User's Manual

SL1000 Input Module

YOKOGAWA
Yokogawa Electric Corporation

IM 720120-51E
1st Edition

Thank you for purchasing the SL1000 High-Speed Data Acquisition Unit. This user's manual explains the functions and operating procedures of the SL1000 Acquisition Software. To ensure correct use, please read this manual thoroughly before beginning operation.
After reading the manual, keep it in a convenient location for quick reference whenever a question arises during operation. The following manuals, including this one, are provided as manuals for the SL1000. Please read all of them.
This user's manual contains specifications of the measurement modules that can be used on the SL1000 unit.
For information such as setup procedures, see the Data Acquisition Software User's Manual.

Notes

- The contents of this manual are subject to change without prior notice as a result of continuing improvements to the instrument's performance and functions. The figures given in this manual may differ from those that actually appear on your screen.
- Every effort has been made in the preparation of this manual to ensure the accuracy of its contents. However, should you have any questions or find any errors, please contact your nearest YOKOGAWA dealer.
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Revisions

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1 High-Speed 10 MS/s, 12-Bit Isolation Module (701250) Specifications

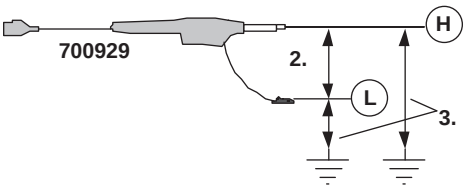
Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, and GND
Maximum sample rate	10 MS/s
Input format	Isolated unbalanced
Frequency characteristics[1]	(–3 dB point when sine wave of amplitude 60 % of range is input) DC to 3 MHz
Voltage-axis range setting	50 mV to 200 V range (1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	Combined with the 700929(10:1)[2] 600 V (DC+ACpeak) Combined with the 701901+701954 (1:1)[4] 250 V (DC+ACpeak) Direct input or cable not complying with the safety standard[6] 250 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Working voltage of safety standard Combined with the 700929 (10:1)[3] or combined with the 701901+701954 (1:1)[5] 400 Vrms (CAT I) 300 Vrms (CAT II) Direct input or cable not complying with the safety standard[7] 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)
Vertical (voltage) axis accuracy DC accuracy[1]	50 mV to 200 V range: ±(0.5% of range)
Input connector	BNC connector (isolated type)
Input impedance	1 MΩ ± 1%, approx. 35 pF
–3 dB point when AC coupled low frequency attenuation point	10 Hz or less (1 Hz or less when using the 700929)
Common mode rejection ratio	80 dB (50/60 Hz) or more (typical[8])
Residual noise level (Input section shorted)	±400 μV or ±0.6% of range whichever is greater (Typical[8])
Withstand voltage	1500 Vrms for 1 minute (across each terminal and earth) (60 Hz)
Allowable transient surge voltage (instantaneous)	±2100 Vpeak (across each input terminal and earth)
Insulation resistance	500 VDC, 10 MΩ or more (across each input terminal and earth)
A/D conversion resolution	12 bit (1500 LSB/range)
Temperature coefficient	Zero point: 50 mV to 200 V range: ±(0.05% of range)/° C(Typical[8]) Gain: ±(0.02% of range)/° C(Typical[8])
Bandwidth limit	Select from OFF, 500 kHz, 50 kHz, 5 kHz, and 500 Hz Cut-off characteristics: –18 dB/OCT (Typical[8])
Probe attenuation setting	Voltage probe: 1:1, 10:1, 100:1, 1000:1 Current probe: 10 A:1 V (for the 700937/701933), 100 A: 1 V (for the 701930/701931)

1 High-Speed 10 MS/s, 12-Bit Isolation Module (701250) Specifications

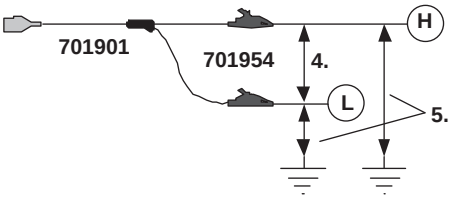
Item	Specifications
Compatible probes/cables	Voltage probe (10:1 safety probe): Recommended 700929 (10:1 safety probe).20 to 45 pF: For measuring 600 Vpeak or less Current probe (power can be supplied from the SL1000 Unit. Option) 700937 (15 A), 701930 (150 A), 701931 (500 A), 701933 (30 A) High voltage differential probe (connect the GND cable provided with the probe to the SL1000 Unit case) 700924 (1000:1, 100:1/1400 Vpeak): For measuring 1400 Vpeak or less Connection cable (for high voltage 1:1) 701901 (isolated type BNC-safety alligator clip adapter ×2: For measuring 250 Vpeak or less), 701954 (alligator clip (dolphin type) red/black 2-piece set) is required separately Connection cable (for low voltage 1:1) 366926 (non-isolated type BNC-alligator clip ×2: For measuring low voltage less than or equal to 42 Vpeak)

1. Value measured under standard operating conditions.

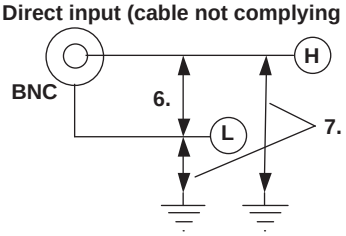
Combined with the 700929



Combined with the 701901+701954



Direct input (cable not complying with the safety standard)



Withstand voltage: 1500 Vrms for 1 minute
Allowable transient surge voltage: 2100 Vpeak (between earth and input)

8. The typical value is a representative or standard value. It is not strictly warranted.

WARRNING

- Do not apply input voltage exceeding the maximum input voltage, withstand voltage, or allowable surge voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage or higher voltage may occur.
- To prevent the possibility of electric shock, be sure to connect the GND lead of the differential probe (700924/700925) to the SL1000.

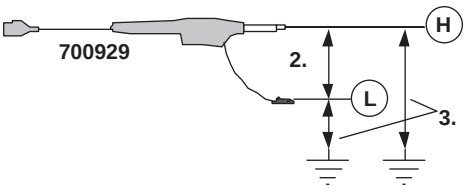
2 High-Speed High-Resolution 1 MS/s, 16-Bit Isolation Module (701251) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, and GND
Maximum sample rate	1 MS/s
Input format	Isolated unbalanced
Frequency characteristics[1] (–3 dB point when a sine wave of amplitude 60 % of range is input)	50 mV to 200 V range: DC to 300 kHz 20 mV and 10 mV range: DC to 200 kHz
Voltage-axis range setting	10 mV to 200 V range (1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	Combined with the 700929(10:1)[2] 600 V (DC+ACpeak) Combined with the 701901+701954 (1:1)[4] 140 V (DC+ACpeak) Direct input or cable not complying with the safety standard[6] 140 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Working voltage of safety standard Combined with the 700929 (10:1)[3] or combined with the 701901+701954 (1:1)[5] 400 Vrms (CAT I), 300 Vrms (CAT II) Direct input or cable not complying with the safety standard[7] 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)
Vertical (voltage) axis accuracy DC accuracy[1]	50 mV to 200V range: ±(0.25% of range) 20 mV range: ±(0.3% of range) 10 mV range: ±(0.5% of range)
Input connector	BNC connector (isolated type)
Input impedance	1 MΩ ± 1%, approx. 35 pF
–3 dB point when AC coupled low frequency attenuation point	10 Hz or less (1 Hz or less when using the 700929)
Common mode rejection ratio	80 dB (50/60 Hz) or more (typical[8])
Residual noise level (Input section shorted)	±100 μV or ±0.1% of range whichever is greater (Typical[8])
Withstand voltage	1500 Vrms for 1 minute (across each terminal and earth) (60 Hz)
Allowable transient surge voltage (instantaneous)	±2100 Vpeak (across each input terminal and earth)
Insulation resistance	500 VDC, 10 MΩ or more (across each input terminal and earth)
A/D conversion resolution	16 bit (24000 LSB/range)
Temperature coefficient	Zero point: 50 mV to 200 V range: ±(0.02% of range)/° C(Typical[8]) 20 mV range: ±(0.05% of range)/° C(Typical[8]) 10 mV range: ±(0.10% of range)/° C(Typical[8]) Gain: 10 mV to 200 V range: ±(0.02% of range)/° C(Typical[8])
Bandwidth limit	Select from OFF, 40 kHz, 4 kHz, and 400 Hz Cut-off characteristics: –12 dB/OCT (Typical[8])
Probe attenuation setting	Voltage probe: 1:1, 10:1, 100:1, 1000:1 Current probe: 10 A:1 V (for the 700937/701933), 100 A: 1 V (for the 701930/701931)

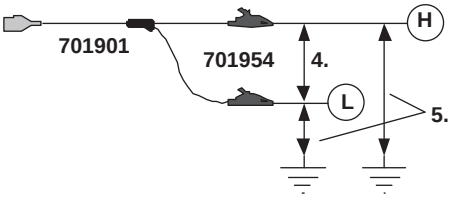
Item	Specifications
Compatible probes/cables	Voltage probe (10:1 safety probe): Recommended 700929 (10:1 safety probe).20 to 45 pF: For measuring 600 Vpeak or less Current probe (power can be supplied from the SL1000 Unit. Option) 700937 (15 A), 701930 (150 A), 701931 (500 A), 701933 (30 A) High voltage differential probe (connect the GND cable provided with the probe to the SL1000 Unit case) 700924 (1000:1, 100:1/1400 Vpeak): For measuring 1400 Vpeak or less Connection cable (for high voltage 1:1) 701901 (isolated type BNC-safety alligator clip adapter ×2: For measuring 250 Vpeak or less), 701954 (alligator clip (dolphin type) red/black 2-piece set) is required separately Connection cable (for low voltage 1:1) 366926 (non-isolated type BNC-alligator clip ×2: For measuring low voltage less than or equal to 42 Vpeak)

1. Value measured under standard operating conditions.

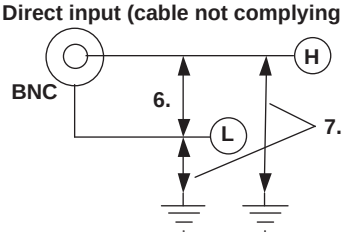
Combined with the 700929



Combined with the 701901+701954



Direct input (cable not complying with the safety standard)



Withstand voltage: 1500 Vrms for 1 minute
Allowable transient surge voltage: 2100 Vpeak (between earth and input)

8. The typical value is a representative or standard value. It is not strictly warranted.

WARRNING

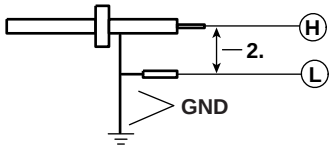
- Do not apply input voltage exceeding the maximum input voltage, withstand voltage, or allowable surge voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage or higher voltage may occur.
- To prevent the possibility of electric shock, be sure to connect the GND lead of the differential probe (700924/700925) to the SL1000.

