INSTRUCTION MANUAL

2100 SYSTEM
STRAIN GAGE CONDITIONER AND AMPLIFIER SYSTEM

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COMPLETE 10-CHANNEL 2100 SYSTEM

4-CHANNEL SYSTEM IN 2160 PORTABLE ENCLOSURE

2120 CONDITIONER MODULE 2110 POWER SUPPLY MODULE

2160 10-CHANNEL RACK ADAPTER
SECTION 1
DESCRIPTION

1.1 The Series 2100 modules comprise a multichannel system for generating conditioned high-level signals from strain gage inputs for display or recording on external equipment. A system would be comprised of:
   a) One or more 2-channel 2120 Strain Gage Conditioners;
   b) One or more 2110 Power Supplies (each Power Supply will handle up to 10 channels; i.e., five 2120 Conditioner/Amplifiers); and,
   c) One or more rack adapters or cabinets, complete with wiring, to accept the above modules.

1.2 The principal features of the system include:
   ... Independently variable and regulated excitation for each channel (1 to 12 Vdc).
   ... Independently continuously variable gain (100 to 2100) for each channel.
   ... Bridge completion components to accept quarter- (120Ω and 350Ω), half- and full-bridge inputs to each channel as standard.
   ... LED null indicators on each channel – always active.
   ... 100 mA output as standard.
   ... All supplies and outputs short-circuit proof with current limiting.
   ... Compact packaging – 10 channels in 5⅞ in x 19 in rack space.

SPECIFICATIONS

All specifications nominal or typical at 23°C unless noted.

1.3 2120 STRAIN GAGE CONDITIONER

Note: These specifications apply for each of two independent channels per module.

INPUTS
Quarter (120Ω and 350Ω), half and full bridge.
Quarter-bridge dummy resistors provided.

BRIDGE EXCITATION
1 to 12 Vdc (adjustable for each channel) with 120Ω full bridge load.
Short-circuit current: less than 40 mA.
Ripple, noise, and 10% line change: 2 mV max.
Load regulation: ±0.2% no-load to 120Ω load.

BRIDGE BALANCE
±2000 μV (quarter, half, or 350Ω full bridge); range can be changed by internal resistance change.

CALIBRATION
Two-position (center off) toggle switch.
As delivered: ±1000 μV ±1% at GF = 2
(see also Section 3).

AMP GAIN
100 to 2100 continuously adjustable,
Gain equal to twice dial reading (±2%).

BANDPASS
dc to 5 kHz (min): ±0.5 dB (±5%)
dc to 15 kHz: ±3 dB

AMP INPUT
Temperature coefficient: ±2 μV RTI/°C (max).
Warm-up: 25 μV RTI over 30 minutes.
Noise and drift (pk-pk):
   dc – 10 μV RTI/day;
   0.01 to 100 Hz – 3 μV RTI (max);
   1 Hz up – 10 μV RTI (max).

OUTPUT
Input impedance: >25 MΩ differential or common mode (balance limit resistor removed).
CMR: dc – 120 dB (min);
   0 to 500 Hz – 100 dB
Input bias: ±0.1 μA each input.

SIZE & WEIGHT
5.25 in H x 2.94 in W x 10.97 in D
(133 mm x 75 mm x 279 mm)
2.2 lb (1.0 kg)

1.4 2110 POWER SUPPLY

OUTPUTS
±15 V at 1.2 A and ±17.5 V at 1.1 A;
all regulators current-limited against overload.

INPUT
107, 115, 214, 230 Vac ±10% (selected internally); 50-60 Hz.
Power: 40 W typical, 100 W max.

METER
0 to 12 Vdc (with switch) to read bridge excitation.
Also ac input and dc output test/monitor.

SIZE & WEIGHT
5.25 in H x 2.44 in W x 12.82 in D
(133 mm x 62 mm x 325 mm)
6.7 lb (3.1 kg)

1.5 2150 RACK ADAPTER

APPLICATION
Fits standard 19-in (483-mm) electronic equipment rack.
Accepts one 2110 Power Supply and one to five 2120 Strain Gage Conditioners.
Completely wired.

