

Load cell system fault finding guide
(Application Note: Number AN1)



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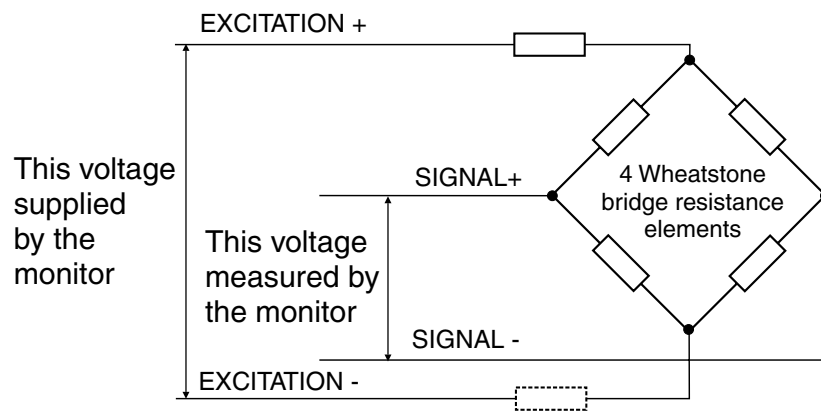
1 Basic checks

This first chapter is intended to aid in fault finding in load cell systems using Wheatstone bridge type load cells. The items covered are designed to assist in checking connection of the load cell and obtaining a display from a load cell monitor. Since only a load cell and monitor are being checked the main purpose is to isolate whether any problems seen arise from the load cell or the monitor. For other load cell system requirements such as alarm setting and retransmission outputs consult the instruction manual of the load cell monitor being used.

Equipment required: A multimeter capable of measuring Ohms, Volts and mV. To test the monitor independently a load cell simulator will be required.

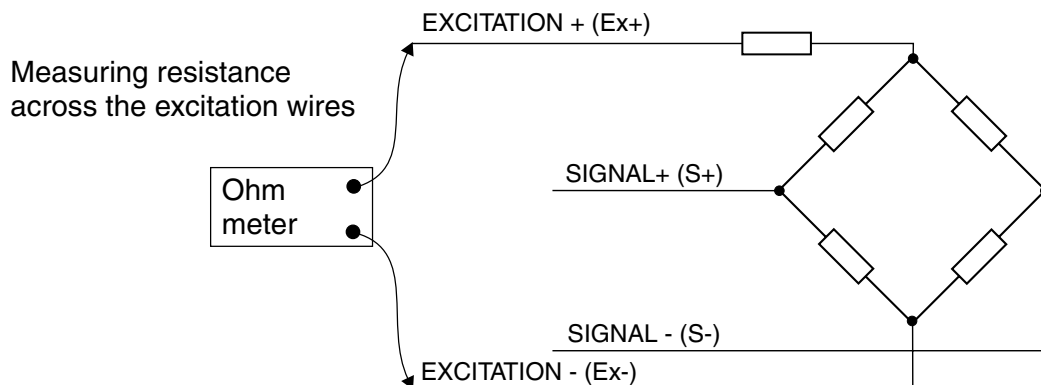
1.1 Basic load cell system

The basic load cell system consists of a 4 wire load cell connected to a load cell monitor. The monitor supplies a voltage called the excitation voltage to the load cell and the load cell returns a millivolt (mV) signal back to the monitor. The mV signal changes with the load experienced by the load cell and this mV signal is used to determine the display value on the monitor.



1.2 Basic load cell resistance checks

Unfortunately there is no standard wiring colour code for load cells so you will need to know from data supplied with the cell which wires are the excitation wires and which wires are the signal wires (see section 2.6 for colour code examples). If you do not have this information then as shown in the diagram above in addition to the 4 resistance elements which make up the Wheatstone bridge there are commonly one or two resistors in the excitation lines. This means that the resistance across the excitation wires is usually the highest resistance measured across any two wires. The resistances also vary between manufacturers and load cell types, input and output resistance values are often provided in the data supplied with the load cell.



To test the cell obtain a meter capable of measuring Ohms, measure across each pair of wires in turn and record the results (space provided in the table which follows). The load cell must be completely disconnected from the monitor and at no load when these tests are made.

The table which follows gives measurements taken with a sample 350Ω load cell with one resistor in its Ex+ line i.e. these readings show lowest values between signal lines and Ex-. For a load cell with two resistors in its excitation lines (one in Ex+ and one in Ex-) you would expect the Ex+ and Ex- to S+ and S-

measured values to be roughly the same. In a typical load cell the S+ to S- should be close to the specified output resistance of the cell i.e within an one or two Ohms, other values are nominal.

