

**Operating Instructions,
Installation Information
and
Calibration Certificate
for
Servo Inclinometers**



Warranty

Jewell's instruments are warranted during a period of one year from date of shipment to original purchaser, to be free from defects in material and workmanship. The liability of Seller under this warranty is limited to replacing or repairing any instrument or component thereof which is returned by Buyer, at his expense, during such period and which has not been subjected to misuse, neglect, improper installation, repair, alteration or accident. Seller shall have the right to final determinations as to the existence and cause of defect. In no event shall Seller be liable for collateral or consequential damages. This warranty is in lieu of any other warranty, expressed, implied or statutory; and no agreement extending or modifying it will be binding upon Seller unless in writing and signed by a duly authorized officer.

Receiving Inspection

Every Jewell instrument is carefully inspected and is in perfect working order at the time of shipment. Each instrument should be checked as soon as received. If the unit is damaged in any way or fails to operate, a claim should immediately be filed with the transportation company.

Factory Service

Whenever a Jewell instrument requires service, the nearest Jewell representative should be contacted. If it is determined that the unit does require factory service, call the Repair Department at 603-669-6400 at which time a Return Material Authorization (RMA) number will be assigned. The following information is necessary to obtain the RMA number:

- Model number
- Serial number
- Quantity
- Symptoms of the problem with the unit to be repaired
- If under warranty, Original Purchase Order Number or Jewell Sales Order Number

Repairs will not be accepted without the RMA number. Address all inquiries on operation or applications to your nearest Sales Representative or to:

Sales Manager
Jewell Instruments, LLC
850 Perimeter Road
Manchester, NH 03103

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INTRODUCTION

The LS series of inclinometers are solid-state, dc, closed-loop, force-balance tilt sensors with accuracy, stability and reliability several orders of magnitude greater than open-loop types. They are ideally suited for use in the construction industry for setting tilt of road grading and paving machines. In the geophysics field for tilt and strong motion studies, in the civil engineering field for evaluation of tilt of supporting walls in dams and other structures, and other applications where high-accuracy measurement of tilt is required.

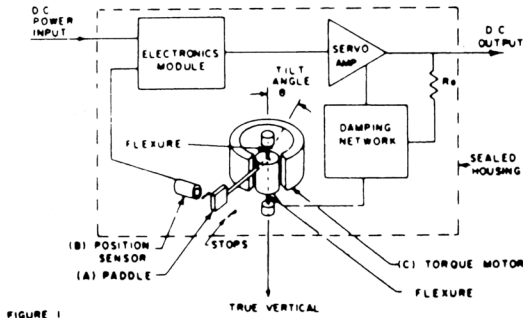
DESCRIPTION

The Jewell inclinometer is fully self-contained and designed to operate from a standard DC power source. Its output is an analog DC signal directly proportional to the sine of the angle of tilt. In level (horizontal) position, the DC output is zero. When tilted in one direction, the inclinometer output is 0 to +5V DC full scale. When tilted in the opposite direction, the output is 0 to -5V DC full scale. The heart of this closed-loop, gravity-referenced sensor is a flexure supported torque-balance system, rugged enough to withstand severe shock and vibration and still maintain excellent accuracy. The solid state electronics and sensor are enclosed within the sealed housing, permitting operation in hostile environments.

PRINCIPLES OF OPERATION (REFER TO FIGURE 1)

As inclinometer tilts angle " θ ", paddle "A" tries to move in direction of tilt (due to force of gravity). Any resultant motion is converted by sensor B to a signal input to the electronic amplifier whose current output is applied to the torque motor C. This develops a torque equal and opposed to the original so the pendulous mass no longer moves, but assumes a position minutely different from its original to provide the required error signal. The torque motor current is directly and accurately proportional to tilt, and by allowing it to flow through stable resistor R_o , an equally accurate output voltage is developed.

Steps are provided on both sides of the paddle to limit its travel when not powered. When powered, the paddle automatically moves to its null position.



A DISCUSSION OF TERMS AND OPERATIONAL PARAMETERS

Specific information about your inclinometer appears on the individual INCLINOMETER DATA SHEET, which is included in this document. An explanation of the terms appearing on the data sheet follows.

POWER SUPPLY VOLTAGE

An entry such as ± 15 volts describes the required dual (or balanced) power supply. To eliminate misinterpretation, such a supply will measure 30 volts between the plus terminal of the plus supply and the minus terminal of the minus supply.

POWER SUPPLY CURRENT

The entry made here is the maximum of either of the dual supplies.

RANGE

This describes the plus and minus input tilt limits for linear output.