3 High-Speed 10 MS/s, 12-Bit Non-Isolation Module (701255) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, and GND
Maximum sample rate	10 MS/s
Input format	Non-isolated, unbalanced
Frequency characteristics[1]	(–3 dB point when sine wave of amplitude 60 % of range is input) DC to 3 MHz
Voltage-axis range setting	50 mV to 200 V range (1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	Combined with the 701940(10:1)[2] 600 V (DC+ACpeak) Direct input(1:1)[3] 250 V (DC+ACpeak)
Vertical (voltage) axis accuracy DC accuracy[1]	50 mV to 200 V range: ±(0.5% of range)
Input connector	BNC connector (metallic type)
Input impedance	1 MΩ ± 1%, approx. 35 pF
–3 dB point when AC coupled low frequency attenuation point	10 Hz or less (1 Hz or less when using the 701940)
Residual noise level (Input section shorted)	±400 μV or ±0.6% of range whichever is greater (Typical[4])
A/D conversion resolution	12 bit (1500 LSB/range)
Temperature coefficient	Zero point: 50 mV to 200 V range: ±(0.05% of range)/° C(Typical[4]) Gain: ±(0.02% of range)/° C(Typical[4])
Bandwidth limit	Select from OFF, 500 kHz, 50 kHz, 5 kHz, and 5400 Hz Cut-off characteristics: –18 dB/OCT (Typical[4])
Probe attenuation setting	Voltage probe: 1:1, 10:1, 100:1, 1000:1 Current probe: 10 A:1 V (for the 700937/701933), 100 A: 1 V (for the 701930/701931)
Compatible probes/cables	Voltage probe (10:1 safety probe): Recommended 701940, 17 to 46 pF: For measuring 600 Vpeak or less Current probe (power can be supplied from the SL1000 Unit. Option) 700937 (15 A), 701930 (150 A), 701931 (500 A), 701933 (30 A) High voltage differential probe (connect the GND cable provided with the probe to the SL1000 Unit case) 700924 (1000:1, 100:1/1400 Vpeak): For measuring 1400 Vpeak or less Connection cable (for high voltage 1:1) 701901 (isolated type BNC-safety alligator clip adapter ×2: For measuring 250 Vpeak or less), 701954 (alligator clip (dolphin type) red/black 2-piece set) is required separately Connection cable (for low voltage 1:1) 366926 (non-isolated type BNC-alligator clip ×2: For measuring low voltage less than or equal to 42 Vpeak)

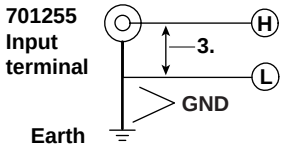
1. Value measured under standard operating conditions.

Recommended:
Combined with the 10:1 passive probe (701940)



GND is connected to the case potential.

Direct input
(When a cable that does not comply with the safety standard is connected)



GND is connected to the case potential.

8. The typical value is a representative or standard value. It is not strictly warranted.

WARRNING

- Do not apply input voltage exceeding the maximum input voltage, withstand voltage, or allowable surge voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws.
- The module screws must be fastened for the module to function as a nonisolation module. In addition, all electrical and mechanical protection functions are activated only when the screws are fastened.
- The maximum input voltage of the module is valid only when all the screws are fastened, and the protection path of the metal BNC is secured.

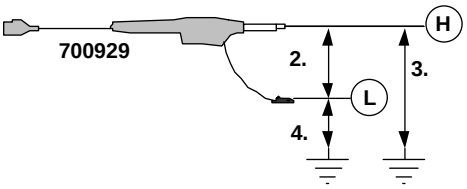
4 High-Voltage 100 kS/s, 16-Bit Isolation Module (with RMS) (701260) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, GND, AC-RMS, and DC-RMS
Maximum sample rate	100 kS/s
Input format	Isolated unbalanced
Frequency characteristics[1] (–3 dB point when a sine wave of amplitude 60 % of range is input)	Waveform observation mode: DC to 40 kHz RMS observation mode: DC, 40 Hz to 10 kHz
Voltage-axis range setting	200 mV to 2 kV range (1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	Combined with the 700929(10:1)[2] 1000 V (DC+ACpeak) Combined with the 701901+701954 (1:1)[5] 850 V (DC+ACpeak) Direct input or cable not complying with the safety standard[8] 850 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Working voltage of safety standard Combined with the 700929 (across probe tip H and earth[3]): 1000 Vrms (CAT II) (across probe tip L and earth[4]): 400 Vrms (CAT II) Combined with the 701901+701954 (1:1)[5] (across tip H and earth[6]): 700 Vrms (CAT II) (across tip L and earth[7]): 400 Vrms (CAT II) Direct input or cable not complying with the safety standard[9]: 30 Vrms (42 VDC+ACpeak) (across the input terminal, H or L, and earth)
Vertical (voltage) axis accuracy DC accuracy[1]	Waveform observation mode DC accuracy ±(0.25% of 10 div) RMS observation mode DC accuracy ±(1.0% of 10 div) (when a sine wave is input) AC accuracy ±(1.5% of 10 div) At frequency of 40 Hz to 1 kH AC accuracy ±(2.0% of 10 div) At frequency of 40 Hz to 1 kH (when the crest factor is 2 or less) AC accuracy ±(3.0% of 10 div) At frequency of 40 Hz to 1 kH (when the crest factor is 3 or less)
Input connector	BNC connector (isolated type)
Input impedance	1 MΩ ± 1%, approx. 35 pF
–3 dB point when AC coupled low frequency attenuation point	1 Hz or less (0.1 Hz or less when using the 700929)
Common mode rejection ratio	80 dB (50/60 Hz) or more (typical[10])
Residual noise level (Input section shorted)	±1 mV or ±0.2% of range whichever is greater (Typical[10])
Withstand voltage	3700 Vrms for 1 minute (across each terminal and earth) (60 Hz)
Allowable transient surge voltage (instantaneous)	±5200 Vpeak (across each input terminal and earth)
Insulation resistance	500 VDC, 10 MΩ or more (across each input terminal and earth)
A/D conversion resolution	16 bit (24000 LSB/range)
Temperature coefficient	Zero point: ±(0.02% of range)/° C(Typical[10]) Gain: ±(0.02% of range)/° C(Typical[10])
Response time (only when observing RMS)	Rising (0 to 90% of range): 100 ms (typical[10]) Falling (100 to 10% of range): 250 ms (typical[10])
Bandwidth limit	Select from OFF, 10 kHz,1 kHz, and 100 Hz Cut-off characteristics: –12 dB/OCT (Typical[10])
Probe attenuation setting	Voltage probe: 1:1, 10:1, 100:1, 1000:1 Current probe: 10 A:1 V (for the 700937/701933), 100 A: 1 V (for the 701930/701931)

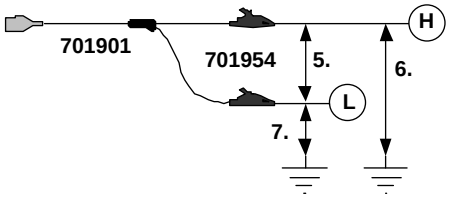
Item	Specifications
Compatible probes/cables	Connection cable (for high voltage 1:1) 701901 (isolated type BNC-safety alligator clip adapter ×2: For measuring 850 V (DC+ACpeak)or less), 701954 (alligator clip (dolphin type) red/black 2-piece set) is required separately Voltage probe (10:1 safety probe): Recommended 700929 (10:1 safety probe).20 to 45 pF: For measuring 600 Vpeak or less Current probe (power can be supplied from the SL1000 Unit. Option) 700937 (15 A), 701930 (150 A), 701931 (500 A), 701933 (30 A) High voltage differential probe (connect the GND cable provided with the probe to the SL1000 Unit case) 700924 (1000:1, 100:1/1400 Vpeak): For measuring 1400 Vpeak or less Connection cable (for low voltage 1:1) 366926 (non-isolated type BNC-alligator clip ×2: For measuring low voltage less than or equal to 42 Vpeak)

1. Value measured under standard operating conditions.

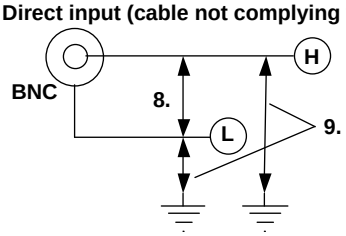
Combined with the 700929



Combined with the 701901+701954



Direct input (cable not complying with the safety standard)



Withstand voltage: 3700 Vrms for 1 minute

10. The typical value is a representative or standard value. It is not strictly warranted.

WARRNING

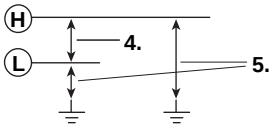
- When applying high voltage using this module, use the 1:1 safety cable (combination of 701901 and 701954) or the isolated probe (700929).
- The Measurement Category of the direct input of this module is 400 Vrms-CATII on the low side and 700 Vrms-CAT II on the high side. Use caution because the overvoltage category differs between the low and high sides.
- Do not apply input voltage exceeding the maximum input voltage, withstand voltage, or allowable surge voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage or higher voltage may occur.

