

AUTOMOTIVE MEASURING SYSTEM

6-COMPONENT WHEEL FORCE MEASUREMENT

■ Slip-ring type

SLW-NC	6-Component Wheel Force Transducer
MFT-306/MFT-306R	6-Component Force Analyzer
MFT-7306	Control Software

■ Digital telemeter type

SLW-ND	6-Component Wheel Force Transducer
DT-24R	Telemeter Receiver
MFT-306T	6-Component Force Analyzer
MFT-7306T	Control Software

WHEEL ALIGNMENT MEASUREMENT

WAD-1A	Wheel Alignment Displacement Transducer
WAM-1A	Wheel Alignment Analyzer
WAM-701A	Control Software

WHEEL TORQUE MEASUREMENT

■ Digital telemeter type

LTW-ND	Wheel Torque Transducer
DT-24R	Telemeter Receiver

■ Slip-ring type

LTW-NA	Wheel Torque Transducer
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PEDAL FORCE MEASUREMENT

MLA-NA	Pedal Force Transducer
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VEHICLE ONBOARD MEASUREMENTS

*Applications of vehicle onboard measurement with
Multi-Recorder TMR-200*

Miniature strain gauge application



Tokyo Sokki Kenkyujo Co., Ltd.

Vehicle onboard measuring system

Among all the mechanisms in an automobile, there are many items to measure for the maintenance of the power source of a car, the engine, and electrical components. Other things need to be measured as well such as the effectiveness of the power transfer to the drive wheels, driving stability that determines riding comfort, and braking that controls movement. Our automotive measuring systems have in-driving automotive instrumentation get lined up with the concepts below, which allows you to have an all-in-one system built incorporating even a recorder and PC. Upon your request, we also fabricate steering torque transducers, power window force transducers, etc.

Steering Torque Transducer



By attaching the transducer to passenger car's steering column, driving torque is measured. It equips with slip-ring, while telemeter model is available.

Braking Pedal Force Transducer **MLA-NA**



The Braking Pedal Force Transducer is a load cell to measure brake pedal force, and can easily be attached without modifying the pedal.

• Powertrain (power transfer)

6-component Wheel Force Transducer SLW series (Slip-ring type/Digital telemeter type)

6-component Force Analyzer MFT-306/MFT-306R

Wheel Torque Transducer LTW series (Slip-ring type/Digital telemeter type)

Telemeter Receiver DT-24R

Multi-Recorder TMR-200

• Suspension (driving stability)

Wheel Alignment Displacement Transducer WAD-1A

Wheel Alignment Analyzer WAM-1A

• Pedal force

Braking Pedal Force Transducer MLA-NA

Power Window Force Transducer



This transducer measures a force applied when passenger car's power window is closed. Its sensing part moves horizontally to enable you to adjust shift loading point easily. Moreover, since the move is also done to the vertical direction, a difference between the window and loading point can be adjusted.

6-Component Wheel Force Transducer

SLW-NC (slip-ring type)

SLW-ND (digital telemeter type)

The signals sent from the 6-Component Wheel Force Transducers (SLW series) attached to the axle shafts are amplified by the exclusive force analyzer (MFT series) to be converted into digital values. The digitalized measurements are used to perform real-time computational correction for the crosstalk correction between each component force, the rotation correction to cancel the rotational influences on the sensor, and the moment position correction, which allows the front/back (Fx), right/left (Fy), and up/down (Fz) loads and each component force's torque (Mx, My, Mz) to be output in analog form or to be recorded in the CF card. The digital telemeter model has been newly added to the line up so you can build a wireless all-in-one system when used with the exclusive receiver.

Wheel Alignment Displacement Transducer **WAD**

By installing it with the 6-Component Wheel Force Transducer (SLW series), the Wheel Alignment Displacement Transducer can measure tire displacement in three orthogonal directions passed from a road surface while driving, as well as camber angle and steering angle.