FULL RANGE OUTPUT

The number entered bears no plus or minus sign, and the sign is carried by the entry under RANGE.

CROSS AXIS SENSITIVITY

Ideally, input vectors perpendicular to the true sensitive axis should not introduce vector components of gravity in line with the sensitive axis, and thus cause equivalent voltage signal outputs. CROSS AXIS SENSITIVITY is defined as inclinometer output for 1 g of gravity perpendicular to the sensitive axis. The approximate magnitude of the CROSS AXIS SENSITIVITY can be determined by placing the inclinometer with (1) its sensitive axis and (2) a side of the inclinometer, both perpendicular to the gravity vector. After making allowance for ZERO OFFSET, the inclinometer output will then approximate the stated CROSS AXIS SENSITIVITY.

NOISE

Generally random, and the value is entered as read on an averaging type unfiltered, high-impedance ac voltmeter.

LINEARITY

As entered here, this defines the maximum plus or minus voltage deviation from a straight line plot of actual versus theoretical sine output divided by the total voltage between rated voltage limits times 100. For the usual ± 5 volt instrument, if the maximum deviation is ± 0.005 volts, the % linearity will be

$$\frac{\pm 0.005}{+5 - (-5)} \times 100 = \pm 0.05\%$$

As entered, the \pm sign is omitted. Deviation and best fit straight line are as determined by the method of least squares.

OUTPUT IMPEDANCE

This defines the dc resistance of internally-installed load resistor across which rated force-balance current develops the rated output-signal-voltage.

ZERO OFFSET

This is defined as the voltage-signal-output with no intentional input components along the sensitive axis and is caused by a small residual spring force. The resultant offset voltage adds to the output signal for one direction of applied tilt and subtracts for the other. This generally is limited to $\pm 0.05\%$ of full scale; that is, ± 0.005 volts for a ± 5 volt instrument.

SCALE FACTOR TEMPERATURE COEFFICIENT

This is a measure of the change in output voltage due to a change in temperature. It is defined as the change in output voltage (for any input angle) per degree Celsius divided by the output voltage (x 100 to convert to percentage).

NULL TEMPERATURE COEFFICIENT

This is a measure of the change in output at zero input due to temperature. It is defined as the change in output per degree Celsius divided by full range output (10 volts for a 5 volt full scale output) (x 100 to convert to percentage).

HOW TO USE THE INCLINOMETER

In the most common configuration, a dual power source is used, and a VOLTAGE OUTPUT SIGNAL is available. In this configuration, the force-balance current flows through a low-temperature-coefficient internal resistor R_I which returns the current to the midpoint of the dual power supply. This operating mode is shown in Figure 1.

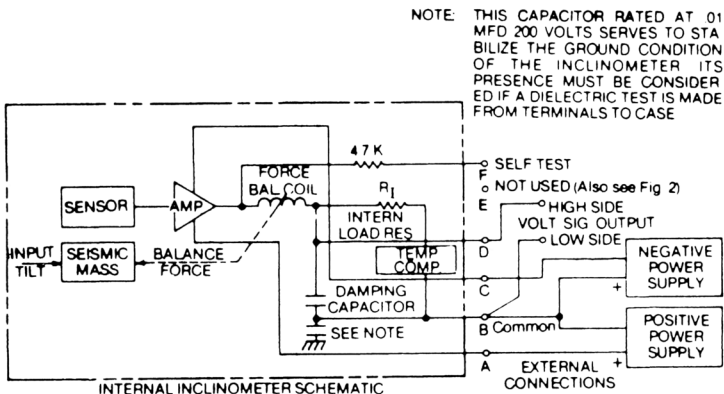


FIGURE 1 VOLTAGE SIGNAL OUTPUT WITH INTERNAL LOAD AND TEMPERATURE COMPENSATION

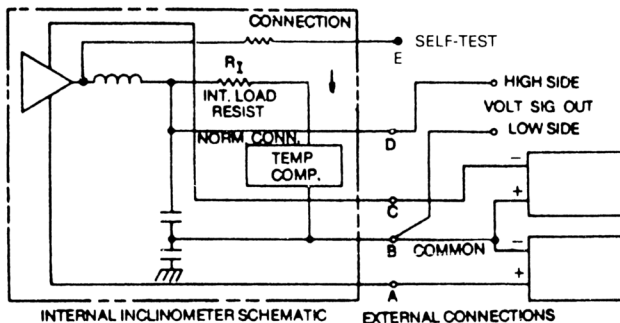


FIGURE 2 VOLTAGE SIGNAL OUTPUT WITH INTERNAL LOAD AND TEMPERATURE COMPENSATION (5 TERMINALS)

Some types of inclinometers have only five terminals: connections are shown in Figure 2.