5 Universal (Voltage/Temp.) Module (701261) / Universal (Voltage/Temp.) Module (with AAF) (701262) Specifications

<table>
<tr><th>Item</th><th>Specifications</th></tr>
<tr><td>Standard operating conditions</td><td>Temperature: 23° C±5° C
Humidity: 55%±10% RH
After a 30-minute warm-up and after calibration</td></tr>
<tr><td>Function</td><td>Temperature (thermocouple) or voltage measurement (switchable)</td></tr>
<tr><td>Effective measurement range</td><td>Voltage measurement: Twice of setting range</td></tr>
<tr><td>Number of input channels</td><td>2</td></tr>
<tr><td>Input coupling</td><td>TC, DC, AC, and GND
TC: Temperature (thermocouple) measurement
DC: Voltage measurement (DC coupling)
AC: Voltage measurement (AC coupling)</td></tr>
<tr><td>Voltage measurement maximum sample rate</td><td>100 kS/s</td></tr>
<tr><td>Temperature measurement data update rate</td><td>500Hz</td></tr>
<tr><td>Input format</td><td>Isolated unbalanced</td></tr>
<tr><td>Measurement range/accuracy[1]</td><td>[Voltage measurement] Voltage sensitivity: 50 mV to 200 V range (1-2-5 steps)
Voltage accuracy: ±(0.25% of range)
[Temperature measurement][2]
<table>
<tr><th>Type</th><th>Measurement Range</th><th>Accuracy</th></tr>
<tr><td>K
E
J
T
L
U
N</td><td>−200 to 1300° C
−200 to 800° C
−200 to 1100° C
−200 to 400° C
−200 to 900° C
−200 to 400° C
0 to 1300° C</td><td>±(0.1% of reading + 1.5° C)
Except ±(0.2% of reading + 1.5° C)
for –200° C to 0° C</td></tr>
<tr><td>R
S</td><td>0 to 1700° C
0 to 1700° C</td><td>±(0.1% of reading + 3° C)
Except, 0 to 200° C: ±8° C
200 to 800° C: ±5° C</td></tr>
<tr><td>B</td><td>0 to 1800° C</td><td>±(0.1% of reading + 2° C)
Except, 400 to 700° C: ±8° C
Effective range is 400 to 1800° C</td></tr>
<tr><td>W</td><td>0 to 2300° C</td><td>±(0.1% of reading + 3° C)</td></tr>
<tr><td>Au7Fe[3]</td><td>0 to 300K</td><td>0 to 50K: ±4K
50 to 300K: ±2.5K</td></tr>
</table></td></tr>
<tr><td>Frequency characteristics[1]
(–3 dB point when a sine wave of amplitude 60 % of range is input)</td><td>[Voltage measurement] DC to 40 kHz
[Temperature measurement] DC to 100 Hz</td></tr>
<tr><td>Maximum input voltage[4]
(at a frequency of 1 kHz or less)</td><td>Both temperature and voltage input: 42 V (DC + ACpeak) (as a value that meets the safety standard)
150 V (DC + ACpeak) (maximum allowable voltage, as a value that does not damage the instrument when applied)</td></tr>
<tr><td>Maximum allowable common mode voltage[5]
(at a frequency of 1 kHz or less)</td><td>Both temperature and voltage input: 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)</td></tr>
<tr><td>Vertical resolution</td><td>[Voltage measurement] During voltage input: 24000 LSB/range
[Temperature measurement] When measuring temperature: 0.1° C</td></tr>
<tr><td>–3 dB point when AC coupled low frequency attenuation point</td><td>[Voltage measurement] 0.5 Hz or less</td></tr>
<tr><td>Input connector</td><td>Binding post</td></tr>
<tr><td>Input impedance</td><td>Approx. 1 MΩ</td></tr>
</table>

<table>
<tr><th>Item</th><th>Specifications</th></tr>
<tr><td>Common mode rejection ratio</td><td>[Voltage measurement] 80 dB (50/60 Hz) or more (typical[6])
[Temperature measurement] 120 dB or more (50/60 Hz, with 2-Hz filter ON, signal source resistance of 500 Ω or less) (typical[6])</td></tr>
<tr><td>Residual noise level (Input section shorted)</td><td>[Voltage measurement]: ±100 μ V or ±0.1% of range, whichever is greater (typical[6])</td></tr>
<tr><td>A/D conversion resolution</td><td>[Voltage measurement] 16 bits (24000 LSB/range)</td></tr>
<tr><td>Temperature coefficient</td><td>[Voltage measurement] Zero point: ±(0.01% of range)/° C (typical[6])
Gain: ±(0.02% of range)/° C (typical[6])</td></tr>
<tr><td>Reference junction compensation accuracy (when the input terminal temperature is balanced)</td><td>K, E, J, T, L, U, N: ±1° C
R, S, B, W: ±1.5° C
Au7Fe: ±1K</td></tr>
<tr><td>Bandwidth limit</td><td>[Temperature measurement] (Digital filter + analog filter)
Select from OFF, 30 Hz, 8 Hz, and 2 Hz + 150 Hz secondary analog filter
[Voltage measurement] Select from OFF, AUTO, 4 kHz, 400 Hz, or 40 Hz.
Cutoff characteristics: –12 dB/OCT (typical6, setting other than AUTO)
Cutoff frequency (fc) when set to AUTO (701262 only)
<table>
<tr><th>Sample Rate</th><th>Cutoff Frequency (fc)</th></tr>
<tr><td>100 kS/s or higher</td><td>40kHz</td></tr>
<tr><td>100 S/s to 50 kS/s</td><td>40% of the sample rate</td></tr>
<tr><td>50 S/s or less</td><td>20Hz</td></tr>
</table>
Cutoff characteristics for AUTO: –65 dB at 2 × fc (typical[6])</td></tr>
<tr><td>Table of cutoff frequency characteristics of the anti-aliasing filter (AAF)</td><td>When the filter is set to Auto, the anti-aliasing filter and low-pass filter are automatically set according to the sample rate.
<table>
<tr><th>Sample Rate</th><th>AAF</th><th>Low-Pass Filter</th></tr>
<tr><td>100kS/s</td><td>40kHz</td><td>OFF</td></tr>
<tr><td>50kS/s</td><td>20kHz</td><td>OFF</td></tr>
<tr><td>20kS/s</td><td>8kHz</td><td>OFF</td></tr>
<tr><td>10kS/s</td><td>4kHz</td><td>4kHz</td></tr>
<tr><td>5kS/s</td><td>2kHz</td><td>4kHz</td></tr>
<tr><td>2kS/s</td><td>800Hz</td><td>4kHz</td></tr>
<tr><td>1kS/s</td><td>400Hz</td><td>400Hz</td></tr>
<tr><td>500S/s</td><td>200Hz</td><td>400Hz</td></tr>
<tr><td>200S/s</td><td>80Hz</td><td>400Hz</td></tr>
<tr><td>100S/s</td><td>40Hz</td><td>40Hz</td></tr>
<tr><td>50S/s</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>20S/s to 5S/s</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>2S/s or less</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>Ext sample</td><td>40kHz</td><td>OFF</td></tr>
</table></td></tr>
</table>

1. Value measured under standard operating conditions (section 19.11).
2. Does not include the reference junction temperature compensation accuracy.
3. This module supports Au7Fe with 0.07% metal content with respect to gold.



6. Typical value represents a typical or average value. It is not strictly warranted.

WARRNING

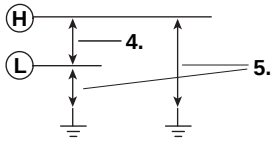
- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the DL750/DL750P.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.

6 Temperature, High Precision Voltage Isolation Module (701265) Specifications

<table>
<tr><th>Item</th><th>Specifications</th></tr>
<tr><td>Standard operating conditions</td><td>Temperature: 23° C±5° C
Humidity: 55%±10% RH
After a 30-minute warm-up and after calibration</td></tr>
<tr><td>Function</td><td>Temperature (thermocouple) or voltage measurement (switchable)</td></tr>
<tr><td>Effective measurement range</td><td>Voltage measurement: Twice of setting range</td></tr>
<tr><td>Number of input channels</td><td>2</td></tr>
<tr><td>Input coupling</td><td>TC, DC, and GND
TC: Temperature (thermocouple) measurement
DC: Voltage measurement (DC coupling)</td></tr>
<tr><td>Voltage measurement maximum sample rate</td><td>100 kS/s</td></tr>
<tr><td>Temperature measurement data update rate</td><td>500Hz</td></tr>
<tr><td>Measurement range/accuracy[1]</td><td>[Voltage measurement] Voltage sensitivity: 1 mV to 100 V range (1-2-5 steps)
Voltage accuracy: ±(0.08% of range + 2µ V)
[Temperature measurement][2]
<table>
<tr><th>Type</th><th>Measurement Range</th><th>Accuracy</th></tr>
<tr><td>K
E
J
T
L
U
N</td><td>−200 to 1300° C
−200 to 800° C
−200 to 1100° C
−200 to 400° C
−200 to 900° C
−200 to 400° C
0 to 1300° C</td><td>±(0.1% of reading + 1.5° C)
Except ±(0.2% of reading + 1.5° C)
for –200° C to 0° C</td></tr>
<tr><td>R
S</td><td>0 to 1700° C
0 to 1700° C</td><td>±(0.1% of reading + 3° C)
Except, 0 to 200° C: ±8° C
200 to 800° C: ±5° C</td></tr>
<tr><td>B</td><td>0 to 1800° C</td><td>±(0.1% of reading + 2° C)
Except, 400 to 700° C: ±8° C
Effective range is 400 to 1800° C</td></tr>
<tr><td>W</td><td>0 to 2300° C</td><td>±(0.1% of reading + 3° C)</td></tr>
<tr><td>Au7Fe[3]</td><td>0 to 300K</td><td>0 to 50K: ±4K
50 to 300K: ±2.5K</td></tr>
</table></td></tr>
<tr><td>Frequency characteristics[1]
(–3 dB point when a sine wave of amplitude 60 % of range is input)</td><td>[Voltage measurement] DC to 100 Hz
[Temperature measurement] DC to 100 Hz</td></tr>
<tr><td>Maximum input voltage[4]
(at a frequency of 1 kHz or less)</td><td>Both temperature and voltage input: 42 V (DC + ACpeak)</td></tr>
<tr><td>Maximum allowable common mode voltage[5]
(at a frequency of 1 kHz or less)</td><td>Both temperature and voltage input: 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)</td></tr>
<tr><td>Vertical resolution</td><td>[Voltage measurement] During voltage input: 2400 LSB/div
[Temperature measurement] When measuring temperature: 0.1° C</td></tr>
<tr><td>–3 dB point when AC coupled low frequency attenuation point</td><td>[Voltage measurement] 0.5 Hz or less</td></tr>
<tr><td>Input connector</td><td>Binding post</td></tr>
<tr><td>Input impedance</td><td>Approx. 1 MΩ</td></tr>
<tr><td>Common mode rejection ratio</td><td>[Voltage measurement] 80 dB (50/60 Hz) or more (typical[6])
[Temperature measurement] 120 dB or more (50/60 Hz, with 2-Hz filter ON, signal source resistance of 500 Ω or less) (typical[6])</td></tr>
<tr><td>Residual noise level
(Input section shorted)</td><td>[Voltage measurement]: ±4 µ V or ±0.1% of range, whichever is greater (typical[6])</td></tr>
<tr><td>A/D conversion resolution</td><td>[Voltage measurement] 16 bits (24000 LSB/range)</td></tr>
<tr><td>Temperature coefficient</td><td>[Voltage measurement] Zero point: ±(0.01% of range)/° C (typical[6])
Gain: ±(0.02% of range)/° C (typical[6])</td></tr>
</table>

Item	Specifications
Reference junction compensation accuracy (when the input terminal temperature is balanced)	K, E, J, T, L, U, N: ±1° C R, S, B, W: ±1.5° C Au7Fe: ±1K
Bandwidth limit (digital filter)	Select from OFF, 30 Hz, 8 Hz, and 2 Hz
Input bias current	20 nA or less The zero point appears to be offset when the input is open due to the effects of bias current on this module. However, this is not a malfunction. Connect the input to the object to be measured.