POWER
2-ft (0.6-m) 3-wire line cord; 10-ft (3-m) extension available.
Fuse: A size 3 AG (32 mm x 6.4 mm dia.).
Receptacle to accept line cord from adjacent 2150 Rack Adapter.

SIZE & WEIGHT
5.25 in H x 19 in W x 12.82 in D
overall (133 mm x 483 mm x 325 mm)
6.6 lb (3.0 kg)

1.6 2160 PORTABLE ENCLOSURE

DESCRIPTION
Completely self-contained adapter and cabinet with all wiring for two or four channels.
Accepts one 2110 Power Supply and one or two 2120 Strain Gage Conditioners.

POWER
8-ft (2.4-m) detachable 3-wire cord.
Fuse: A size 3 AG (32 mm x 6.4 mm dia.).

SIZE & WEIGHT
5.50 in H x 8.75 in W x 13.13 in D
(140 mm x 222 mm x 333 mm)
5.2 lb (2.4 kg)
CONTROLS

1.7 2110 POWER SUPPLY

BRIDGE VOLTS
Displays the voltage on each input bridge (as selected by CHANNEL selector). Also used to monitor ac line and dc outputs of Power Supply (see below).

CHANNEL Selector
Positions 1 to 10 select channel to display bridge excitation on Meter (”1” is channel farthest to left in cabinet, etc).

The DC position monitors a mixed output from the +15, -15, and +17.5 V power supplies and should always read on the “DC” line at “10” on the Meter.

The AC position monitors the peak-to-peak ac line input (at a fixed transformer tap). A reading anywhere in the band from 9 to 11 on the Meter indicates that the input voltage is proper for the selected transformer tap (see paragraph 2.5). No reading indicates the equipment is ungrounded; noticeable needle vibration indicates reversal of the ac input line.

EXTERNAL METER Jacks
Supplies Meter voltage to an external meter, if desired for precise adjustment of bridge supply voltages.

POWER Switch
The main power switch for this supply and all Conditioners connected to it. (The pilot lamp may take several seconds to extinguish when the power is turned off.)

1.8 2120 STRAIN GAGE CONDITIONER (one channel described; both identical and independent)

OUTPUT Lamps
LED indicators always monitoring amplifier output. Primarily used to adjust AMP BAL and Bridge BALANCE. (Fully lit with 0.07 V output)

OUTPUT receptacle (rear panel)

BALANCE Control
A 10-turn potentiometer to adjust bridge balance. Normal range +2000 μV. (See paragraph 2.26 to extend range.) EXCIT must be ON to set bridge balance.

GAIN Control
A 10-turn potentiometer to adjust amplifier gain. The nominal gain equals twice the dial reading (e.g., with the dial set at 500 the gain is approximately 1000). Gain is adjustable from 100 to 2100 (050 to 1050 on GAIN dial).

GAGE EXCIT
A 22-turn trimmer to adjust bridge excitation from 1 to 12 Vdc. The actual setting is monitored on the Meter and the EXTERNAL METER jacks on the 2110 Power Supply (the proper channel must be selected).

AMP BAL
A 22-turn trimmer to adjust the amplifier balance. (EXCIT should be OFF when this is done.) Thermal EMF’s in the bridge may also affect this balance.

EXCIT switch
A toggle switch controlling the excitation to the input bridge. (Any amplifier output with EXCIT at OFF is dc amplifier offset, thermal EMF from the bridge or ac pickup in the wiring.)

CAL Switch
A 2-position (with center off) toggle switch to shunt-calibrate the input bridge. As delivered, “A” simulates +1000 μV, and “B” simulates -1000 μV by shunting the internal 35Ω half bridge. Many other arrangements possible by internal resistor and jumper changes (see Section 3).

INPUT receptacle (rear panel)
A 10-pin quarter-turn connector to connect input gage(s). (Quarter, half and full bridges can be adapted simply by using the appropriate pins. See paragraph 2.11 for details.) Mating connector supplied.