Resistance check	Typical 350Ω	Record your readings	Record your readings	Record your readings
Ex + to Ex -	410Ω approx.			
S+ to S-	350Ω			
Ex + to S+	315Ω approx.			
Ex+ to S-	315Ω approx.			
Ex- to S+	280Ω approx.			
Ex- to S-	280Ω approx.			

If the resistance readings appear to be correct move on to section 1.3. If the resistance readings appear to be incorrect e.g. outside expected range, open circuit or short circuit across any two wires then the likely cause is a damaged or faulty load cell or incorrect/faulty wiring.

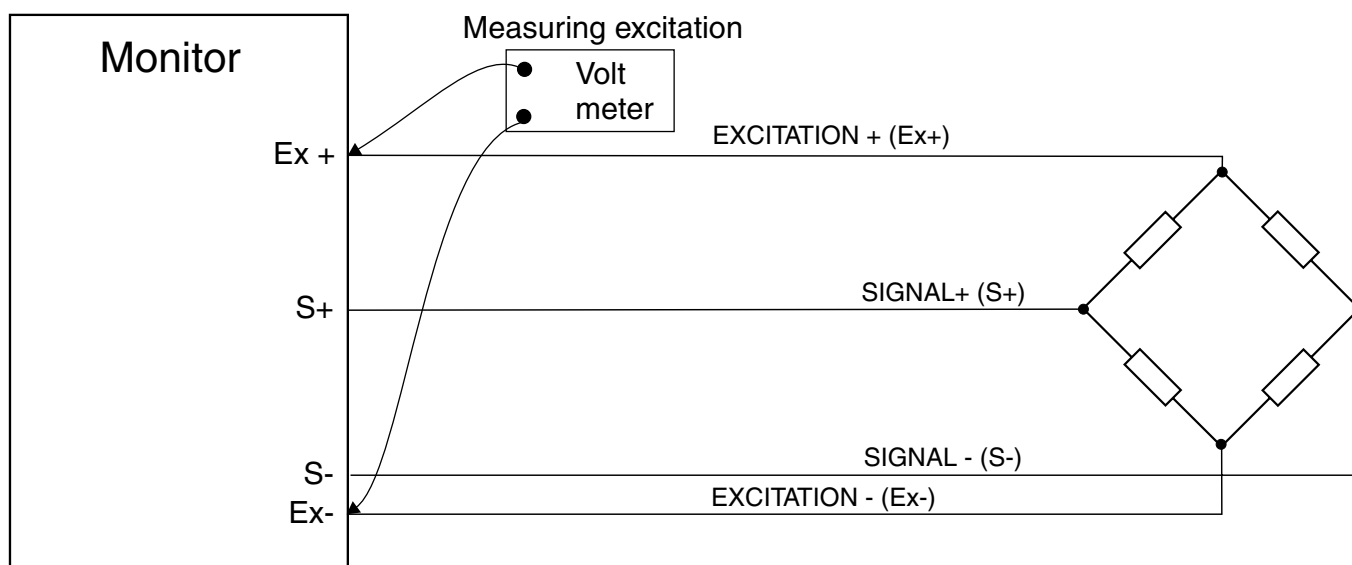
1.3 Checks when load cell is connected to monitor

When installing a load cell system the usual installation procedure would be:

1. Install load cell in position
2. Connect excitation and signal wires to monitor
3. Calibrate monitor to read the load in the units required e.g. kg or tonnes (consult monitor instruction manual for calibration procedures)
4. Check monitor is reading correctly over a range of values

If you wish to check the system prior to installation or if the load cell will not calibrate or the monitor cannot be made to read correctly or is giving unstable readings make the following measurements.

1. Using a voltmeter measure and record the excitation voltage
2. Using a mV meter measure and record the signal voltage at the lowest load you can apply
3. Using a mV meter measure and record the signal voltage at a load as close to the rating of the load cell as possible.
4. Obtain the mV/V output figure from the load cell data supplied with the load cell and compare the signal changes seen with the theoretical values from the load cell data.



The table below shows the theoretical signal measurements at zero and full load for a 2mV/V output load cell.