1. Value measured under standard operating conditions.
2. Does not include the reference junction temperature compensation accuracy.
3. This module supports Au7Fe with 0.07% metal content with respect to gold.



6. The typical value is a representative or standard value. It is not strictly warranted.

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.

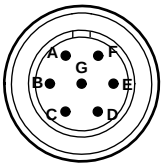
7 Strain Module (NDIS) (701270) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration and auto balance
Effective measurementrange	–FS to +FS (set using upper and lower limits)
Number of input channels	2
Maximum sample rate	100 kS/s
Input format	DC bridge (auto balancing), balanced differential input, and isolated
Auto balance type	Electronic auto balance
Auto balance range	±10000 μ STR (1 gauge method)
Bridge voltage	Select from 2 V, 5 V, and 10 V.
Gauge resistance	120 Ω to 1000 Ω (bridge voltage: 2 V) 350 Ω to 1000 Ω (bridge voltage: 2 V, 5 V, and 10 V)
Gauge factor	1.90 to 2.20 (set in 0.01 steps)
Frequency characteristics[1] (–3 dB point when a sine wave of amplitude 60 % of range is input)	DC to 20 kHz
mV/V range support	Supports the strain gauge transducer unit system. mV/V range = 0.5×(μSTR range/1000)
Measurement range (FS) and measurement range	When using STR range Measurement Range (FS) Measurement Range 500μSTR −500μSTR to +500μSTR 1000μSTR −1000μSTR to +1000μSTR 2000μSTR −2000μSTR to +2000μSTR 5000μSTR −5000μSTR to +5000μSTR 10000μSTR −10000μSTR to +10000μSTR 20000μSTR −20000μSTR to +20000μSTR When using mV/V range Measurement Range (FS) Measurement Range 0.25mv/V −0.25mV/V to +0.25mV/V 0.5mV/V −0.5mV/V to +0.5mV/V 1mV/V −1mV/V to +1mV/V 2.5mV/V −2.5mV/V to +2.5mV/V 5mV/V −5mV/V to +5mV/V 10mV/V −10mV/V to +10mV/V
DC accuracy[1]	±(0.5% of FS+5μSTR)
Maximum input voltage (at a frequency of 1 kHz or less)	Between Input+ and Input– 10 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Between each terminal and earth ground 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)
Input connector	NDIS connector (Recommended by JSNDI (The Japanese Society for Non-destructive Inspection)
Common mode rejection ratio	80 dB (50/60 Hz) or more (Typical[2])
A/D conversion resolution	16 bit (48000 LSB/range: Upper = +FS, Lower = –FS)
Temperature coe	Zero point: ±5μSTR/° C(Typical[2]) Gain: ±(0.02% of FS)/° C (Typical[2])
Bandwidth limit	Select from OFF, 1 kHz, 100 Hz, and 10 Hz Cutoff characteristics: –12 dB/OCT (Typical[2])
Function	mV/V support. Supports the strain gauge transducer unit system.
Standard accessories	NDIS connector (for external connection: PRC03-12A10-7M10.5 by Tajimi) A1002JC: 2 pieces
Compatible accessories (sold separately)	Recommended bridge head 701955 (NDIS 120 Ω, enhanced shield version, comes with a 5-m cable) Recommended bridge head 701956 (NDIS 350 Ω, enhanced shield version, comes with a 5-m cable))

Item	Specifications
Precautions	• Highly sensitive measurements are made in the µ V level in strain measurements. Therefore, take measures against noise at the strain sensor perimeter, bridge head, and cable wiring. • Depending on the noise environment, an error may result in the balance. Check the influence before making measurements. • The bridge head specified by YOKOGAWA has high noise resistance. • Some of the strain gauge sensors and bridge heads made by other manufacturers do not have sensing wires connected. (No such problems with bridge heads made by YOKOGAWA.) If such products are used, an error may result in the bridge voltage leading to measurement errors, because sensing does not work effectively. If possible, it is desirable that sensing be done very close to the bridge. However, if this is not possible, use the NDIS conversion cable (DV450-001) that is sold separately by YOKOGAWA. Outline specifications of the DV450-001: Sensing cable, NDIS male-female, 30 cm in length, insert it as close to the bridge as possible • The connector shell is connected to the case potential. • When a bridge head (701955 or 701956) is used, the connector shell, cable shield, and the bridge head case are all connected to the case potential of the SL1000 unit. • When a bridge head (701955 or 701956) is used, the floating GND is connected to the bridge head case inside the bridge head. • Be sure to execute balancing again when you change the range or the bridge voltage.

1. Value measured under standard operating conditions.
2. The typical value is a representative or standard value. It is not strictly warranted.

Module front View



A: Bridge+ (positive bridge voltage)
B: Input- (negative measurement signal)
C: Bridge- (negative bridge voltage)
D: Input+ (positive measurement signal)
E: Floating common
F: Sense+ (positive bridge voltage sensing)
G: Sense- (positive bridge voltage sensing)

The connector shell is connected to the case potential.

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage may occur.

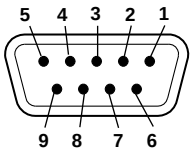
8 Strain Module (DSUB, Shunt-Cal) (701271) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration and auto balance
Effective measurementrange	–FS to +FS (set using upper and lower limits)
Number of input channels	2
Maximum sample rate	100 kS/s
Input format	DC bridge (auto balancing), balanced differential input, and isolated
Auto balance type	Electronic auto balance
Auto balance range	±10000 μ STR (1 gauge method)
Bridge voltage	Select from 2 V, 5 V, and 10 V.
Gauge resistance	120 Ω to 1000 Ω (bridge voltage: 2 V) 350 Ω to 1000 Ω (bridge voltage: 2 V, 5 V, and 10 V)
Gauge factor	1.90 to 2.20 (set in 0.01 steps)
Frequency characteristics[1] (–3 dB point when a sine wave of amplitude 60 % of range is input)	DC to 20 kHz
mV/V range support	Supports the strain gauge transducer unit system. mV/V range = 0.5×(μSTR range/1000)
Measurement range (FS) and measurement range	When using STR range Measurement Range (FS) Measurement Range 500μSTR −500μSTR to +500μSTR 1000μSTR −1000μSTR to +1000μSTR 2000μSTR −2000μSTR to +2000μSTR 5000μSTR −5000μSTR to +5000μSTR 10000μSTR −10000μSTR to +10000μSTR 20000μSTR −20000μSTR to +20000μSTR When using mV/V range Measurement Range (FS) Measurement Range 0.25mv/V −0.25mV/V to +0.25mV/V 0.5mV/V −0.5mV/V to +0.5mV/V 1mV/V −1mV/V to +1mV/V 2.5mV/V −2.5mV/V to +2.5mV/V 5mV/V −5mV/V to +5mV/V 10mV/V −10mV/V to +10mV/V
DC accuracy[1]	±(0.5% of FS+5μSTR)
Maximum input voltage (at a frequency of 1 kHz or less)	Between Input+ and Input– 10 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Between each terminal and earth ground 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)
Input connector	9-pin D-Sub connector (female)
Common mode rejection ratio	80 dB (50/60 Hz) or more (Typical[2])
A/D conversion resolution	16 bit (48000 LSB/range: Upper = +FS, Lower = –FS)
Temperature coe	Zero point: ±5μSTR/° C(Typical[2]) Gain: ±(0.02% of FS)/° C (Typical[2])
Bandwidth limit	Select from OFF, 1 kHz, 100 Hz, and 10 Hz Cutoff characteristics: –12 dB/OCT (Typical[2])
Function	mV/V support. Supports the strain gauge transducer unit system. Shunt calibration support. Built-in shunt calibration relay (1 gauge method).
Standard accessories	Connector shell set for soldering A1520JD (9-pin D-Sub): 2 pieces, A1618JD (connector shell): 2 pieces
Compatible accessories (sold separately)	Recommended bridge head 701957 (D-Sub 120 Ω, shunt-Cal, comes with a 5-m cable) (sold separately) Recommended bridge head 701958 (D-Sub 350 Ω, shunt-Cal, comes with a 5-m cable)

Item	Specifications
Precautions	• Highly sensitive measurements are made in the µ V level in strain measurements. Therefore, take measures against noise at the strain sensor perimeter, bridge head, and cable wiring. • Depending on the noise environment, an error may result in the balance. Check the influence before making measurements. • The bridge head specified by YOKOGAWA has high noise resistance. • When executing shunt calibration, be sure to calculate the shunt resistance in advance, and execute it in a range so that the measured values do not exceed the range even when the shunt resistance is ON. • Some of the strain gauge sensors and bridge heads made by other manufacturers do not have sensing wires connected. (No such problems with bridge heads made by YOKOGAWA.) If such products are used, an error may result in the bridge voltage leading to measurement errors, because sensing does not work effectively. Perform sensing as close to the bridge head as possible. (There is no conversion cable for sensing on D-Sub connector types.) • The connector shell is connected to the case potential. • When a bridge head (701957 or 701958) is used, the connector shell, cable shield, and the bridge head case are all connected to the case potential of the DL750/DL750P. • When a bridge head (701957 or 701958) is used, the floating GND is connected to the bridge head case inside the bridge head. • Be sure to execute balancing again when you change the range or the bridge voltage.

1. Value measured under standard operating conditions.
2. The typical value is a representative or standard value. It is not strictly warranted.

Module front View



1: Floating common
2: Sense- (positive bridge voltage sensing)
3: Shuntcal- (negative shunt signal)
4: Shuntcal+ (positive shunt signal)
5: Sense+ (positive bridge voltage sensing)
6: Bridge- (negative bridge voltage)
7: Input- (negative measurement signal)
8: Input+ (positive measurement signal)
9: Bridge+ (positive bridge voltage)

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage may occur.