A final mode of operation is SELF TEST, also known as current-forcing. This is illustrated in Figures 3 and 4. Preferably, the isolated current source should be of high-impedance, 100,000 ohms or higher. In the circuit shown using an operational amplifier current source, it is higher than 10 megohms. If the inclinometer is operating properly, servo-action will cause it to develop a current in the force-balance coil equal and opposite to the injected current. The net effect is that the current will be forced through the internal load resistor just as if it were being developed by an applied tilt. Rated current injected will result in rated signal-voltage-output. Once the self-test source has been set up to produce this response, any failure to achieve rated signal-voltage-output is an indication that the inclinometer is not operating properly.

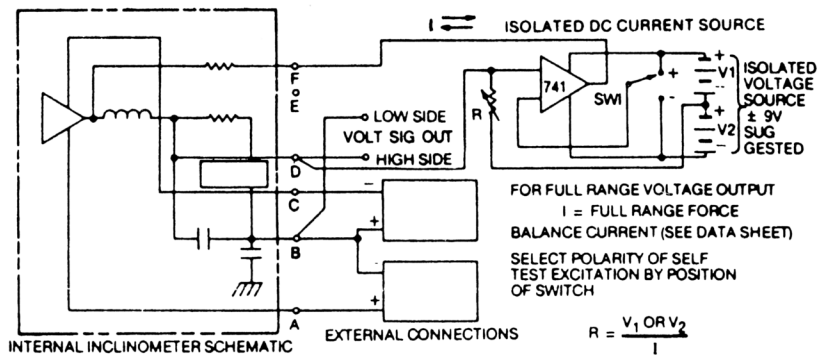


FIGURE 3 DC SELF TEST

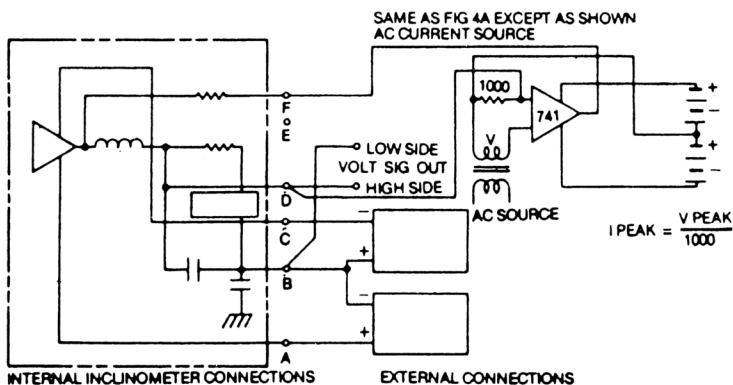
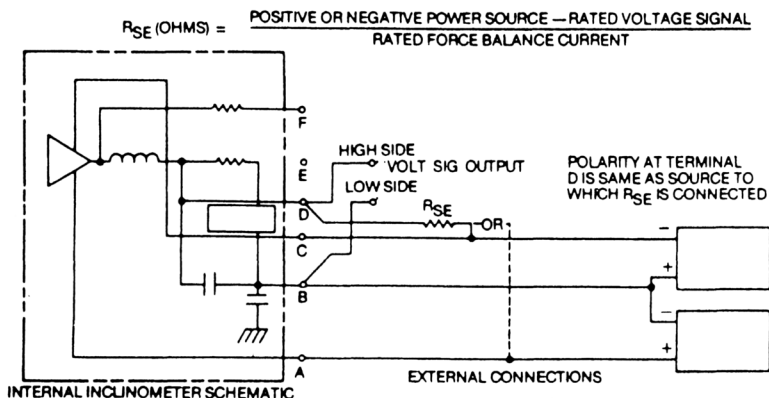


FIGURE 4 AC SELF TEST

Direct-current self-testing is shown in Figure 3. A high-impedance isolated ac source shown in Figure 4 may be employed if the frequency response characteristic is to be examined.

Since this method of self-testing verifies proper operation of the inclinometer, it is obvious that it can also verify the operation of a control system fed by the inclinometer. If it is desired only to check the operation of a control system, a simpler method is possible, illustrated in Figure 5.



This method provides a signal to a control system but note that it does not always verify proper operation of the inclinometer.

Figure 6 illustrates operation of the inclinometer from a single power source. Note that in this configuration the power source cannot have a terminal common to the signal return.