Excitation (2mV/V load cell)	Signal mV at zero load	Signal mV at full load
10V	0mV	20mV
5V	0mV	10mV

Example: for a 1000kg load cell with 2mV/V output and 10V excitation you would expect a change of 0.02mV per kg change in load i.e. $20\text{mV}/1000 = 0.02\text{mV}$ per kg. At a load of 150kg you would therefore expect the signal voltage to increase by 3mV from the value measured at no load.

If the excitation and signal voltages appear to be correct move on to section 1.4 below.

1.4 Testing the monitor

If the resistance checks and mV output checks from the load cell appear to be correct but the system is not responding correctly to a change in load the load cell monitor needs to be checked using a load cell simulator. Suitable simulators are available from many manufacturers e.g. Model PA8201 available from AIC. A simple simulation circuit diagram is given below which together with a mV meter can be used to test the monitors response. Procedure for testing is as follows.

1. Check all settings in the monitor are correct. The most important settings are excitation voltage and mV/V input range but also check that the display is free to change with input i.e. that display hold, display rounding, peak hold, peak/valley memory facilities are not interfering with normal live input display operation.
2. Connect the simulator and vary the input over the required mV range.
3. If the monitor is not responding correctly try to recalibrate the monitor using the simulator. Note: the original calibration will be lost if the system is recalibrated so do not recalibrate if losing the original calibration is a problem. When the monitor is seen to be working using the simulator check that the monitor reading is stable for a steady input and then recalibrate the system again using the load cell.

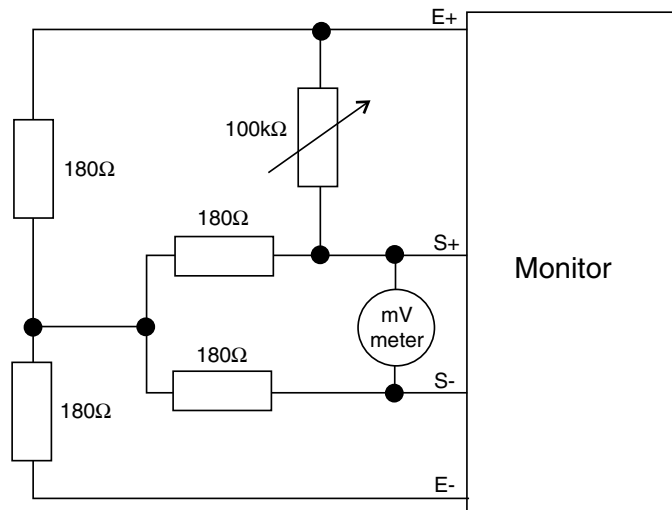
If the monitor can be calibrated successfully and is stable when using a simulator then any problems seen when calibrating using the load cell would indicate a problem with the load cell or the wiring between the load cell and the monitor.

Notes:

If these resistor values are not obtainable use the closest value available of a higher resistance. Use close tolerance metal film resistors.

This circuit is for testing purposes only and should not be used for final calibration of the monitor.

A zero mV input can only be obtained by removing the 100kΩ potentiometer. At lower resistance values the potentiometer will overload the input resulting in a display over voltage indication. Connect a 10KΩ resistor in series with the potentiometer if this is a problem. Fitting the 10KΩ resistor will limit the span voltage available.



1.5 Other common system problems

Some common problems which may cause difficulty when installing a system.

1. Incorrect wiring of load cell to monitor - i.e. signal & excitation wires crossed at one or more points. In AIC monitors this is likely to show an error message of - - - - or -or- on the display.

2. Friction or restriction of load cell movement - If the load cell is prevented from moving freely due to friction or is prevented from moving to its full deflection due to an obstacle the output from the load cell will not be correct. Typical display reading indications are that the display is slow to respond to load changes and/or that the display does not always return to zero when expected and/or that the display is not linear. Check that there are no obstructions to free movement and that the load cell is mounted correctly.

3. Over stressed load cell - If the load cell becomes over stressed sufficiently it will take on a permanent deformation. This will lead to a high offset voltage which may make it impossible to calibrate successfully and may also lead to non linearity over its operating range.

4. Moisture in the load cell or wiring - if moisture is allowed to enter the electrical circuit of the load cell or wiring the display reading will change due to current flowing through both the load cell bridge and the new current paths created by moisture. Ensure that cells of the correct environmental protection (IP) rating are used for the application and that moisture cannot enter the cable through cuts, cable joins and exposed cables.