Wheel Torque Transducer **LTW-ND** (digital telemeter type)

LTW-NA (slip-ring type)

The wheel torque measuring system can measure the drive torque and braking torque while driving, in analog output form. The slip-ring built-in model, which incorporates an encoder, can also measure rotation speed. The model incorporating a miniature transmitter is lightweight and has almost no projections and so can take measurements without disturbing driving conditions.

Vehicle onboard measuring system

6-Component Wheel Force Measuring System

Slip-ring type
SLW-NC 6-component wheel force transducer
(Refer to pages 3-6)

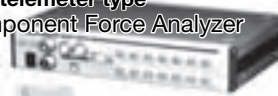


MFT-306
Miniature
6-Component Force Analyzer



MFT-306R
CF card recording
6-Component Force Analyzer

MFT-306T
Digital telemeter type
6-Component Force Analyzer



DT-24R
Telemeter Receiver

DC-204R/DC-204Ra
Smart Dynamic Strain Recorder



TMR-200
Multi-Recorder
Small multi-channel data acquisition system



Digital telemeter type
SLW-ND 6-component wheel force transducer
(Refer to pages 7-10)



Wheel Torque Measuring System

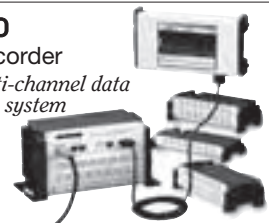
Digital telemeter type
LTW-ND Wheel torque transducer
(Refer to pages 15-16)



DT-24R
Telemeter Receiver



TMR-200
Multi-Recorder
Small multi-channel data acquisition system



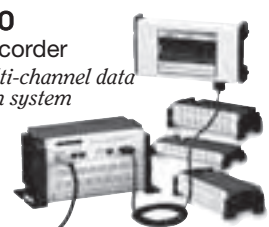
Slip-ring type
LTW-NA Wheel torque transducer
(Refer to page 17)



DA/DC-series
Dynamic Strainmeter



TMR-200
Multi-Recorder
Small multi-channel data acquisition system



Wheel Alignment Measuring System

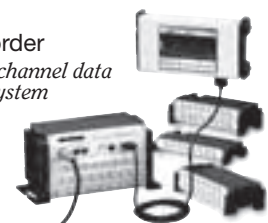
WAD-1A Wheel alignment displacement transducer
(Refer to pages 11-14)



WAM-1A
Wheel Alignment Analyzer



TMR-200
Multi-Recorder
Small multi-channel data acquisition system



Pedal Force Measuring System

MLA-NA Braking pedal force transducer

(Refer to page 18)