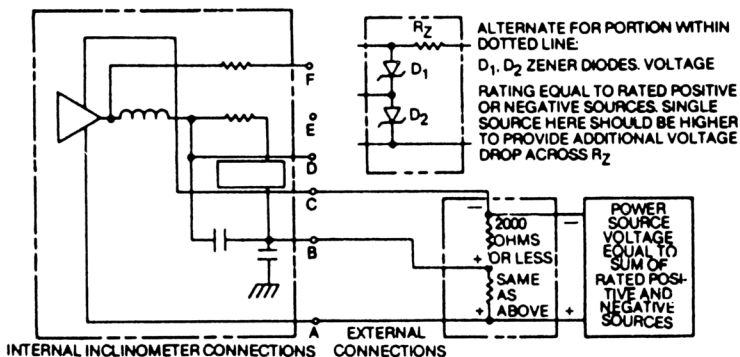
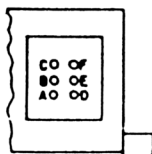
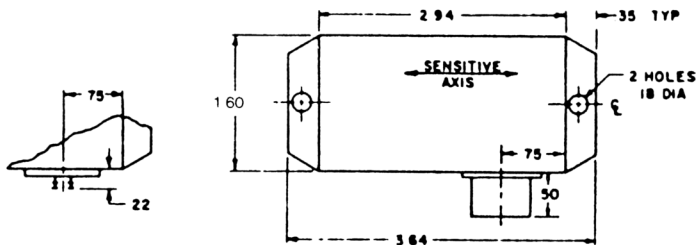


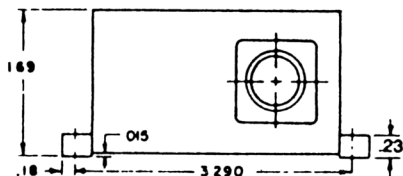
FIGURE 6. OPERATION FROM SINGLE POWER SOURCE

INSTALLATION

The inclinometer should be installed on a mounting surface known to be flat and in one plane. The simplest way of verifying qualitative operation of the inclinometer is to connect it in accordance with one of the diagrams and place it at rest in the position in which it is to be installed. For most the sensitive axis will be horizontal. The ZERO OFFSET output should appear in either the measuring or control systems being fed by the inclinometer. Tilt the inclinometer up and down by hand; the readout system should display a periodic output.



SOLDER PIN
TYPE TERMINATION



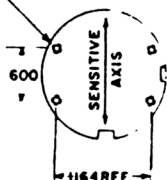
CONNECTOR TYPE TERMINATION
(MATES WITH PT06A-10-65)

UNIT WEIGHT = 13 OZ

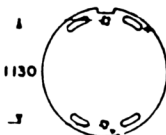
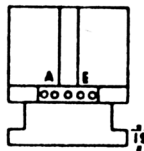
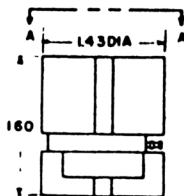
LSOC, LSOP SERIES OUTLINE

NOTE: SLOTS AND 1-72 TAPPED HOLES PERMIT PIGGYBACK MOUNTING WITH UNITS ROTATED 90°

4 HOLES TAPPED 1-72 X $\frac{3}{16}$



VIEW A-A



4 HOLES .078 WIDE
SLOTTED .23 LONG
ON .655R

2 HOLES TAPPED 8-32 X $\frac{3}{16}$

UNIT WEIGHT = 4 OZ

LSRP SERIES OUTLINE



A +POWER
B COMMON
C -POWER
D SIGNAL OUT
E SELF TEST
F SPARE

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INCLINOMETER DATA SHEET

DATE _____ TESTED BY _____

MODEL NO _____ APPROVED BY _____

SERIAL NO _____ CUSTOMER INSP _____

CUSTOMER _____ GOVT INSP _____

SALES NO _____

PO NO _____

CONNECTIONS _____ DRAWING NO _____

POWER SUPPLY VOLTAGE(S): _____ volts

POWER SUPPLY CURRENT _____ mA

FREQUENCY RESPONSE (-3db) _____ Hz

RANGE _____ degrees

FULL RANGE OUTPUT _____ volts

CROSS AXIS SENSITIVITY _____ volts/g

NOISE _____ volts rms

LINEARITY _____ %

OUTPUT IMPEDANCE _____ ohms

ZERO OFFSET _____ volts

SCALE FACTOR
TEMPERATURE COEFFICIENT _____ %/oC

NULL TEMPERATURE COEFFICIENT _____ %FR /oC

TILT APPLIED SO THAT CONNECTOR
END IS LOWER CAUSES OUTPUT
VOLTAGE TO BECOME MORE

MOUNTING DIMENSIONS





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