

Preliminary

ICA5

2 wire 4-20mA

**Miniature In Cell Amplifier
For Strain Gauges**



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User Manual Instructions

ME **MANTRACOURT**
ELECTRONICS LIMITED

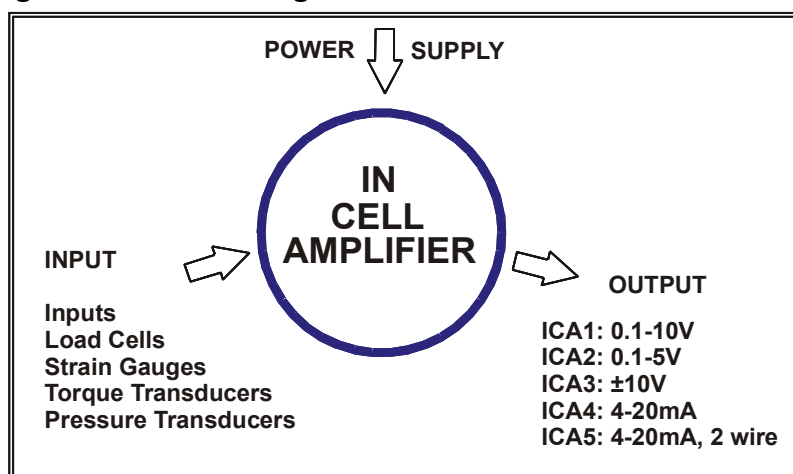
ICA5 Manual

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Chapter 1 Introduction to The ICA Range

Figure 1.1 Block Diagram



The ICA is a Strain Gauge Amplifier, converting a strain gauge input to a Volt or mA output – otherwise known as a Signal Conditioner.

The ICA provides a wide range of signal conditioning for Strain Gauges, Load Cells, Pressure and Torque Transducers.

Offered in 5 versions

- ICA1 - 3 wire – 0.1 to 10 volts
- ICA2 - 3 wire – 0.1 to 5 volts
- ICA3 - 4 wire - ± 10 volts
- ICA4 - 3 wire – 4 to 20 mA
- ICA5 – 2 wire – 4 to 20mA

Special unique features to the 2 wire, 4-20mA amplifier ICA5

Auto zero amplifier giving very high stability
Linerisation
Screw mounting & earth bonding for EMC
Shunt calibration option
Operating voltage from as low as 7.5 volts dc
Low profile option 7.0mm (0.275") high ICA5L

N.B. The ICA5 is designed for a 1k bridge, however 350R can be used with a reduced performance.

This manual only deals with the ICA5 version, separate manuals exist for versions ICA1 & 2, ICA3 and ICA4.

Transducer **SENSITIVITY** of between 0.5 mV/V and 6 mV/V are possible. It is optimized to 2.5 mV/V.

Sensitivity adjustment is achieved by a combination of gain (span) resistor 'R4' change and associated *fine adjustment* by potentiometer.

Similarly transducer **ZERO** can be compensated for in the module. This adjustment is to compensate for slight errors in the strain gauge and not to offset tare. The value of R1 (Figure 2.2) can be modified to increase the trim range of the zero point.

A high stability resistor, R11 (Figure 5.2) can be fitted to give a greater positive offset e.g. 12mA output at zero input.

Chapter 2 Installing The ICA5

Pre Installation

See Specification Details in Chapter 9 for details of Environmental Approvals.

Carefully remove the ICA unit from its shipment box. Check that the unit is complete and undamaged.

Check The Model: Type (1,2,3, 4 or 5) – they look similar.

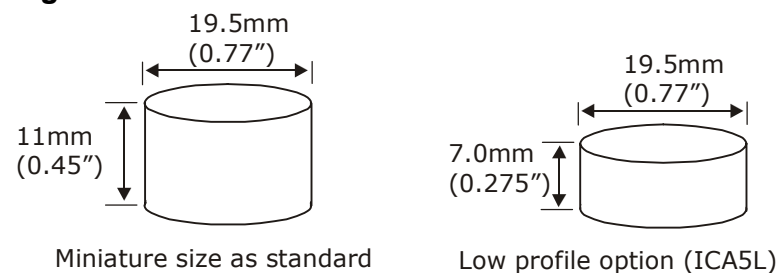
The ICA units can operated in any industrial environment providing the following limits are not exceeded

Operating Temperature	-40°C to +85°C
Humidity	95% non condensing
Storage temperature	-40°C to +85°C

The following installation practices are advised:

- Minimise vibration
- Do not mount next to strong electrical fields (transformers, power cables)
- Ensure easy access to the module
- Install electrical protection device as the unit is not internally fused
- Always ensure the package is secure and protected

Figure 2.1 Dimensions



The module is designed to fit in the strain gauge pocket.