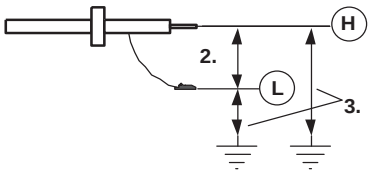
9 Acceleration/Voltage Module (with AAF) (701275) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, GND, ACCL (acceleration), and GND
Maximum sample rate	100 kS/s
Input format	Isolated unbalanced
Frequency characteristics[1] (–3 dB point when a sine wave of amplitude 60 % of range is input)	Waveform observation mode: DC to 40 kHz Acceleration measurement mode: 0.4 Hz to 40 kHz
Voltage-axis range setting	50mV to 100V renge (1-2-5 steps) Acceleration (±5 V = ×1 range): ×0.1 to ×1 to ×100 (in 1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	42V(DC+Acpeak)[*2]
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Working voltage of safety standard 30Vrms(CAT and CAT II)[3]
Vertical (voltage) axis accuracy DC accuracy[1]	Waveform measurement mode DC accuracy: ±(0.25% of range) Acceleration measurement mode: ±(0.5% of range) at 1kHz
Input connector	Metal BNC connector
Input impedance	1MΩ±1%, approx. 35pF
–3 dB point when AC coupled low frequency attenuation point	0.4 Hz or less (0.04 Hz or less when using the 701940)(Typical[4])
Common mode rejection ratio	80dB(50/60Hz) or more(Typical[4])
Residual noise level (Input section shorted)	±100μV or ±0.1% of range, whichever is greater (Typical[4])
A/D conversion resolution	16 bits(24000LSB/range)
Temperature coefficient	When in waveform measurement mode (excluding AUTO filter) Zero point: ±(0.02% of range)/° C(Typical[4]) Gain: ±(0.02% of range)/° C(Typical[4])
Response time (only when observing RMS)	Select from OFF, Auto, 4 KHz, 400 Hz, and 40 Hz Cutoff characteristics: –12 dB/OCT (typical[4]4, excluding AUTO) Cutoff frequency (fc) when set to AUTO Sample rate of 100 kHz or higher: fc = 40 kHz Sample rate of 100 Hz to 50 kHz: fc = 40% of the sampling rate Sample rate of 50 Hz or less: fc = 20 Hz Cutoff characteristics when set to AUTO: –65dB at 2×fc (typical[4])
Bandwidth limit	Voltage probe 1:1, 10:1, 100:1, or 1000:1 Current probe 10 A:1 V (for the 700937/701933), 100 A:1 V (for the 701930/701931)
Probe attenuation setting	Connection cable (for low voltage 1:1) 366926 (non-isolated type BNC-alligator clip × 2: For measuring low voltage less than or equal to 42 Vpeak) Voltage probe (10:1 passive probe) 701940 17 to 46 pF: For measuring 600 V (DC+ACpeak) or less Current probe (power can be supplied from the DL750/DL750P) 700937 (15 A), 701930 (150 A), 701931 (500 A), 701933 (30 A)
Sensor supply current (voltage)	OFF/4mA±10%(approx. 22VDC)
Applicable acceleration sensor	Built-in amplifier type Kistler Instrument Corporation: Piezotron, PCB Piezotronics Incorporated: ICP, ENDEVCO Corporation: ISOTRON, etc.

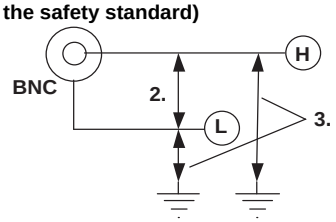
<table>
<tr><th>Item</th><th>Specifications</th></tr>
<tr><td>Table of Cutoff Frequency Characteristics of the Anti-Aliasing Filter (AAF)</td><td>When the filter is set to Auto, the anti-aliasing filter and low-pass filter are automatically set according to the sample rate.
<table>
<tr><th>Sample Rate</th><th>AAF</th><th>Low-pass filter</th></tr>
<tr><td>100kS/s4</td><td>0kHz</td><td>OFF</td></tr>
<tr><td>50kS/s</td><td>20kHz</td><td>OFF</td></tr>
<tr><td>20kS/s</td><td>8kHz</td><td>OFF</td></tr>
<tr><td>10kS/s</td><td>4kHz</td><td>4kHz</td></tr>
<tr><td>5kS/s</td><td>2kHz</td><td>4kHz</td></tr>
<tr><td>2kS/s</td><td>800Hz</td><td>4kHz</td></tr>
<tr><td>1kS/s</td><td>400Hz</td><td>400Hz</td></tr>
<tr><td>500S/s</td><td>200Hz</td><td>400Hz</td></tr>
<tr><td>200S/s</td><td>80Hz</td><td>400Hz</td></tr>
<tr><td>100S/s</td><td>40Hz</td><td>40Hz</td></tr>
<tr><td>50S/s</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>20S/s to 5S/s</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>2S/s or less</td><td>20Hz</td><td>40Hz</td></tr>
<tr><td>Ext sample</td><td>40kHz</td><td>OFF</td></tr>
</table></td></tr>
</table>

1. Value measured under standard operating conditions.

Combined with the 10:1 passive probe (701940)



Direct input (cable not complying with the safety standard)



4. The typical value is a representative or standard value. It is not strictly warranted.

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage may occur.

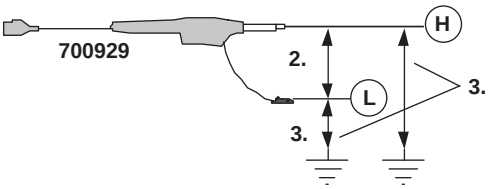
10 Frequency Module (701280) Specifications

Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Measurement function	Frequency, RPMs, RPSs, period, duty cycle, power supply frequency, pulse width, pulse integration, and velocity
Effective measurement range	Twice of setting range
Number of input channels	2
Data update rate	25kHz(40μs)
Output delay time	Up to 2 computation periods
Input format	Isolated unbalanced
Input connector	Metal BNC connector
Maximum input voltage	Module only (when 1:1 cable is connected, across input terminals H and L): 42V(DC+ACpeak)[4] Combined with the 700929(10:1) (across the probe tips, H and L3): 420V(DC+ACpeak)[2]
Maximum allowable common mode voltage	Working voltage of safety standard Module only (when 1:1 cable is connected, across input terminal L and earth) 30 Vrms (CAT I and CAT II)[5] Combined with the 700929 (10:1) (across probe tip H or L and earth) 300 Vrms (CAT I and CAT II)[3]
Insulation resistance	500 VDC, 10 MΩ or more (across each input terminal and earth))
Minimum measurement resolution	50ns
Measured data resolution	16 bits (24000LSB/range)
Measurement accuracy[1]	• **When in frequency, RPM, RPS, or velocity measurement mode[6]** Measurement accuracy is specified according to the measurement range and input frequency [Definition of measurement accuracy] v±(0.05% of 10 div + accuracy dependent on the input frequency) [Accuracy dependent on the input frequency] When input frequency is 2 kHz or less: 0.05% of the input frequency + 0.001 Hz Input frequency of 2 kHz to 10 kHz: 0.1% of the input frequency Input frequency of 10 kHz to 20 kHz: 0.3% of the input frequency Input frequency of 20 kHz or higher: 0.5% of the input frequency • **When in power supply frequency mode[7]** When the center frequency is 50/60 Hz: ±0.03 Hz (0.01 Hz resolution) When the center frequency is 400 Hz: ±0.3 Hz (0.01 Hz resolution) (Input set to AC100V or AC200V with sine wave input) • **When in period measurement mode[6]** Measurement accuracy is specified according to the measurement range and input period [Definition of measurement accuracy] ±(0.05% of 10 div + accuracy dependent on the input period) [Accuracy dependent on the input period] Input period of 500 μ s or greater: 0.05% of the input period Input period of 100 μ s to 500 μ s: 0.1% of the input period Input period of 50 μs to 100 μ s: 0.3% of the input period Input period of 50 μs or less: 0.5% of the input period + 0.1 μs • **When in duty cycle measurement mode8[6]** Dependent on the input frequency Input frequency of 1 kHz or less: ±0.1% Input frequency of 1 kHz to 10 kHz: ±0.2% Input frequency of 10 kHz to 50 kHz: ±1.0% Input frequency of 50 kHz to 100 kHz: ±2.0% Input frequency of 100 kHz to 200 kHz: ±4.0% • **When in pulse width measurement mode[8]** Measurement accuracy is specified according to the measurement range and input pulse width [Definition of measurement accuracy] ±(0.05% of 10 div + accuracy dependent on the input pulse width) [Accuracy dependent on the input pulse width] Input pulse width of 500 μ s or greater: 0.05% of the input pulse width Input pulse width of 100 μ s to 500 μ s: 0.1% of the input pulse width Input pulse width of 50 μ s to 100 μ s: 0.3% of the input pulse width Input pulse width of 50 μ s or less: 0.5% of the input pulse width + 0.1 μ s

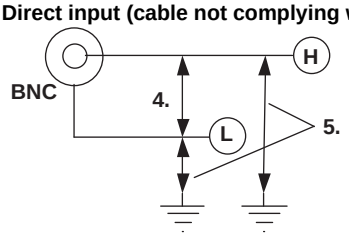
Item	Specifications
Input voltage range (±FS)	When using 1:1 probe attenuation: ±1V, ±2V, ±5V, ±10V, ±20V, ±50V(±FS)
Input impedance	1MΩ±1 approx. 35pF Pull-up function: 4.7 kΩ, approx. 5 V (pull-up can be turned ON only when the input is set to Pull-Up 5V)
Input coupling settings	AC, DC
Probe attenuation setting	10:1, 1:1
Minimum voltage width for pulse detection	200mV$_{P-P}$
Bandwidth limit	Select from Full, 100 kHz, 10 kHz, 1 kHz, and 100 Hz Cutoff characteristics: –12 dB/OCT (typical[9])
Threshold	Set within the FS of the voltage range. Set in units of 1% of the FS.
Hysteresis	Select ±1%, ±2.5%, or ±5% of the FS of the voltage range
Preset function	Logic (5V/3V/12V/24V), electromagnetic pickup, zero crossing, pull-up, AC100V, AC200V, and user-defined
Slope selection	Select rising or falling
Lower –3 dB point when AC coupled	0.5 Hz or less (0.05 Hz or less when using the 700929) (typical[9])
Chatter elimination function	OFF or 1 to 1000 ms (1 ms resolution) Eliminates the chatter that occurs such when the contact input is turned ON/OFF. Can discard the signal changes over the specified interval.
Input status indication function	Input status indication through the LEDs of each channel function When in operation: Illuminates in green when pulse input is detected When overdriven: Illuminates in red when the input voltage exceeds the range
Compatible probes/cables	Connection cable (1:1): Recommended 1 366926 Voltage probe (10:1 safety probe): Recommended 2 700929 (10:1 safety probe) .20 to 45 pF: For measuring 1000 V (DC+ACpeak) or less

1 Value measured under standard operating conditions.

Combined with the 700929



Direct input (cable not complying with the safety standard)



Withstand voltage: 1500 Vrms for 1 minute
Allowable transient surge voltage (between earth and input): 2100 Vpeak

6 Input waveform of 1 Vpp, rectangular wave, rise/fall time within 1 ms (input range: ±10 V, bandwidth limit: Full, and hysteresis: ±1%)
7 Input waveform of 90 Vrms, sine wave (input range: AC100V, bandwidth limit 100 kHz, and hysteresis: ±1%)
8 Input waveform of 1 Vpp, rectangular wave, rise/fall time within 5 ns (input range: ±10 V, bandwidth limit: Full, and hysteresis: ±1%)
9 Typical value represents a typical or average value. It is not strictly warranted.