OUTPUT receptacle (rear panel)
A 3-pin connector delivers the amplifier output (±10 V or ±100 mA). Mating connector supplied.
SECTION 2
OPERATING PROCEDURE

2.1 Power Supply

The individual Conditioner and Power Supply modules are not stand-alone instruments. They are designed to plug into a prewired cabinet or rack adapter which (1) supplies ac line power (fused) to the Power Supply, (2) distributes dc regulated voltages to all Conditioners and (3) connects the bridge voltage monitoring meter in the Power Supply to the various channels.

2.2 Before installing a 2110 Power Supply module in each cabinet or rack adapter, check that each 2110 module is set for the proper ac line voltage:

- Slide the right-hand side cover almost all the way back to expose the two toggle switches on the printed-circuit board. One switch, at marked points for nominal 115 or 230 V; the other sets for NORM line (115/230 V ±10%) or LOW line (107/214 V ±10%).
- Install the Power Supply in the right-hand position of the cabinet; push in the input/output plug and secure the thumb screws. The POWER switch on the front panel should be off.
- Install 2120 Conditioners in the remaining positions in the cabinet. Push in the modules to engage the power-input plugs and secure the thumb screws. (If there is less than a full complement, it makes little difference which positions are used. Blank covers are available for unused positions.)

2.4 Plug the line cord into an ac receptacle, making certain that the third pin goes to a good ground. The equipment must be grounded for good performance.

NOTE: If the line plug must be replaced with a different type, observe this color code when wiring the new plug.

Black: High line voltage
White: Low line voltage (i.e., “neutral” or common)
Green: Ground

2.5 Check ac power. On each Power Supply, turn the CHANNEL selector to “AC”. Turn the POWER switch on (up). The red pilot lamp should light and the meter should read between 9 and 11 on the scale. If not, observe meter reading:

- Pegs at full scale. Turn power off immediately. This indicates that the input voltage is too high for the internal switch settings (probably a 230 V input with switches set for 115 V; see paragraph 2.2).

- Reads low (between 8 and 9%). The ac line voltage is significantly lower than 115 V. Remove Power Supply and reset internal switch for LOW line.

- Reads around 5. This probably indicates that the internal switches are set for 230 V input, whereas the voltage is actually 115 V. Turn POWER OFF, remove module, and reset switches (see paragraph 2.2).

- Reads 0 (no reading). Red pilot lamp not lit. The ac receptacle has no power or the fuse (at the rear of the instrument) is open. Pilot lamp lit: Equipment is not properly grounded. Either the third pin was not used, or the receptacle used is not properly grounded.

If the meter reads properly but the pointer vibrates noticeably (at 50 or 60 Hz), the “phasing” of the input is improper. Reverse the line wiring.

2.7 Check dc power. On each Power Supply, turn the CHANNEL selector to “DC”. The meter should read very near the line at 10 on the scale, if not, this indicates that either: (1) there is an internal short in one of the Conditioner modules (remove them one at a time), or (2) one or more of the regulated power supply circuits is defective (see paragraph 4.4).

2.7 Check bridge excitation regulators. Scan the CHANNEL switch through positions 1 to 10; all positions should read some voltage between 1 and 12 volts. (However, switch positions corresponding to channels not installed will, of course, read zero.)

2.8 The system is now ready for use. If it is planned to use the system immediately, it is suggested that the POWER be left on (for warm-up); otherwise turn all POWER switches to OFF.

INPUT CONNECTIONS

2.9 It is suggested that the system be turned on and allowed to stabilize while preparing the input connectors; power consumption is negligible. To prevent powering any input circuits at this time, turn the EXCIT toggle switches OFF on all channels.

2.10 Each channel uses a separate (and interchangeable) input plug. Two loose plugs are supplied with each 2120 Conditioner (one per channel). If additional plugs are desired they are available from Measurements Group (see paragraph 4.3) or from the manufacturer or his distributor. Suggested types:

- ITT/Cannon KPT06B12-10P
- Bendix PT06A-12-10P(SR)

These connectors are designed to MIL-C-26482 and may be available from additional sources.

2.11 Connect the input to each channel, using the connectors supplied, in accordance with Fig. 1. Note: Except when using an external full bridge, there must be a jumper in the input circuit to pins D and E; this connects the midpoint of the internal 350Ω half bridge to the + amplifier input, thus completing the necessary full bridge for proper amplifier operation.