The low profile (ICA5L) version has single-turn gain potentiometer to reduce the height.

Use a bolt through the 2mm hole to secure the unit and to provide a good ground connection.

Take care soldering cables to the pads. Use a temperature controlled soldering iron set to a maximum 330 °C, for no longer than 2 seconds per pad. Excessive heat or increased soldering time may result in damage to the PCB.

If changing resistor R1 or R4 do so at a workbench and not on site.

Check the relevant details for model ICA5– ensure the module matches the instructions.

The ICA5 solder pads are as shown

4 pads for the strain gauge

2 pads for power supply/signal

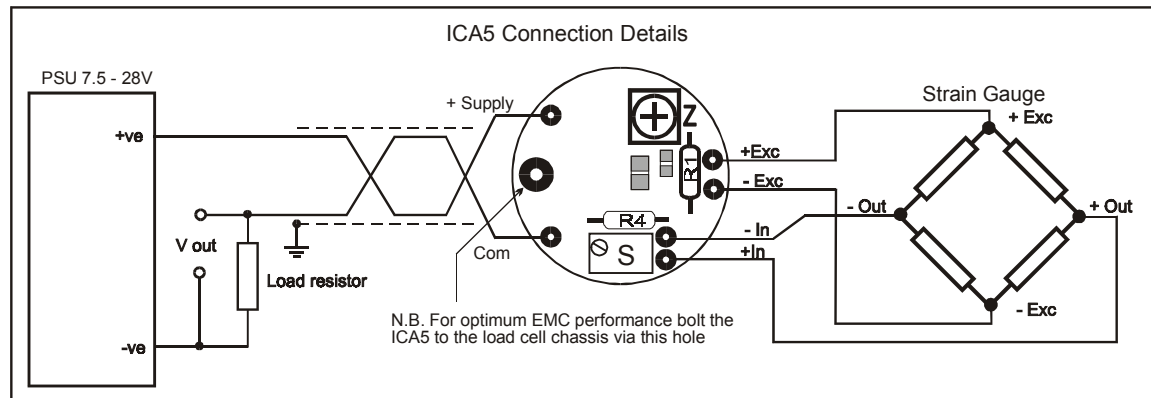
4 pads for fitting and linking a calibrating resistor

1 pad for earth bolt to chassis, this is important for best EMC performance

Power Connections

The power supply for the ICA5 should be between 7.5 and 28V

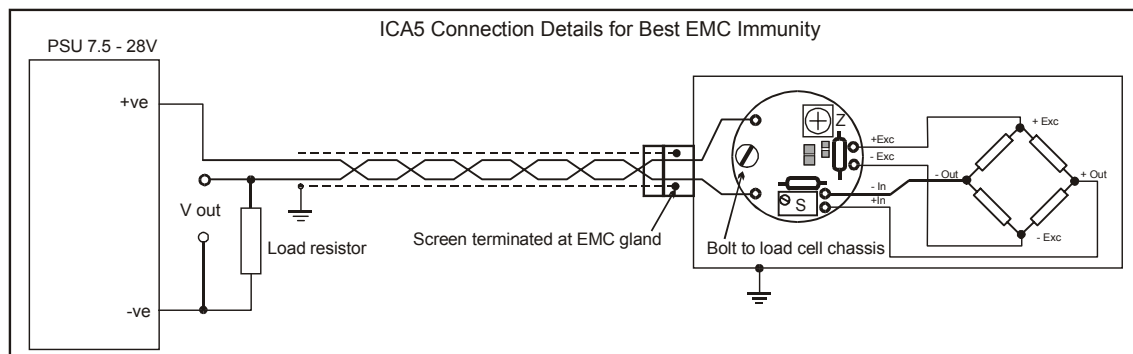
Figure 2.2 Connection Details



The strain gauge cable should be attached to the solder pads as illustrated.

N.B The voltage between either of the power supply connections and the load cell chassis should not exceed 50V. Any leakage will be greater than 10M Ohms.

Figure 2.3 Connection Details for Best EMC Immunity



The securing bolt should be used to provide a good electrical ground and mechanical support. This is important for optimum EMC performance.

This typical cable data is provided for information only.
The cable should have single pair twisted cables.