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage may occur.

Specifications by Measurement Modes

Item	Specifications
Frequency	
Measurable frequency range	0.01 Hz to 200 kHz
Selectable vertical axis range	1Hz to 500kHz/range (1-2-5 steps)
Minimum resolution	0.001Hz
RPMs	
Measurable RPMs range	0.01 rpm to 100000 rpm (where the input frequency is DC to 200 kHz).
Selectable vertical axis range	1 rpm to 100000 rpm range (1-2-5 steps)
Computing method	Computed from the frequency based on the number of pulses per rotation RPMs = Frequency/(pulse/rotate value) × 60
Selectable pulse/rotate range	1 to 99999
RPSs	
Measurable RPSs range	0.001 rps to 2000 rps (where the input frequency is DC to 200 kHz).
Selectable vertical axis range	0.1 rps to 2000 rps range (1-2-5 steps)
Computing method	Computed from the frequency based on the number of pulses per rotation RPSs = Frequency/(pulse/rotate value)
Selectable pulse/rotate range	1 to 99999
Period	
Measurable period range	5 ms to 50 s (where the minimum pulse width is 2 μs)
Selectable vertical axis range	100 μs to 50 s range (1-2-5 steps)
Minimum resolution	0.1 μs
Duty cycle	
Measurable duty cycle range	0 to 100%
Selectable vertical axis range	10 to 200% range (1-2-5 steps)
Measurable frequency range	0.1 Hz to 200 kHz
Measurement pulse selection	Select positive or negative pulse
Minimum resolution	0.01%
Power supply frequency	
Measurable frequency range	30 Hz to 70 Hz (when the center frequency is 50 Hz), 40 Hz to 80 Hz (when the center frequency is 60 Hz), 380 Hz to 420 Hz (when the center frequency is 400 Hz)
Selectable vertical axis range	1 Hz/div to 20 Hz range (0.01 Hz resolution)
Center frequency setting	Select 50 Hz, 60 Hz, or 400 Hz
Minimum resolution	0.01 Hz
Pulse width	
Measurable pulse width	2 μs to 50 s (where the input frequency is up to 200 kHz)
Selectable vertical axis range	100 μs to 50s range (1-2-5 steps)
Measurement pulse selection	Select positive or negative pulse
Minimum resolution	0.1 μs
Pulse integration	
Maximum pulse count	2×109 pulses
Selectable vertical axis range	500.0E+18 value/div to 10.00E–21 value/div (1-2-5 range: total of 123 ranges)
Frequency measuring range	0.1 Hz to 200 kHz (where the minimum pulse width is 2 μs)
Computation function	Set the physical amount per pulse and display by converting the values intophysical values such as distance and flow rate.
Selectable Unit/Pulse range	–9.9999E+30 to +9.9999E+30
Counter reset	Manual reset and over-limit reset
Velocity	
Selectable vertical axis range	500.0E+18 range to 10.00E–21 range (1-2-5 range: total of 123 ranges)
Computing method	Set the amount of displacement per pulse and compute the velocity from the frequency Automatic unit time conversion of s, min, and hour.
Selectable Distance/Pulse range	–9.9999E+30 to +9.9999E+30

Functional Specifications

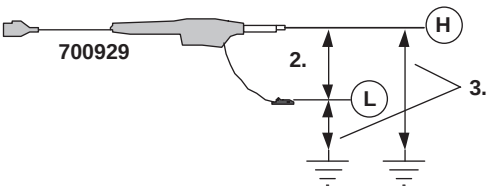
Item	Specifications
Deceleration prediction	Computes the deceleration condition in realtime when the pulse input is cut off. Can be specified when measuring the frequency, RPMs, RPSs, period, and velocity
Stop prediction	Sets the frequency to 0 after a certain time elapses after the pulse input is cut off. Stop interval setting: Set in the range of 1.5 to 10 times (10 settings) the period of the pulse measured last Can be specified when measuring the frequency, RPMs, RPSs, period, and velocity
Smoothing	Computes the moving average of the measured data using the specified time Specified time: 0.1 to 1000 ms (0.1 ms resolution) Can be specified on all measurement parameters
Pulse average	Performs frequency measurement per specified number of pulses. When fluctuation exists periodically in the pulse interval, the fluctuation can be eliminated. Specified number of pulses: 1 to 4096 Can be specified when measuring the frequency, RPMs, RPSs, power supply frequency, period, pulse integration, and velocity
Offset function	Observe fluctuation with respect to the offset frequency Offset range: Can be set up to 100 times the maximum range value • Frequency: 0 Hz to 200 kHz • RPMs: 0 rpm to 50 krpm • RPSs: 0 rps to 1000 rps • Period: 0 s to 50 s • Duty cycle: 0% to 100% • Pulse width: 0 s to 50 s • Pulse integration: -1.0000×10^{22} to 1.0000×10^{22} • Velocity: -1.0000×10^{22} to 1.0000×10^{22}

11 High-Speed 100 MS/s, 12-Bit Isolation Module (720210) Specifications

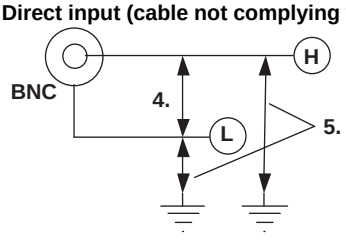
Item	Specifications
Standard operating conditions	Temperature: 23° C±5° C Humidity: 55%±10% RH After a 30-minute warm-up and after calibration
Effective measurement range	Twice of setting range
Number of input channels	2
Input coupling	AC, DC, and GND
Maximum sample rate	100 MS/s
Input format	Isolated unbalanced
Frequency characteristics[1]	(–3 dB point when sine wave of amplitude 60 % of range is input) DC to 20 MHz
Voltage-axis range setting	50 mV to 200 V range (1-2-5 steps)
Maximum input voltage (at a frequency of 1 kHz or less)	Combined with the 700929(10:1)[2] 1000 V (DC+ACpeak) CATII Direct input or cable not complying with the safety standard[4] 200 V (DC+ACpeak)
Maximum allowable common mode voltage (at a frequency of 1 kHz or less)	Working voltage of safety standard Combined with the 700929 (10:1)[3] 1000 Vrms (CAT II) Direct input or cable not complying with the safety standard[5] 42 V (DC+ACpeak) (CAT I and CAT II, 30 Vrms)
Vertical (voltage) axis accuracy DC accuracy[1]	100mV to 200 V range: ±(0.5% of range)
Input connector	BNC connector (isolated type)
Input impedance	1 MΩ ± 1%, approx. 35 pF
–3 dB point when AC coupled low frequency attenuation point	10 Hz or less (1 Hz or less when using the 700929)
Common mode rejection ratio	80 dB (50/60 Hz) or more (typical[6])
Residual noise level (Input section shorted)	±1.1 mV or ±1.5% of range whichever is greater (Typical[6])
Withstand voltage	1500 Vrms for 1 minute (across each terminal and earth) (60 Hz)
Insulation resistance	500 VDC, 10 MΩ or more (across each input terminal and earth)
A/D conversion resolution	12 bit (1500 LSB/range)
Temperature coefficient	Zero point: 100 mV to 200 V range: ±(0.1% of range)/° C(Typical[6]) Gain: ±(0.05% of range)/° C(Typical[6])
Bandwidth limit	Select from OFF, 2 MHz, 1.28 MHz, 640 kHz, 320 kHz, 160 kHz, 80 kHz, , 40 kHZ, 20 kHz, and 10 kHz Cut-off characteristics: –12 dB/OCT (when 2 MHz, Typical[6])
Probe attenuation setting	Voltage probe: 1:1, 10:1, 100:1, 1000:1 Current probe: 10 A:1 V (for the 700937/701933), 100 A: 1 V (for the 701930/701931)

1 Value measured under standard operating conditions.

Combined with the 700929



Direct input (cable not complying with the safety standard)



Withstand voltage: 1500 Vrms for 1 minute
Allowable transient surge voltage (between earth and input): 2100 Vpeak

6 Typical value represents a typical or average value. It is not strictly warranted.

WARNING

- Do not apply input voltage exceeding the maximum input voltage or allowable common mode input voltage.
- To prevent the possibility of electric shock, be sure to furnish protective earth grounding of the SL1000.
- To prevent the possibility of electric shock, be sure to fasten the module screws. Otherwise, the electrical and mechanical protection functions will not be activated.
- Avoid continuous connection under an environment in which the allowable surge voltage or higher voltage may occur.

12 Basic Defining Equation of Strain

Definition of Strain

$\Delta L/L = \varepsilon$ (1)

- ε Strain
- L: Initial length of the material
- ΔL: Amount of change due to external strain

Definition of the Gauge Factor

Gauge factor (K) refers to the ratio between the mechanical strain and the change in the resistance of the strain gauge resistor.

$$\varepsilon = \frac{\Delta L}{L} = \frac{\Delta R/R}{K} \quad (2)$$

$(\Delta R/R) = K \times \varepsilon$ (3)

- R G auge resistance
- ΔR Amount of change in resistance when a strain is received

Normally, K=2.0. However, the value varies depending on the strain gauge material.

General Equation of the Measured Voltage (V) and Strain (ε) of the Wheatstone Bridge (1 Gauge Method)

If we assume V to be the voltage measured on the bridge and E to be the voltage applied to the bridge,

$V = (1/4) \times E \times (\Delta R/R)$ (4)

From equation (3)

$(\Delta R/R) = K \times \varepsilon$

Thus, $V = (1/4) \times E \times K \times \varepsilon$ (5)

- **When Determining the Strain (ε) from the Measured Voltage (V) (Strain Gauge (1Gauge Method))**

  If we derive ε from equation (5)

  $\varepsilon = (4/K) \times (V/E)$ (6)

- **When Determining the Measured Value of the Strain Gauge Sensor (e) from the Voltage Measured on the Bridge (V) (Strain Gauge Sensor)**

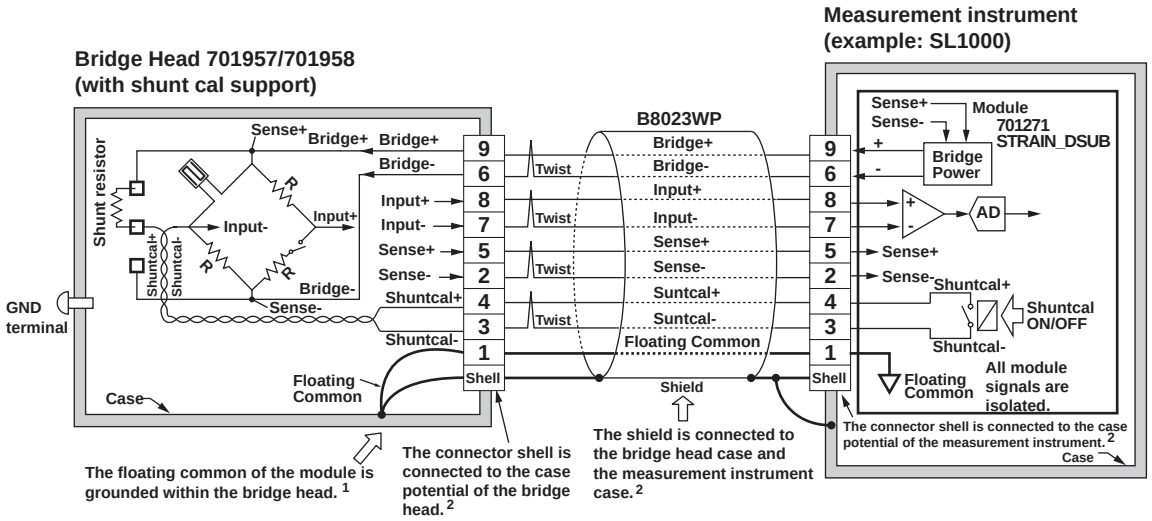
  Assuming e to be the measured value (measured value of the strain gauge sensor: mV/V unit) and substituting $\varepsilon = e$ in equation (6),

  $e = (4/K) \times (V/E)$ (7)

  In the case of a strain gauge sensor, set the Gauge Factor (K) to 2 on the SL1000 unit. If you change the value of K, conversion is made using the above equation.