5. High resistance cable joins - When a load cell cable is extended it is important that the joins made are electrically sound and free from moisture. A damp or corroded join will lead to unreliable readings.

6. Incorrect mounting of the load cell - Load cells are manufactured in many types e.g. shear beam, "S" type etc. Each type requires a particular form of mounting for correct operation. Check the load cell type and mounting requirements if in doubt. See section 2.3 "Load cell types".

7. Electrical damage to load cells - Electrical damage can often occur due to lightning strikes, welding on the structure to which the load cell is attached and other causes. Surge suppression devices for load cell systems are available from suppliers such as MTL. Welding currents will destroy the cell. If welding on the structure is likely and the load cell is not insulated from the current flow, copper or stainless steel braids should be used to connect each end of the load cells to ground to help prevent electrical damage.

8. Non linearity of display reading - Friction & restriction as described in 2. above could be the cause of non linearity. With some load cell designs, particularly those designed for high loads e.g. tonnes the output of the cell may be non linear over parts of its measurement range, typically the low load end of the curve may not be quite linear. Some load cell monitors allow extra calibration points to correct this non linear output from the cell. Models such as AIC's PM4-WT, RM4-WT, LD-WT, TP4-WT and the load cell interface model XT4-WT have this linearising feature. It is also worth checking in instruments with this feature that the linearising functions have been turned off if they are not required i.e. if it is turned on and the cell output is linear the linearising functions may make it appear non linear.

1.6 Technical assistance

To save time when seeking assistance, as much as possible of the information below should be obtained before contacting the monitor or load cell manufacturer for technical assistance. Photocopy this page and fill in as much information as you can.

Question	Record your answer
Model number of monitor	
Model number of load cell	
Capacity of load cell	
mV/V output of load cell	mV/V
Load cell resistance Ex+ to Ex-	Ω
Load cell resistance S+ to S-	Ω
Load cell resistance Ex+ to S+	Ω
Load cell resistance Ex+ to S-	Ω
Load cell resistance Ex- to S+	Ω
Load cell resistance Ex- to S-	Ω
Excitation voltage measured	V
mV signal at low load & load value	mV at load
mV signal at high load & load value	mV at load
Monitor mV/V input range setting	mV/V

2 Appendix

2.1 mV/V explained

When a load cell is obtained it is usually accompanied by a certificate which details the specifications for the load cell including the signal output span per volt of excitation or mV/V output.

Usually the output from a load cell will be approximately 0mV at zero load though typically there may be a small offset voltage at zero load. Over the full rated capacity of the load cell the mV output will change. The amount by which it changes depends on the resistance change in the cell and on the excitation voltage applied. Since the load cell manufacturer does not know what excitation voltage will be applied to the cell rather than quote the mV output over full range they will quote the milli Volt output per volt of excitation or in its short form mV/V.

For example a 250kg load cell may be quoted as having a 2.357mV/V output. If the excitation voltage is 10V they you could expect a mV output of 0mV at zero load and 23.57mV at 250kg load. Again the actual voltages seen could be affected by a usually small offset voltage.

2.2 AIC error messages

The following error messages may be seen when using AIC load cell input instruments. Refer to the monitor instruction manual for further information if required.

CAL ERR - This indicates that one of the calibration points has caused an overrange error in the analog to digital converter. Change the mV/V (**RNGE** function) setting to a higher value and try calibration again.

SPAN ERR - This indicates that the calibration points entered were too close together. Either calibrate again with the points further apart or change the mV/V (**RNGE** function) setting to make the instrument more sensitive. The calibration points need to be at least 2% of full scale apart. If you are fairly that the change in load is sufficient (ideally no less than 20% of the rated capacity) then ignore the **SPAN ERR** message and continue with the 2 point calibration then check to see if calibration is correct.

ADC RANGE ERR - This indicates that when an **ECAL/ESCL** method of calibration has been used the mV/V figure entered at the **ECAL** function is greater than the mV/V range entered at the **RNGE** function. The **RNGE** function should be set to be equal the **ECAL** value or to the next available value higher than the **ECAL** value.

ZERO RANGE ERR - This indicates that an attempt to zero or preset a value on the display has failed due to the **ZERO RNGE** function value being exceeded. Check the **ZERO RNGE** function setting, if this is set at the required figure and the display value seems to be within the zero range limits then it could be that previous preset or zero operations has caused the limit to be exceeded.

" - - - - " - This display indicates that the actual mV/V input is higher than the value set at the **RNGE** function. Check the **RNGE** function setting and if this is OK then check the actual mV input from the cell.