Table 2.1

Country	Supplier	Part No	Description
UK	RS	367-533	Braided screened twisted multipair cable (7/0.2mm)- 1 pair Miniature- twin -round Diameter: 4.8 mm Impedance: 62 Ohms: Capacitance/m: core to core 120 pF & core to screen 210 pF
Note: For easy connections the above 1 pair cable is recommend, however the ones below can be used:			
UK	Farnell	148-539	Individually screened twisted multipair cable (7/0.25mm)- 2 pair Tinned copper drain. Individually screened in polyester tape. Diameter: 4.19 mm Impedance: 54 Ohms: Capacitance/m: core to core 115 pF & core to screen 203 pF
UK	Farnell	585-646	Individually screened twisted multipair cable (7/0.25mm)- 3 pair Tinned copper drain. Individually screened in polyester tape. Diameter: 6.86 mm Impedance: 62 Ohms: Capacitance/m: core to core 98 pF & core to screen 180 pF

The earth connection conductor should have sufficient cross-sectional area to ensure a low impedance path to attenuate RF interference.

Output Connections

The ICA5 analogue output is 4 to 20mA. The power and signal are combined in a single pair cable, simplifying installation.

N.B. Neither connection to the output load is electrically common to the load cell.

The following formula gives the suitable range of shunt resistance for low supply voltage operation.

Output Shunt Resistance Formula

The shunt resistance must be less than:

$$((V_{\text{supply}} - 7.5) / 20\text{mA}) - R_{\text{wiring}}$$

e.g. assuming 10 Ohms wiring resistance and 9V supply:

$$\text{Max shunt resistance} = ((9 - 7.5) / 0.02) - 10 = 65 \text{ Ohms}$$

Chapter 3 Setting Gain and Offset Values

The ICA5 (4 to 20mA) In-Cell strain gauge amplifier is supplied un-calibrated but optimized for a sensitivity of 2.5mV/V. To accommodate other sensitivities the gain resistor 'R4' as shown in Figure 2.2, can be changed according to the following formulae.

N.B. a high quality component (e.g. 1% 50 ppm metal film device) should be used for optimum performance. It may be necessary to use an E96 value for optimum trim range: -

Calculating the Gain Resistor (R4)

$$R_g = \left(\frac{40 * (mV / V * V_{exc} * 0.048 * 0.95)}{0.016} \right) = 114 * (mV / V * V_{exc})$$

Where mV / V is the sensitivity of the load cell and V_{exc} is the excitation voltage.

R_g comprises R4 in parallel with 919 Ohms

$$\therefore R4 = \left(\frac{919 * R_g}{919 - R_g} \right)$$

e.g. For 2.5mV/V and $V_{exc} = 1V$:-

$$R_g = 285 \text{ Ohms}$$

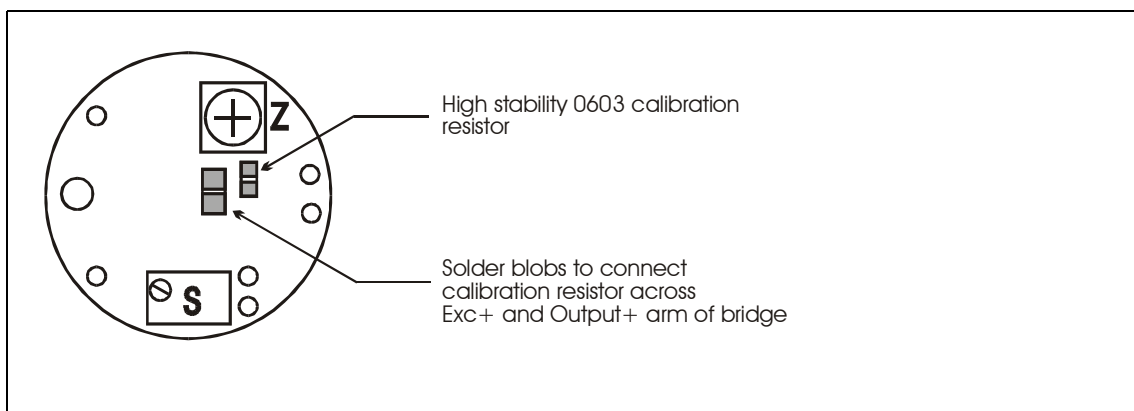
$$\therefore R4 = \left(\frac{919 * 285}{919 - 285} \right) = 413 \text{ Ohms} - \text{nearest preferred value is 412 Ohms (E96)}$$

Offset Resistor (R1)

The value of R1 can be changed to offset the zero point, if outside of the normal range ($\pm 3\%$).