13 Shunt Calibration of the Strain Module

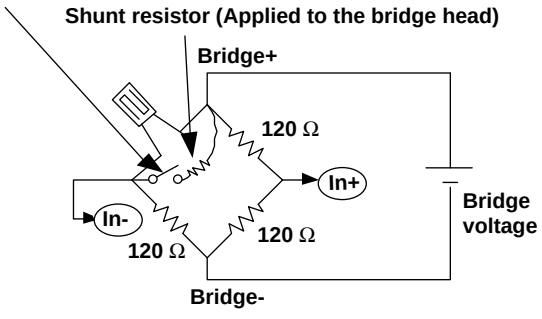
Shunt calibration is used to correct the gain of strain measurements by inserting a known resistance (shunt calibration resistance (shunt resistance)) in parallel with the strain gauge. The Strain Module (701271(STRAIN_DSUB) supports shunt calibration and contains a built-in relay circuit for shunt calibration.
To execute shunt calibration, a bridge head that supports shunt calibration (701957/701958) is needed.



1. The GND (floating common) of the module is connected to the case potential inside the bridge box.
2. The bridge head case, the cable shield, and the measurement instrument case are connected as measures against noise.

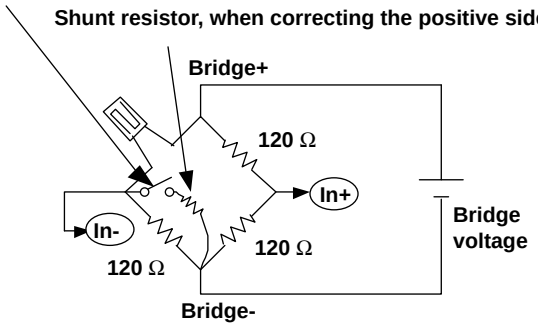
• When correcting the gain on the negative side (normal)

Shunt calibration relay circuit (Built into the strain module. Turns ON/OFF automatically when shunt calibration is executed.)



• When correcting the gain on the positive side

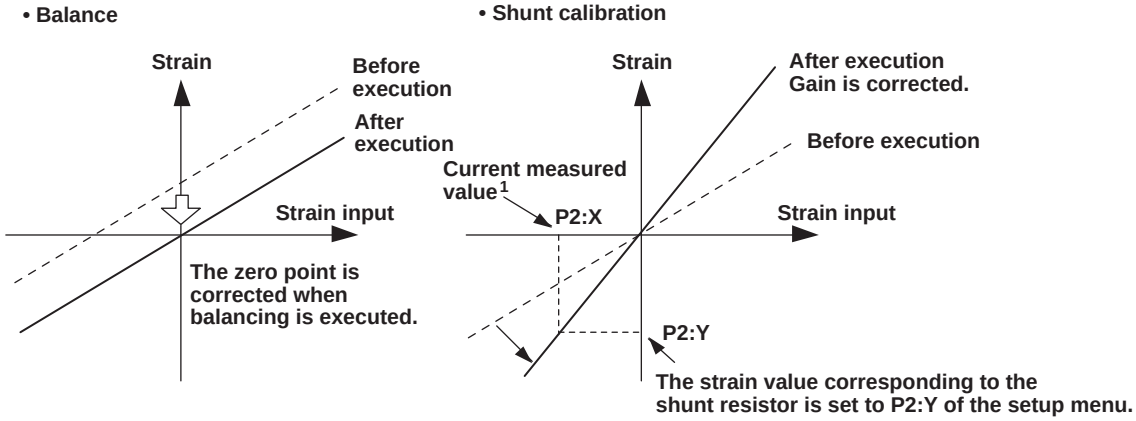
Shunt calibration relay circuit (Built into the strain module. Turns ON/OFF automatically when shunt calibration is executed.)



Shunt Calibration Procedure

1. Calculate the strain value (μSTR) corresponding to the shunt resistor to be used. For the calculation procedure, see “Calculating the Shunt Resistance” in the next section.
2. Execute balancing without applying a load to the strain gauge and correct the zero point.
3. Execute shunt calibration and correct the gain.

   Usually, the negative gain is corrected. However, if you are correcting the positive gain, change the position of the shunt resistor as shown in the right figure in the previous page.



1. Automatically obtained when shunt calibration is executed.

Execute shunt calibration according to the procedures appropriate for the instrument that you are using (SL1000 unit for example).

Note

- When executing shunt calibration, select an appropriate range so that the measured values do not exceed the range when the shunt calibration relay circuit is ON. The SL1000 unit attempts shunt calibration within the current specified range.
- If shunt calibration fails (the measured value exceeds the range, for example), an error message is displayed. In such case, change the range and execute shunt calibration again.

Taking Measures against Noise

Because measurements are made at the μV level, the strain gauge is extremely susceptible to noise. If the execution of balancing or shunt calibration fails, it may be due to the effect of noise. Check the following points.

- Because the strain gauge is attached away from the bridge head, it is recommended that twisted wire be used for extension.
- Use a bridge head with high noise resistance. It is recommended that YOKOGAWA bridge head (701957/701958) with high noise resistance be used.

Calculation of the Shunt Resistance

To execute shunt calibration, the shunt resistance (Rs) and the expected strain (ε) need to be calculated in advance. Use ε as given in the equation below (normally a negative value). Enter the value into "P2Y" under the shunt calibration execution menu. However, when using the general method given for shunt calibration (the easy method), an error of 1 to 2% can be introduced as the strain value (ε) increases. Therefore, calculate using the detailed method whenever possible. Also, you must select a setting range value that will not result in an overrange.

Equation for Rs and ε When Executing Shunt Calibration

General Equation

$\Delta R/R = K \times \varepsilon$ (1): Basic Equation of Strain

$\Delta R = R - R//Rs$ (2): Equation of the change in resistance when the shunt resistance is ON

In this manual, the parallel equation of resistors are expressed as follows:

$$R//Rs = \frac{1}{\frac{1}{R} + \frac{1}{Rs}} = \frac{R \times Rs}{R + Rs}$$

If ΔR is cancelled out from (1) and (2),

$Rs = R \times (1 - K \times \varepsilon)/(K \times \varepsilon)$ (Equation A): General equation used to calculate the shunt resistance (includes error)

ε: Strain (strain you wish to generate when the shunt resistance is turned ON)
K: Gauge factor
R: Bridge resistance
ΔR: Resistance change
Rs: Shunt resistance (shunt resistance you wish to derive)

General Equation

$V_0 = E \times (R_1 \times R_3 - R_2 \times R_4)/\{(R_1 + R_2) \times (R_3 + R_4)\}$ (1): Basic Equation of Wheatstone Bridge

When shunt calibration is ON,
$V_0 = E \times (R_1 \times R_3 - R' \times R_4)/\{(R_1 + R') \times (R_3 + R_4)\}$ (2): Equation when turned ON

$R' = R_2//Rs$ (3): Equation of combined resistance R'

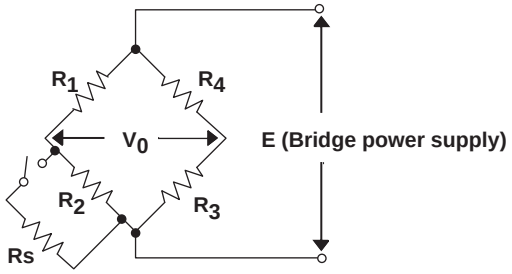
$R_1 = R_2 = R_3 = R_4 = R$ (4): Since R_1 to R_4 are equal, we represent them as R

Also, from the basic equation of strain,
$V_0/E = K \times \varepsilon/4$ (5): Basic equation of strain

If V_0/E and R_1 to R_4 are cancelled out from (2), (3), (4), and (5),

$Rs = R \times (1 - K \times \varepsilon/2)/(K \times \varepsilon)$ (Equation B): Detailed equation used to calculate the shunt resistance (no error)

E: Bridge voltage
V_0: Bridge output voltage
R_1 to R_4: Bridge resistance (except, $R_1 = R_2 = R_3 = R_4$)
Rs: Shunt resistance (shunt resistance you wish to derive)
R': Combined resistance when the relay is turned ON (R'=R//Rs)



Calculation Example

When Determining the Corresponding Shunt Resistance (Rs) from the Strain (ε)

Given a gauge factor (K) of 2,

Detailed equation (equation B) Rs = R×(1–ε)/(2×ε) (6)

General equation (equation A) Rs = R×(1–2×ε)/(2×ε) (7): Error of 1 to 2% present

Desired Strain ε(μSTR)	Derived by the Detailed Equation (6) Rs Value (Ω)		Rs value (Ω) Derived by the General Equation (7)	
	R = 120Ω	R = 350Ω	R = 120Ω	R = 350Ω
1,000	59,940	174,825	59,880	174,650
2,000	29,940	87,325	29,880	87,150
5,000	11,940	34,825	11,880	34,650
10,000	5,940	17,325	5,880	17,150

When Determining the Corresponding Strain (ε) from the Shunt Resistance (Rs)

If we derive e from equation (6) and (7),

Detailed equation (equation B) ε = 1/(1+2×Rs/R) (8)

General equation (equation A) ε = 1/{2×(1×Rs/R)} (9): Error of 1 to 2% present

When the Bridge Resistance R is120 Ω

RS Value(Ω)	Strain ε(μSTR) Derived by the Detailed Equation (8)	Strain ε(μSTR) Derived by the General Equation (9)
60,000	999	998
30,000	1,996	1,992
12,000	4,975	4,950
6,000	9,901	9,804

When the Bridge Resistance R is350 Ω

RS Value(Ω)	Strain ε(μSTR) Derived by the Detailed Equation (8)	Strain ε(μSTR) Derived by the General Equation (9)
180,000	971	970
90,000	1,941	1,937
36,000	4,838	4,814
18,000	9,629	9,537

14 Measurement Principles (Measurement Method and Update Rate) of the Frequency Module

Measurement Principles of the Frequency Module

The measurement principles of period, frequency, pulse width, and duty cycle on the frequency module (701280 (FREQ)) are described below.

