1-gauge 4-wire strain measurement method

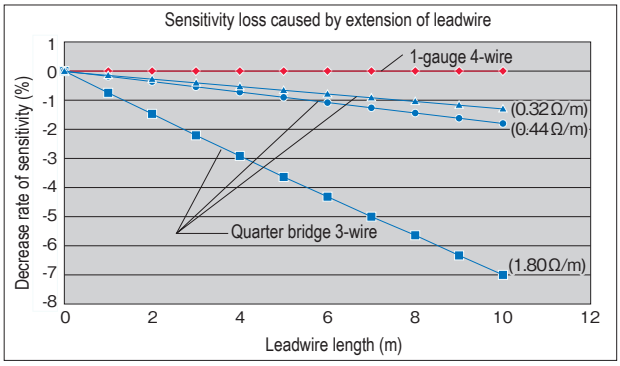
Abstract

When measuring strain gauges, various connection methods are available according to the number of strain gauges used and the purpose of measurement. In quarter bridge method, 3-wire connection is widely used to remove the effect of temperature change in the resistance of the strain gauge leadwire. However in the method, gauge factor correction is required depending on the leadwire resistance. In addition, some measurement error may be caused by the contact resistance in the connection part such as between the strain gauge leadwire and the instrument terminal. The 1-gauge 4-wire strain measurement is our unique method which eliminates the need of gauge factor correction depending on the leadwire resistance and the measurement error caused by the contact resistance.
Since a new leadwire and a simple connector (modular plug) can be used, it helps to streamline the wiring works and to prevent wiring mistakes, and also to reduce the cost of strain measurement by reusing the leadwires. Furthermore, since soldering works are not necessary, it can save wiring materials and realize lead-free connections.

Advantage over quarter bridge 3-wire method

●Leadwire resistance

In the conventional method, leadwires as thick and short as possible are recommended to keep the resistance of the leadwire as small as possible. However, since there is no influence of the leadwire resistance in 1-gauge 4-wire method, it is possible to use thin and/or long leadwires for connecting strain gauges.

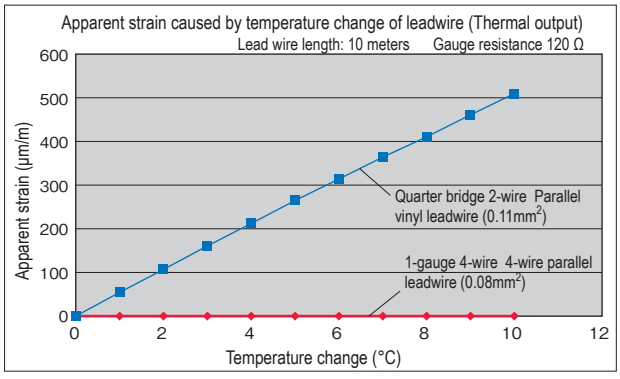


Comparison of strain measurement method between Quarter bridge 3-wire and 1-gauge 4-wire
Advantage of not being affected by leadwire resistance

	Quarter bridge 3-wire (Wheatstone bridge circuit)	1-gauge 4-wire strain measurement method
Thickness of leadwire	Thick	Thin
Weight of leadwire	Heavy	Light
Material of leadwire	The same material must be used	No need of using the same material
Sheath color of leadwire	Must be the same color depending on the measurement	No need of using the same color
Load on the specimen	Heavy	Light
Transportation cost	High	Low

●Not influenced by thermal output of leadwire

When a 10 meter long leadwire having cross sectional area of 0.11mm^2 is used for measurement of 120 Ω strain gauge in quarter bridge (2-wire) method, thermal output of about 50×10^{-6} strain/°C will be resulted if there is a temperature change during the measurement. Therefore, compensation is necessary. Even if the quarter bridge 3-wire method is used, compensation is necessary when the type, length, cross sectional area, or temperature environment of the three wires is not the same. In 1-gauge 4-wire strain measurement method, compensation is not necessary even under such conditions.