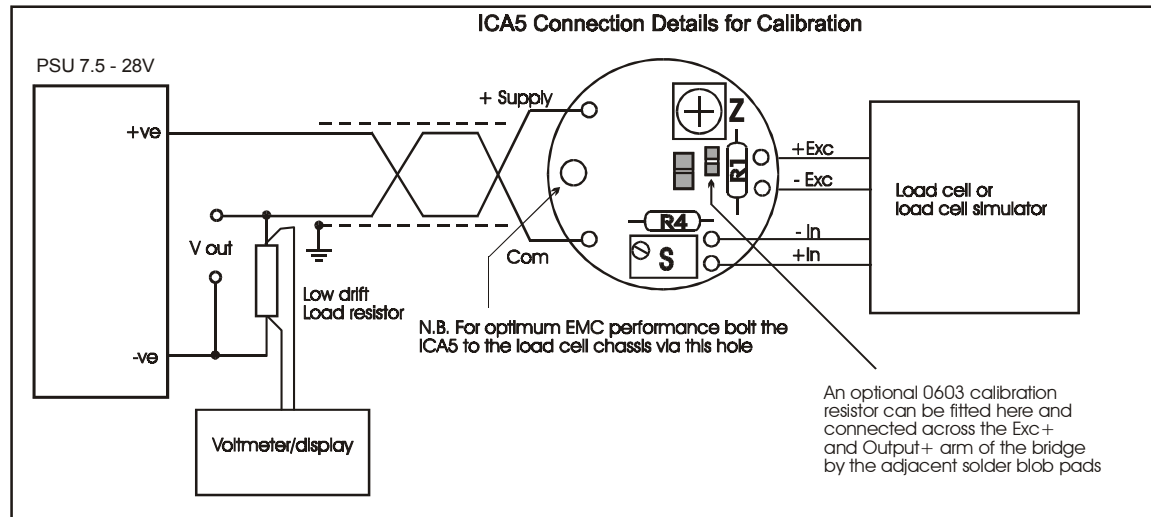
Figure 3.1 Calibration Resistor

There is provision on the PCB to add a (0603) high stability calibration resistor and a 'solder blob' link.



Chapter 4 Calibration

Figure 4.1 Connection Details for Calibration

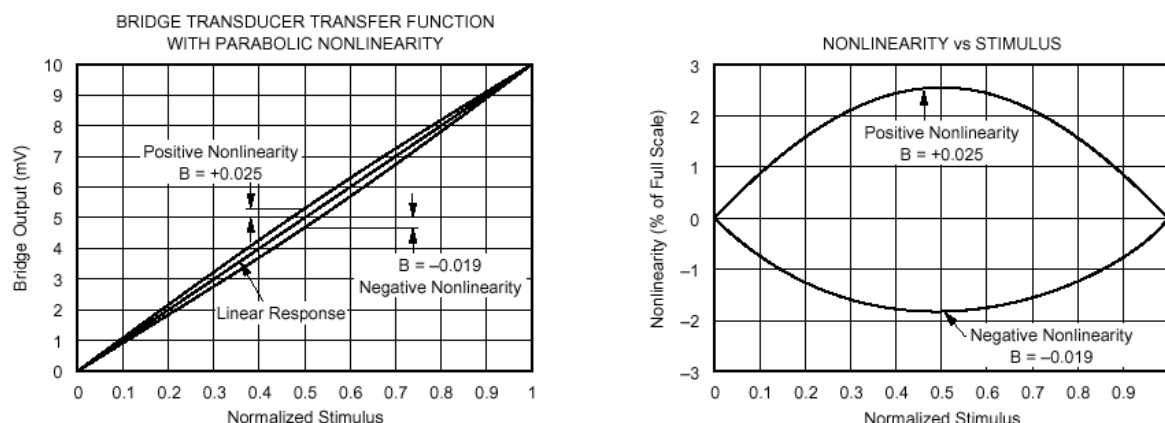


1. Apply the **low** calibration conditions (weight, force or mV/V). Set the output to 4mA using the 'Z' potentiometer.
2. Apply the known **high** calibration conditions (ideally between 75% and full scale) and adjust the 'S' potentiometer to give the required output current for the known input.
e.g. 16mA for 4-20mA final calibration with 75% input or 20mA if 100% input.

Chapter 5 Linearisation

Many bridge sensors are inherently non-linear. With the addition of one external resistor, it is possible to compensate for parabolic non-linearity resulting in up to 20:1 improvement over an uncompensated bridge output.