No modifications or jumpers are required inside of the 2120 Conditioner regardless of the external bridge configuration used. (However, there are provisions for changing the shunt calibration circuit – see Section 3.)
WIRING CONSIDERATIONS

2.12 Certain important considerations affect wiring technique, depending on whether the purpose of the test is to measure static or dynamic data; if both may be required, observe both sets of precautions.

**Dynamic Data**: It is extremely important to minimize the extent to which the gages and leadwires pick up electrical noise from the test environment; this noise is usually related to the 50 or 60 Hz line power in the area.

a) **Always** use twisted multiconductor wire (*never* parallel conductor wire); shielded wire is greatly preferred, although it may prove unnecessary in some cases using short leads.

b) Shields should be grounded at one (and only one) end; normally the shield is grounded at the INPUT connector and left disconnected (and insulated against accidental grounding) at the gage end. Do not use the shield as a conductor (that is, do not use coaxial cable as a 2-conductor wire).

c) The specimen or test structure (if metal) should be electrically connected to a good ground.

d) Keep all wiring well clear of magnetic fields (shields do not protect against them) such as transformers, motors, relays and heavy power wiring.

e) With long leadwires, a completely symmetrical circuit will yield less noise (e.g., a half bridge on or near the specimen will usually show less noise than a true quarter-bridge connection).

**Static Data**: Precise symmetry in leadwire resistance is highly desirable to minimize the effects of changes in ambient temperature on these wires.

a) In the quarter-bridge circuit, always use the 3-leadwire circuit shown in Fig. 1, rather than the more obvious 2-wire circuit.

b) Insofar as possible, group all leadwires to the same channel in a bundle to minimize temperature differentials between leads.

c) If long leads are involved, calculate the leadwire desensitization caused by the lead resistance. If excessive in view of data accuracy required, adjust effective gage factor, increase wire size, or increase gage resistance — or all three, as best suits the situation.

**MILLIVOLT INPUTS**

2.13 The 2120 Conditioner can accept low-level dc inputs, such as thermocouples (using pins A and D), provided two requirements are observed:

a) The common-mode voltage should not exceed 45 V in normal operation, and must never exceed a peak voltage of ±13 V.

b) The input cannot be completely floating; there must be a ground return, either external or within the 2120. In the case of thermocouples welded to a nominally grounded structure, this return is adequate. A 75-kΩ ground return exists within the standard 2120 due to the presence of the bridge-balance circuit. However, if the external signal is adequately grounded, this resistance can be removed (remove R7 — see paragraph 2.26).
The user is also cautioned regarding two sources of possibly significant error:

a) Bias current: Each input (pins A and D) requires an input current of approximately +100 nA; this current will flow through the input wiring to the ground return, which must exist. With a floating input (in which case R7 must remain installed), the bias required at pin D will flow directly from R7, but the bias for pin A will flow through the entire input circuit; with low source impedances, this is insignificant and can be offset with the AMP BAL control. High source impedances can result in measurable offsets (with a 50000Ω source impedance the offset may approach 1 mV, which considerably exceeds the range of the AMP BAL control). 

b) Any nonsymmetry in the ground returns of the inputs will reduce the CMR of the amplifier to some degree.

OUTPUT CONNECTIONS

CAUTION: If it is possible in any way to damage the indicator or recorder connected to the OUTPUT with inputs of 15 V or 120 mA, the OUTPUT should not be connected until the channels have been balanced (paragraphs 2.25 and 2.26).

2.14 Each channel uses a separate output plug. Two loose plugs are supplied with each 2120 Conditioner (one per channel). If additional plugs are desired they are readily available through electronic parts distributors.

Cinch-Jones P-303-CCT

2.15 Three pins are provided for each channel:

1 2 3

OUT PUT
GROUND
SHIELD
(CHASSIS GROUND)

It is probably not essential that the output leads be shielded, but in critical low-level situations it may be advisable.