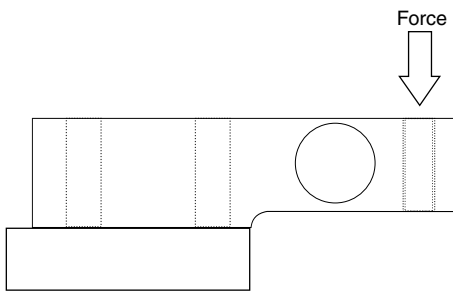
" - or - " - This display indicates an overrange reading. This could be due to the instrument not being able to display the number because it is too large e.g. above 9999 on a 4 digit display. Alternatively it could mean that the **Lo** or **Hi SH d: SP** limit value has been exceeded and the instrument is showing a warning message.

Display value flashes on and off - This means that the **Lo** or **Hi SH d: SP** limit value has been exceeded and the instrument is showing a warning message as instructed.

NO ACCESS - This display mean that function access has been denied. This will be due to either one of the remote input functions being set to **No.Ac** or that the **ACCESS** function being set to **NONE**. To override the remote input functions and gain access you can either place a short circuit between the appropriate remote input and ground or power up the instrument in **CAL** mode. To override the **ACCESS** function you must power up in **CAL** mode.

NO SPAC - This display mean that function access has been denied. This will be due to either one of the remote input functions being set to **SP.Ac** or the **ACCESS** function has being set to **EASY** and all alarm setpoints have been set to **OFF**. To override the remote input functions and gain access you can either place a short circuit between the appropriate remote input and ground or power up the instrument in **CAL** mode. To override the **ACCESS** function you must power up in **CAL** mode.

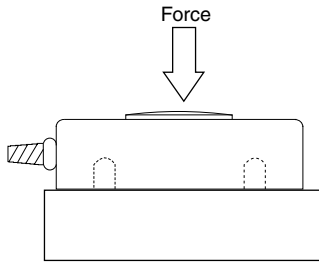
2.3 Load cell types



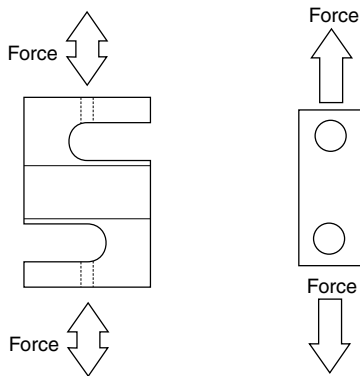
Shear beam - the shear beam load cell is fixed rigidly at one end with the force being applied to the other end. These can be used singly or in groups e.g. a platform scale using one cell in each corner.

Double ended shear beam type cells are of different construction and are fixed rigidly at each end with the force being applied to the centre of the beam.

Single point load cells are of similar design but are intended for use in single cell applications only.

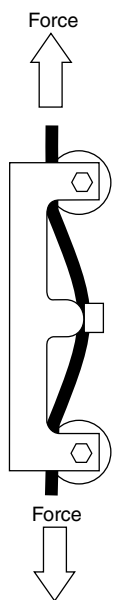


Compression - the compression load cell is designed to operate in compression only. Some designs require load to be applied at one end only, other designs can be compressed by force at both ends.



S type - the S type load cell can be used in tension and compression. The signal voltage output will reverse in polarity when the force changes from tension to compression i.e. the display value may change from positive to negative or vice versa.

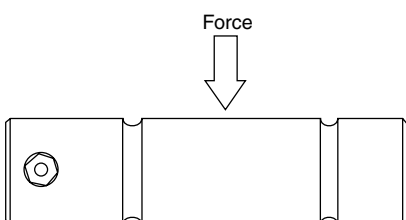
Tension load cells and **Load links** are designed to operate under tension only.



Rope clamp - the rope clamp load cell is popular in hoist and crane applications due to its ease of installation. The rope passes through the cell and when tension is applied to the rope due to a weight being lifted the tension produces a bending force on the cell.

The mounting position of this type of load cell is very important. Most of these type of cells are mounted at the dead end of the rope allowing enough rope at each end for flexing i.e. ensure that the attachment is not so close to the dead end that the rope is rigid and cannot flex.

Since these cells are designed to operate over a very wide range of loads and rope sizes and because the rope system often goes through a series of "drops" it is often the case that the mV output from these cells is at the low end of the range. The sensitivity of the monitor may need to be increased by lowering the mV range to compensate.