Figure 5.1 Bridge Non Linearity

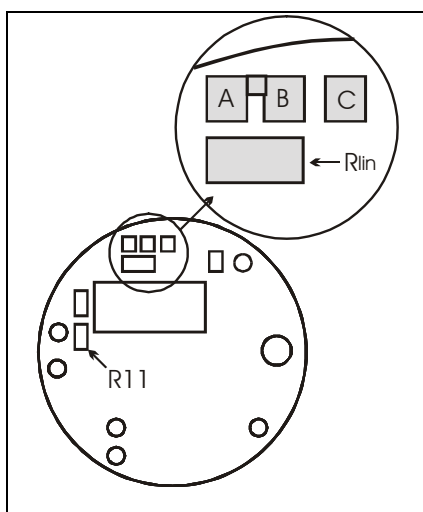


Linearity correction is accomplished by signal-dependant variation of the bridge excitation voltage. This can be tailored to correct for sensor non-linearity between +5 and -2.5%.

Either positive or negative bridge non-linearity errors can be compensated for, by proper connection of the polarity pads. (A, B and C Figure 5.2)

The ICA5 as supplied is set for negative non-linearity (downward bowing). To correct for positive non-linearity (upward bowing) cut the link connecting pads A and B and join pads B and C with a solder blob.

Figure 5.2 Link Options & RLin Locations



If no linearity correction is desired, do not cut the link or remove the resistor RLin.

RLin is the external linearisation resistor. To determine the value of RLin, the non-linearity of the bridge sensor with constant excitation voltage must be known. The linearity circuit can only compensate for the parabolic-shaped portions of a sensors non-linearity. Optimum correction occurs when maximum deviation from linear output occurs at mid- scale. See Figure 5.1.

Sensors with non-linearity curves similar to that shown in Figure 5.1, but not peaking exactly

at mid-scale can be substantially improved. A sensor with an 'S' shaped non-linearity curve (equal positive and negative non-linearity) cannot be improved with existing correction circuitry.

The value of R_{Lin} is chosen according to equation 1.

$$(1) \quad R_{Lin} = K_{Lin} * \left(\frac{4B}{1-2B} \right) \text{ Ohms}$$

Where: $K_{Lin} = 9905 \text{ Ohms}$

B is the sensor non-linearity relative to V_{fs}

e.g. for -2.5% non-linearity $B = -0.025$

V_{fs} is the full scale bridge output (= $V_{exc} * \text{mV/V}$)

The sensor's non-linearity term, B (relative to full scale), is positive or negative depending on the direction of the bow.

The gain is affected by the varying excitation voltage used to correct bridge non-linearity. The corrected value of the gain resistor is calculated from equation 2.

$$(2) \quad R_g = \left(\frac{48 * V_{fs}}{0.4} \right) * \left(\frac{1+2B}{1-2B} \right) \text{ Ohms}$$

When using linearity correction, care should be taken to ensure that the sensor's output common-mode voltage remains within the amplifier's input range of 1.1V to 3.5V.

Equation 3 can be used to calculate the amplifier's new excitation voltage.

$$(3) \quad V_{Exc(Adj)} = V_{Exc(Initial)} * \left(\frac{1+2B}{1-2B} \right) \text{ Volts}$$

The common-mode voltage of the bridge output is simply half of this value if no common-mode resistor is used. Exceeding the common-mode range may yield unpredictable results.

For high precision applications (errors < 1%), a two-step calibration process can be employed. Firstly, the non-linearity of the sensor bridge is measured with the initial gain resistor and R_{Lin} = 0 (R_{Lin} pin connected directly to V_{reg} - this is as supplied). Using the resulting sensor non-linearity, B, values for R_g and R_{Lin} are calculated using equations 1 and 2.

A second calibration measurement is then taken to adjust R_g to account for the offsets and mismatches in the linearisation.

Chapter 6 Troubleshooting

1. No Output

- a) Check power supply is present and the correct polarity
- b) Check the output connections are correct with no open circuit connections
- c) Check terminations (ensure there are no dry joints)
- d) Check the sensor is connected with the power off (Impedance check)
- e) Check the Excitation voltage is correct
- f) Check the load is connected and is not open or short circuited
- g) Check Span and Gain calibration

2. Low Output

This is when an output is present but not of sufficient magnitude to meet the required value. Remember to allow for Tare Weight and ensure it is measured and allowed for in the output from the ICA

- a) Check power supply is within specified limits (i.e. is not low – Impedance check)
- b) Check the sensor is connected (typically reading 350 Ohm across output + & -) with the power off
- c) Check the Excitation voltage is at 1.08V dc for a 1k load cell (0.55V for 350R)
- d) Check the calibration
- e) Check the Zero (offset) is correct for the sensor, this too is a common reason for low outputs

3. High Output

This is when an output is present but higher (in span or zero) than expected.