●Contact resistance

Conventionally, leadwire extension and connection to a measuring instrument are done by soldering or by the use of specially designed connectors in order to eliminate the influence of contact resistance. Since the 1-gauge 4-wire method is not affected at all by contact resistance, a modular plug which is installed by crimping can be used. The modular plug makes easy connection of the leadwire to an instrument or to an extension leadwire, and efficient connection works without wiring mistakes become possible. Furthermore, since soldering is not necessary, lead-free connection is actualized.

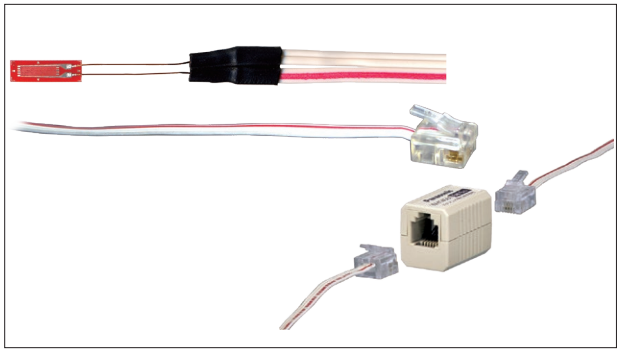
Comparison of strain measurement method between Quarter bridge 3-wire and 1-gauge 4-wire
Advantage of not being affected by the variation of contact resistance at the connection point

	Quarter bridge 3-wire (Wheatstone bridge circuit)	1-gauge 4-wire strain measurement method
Connection using easy connector	Not possible	Possible
Soldering	Necessary (for long-term measurement) For short-term measurement, screwing is possible	Not necessary
Time required for wiring works	Long	Short
Wiring mistakes	Care must be taken	Largely decreased

Strain gauge with leadwire and modular plug

This is a strain gauge applicable to our newly developed 1-gauge 4-wire strain measurement method. Most of our strain gauges can be supplied with the exclusive leadwire and the modular plug (RJ12) pre-attached. Because the modular plug is attached to the end of the leadwire, neither soldering nor screwing is necessary when connecting the strain gauge to a measuring instrument. The strain gauge is connected by simply inserting the modular plug into the modular connector receptacle which is equipped in data logger TDS-630, TDS-540 (with option), TDS-150 and TC-32K, and switching box IHW-50H, IHW-50G, ISW-50G, SSW-50D and FSW-10. The sheath of the 4-wire leadwire is made of polypropylene, which does not generate noxious gas even if exposed to fire. A vinyl sheathed leadwire is also available at a lower cost.

Easy leadwire extension using modular connectors



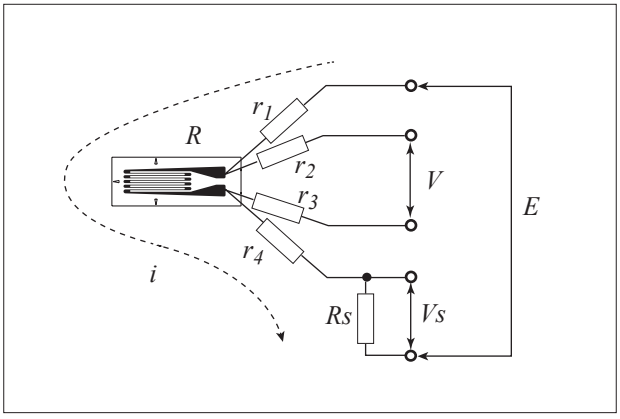
1-gauge 4-wire strain measurement method

Measurement principle

The 1-gauge 4-wire strain measurement method uses a simple series circuit which is composed of a resistance of strain gauge (R) and a reference resistance (Rs) to measure strain. The voltage (E) is applied to the both ends of the series circuit to flow the current (i). The strain is obtained from the voltage (V) generated by the strain gauge resistance and the voltage (Vs) generated by the reference resistance. As the path where the current flows and the path where the voltage is measured are different, measurement is possible without being affected by the leadwire resistance or the contact resistance (r).