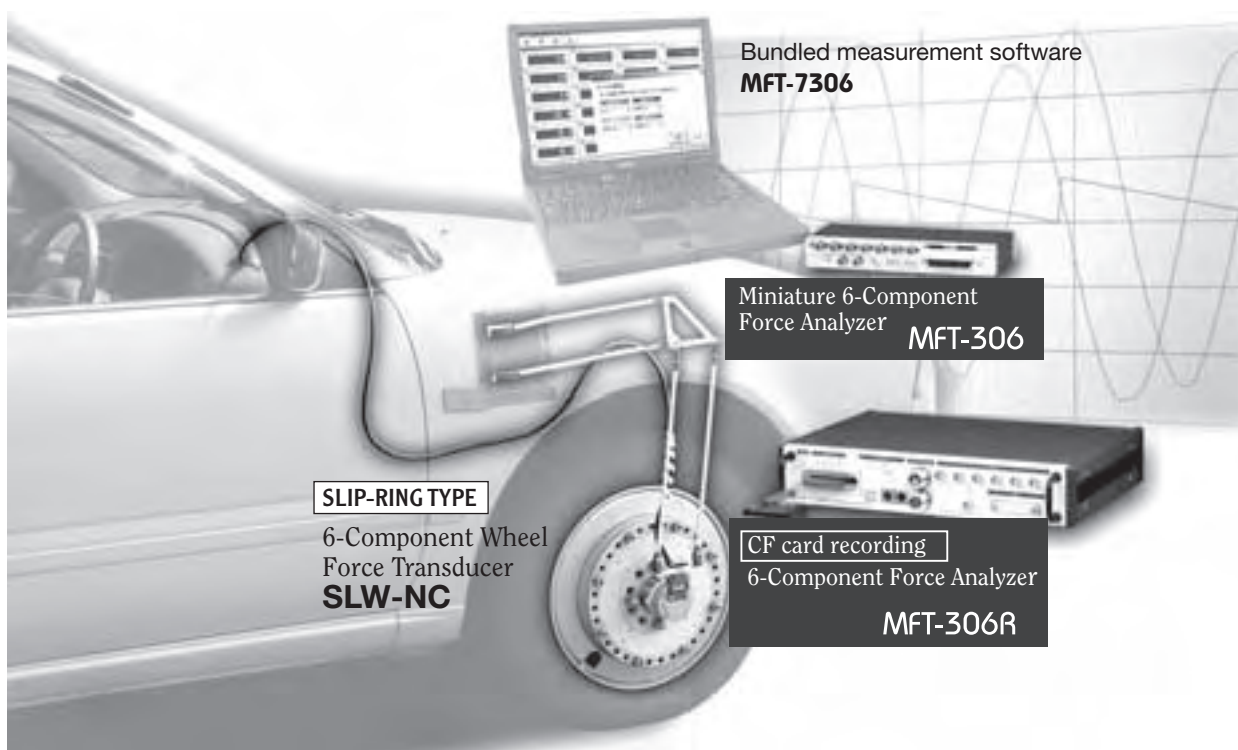


DC-204R/DC-204Ra
Smart Dynamic Strain Recorder



Slip-ring type

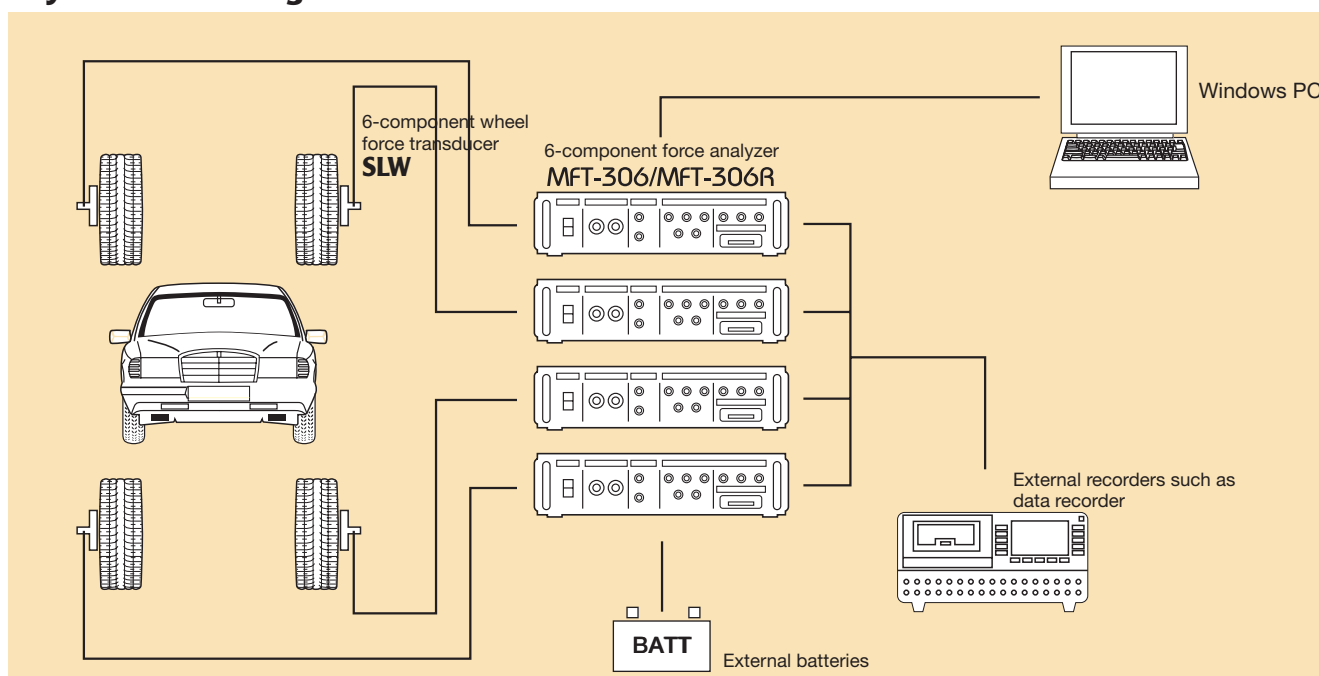
6-Component Wheel Force Measurement



The 6-Component Wheel Force Measuring System is comprised of the 6-Component Wheel Force Transducer and the exclusive 6-component force analyzer. Depending on how the 6-component force is detected, there are two types available, the slip-ring type and the digital telemeter type. The slip-ring 6-Component Wheel Force Measuring System is the combination of the 6-Component Wheel Force Transducer SLW-NC and the 6-Component Force Analyzer MFT-306 or MFT-306R. The MFT-306 is a miniature model (160(W)x25(H)x75(D) mm.)