High output is not normally a problem. It is most likely to be incorrect connections and as such the output would be high and fixed.

- a) Check the sensor is connected (Impedance check) with the power off
- b) Check the Excitation voltage is at 1.08V dc (assuming a 1k load cell)
- c) Check the Zero (offset)
- d) Check the calibration

4. Unstable Output

This is when the output is unstable or varies. The cause could be (a) poor installation or (b) a noisy environment.

Poor Installation -This is when an output is present but higher or lower (in span or zero) than expected:

- a) Check the installation for problems and repair where necessary
- b) Poor termination
- c) High resistance on cable leads
- d) Low insulation impedance
- e) Proximity to High Voltage Equipment – Transformers, Contactors, Motors etc.

Noisy Environment-

- a) Check if the source can be found and remove noise
- b) Check the cable screening and ensure it is correctly installed and terminated

5. Calibration

This section assumes that the unit is providing an output that is not stuck at top or bottom of the scale.

(See paragraphs 1-3 if this is the case)

Ensure you are connected to the correct sensor and not to another adjacent unit.

Ensure you have the correct calibration data from the sensor manufacturer. This must include a certified table with offset, zero and linearity.

Ensure you have the calibration set-up correctly installed i.e. mV source and output as required.

Ensure the temperature and other environmental parameters are within specification and where necessary taken into account when calibrating should such parameters have an effect on the calibration.

6. Fine Span (Gain) and Zero (Offset) Adjustment Problems

If the adjustment cannot reach the maximum output desired then, check the tare is not too high.

If the potentiometer does not alter the output the unit must be repaired – remove from service. It is always wise to check a known good ICA against the problem Installation before rejecting the suspect ICA.

Chapter 7 Product Care

A worn out component, excessive use in harsh environments, an overly zealous operator; regrettably some circumstances necessitate repair.

At Mantracourt Electronics Ltd we can't guarantee that a product will never require repairing. We can, however, promise a repair service of exceptional quality, one which is governed by a rigorous procedure.

Detailed below is our pledge to you: a defined set of ground rules and procedures to which we will adhere. All we ask in return is that you assist us with our procedure, such that we can maintain our promise to you. Please note that warranty repairs may not be available on overdue accounts, and that a strict interpretation of our conditions of trading invalidates warranty claims where late payment has occurred.

Please refer to 'Customer Repair Service Procedure' document – contact your supplier for a copy.

In the unlikely event you have problems with the ICA module we would advise that you take the following precautions:-

- The unit is installed as instructed.
- Recommended spares are kept in stock. We can assist.
- Sufficient expertise available for first line maintenance.
- Routine maintenance checks are performed – annually is recommended.
- The necessary documentation for the product is available to the maintenance personnel.

We recommend you keep on file – as a minimum

- This Manual
- The calibration figures for the attached sensors
- A record of the 'normal' output – if applicable
- A calibration record of the ICA
- A contact phone number from the supplier for assistance