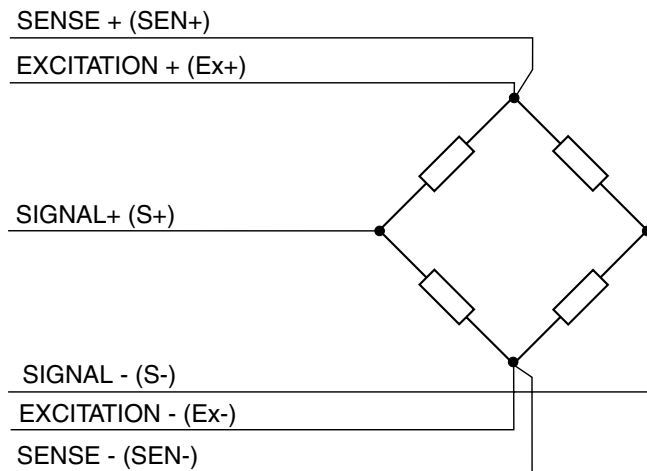


Load pin - load pin cells are designed to be installed in the axis of a sheave, shackle etc. through which force is applied. Most common load pins will measure force in one direction only. The direction of force is often marked with an arrow at one end of the pin or instructions for alignment may be given in the load cell certificate. If the load is off axis the output will be reduced. At 90 degrees off axis the output will not change with a change in load.

2.4 Six wire load cells

Six wire load cells use two extra wires known as sense or reference wires. These sense wires connect to the excitation wires at the load cell as shown below. Monitors which will accept 6 wire load cells measure the current passing down the Ex+ to SEN+ and Ex- to SEN- wires. This measurement allows the monitor to compensate for any resistance changes in the wiring to the load cell due to changes in temperature.

As can be seen below the sense wiring can be tested using an Ohm meter. The resistance between Ex+ & SEN+ and Ex- & SEN- should be no more than a few Ohms.



2.5 Summing modules and parallel load cells

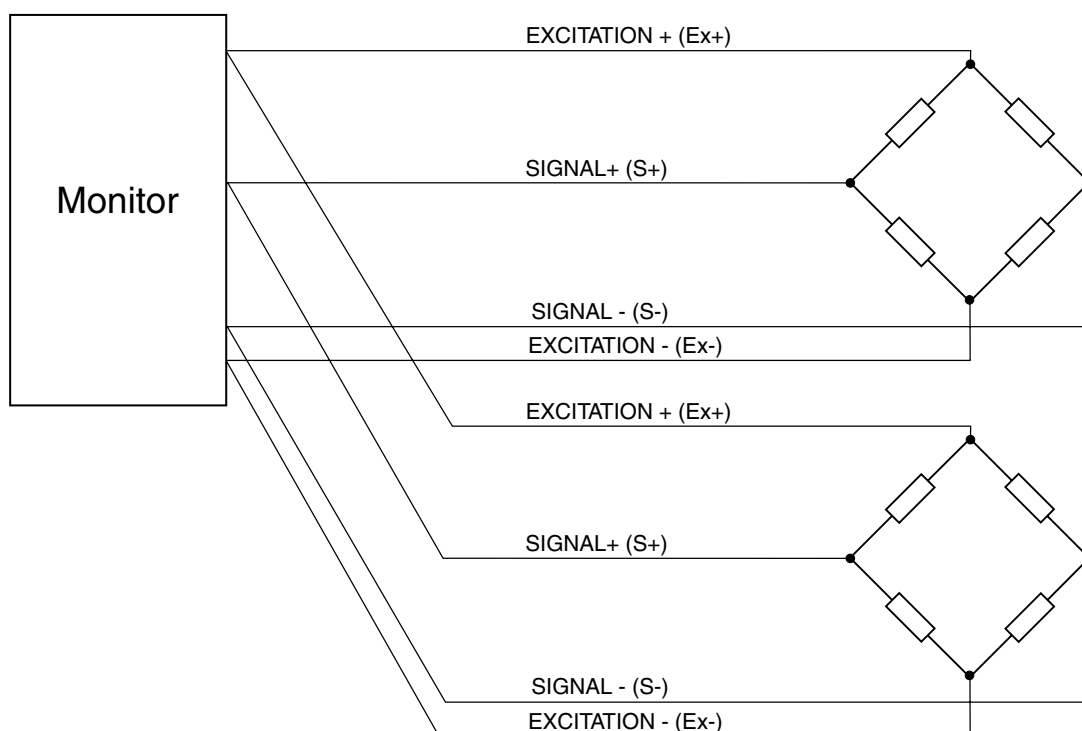
When two or more load cells are connected to a single input on a monitor they are either simply wired in parallel to the input or are wired to a load cell summing/combining module (e.g. AIC model TP-SG-SUM).