Pin 2 is circuit ground, which is connected at one point to chassis-ground (in the cabinet or rack-adapter harness). If the OUTPUT is connected to a low impedance device (such as a galvanometer), it is essential that this device be connected between pins 3 and 2; any other connection may cause crosstalk between channels. However, if the output is to be fed into a high impedance device (such as an oscilloscope) which has only a single input pin (plus ground), the input can be connected to pin 3 of the OUTPUT plug with little error (typically 1 mV referred to the output) due to crosstalk between channels; of course a differential input (using pins 3 and 2) is preferred.

2.16 It should be noted that the OUTPUT indicator lamps on the front of the 2120 at all times monitor the voltage between pins 3 and 2 of the OUTPUT receptacle. If both lamps are extinguished, the output voltage is zero (within 7 mV maximum circuit offset). Full brilliance of either lamp indicates a voltage in excess of 70 mV (possibly as high as 14 V).

OUTPUT LIMITS

2.17 The output is capable of ±10 V into a load of 3000Ω or higher. With a load of 150Ω or lower, the output will deliver up to ±100 mA, but in no case greater than 120 mA. The characteristics of the current limit are as follows:

![Fig. 3: Output Limit Characteristics](image)

The max. output can readily be limited to less than 120 mA by increasing the value of two resistors per channel (R29 and R30, normally 130Ω ±2%), as shown in Fig. 3. It is suggested that below 500Ω 1-W resistors be used; between 500Ω and 1000Ω use at least ½-W resistors.

An alternate procedure to reduce the max. current in the load is to add a resistor across the load; e.g., a 175Ω resistor across a 100Ω load will reduce its max. current from 66 mA to 50 mA; the actual value of the resistor should be determined by test.

OPERATION

2.18 On each channel make certain that the EXCIT switches are OFF (thus removing excitation to all gage circuits) and the CAL switches are in the center (OFF) position.

2.19 If it is possible to damage or overload the indicators or recorders connected to the OUTPUTs with 15 Vdc (or 120 mA for low-resistance devices), the OUTPUT plugs should not be plugged in at this time.

2.20 On the Power Supply module, turn the POWER switch "ON". The red pilot lamp should light.

2.21 On the Power Supply module, set the CHANNEL selector at AC; the meter should read within the AC band on the Meter.

2.22 Turn the CHANNEL selector to DC; the meter should read on the DC check line.

EXCITATION

2.23 Set desired excitation on each channel: turn the CHANNEL selector to channel 1; on the leftmost channel, adjust BRIDGE EXCIT (using a small screwdriver) to read the desired BRIDGE VOLTS on the Power Supply Meter.

If greater accuracy is desired than can be achieved with the small meter, connect an external meter to the EXTERNAL METER banana jacks on the Power Supply (the minus jack is nominally chassis-ground).

Turn CHANNEL selector to channel 2 and repeat this procedure adjusting BRIDGE EXCIT on the next channel; continue until all installed channels are satisfactorily adjusted.

NOTE: To achieve best stability and lowest noise at the output, it is desirable to use the maximum excitation that the input to each channel can accept. Small or low-resistance gages or gages bonded to a poor thermal conductor (such as most plastics or composites) must necessarily use low excitation.
AMPLIFIER BALANCE

2.25 Adjust the AMP BAL for each channel. (To some extent the amplifier balance is affected by symmetry of the source impedances seen by the amplifier inputs.) Using a small screwdriver, adjust each AMP BAL until both OUTPUT lamps are off. (If the lamp is lit, turn the adjustment counterclockwise, etc.)

If, at best null, both lamps are lit, this is an indication of excessive noise (probably 50 or 60 Hz) at the input. Check wire shielding, etc. Refer to paragraph 2.12 for further discussion on this.

BRIDGE BALANCE

2.26 Adjust balance on each channel. On each channel, turn the EXCIT switch to ON; then turn the BALANCE control to extinguish OUTPUT lamps, as above.

NOTE: As delivered, the BALANCE controls will correct for a maximum of 2000 μc unbalance in each bridge. If this proves inadequate for the gages or transducers in use, the "balance limit resistor" (R7, normally 75kΩ) should be replaced with a lower value (or shunted with an additional resistor).