Chapter 8 Glossary

AWG	American Wire Gauge.
Background Noise	The total noise floor from all sources of interference in a measurement system, independent of the presence of a data signal. (See Noise)
Bipolar	The ability of a signal conditioner to display both positive and negative readings.
Bridge Resistance	The resistance measured across the excitation terminals of a Strain Gauge.
Calibration	Adjustment of an instrument or compiling a deviation chart so that it's reading can be correlated to the actual value being measured.
CMR (Common-Mode Rejection)	The ability of an instrument to eliminate the effect of AC or DC noise between signal and ground. Normally expressed in dB at DC to 60 Hz. One type of CMR is specified between SIG LO and PWR GND. In differential meters, a second type of CMR is specified between SIG LO and ANA GND (METER GND).
Common Mode Rejection Ratio	The ability of an instrument to reject interference from a common voltage at its input terminals with relation to ground. Usually expressed in db (decibels).
Drift	Change of a reading/set point value over periods due to several factors including change in ambient temperature, time and line voltage.
Excitation	The external application of electrical voltage current applied to a transducer for normal operation.
Fine Adjustment	Zero and Span calibration have a Fine Adjustment to give accuracy to the calibration. These are potentiometers P1 and P2 for Span and Zero respectively.
Full Bridge	A Wheatstone Bridge configuration utilizing four active elements or Strain Gauges.
Full Range Output	The algebraic difference between the minimum output and maximum output.
Gain	Gain is otherwise identified as SPAN. It relates to the proportional output to the sensor input. Calibration of the ICA is determined by setting the Gain (Span) and Offset (Zero). The amount of amplification used in an electrical circuit.
Ground/Earth	The electrical neutral line having the same potential as the surrounding earth.
Linearity	The closeness of a calibration curve to a specified straight line. Linearity is expressed as the maximum deviation of any calibration point on a specified straight line during any one calibration cycle.
Load	The electrical demand of a process expressed as power (watts), current (amps) or resistance (ohms).
Load Impedance	The impedance presented to the output terminals of a transducer by the associated external circuitry.
Load Cell	The load cell is one of a series of STRAIN GAUGE sensors that the ICA input is designed to accept. (Torque Sensor, Pressure & temperature transducers).
Millivolt	One thousandth of a volt, 10^{-3} volts symbol mV.
Noise	An unwanted electrical interference on the signal wires.
Null	A condition, such as balance, which results in a minimum absolute value of output.
Offset	Offset is otherwise identified as ZERO. Calibration of the ICA is determined by setting the Offset (Zero) and Gain (Span).
Potentiometer	Two potentiometers (variable resistors) are used in the ICA for fine calibration.
Pressure Transducer	The Pressure Transducer is one of a series of Strain Gauge sensors that the ICA input is designed to accept. (Torque Sensor, Load Cell and Temperature Transducers).
Proportional Outputs	The Voltage or Current outputs are calibrated to be directly proportional to the input from the sensor. The output is, within the sensor limits, taken as linear and no linearity compensation is required within the ICA.
Resolution	The input corresponding to a one-unit change in the least significant digit of the data acquisition/display equipment. (Good resolution is not necessarily equal to good accuracy.)
Sensing Element	That part of the Transducer, which reacts directly in response to the input.
Sensitivity	This is the relationship between the change in Strain Gauge input to the level or magnitude of the output.

Signal Conditioner	A circuit module that offsets attenuates, amplifies linearizes and/or filters the signal. The ICA is essentially a Signal Conditioner –more specifically known as a Strain Gauge Amplifier - in that it CONDITIONS (alters) the input signal from a load cell to an electrical output.
Single Card Assembly	The ICA has only the one Printed Circuit Board assembly on which all the components are mounted. The assembly is then mounted inside an environmentally rugged enclosure.
Span	Span is otherwise identified as GAIN. It relates to the proportional output to the sensor input. Calibration of the ICA is determined by setting the Span (Gain) and Zero (Offset).
Span Adjustment	The ability to adjust the gain of a process or strain meter so that a specified display span in engineering units corresponds to a specified signal span.
Stability	The quality of an instrument or sensor to maintain a consistent output when a constant input is applied.
Strain Gauge	The Strain Gauge is a resistance bridge device where the bridge value alters linearly and proportionally to the force exerted on it – be it pressure, torque or load. The ICA is designed to convert this change in the Strain Gauge to a proportional electrical signal.
Strain Gauge Amplifier	The ICA1 & 2 is essentially a type of Signal Conditioner that it conditions (alters) the input signal from a strain gauge to an electrical output
Torque Transducer	The Torque Transducer is one of a series of Strain Gauge sensors that the ICA input is designed to accept.
Wheatstone Bridge	A network of four resistance's, an emf source, and a galvanometer connected such that when the four resistance's are matched, the galvanometer will show a zero deflection or "null" reading.
Zero	Zero is otherwise identified as OFFSET. It relates to the proportional output to the sensor input. Calibration of the ICA is determined by setting the Span (Gain) and Zero (Offset).
Zero Adjustment	The ability to adjust the display of a process or strain meter so that zero on the display corresponds to a non-zero signal.
Zero Offset	The difference between true Zero and an indication given by a measuring instrument. See Zero Suppression.
Zero Suppression	The Span is Offset from Zero (Zero Suppressed) such that neither limit of the Span will be Zero. For example, an instrument which measures a load of a 100kG Span from 400kG to 500kG is said to have 400kG Zero Suppression.
Units	
AC	Alternating Current
DC	Direct Current
Hz	Hertz (Frequency)
kHz	kilohertz (Frequency)
mA	milliamps
mm	millimetres
SC	Signal Conditioner
ICA	Strain Gauge Amplifier
V	Volts
mV	millivolts

