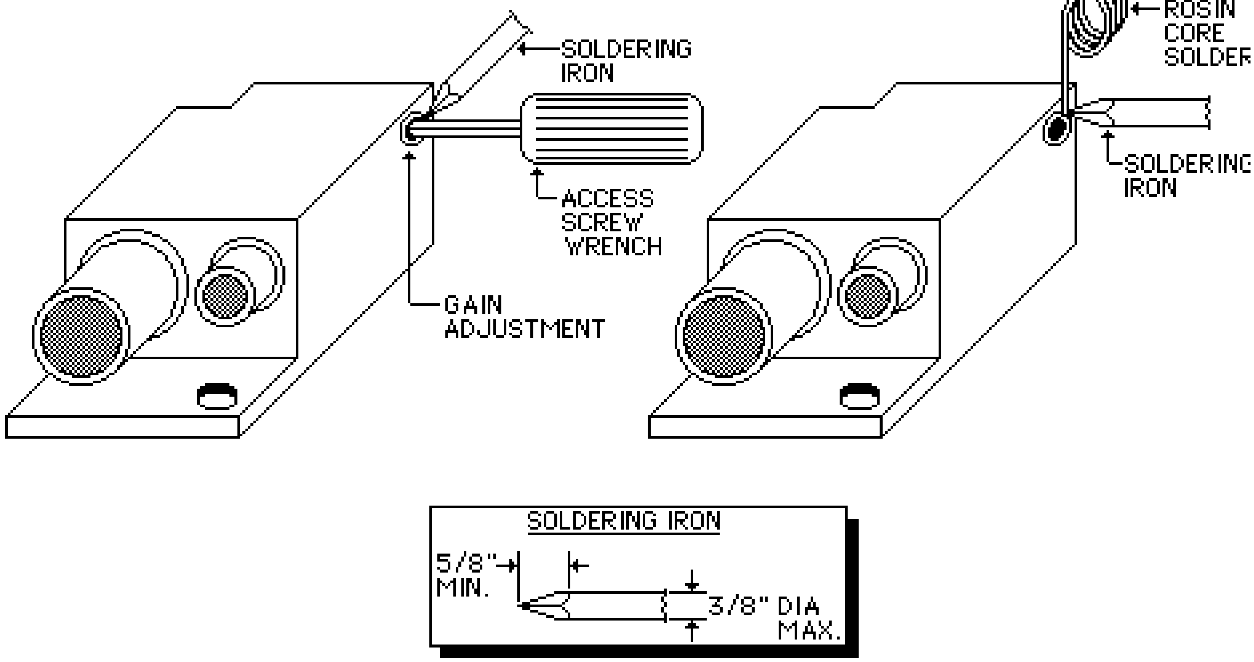


FIGURE B-2: GAIN ADJUSTMENT FOR CHARGE AMPLIFIERS WITHOUT DC-TO-DC CONVERTERS

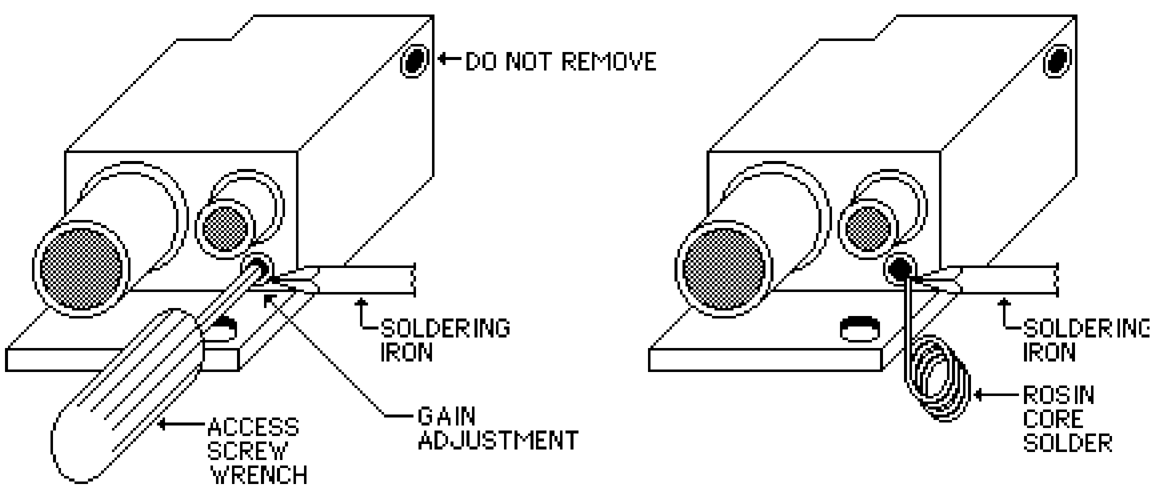


FIGURE B-3. GAIN ADJUSTMENT FOR CHARGE AMPLIFIERS WITH DC-TO -DC CONVERTERS.