2.27 Connect OUTPUT plugs for each channel (unless already connected).

GAIN

2.28 Adjust GAIN for each channel. There are two general methods of setting the GAIN control:

- Mathematical: In many cases it is possible to predict the amplifier gain required; then this can bepreset. For example, assume the input is one active gage with GF = 2 and bridge excitation has been set at 5 Vdc. Further assume that the desired output is 2 Vdc for 500μe. At 500μe the bridge will deliver 500 x 2.5 μV = 1.25 mV; to achieve 2 V output from the amplifier will require a gain of 1600. Set the GAIN control at 800, since the nominal amplifier gain equals twice the dial reading.

- Empirical: Without regard to bridge excitation or amplifier output voltage, assume that the desired output is 25 mm deflection on a recorder for a 500μe input. Using shunt calibration (such as the 1000 μe built into the stock 2120 Conditioner), adjust the GAIN as required to achieve the desired deflection — for example, the 1000 μe cal in the 2120 should give 50 mm deflection (assuming GF = 2, for which the calibration resistors are calculated).

In practice, even though the mathematical approach is possible in many situations, the shunt-calibration method should also be used as the final exact adjustment.

The user is cautioned to consider the effects of leadwire resistance and the calibration circuit actually in use when calculating the strain simulated by shunt calibration. See Section 3.

2.29 All controls are now set. However, just before taking data, it is advisable to check balances on each channel:

a) Briefly turn EXCIT to OFF; if the OUTPUT lamps are not at null (both extinguished) trim AMP BAL as necessary. This can be done at any time during a test — and should be done occasionally on an extended test.

b) Under no-load conditions (and with CAL at OFF) the OUTPUT lamps should indicate null; if not, trim the BALANCE control.

NOTE: In both steps above it may be desirable to observe the output recorder rather than the OUTPUT lamps. First, there may be a very small offset (5-10 mV) between true zero output and the zero indicated by the lamps and, second, it may be necessary to compensate for a small mechanical or electrical zero offset in the recording device.

NOISE

2.30 Before taking dynamic data, it is highly desirable to document the output noise attributable to wiring and amplifier problems vs. the total dynamic output which includes this noise plus the dynamic strain signals:

Momentarily turn EXCIT to OFF and observe the output. Any signal observed now is NOT caused by strain (whether a dynamic strain is being generated or not). "White" noise (full spectrum) is a result of the amplifier and cannot be reduced except by reducing GAIN — it should not exceed several microvolts RMS referred to the input (that is, the observed signal divided by amplifier gain). A recurrent waveform (usually 50 or 60 Hz or multiples of this frequency) indicates electrical pickup at the gages or in the wiring to the gages; if excessive, the source should be located and corrective measures taken.
SECTION 3
SHUNT CALIBRATION

NOTE: It should be emphasized that the purpose of shunt calibration is to determine the performance of the circuit into which the gage(s) is wired, and in no way does it verify the ability of the gage itself to measure strain nor the characteristics of its performance.

EQUATIONS

3.1 Shunt calibration can be achieved by shunting any one of the four arms of the input bridge (which includes an active gage(s) and the bridge completion resistors within the 2120 Conditioner). The 2120 provides for shunting any of these arms. No matter which arm is shunted, the same equation applies:

\[ \mu e_{CAL} = \frac{R'_a}{K'} \left( \frac{R_{CAL}}{R_a + R'_a} \right) \times 10^6 \quad \text{(Eq. 3-1)} \]

where:
- \( \mu e_{CAL} \) = strain simulated (microstrain)
- \( R'_a \) = precise effective resistance of arm shunted (ohms)
- \( K' \) = effective gage factor of strain gage
- \( R_{CAL} \) = resistance of calibration resistor (ohms)

\( K' \) may be the actual package gage factor of the strain gage in use, or it may be adjusted for leadwire desensitization:

\[ K' = K \frac{R_g}{R_{g} + R_{e}} \quad \text{(Eq. 3-2)} \]

where:
- \( K \) = package gage factor of active gage
- \( R_g \) = resistance of strain gage (ohms)
- \( R_e \) = resistance of leadwire(s) in series with the active gage (usually the resistance of one leadwire—ohms)