Setting and monitor viewing are done on a PC, controlling up to 4 analyzers. The other model, MFT-306R, can record measurements using the CF card. After measuring and computing the 6-component force, measurement data and the tire rotation count can be output in voltage form and digitally recorded to the CF card. The CF card can perform recording with up to 4 analyzers synchronously and can also synchronize with the Smart Dynamic Strain Recorder DC-204R.

System block diagram

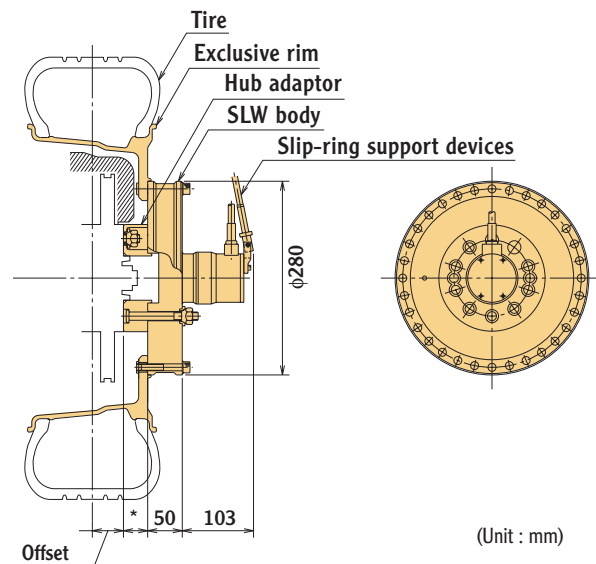


For the details of the Force Analyzer, see page 5.

6-Component Wheel Force Measurement

Slip-ring type

SLW-NC 6-Component Wheel Force Transducer Fx, Fy, Fz 20/30 kN Mx, My, Mz 3/6kN-m



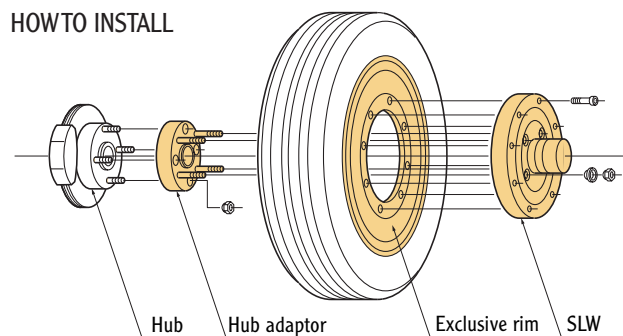
* Somewhat different depending on types of passenger car