Parallel wiring

When connecting load cells in parallel the following important points need to be considered:

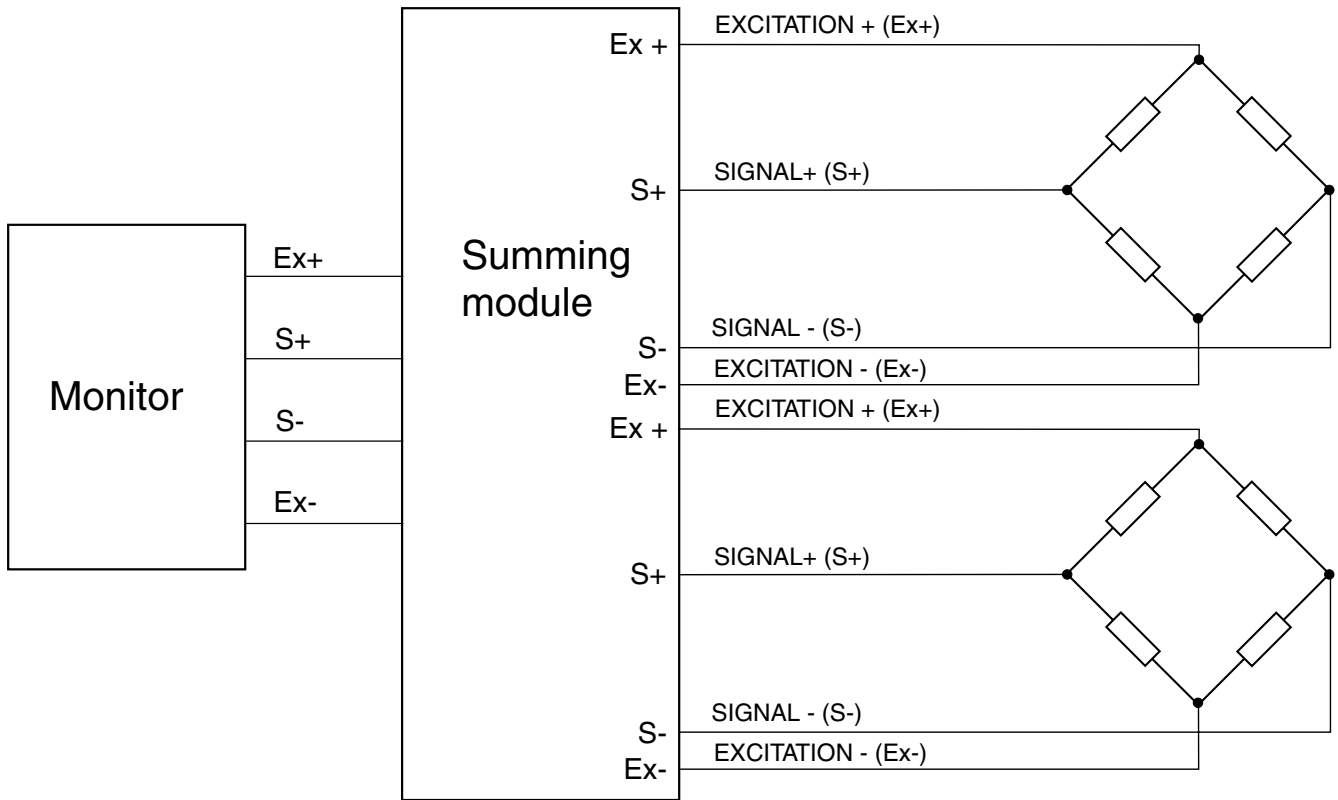
1. The load cell outputs must be closely matched and each load cell must be the same capacity
2. If connected to AIC PM4-SG or PM4-WT monitors the excitation voltage should be set to 5V

When the cells are connected together the mV output will be the average of the output of all cells connected i.e. if all load cells are matched and have 2mV/V outputs with 10V excitation then the output from the parallel group will be 0 to 20mV. The load cells must be arranged to share the load so if 4 load cells are to be fitted to a platform to measure 100kg max. each load cell must be rated to at least 25kg.