where

R	: Gauge resistance
Rs	: Reference resistance
r_1~r_4	: Leadwire resistance and contact resistance
i	: Current flowing in strain gauge resistance and reference resistance
E	: Excitation voltage
V	: Voltage generated by gauge resistance
Vs	: Voltage generated by reference resistance

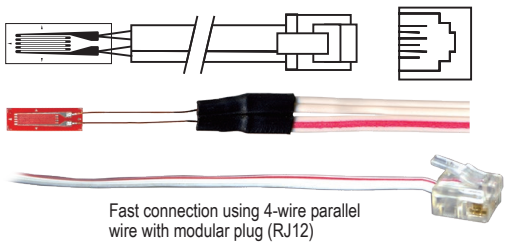


Connection / Applicable instruments

The 1-gauge 4-wire method is a new strain measurement method that does not need gauge factor correction for the leadwire resistance and does not cause measurement error by the contact resistance. In addition, the method can remove the initial unbalance caused by the leadwire resistance and also can remove the influence of leadwire resistance change caused by the temperature change. While the use of a leadwire as thick and short as possible is recommended for quarter bridge 3-wire method, a thin leadwire and/or connectors for connection and extension of the leadwire can be used for 1-gauge 4-wire method. Correction of the measured values is not necessary even if leadwires of various types and/or of different length for each strain gauge are used.

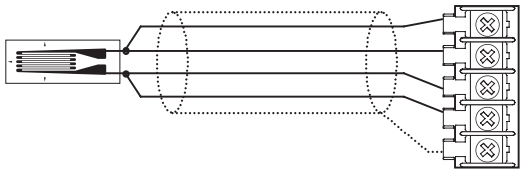
The 1-gauge 4-wire strain measurement method is available only by the data loggers and switching boxes made by our company.

1-gauge 4-wire strain gauge with modular plug



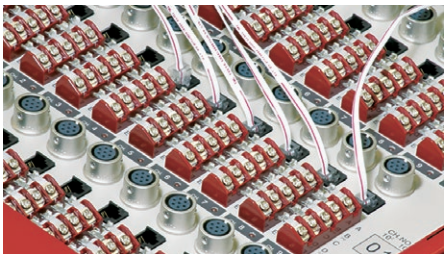
Fast connection using 4-wire parallel wire with modular plug (RJ12)

4-core shielded cable is connected directly if a modular plug is not used



Built-in switching box of data logger TDS-540 is not applicable

The exclusive laedwire with modular plug (RJ12) can be attached to most of our strain gauges. It enables efficient wiring works without mistakes. The leadwires can be used repeatedly to reduce the cost of the measurement.



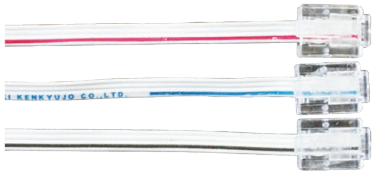
Fast connection to the modular jack provided to the built-in switching box of data logger or the switching box

Applicable sensor mode
1G4W 120Ω Gauge resistance 120 Ω
1G4W 240Ω Gauge resistance 240 Ω
1G4W 350Ω Gauge resistance 350 Ω

Applicable instruments
Data logger TDS-540(with option)/TS-560 /TDS-630/TDS-150/TC-32K
1-gauge 4-wire strain measurement is possible by fast connection to the modular jack of the switching box
Switching box IHW-50H/IHW-50G/ISW-50G/SSW-50D/FSW-10

●3-element rosette strain gauge (shrinkable tube type)

This is a 3-element rosette strain gauge having a 4-wire parallel leadwire with modular plug attached to each element in 1-gauge 4-wire connection. Fast connection of the leadwires are possible to each channel of a data logger or switching box for static strain measurement.
Note: This strain gauge is not applicable to dynamic strain meters.



・3-element 0° /45° /90° stacked type
Used leadwire
0.08mm^2 vinyl sheathed leadwire with modular plug
Applicable temperature -20~+80° C
FRA-2-11-○LQM (modular plug 4-wire RJ12 6-4)
○ shows the lead wire length in meter