When shunting either bridge arm to which the balance limit resistor is connected, it is theoretically necessary to correct for this shunting effect in determining \( R'_a \). While the exact value depends on the position of the balance potentiometer, a good approximation (which assumes the pot is at mid position) is:

\[ R'_a = \frac{R_a (R_p + 4R_{BL})}{2R_a + R_p + 4R_{BL}} \quad \text{(Eq. 3-3)} \]

where:
- \( R_a \) = resistance of resistor or gage in arm
- \( R_p \) = resistance of balance potentiometer
- \( R_{BL} \) = resistance of balance limit resistor

It should be noted that, for the 2120 Conditioner as shipped (where shunt calibration is across the 350Ω dummy half bridge), this correction is only 0.2%.

3.2 SHUNTING INTERNAL DUMMY HALF BRIDGE (350Ω):

Use: Quarter and half bridge (full bridge with reduced accuracy).

Advantages: Same resistors regardless of active gage resistance. No special wiring required. Can simulate tension and/or compression.

Disadvantage: Leadwire desensitization may be significant (use equation 3-2 in equation 3-1).

Location of resistors and jumpers on the printed circuit board is shown in Figs. 4, 5, and 6. (Note that separate resistors are used for CAL A and CAL B, so that these may be different values; to calculate strain use \( R'_a = 349.3Ω \)).

CAL A: Tension (+)
CAL B: Compression (−)

NOTE: This is standard configuration of the 2120 as shipped.

Fig. 4: Cal on Dummy Half Bridge (Tension and Compression)
Fig. 5: Cal on Dummy Half Bridge (Tension)

Fig. 6: Cal on Dummy Half Bridge (Compression)
3.4 SHUNTING ACTIVE GAGES

While there is no electrical problem in shunting active gages at the specimen (they must be accessible and not completely coated), accomplishing this at the Conditioner with only the usual 3-lead connection will introduce serious errors if the leadwires have measurable resistance. The reason is that one signal lead which is supposed to be only a remote voltage-sensing lead, now carries current (to the calibration resistor); the error thus introduced is approximately four times that which would be expected by normal “leadwire desensitization” equations. The above problem applies equally to active (or compensating) gages in stress analysis and to all transducer applications.

As a rough guide, 1% error will be introduced if the resistance of each lead is:

120Ω gages:
0.31Ω (7 ft AWG #26, 30 ft AWG #20) (2.1 m, 0.4 mm dia; 9 m, 0.8 mm dia)

350Ω gages:
0.9Ω (20 ft AWG #26, 85 ft AWG #20) (6 m, 0.4 mm dia; 25 m, 0.8 mm dia)

3.5 To properly shunt-calibrate active gages or transducers, the accepted technique is to provide two additional leads dedicated to the calibration circuit; for quarter-bridge operation this is customarily called the “five-leadwire circuit.” Positions are provided on the 2120 Conditioner circuit board for this application, but wires must be added between the circuit board and INPUT connector (using pins J and K, normally not used). Figs. 8 and 9 show a half bridge, but the calibration wiring also applies to full bridges and transducers; for true quarter bridges, Fig. 8, compression only, applies.

The added external leads should be connected directly to the strain gage terminals. R'ₐ = actual gage resistance, K = K. (In a transducer, the connection should be made at the connector on the transducer. R'ₐ would be the output impedance of the transducer.)
Fig. 8: Cal on Active Gage (Tension or Compression)

Fig. 9: Cal on Active Gage (Tension and Compression)

*No vacant pin available. Remove existing wire and use pin G, H, or F.

CAL A: Tension (+)
CAL B: Compression (−)
CUSTOMER MODIFICATIONS

4.1 There are several simple modifications which can be made by the customer to improve suitability in a given application or satisfy customer preferences:

a) Shunt-calibration circuit and magnitude: See Section 3.

b) Increase bridge BALANCE range: See paragraph 2.26.

c) Increase bandpass: The 2120 is limited to 5 kHz (0.5 dB down) at maximum gain (X2100) due to the gain-bandpass product of the circuit components. At lower gains the bandpass is intentionally limited to 5 kHz by C4 (.0027 µf). If C4 is removed and C3 reduced to .003 µf, the bandpass will be increased to 25 kHz (0.5 dB down) at gains up to X500; but note that the 25 kHz output may be only 6 V pk-pk.

d) Reduced gain. The gain can be reduced below X100 by reducing R24. However, it should be noted that the preamplifier (Q1/Q2, IC1, IC2) has a fixed gain of X100 so that reducing R24 makes IC3 a fractional-gain stage. Below an overall gain of X100 it may not be possible to achieve ±10 V output.