Chapter 9 Specifications

Table 9.1 Specifications

Parameter	Minimum	Typical	Maximum	Units
Power supply (reverse protected)	7.5*	24	28	V dc
Bridge excitation	-	1.1	-	V (1k bridge)
Bridge resistance	350	1000	5000	Ohms
Bridge sensitivity	0.5	2.5	6	mV/V † (1k bridge)
Gain adjustment (Pot - fine adj.)	-	±3	-	%FS
Zero adjustment (Pot - fine adj.)	-	±8	-	%FS
Output load	-	-	800**	Ohms
Bandwidth	0	-	2000	Hz
Zero temperature stability (at 2.5mV/V)	-	0.001	0.005	%FS/ °C (1k bridge)
Span temperature stability (at 2.5mV/V)	-	0.007	0.014	%FS/ °C (1k bridge)
Linearity	-	0.02	-	%FS
Operating temperature range	-40	-	+85	°C
Humidity	0	-	95	%RH

FS = Full scale. † = set by calibration resistor. **24V supply

Connections Solder pads, 4 strain gauge, 2 for power/signal

N.B The voltage between either of the power supply connections and the load cell chassis should not exceed 50V. Any leakage will be greater than 10M Ohms.

*For low supply voltage operation the shunt resistor must be less than:
 $((V_{\text{supply}} - 7.5) / 20\text{mA}) - R_{\text{wiring}}$

e.g. assuming 10 Ohms wiring resistance and 9V supply:

Max shunt resistance = $((9 - 7.5) / 0.02) - 10 = 65 \text{ Ohms}$

NOTE: Recommended bridge impedance is 1,000 Ohms

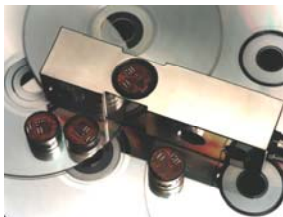
Environmental Approvals

EMC Emissions	EN 50 081-1	:1992 (Light industrial)
EMC Emissions	EN 50 081-2	:1992 (Heavy industrial)
EMC Immunity	EN 50 082-1	:1992 (Light industrial)
(RF Fields Test 500 ppm of reading over 30 to 500MHz)	EN 50 082-2	:1992 (Heavy industrial)
(RF Fields Test 6000 ppm of reading over 30 to 500MHz)		
Low Directive	IEC 1010, EN 61010	

Other Mantracourt Products

www.mantracourt.co.uk

Signal Conditioning

SGA • STRAIN GAUGE AMPLIFIER • Connect up to 4 strain gauges • Proportional mA and/or Voltage output • Simple DIL switch configuration • Set Sensitivity and Low pass filter and output • Simple - Reliable - Rugged	RCA15 • RACK MOUNTED INTELLIGENT • STRAIN GAUGE AMPLIFIER • Complete MULTI-CHANNEL system for Strain gauges. • Relay and/or serial outputs per channel • Multidrop serial link • 19" Eurorack x 3U high. • Capability similar to the ADW 15. • High integrity / compact Data acquisition unit
LCA • IN-LINE INTELLIGENT • STRAIN GAUGE AMPLIFIER • 2 Set Points • 4 to 20 mA AND 0 to 10 V (isolated) outputs • RS 232/485 Communications port • On-Board easy to use Programmer • Auto tare–Auto calibrate–and much more...	ADW15 Mantraweigh • 72 mm DIN Module – Display & Controller • 10 mm LED Display (Configurable) • Sensitivity from 0.5 mV to 200 mV/V • 10 V @150 mA Excitation • Isolated I/O100mSec sample rate • Set Point Relays • 4 to 20 mA Output • Programmable via keypad
FIELD BUS CONNECTIVITY IN TWO EXCELLENT PACKAGES DSC The Digital Strain Card  Mount this package adjacent to the strain gauge Plug-in-and-go-sensor • Integrate the electronics with the load cell, • remove the cost, space and bother of additional electronics and have a direct output • provided in • REAL ENGINEERING UNITS 'D'Cell The 'in-cell' Digital Strain Puck  Mount this package directly into the strain gauge pocket High accuracy • A quantum leap in the quality of measurement • Accuracy (1 part in half a million) • Unwanted Signal noise filter • Temperature compensated • Sensor specific calibration • Elimination induced noise on signals	

In the interests of continued product development, Mantracourt Electronics Limited reserves the right to alter product specifications without prior notice.

CE

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Code No. 517-167

Issue 1.3

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