Using a summing module

A summing module allows a number of load cells to be connected and balanced. The output from each load cell is individually measured then adjusted to match that of the cell with the lowest output. The summing box allows groups of cells with the same capacity but unmatched outputs to be combined accurately.



Testing parallel load cells

If one or more load cells in the group develops a problem causing a display error disconnect all of the load cells then reconnect them to the monitor/summing module one at a time. The display error should reappear when the faulty cell is connected. Normal resistance checks can also be carried out as detailed in section 1.2. The load cells should be resistance tested individually i.e. disconnected from the other cells before testing.

2.6 Common wiring colour codes

Wiring colour codes for load cells stocked by AIC are given below. Please check colour code on documentation supplied with the load cell as there is no guarantee that these colours will not change or are accurate for the manufacturers entire range.

Connection	Manufacturer				
	PT	Kelba	DG	Loadtech	Pacific
Excitation +	Red	Red	Red	Red	Red
Excitation -	Black	Black	White	Blue	Black
Signal +	Green	Green	Green	Green	Green
Signal -	White	White	Blue	Yellow	White
Shield	Screen	Bare wire	Black	Grey	Screen
Sense +	Brown				
Sense -	Blue				

2.7 Single & multi-point weighing

Single point weighing - single point type load cells can be used with single load cell platform designs, usually in fairly low capacity systems. S type, tension type, rope clamp & load pins load cells are also used in single point systems.

Two point weighing - can be used for longer thin platforms, beams and girders e.g. load cell near each end.

Three point weighing - often used in weighing vertical cylinders. Using 3 points gives less complicated leveling than when more load cells are used.

Four point weighing - typically used with high capacity platform scales and rectangular containers.

More than 4 points - typically used in very high capacity and/or very large container/platform measurement systems.

Using pivots and load cells - savings in load cell costs are often made by using pivots e.g. instead of using two load cells the load on a beam can be measured by using a load cell at one end and a pivot on the other. The use of a pivot is not recommended unless accuracy is not important. If a pivot is used instead of an extra cell it must be taken into account that the mechanical design must allow adequate and linear transference of load to the load cells in the system. Any friction in the pivot will result in slow response, inaccurate and non repeatable measurements.

2.8 Definition of load cell specification terms

Accuracy - Normally quoted as either a percentage of full scale output or a percentage of the applied load. The accuracy figure is the combined error caused by non linearity, repeatability and hysteresis error values in the load cell.

Rated Capacity - The maximum load over which the load cell which operate within its specifications.

Compensated temperature range - the range of temperatures over which the output from the cell is compensated. If used outside this range the output cannot be guaranteed to follow the specifications.

Environmental protection - IP rating against moisture and dust e.g. IP65

Excitation - the voltage applied to the Ex+ and Ex- wires, normally quoted as minimum and maximum values e.g. 5 to 15VDC or as a recommended value and maximum value.

Hysteresis - When a load cell is taken from zero to full load and back to zero the mV output for a given load value will be slightly different when the load is rising to when the load is falling. The maximum difference is used to calculate the hysteresis. Normally quoted as a percentage of full load.

Input resistance - the resistance measured across S+ and S- with load cell disconnected and no load.

Insulation resistance - Normally measured at 50VDC this is the minimum resistance between the metal body of the load cell and any of its electrical connections.

Mechanical failure - the load at which the cell is likely to fail mechanically i.e. break or deform.

Rated output - the nominal mV/V output of the load cell.

Output resistance - the nominal resistance measured between Ex+ and Ex- with load cell disconnected and no load.

Repeatability - a measure of the ability of the load cell to repeatedly give the same output for the same load under the same conditions. The error is normally quoted as a percentage of full load.

Safe load - the amount by which the capacity of the cell can be exceeded e.g. 125% of capacity.

Temperature effect on span - usually quoted as a percentage of full scale this is the change in output at full load due to temperature changes. e.g. 0.01%/10°C means a change of up to 0.01% of full load output per temperature change of 10 degrees C.

Temperature effect on zero - as above but measured at zero load.

Zero balance - the output of the load cell at no load, normally quoted as a percentage of full load. Also know as zero offset.

Zero return (creep) - the difference between the mV output at zero before a load is applied and the mV output at zero when returning from being loaded (after being given time to stabilise). Normally quoted as a percentage of full load over a time period e.g. 0.03% (30mins).