The preamplifier gain can be reduced by decreasing R13 and R21; this technique will reduce overall gain and still maintain full ±10 V output. However, noise, drift, and input impedance will be adversely affected.

e) The sensitivity of the LED OUTPUT indicators can be changed by altering the value of R32; increasing R32 will increase sensitivity and vice versa.

f) Output current limit: The current level at which the output limits is controlled by R29 and R30. It may be desirable to reduce this limit by increasing the value of the resistors. See paragraph 2.17.

SERVICING

4.2 Individual schematics of the various modules are included at the back of this instructional manual. To facilitate service, 3-ft (0.9-m) extension cables are available to operate the modules outside the rack or cabinet:

15-pin (for 2120) F/N 200-130596
25-pin (for 2110) F/N 200-130597

COMPONENT REPLACEMENT

4.3 The majority of components used in the 2110 Power Supply and 2120 Conditioner are standard commercially available items. Any component can be purchased from Measurements Group (please provide us with component symbol, value, and module serial number). The following comments apply:

GENERAL: All 5% and 10% resistors are Allen-Bradley composition resistors, as marked (except Power Supply resistors R2, R7, R12 are TRW/IRC). All 1% resistors are Allen-Bradly "CC" Cermet resistors as marked (100 ppm/°C). All 0.1% and 0.02% resistors are Vishay (2 ppm/°C) and must be ordered from Measurements Group.

2110 Power Supply

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>200-130583</td>
<td>Meter MI</td>
</tr>
<tr>
<td>200-130584</td>
<td>Switch S2</td>
</tr>
<tr>
<td>200-130560</td>
<td>Transformer T1, T2</td>
</tr>
<tr>
<td>14X700040</td>
<td>Regulator, IC1-IC3 (LM723CN, Fairchild or National Semiconductor)</td>
</tr>
<tr>
<td>14X200167</td>
<td>Transistor, Q1 - Q3 (2N5977, Motorola)</td>
</tr>
</tbody>
</table>

2120 Conditioner

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12X300515</td>
<td>Input plug, P1</td>
</tr>
<tr>
<td>12X300139</td>
<td>Output plug, P2</td>
</tr>
<tr>
<td>140-000019</td>
<td>Transistor, Input (Q1/Q2)</td>
</tr>
<tr>
<td>140-000020</td>
<td>Transistor, Q3 or Q4 (graded)</td>
</tr>
<tr>
<td>14X700042</td>
<td>Amplifier, IC1, IC4 (LM307N, Fairchild recommended)</td>
</tr>
<tr>
<td>14X700041</td>
<td>Amplifier, IC2 (AN201N, Analog Devices)</td>
</tr>
<tr>
<td>14X700066</td>
<td>Amplifier, IC3 (LM351N, National recommended)</td>
</tr>
<tr>
<td>14X700032</td>
<td>Regulator, IC5 (ceramic) (723DC, Fairchild recommended)</td>
</tr>
</tbody>
</table>

ADJUSTMENTS

4.4 The only adjustments in the 2110 Power Supply are to trim the exact output voltage. The adjustments (from the top) control +17.5 V, -15 V, +15 V; these should be set within 1% if possible, although they are not highly critical.

The only adjustments in the 2120 Conditioner are for common mode rejection. Short the two input pins of one channel (pins A and D) together and supply a low frequency (10 to 20 Hz) input, 2 to 5 V peak-to-peak, with respect to ground (pin C). Adjust the trimmer R14 to achieve minimum ac output. (If it is desired to check the CMR with an input resistance other than zero, it is necessary to temporarily remove R7 during these tests. To adjust high frequency CMR, raise the test frequency to 500 Hz and adjust the piston capacitor C10 to achieve minimum ac output.)