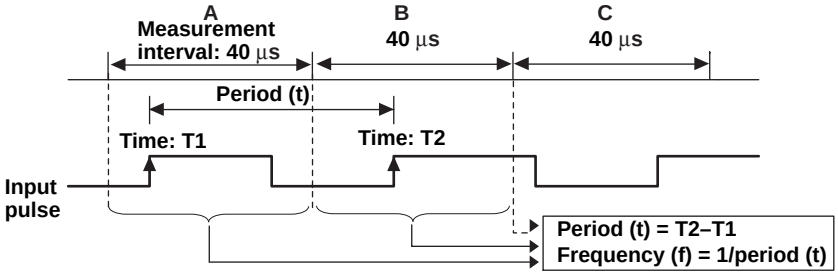
Period and Frequency Measurement

The frequency module updates the waveform at a rate of 25 kHz (40-μs interval). The measurement method differs for frequencies above 25 kHz and below 25 kHz.

- When the input signal is less than or equal to 25 kHz, measurement is made as described in (1).
- When the input signal is greater than or equal to 25 kHz, measurement is made as described in (2).
- The sequence of processing described below is performed simultaneously through pipeline processing. Thus, the period (t) and frequency (f) are updated every 40 μs.

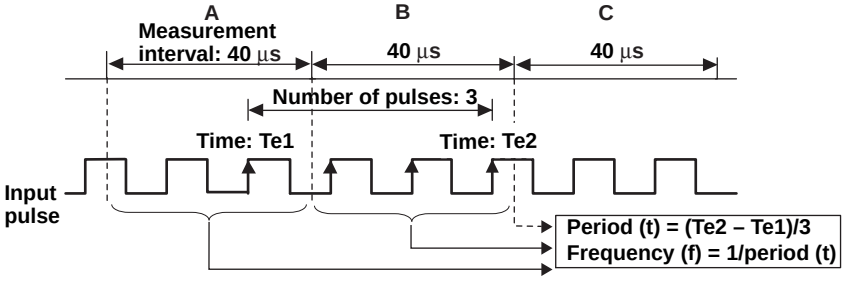
(1)When the input signal is less than or equal to 25 kHz

Measures the time of occurrence of the pulse edge (T1) in measurement interval A.
Measures the time of occurrence of the pulse edge (T2) in measurement interval B.
Calculates the period (t) = T2 – T1 in measurement interval C.
The frequency (f) is calculated as 1/period (t).
When the period of the input pulse spans over multiple measurement intervals, computation is performed at the measurement interval following the interval in which the edge is detected.



(2)When the input signal is greater than or equal to 25 kHz

Measures the time of occurrence of the last pulse edge (Te1) in measurement interval A.
Measures the time of occurrence of the last pulse edge (Te2) in measurement interval B.
Measures the number of pulses between the last pulse edge in measurement interval A and the last pulse edge of measurement interval B.
Calculates the period (t) = (Te2 – Te1)/the number of pulses in measurement interval C.
Period (t) is the average value of multiple pulses.
The frequency (f) is calculated as 1/period (t).
If the input pulse period is short, the DL750/DL750P automatically takes the average of multiple pulses and calculates the period and frequency. Therefore, the resolution does not degrade even when the input pulse period is short, and highly accurate measurement is possible.



Pulse Width and Duty Cycle Measurement

- When the input signal is less than or equal to 25 kHz, measurement is made as described in (1).
- When the input signal is greater than or equal to 25 kHz, measurement is made from the last waveform in the measurement interval as described in (2).
- The sequence of processing described below is performed simultaneously through pipeline processing. Thus, the period (t) and frequency (f) are updated every 40 μs.

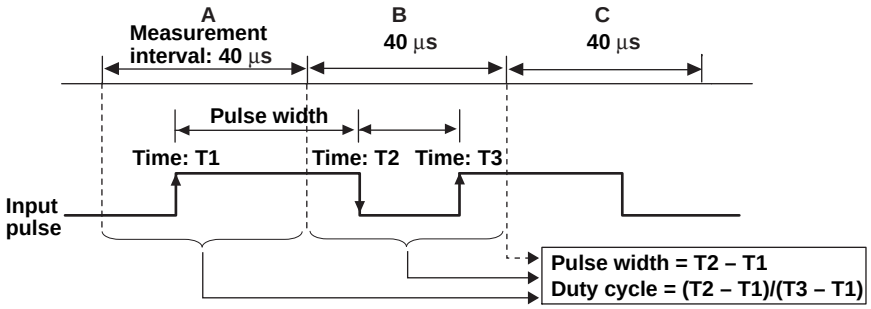
(1) When the input signal is less than or equal to 25 kHz

Measures the times of occurrences of pulse edges (T1, T2, and T3) in measurement intervals A and B.

In measurement interval C:

For pulse width: Calculates pulse width = T2 – T1.

For duty cycle: Calculates duty cycle = (T2 – T1)/(T3 – T1).



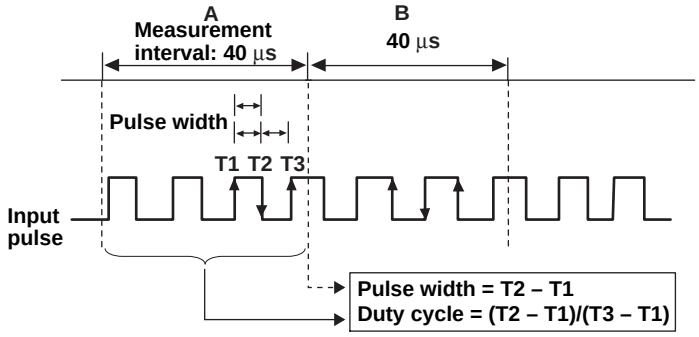
(2) When the input signal is greater than or equal to 25 kHz

Measures the times of occurrences of pulse edges (T1, T2, and T3) in measurement interval A.

In measurement interval B:

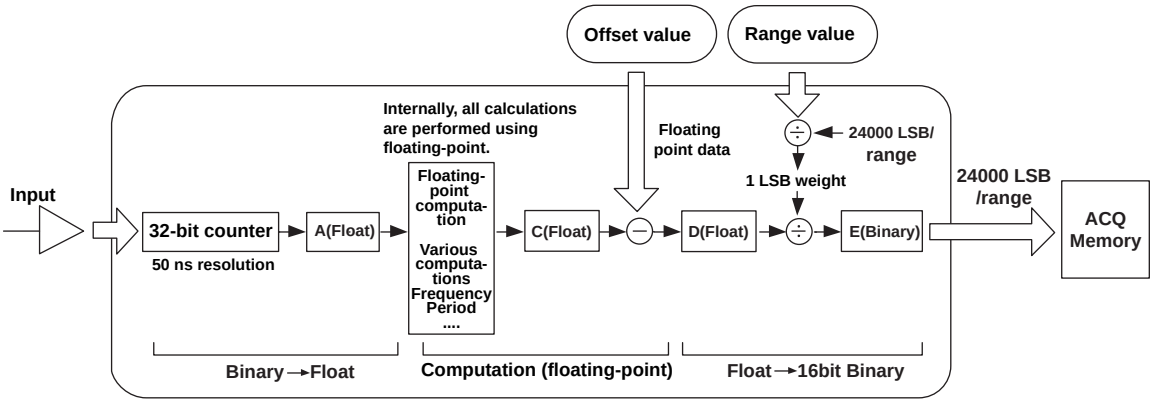
For pulse width: Calculates pulse width = T2 – T1.

For duty cycle: Calculates duty cycle = (T2 – T1)/(T3 – T1).



Computation Format (Resolution) of the Frequency Module

The computation flow on the frequency module is indicated below.



The frequency module measures the period of the input signal using a 32-bit counter of 50-ns resolution. Therefore, the minimum resolution of the counter values is 50 ns. Various computations are performed in floating point format. The data that is output from the frequency module and written to the acquisition memory (ACQ Memory) is 16-bit binary data. The data is converted using a weight of 1 LSB that is determined by Value/div. The data is normalized to 2400 LSB/div when displayed on the screen.

Input: Conversion from the 32-bit Counter Value to Floating Point

Converts the count value obtained using the 32-bit counter with 50-ns resolution to floating point format, and determines period A using the following equation.
Period: A (float) = (count value) × 50 ns

Computation

Various computations are performed in floating point format based on the settings.
Example) Frequency: C (float) = 1/A (float)

Calculation of the 1 LSB Weight of the Output

The 1 LSB weight of the output is determined from the range.
Since range = 24000 LSB,
1 LSB weight of the output =range/24000

Computation Output: Conversion from Floating Point to 16-bit Binary (When Offset Is 0)

When the offset value is 0, offset calculation is not performed, and C (float) = D (float). The data is converted into 16-bit binary data and written to the acquisition memory (ACQ Memory).
16-bit binary data: E (binary) = D (float)/(1 LSB weight of the output)

Offset Computation

When the offset value is not 0, the offset value is computed in floating point format using the following equation and converted to 16-bit binary data.
D (float) = C (float) – offset value (float)
In offset computation, if the computed result C is equal to the offset value, the output is 0. If the computed result C (float) is less than the offset value, E (binary) is negative.

Filter Characteristics (Time Delay) of the Smoothing Filter

The smoothing filter is a moving average filter in which computation is performed in realtime. The computation interval of moving average is 40 μs (25 kHz). It is constant independent of the sampling rate of the main unit.

The moving average order (the number of points of moving average) is specified in time. The maximum value is 25000 order (when set to 1000 ms).

The characteristics of the smoothing filter are as follows:

- The filter is a low-pass filter.
- Pass band is flat.
- Has linear phase characteristics and constant group delay by filter order.
  The group delay is derived using the following equation.
  Group delay = (the number of points of moving average – 1) × 40 μs/2
- Has comb-shaped bandwidth characteristics. (See page app-43.)

The figure below shows the result when the smoothing filter is applied to a waveform that changes in steps. The switching filter setup time follows the step change.