The 6-Component Wheel Force Transducer is a thin lightweight load cell, which measures an external force passed to the tires while in motion from the road surface by breaking it down into orthogonal three-component forces and also into three moments around it, can take high-precision measurements in every driving condition using the load detection area in which a strain gauge is strategically applied, the slip-ring and the rotary encoder's fitting area, which are designed with full consideration to vibration resistance, and a waterproof structure. This transducer is used with the exclusive 6-component force analyzer MFT-306/-306R to show the 6-component force with the car body as the reference for the coordinates. The encoder required for the computation of these angles is built in and also the slip-ring hold mechanism for maintaining the encoder at a constant reference position with respect to the car body is provided as an accessory.

Protection ratings : IP 54 equivalent

- **High stability**
- **Light weight**
- **Possible installation to various vehicles using exclusive rim and hub adaptor**
- **Easy fixture to a real car**
- **Waterproof construction making driving in the rain possible**

HOW TO INSTALL



Specifications

Type	SLW-20KNC	SLW-30KNC
Capacity	Fx, Fy, Fz 20kN Mx, My, Mz 3kN-m	Fx, Fy, Fz 30kN Mx, My, Mz 6kN-m
Non-linearity	1%RO	
Hysteresis	1%RO	
Temperature effect on zero	0.02%RO/ °C	
Temperature effect on span	0.01%/ °C	
Overload	Fx, Fy, Fz 150% Mx, My, Mz 130%	Fx, Fy, Fz 130% Mx, My, Mz 130%
Compensated temperature range	-10 ~ +60 °C	
Temperature range	-20 ~ +80 °C	
Maximum rotation	2500 rpm	
Fixing to hub	Using hub adaptor Applicable hub : 100.0-4/100.0-5/114.3-4/114.3-5 holes	
Fixing to tire	Using exclusive rim Applicable rim : 12-in. or larger	
Input/Output cable	φ9mm multi-core shielded polyurethane cable 5m	
Weight	5.2 kg.	5.6 kg.

Slip-ring type

6-Component Wheel Force Measurement

Miniature

MFT-306 6-Component Force Analyzer



The Miniature 6-Component Force Analyzer MFT-306 uses the 6-Component Wheel Force Transducers attached to the axle shafts to input an external force passed to the tires from a road surface on the basis of an orthogonal three-component force and also of the three moments around it. After being converted into digital form, the input signals are used to digitally compute the crosstalk correction between each component force and the rotation correction with the encoder's rotation signal. The 6-component force and tire rotation count signals are output in voltage form through the front panel's output connector. Setting and monitor viewing are done on a PC, controlling 6-Component Force Analyzers up to 4 units. After they are set, the analyzer can perform measurements by itself with the PC disconnected.

- Small and lightweight - Reduction of installation area
- High-speed operation of crosstalk, rotation correction, etc.
- 6-component force data, tire rotation count signal output in voltage form
- Forward and backward measurement possible with this encoder
- 6-Component Wheel Force Transducer characteristics data set by PC
- Up to 4 controllable units

Specifications MFT-306

Interface	RS-232C
Baud rate	19200bps
Data length	8-bit
Parity	none
Stop bit	1-bit
Control	none
Operating environments	0~+50°C, 85% RH or less (No condensation allowed)
Power supply	DC 10~16V 1A MAX.
Anti-vibration	
Vibration	29.4m/s ²
Dimension	160(W) x 25(H) x 75(D) mm (excluding projections)
Weight	500g

Common specifications

Applicable transducer	6-Component Wheel Force Transducer SLW-NC
Rotary encoder	360 pulses/rev. (A-phase, B-phase) 1 pulse/rev. (Z-phase)
Bridge excitation	DC 4.8V
Balancing range	±2000x10 ⁻⁶ strain
Measuring range	±8000x10 ⁻⁶ strain
Measuring full scale	±200x10 ⁻⁶ strain or equivalent to capacity
Frequency response	DC~400MHz (-3dB±1dB)
Crosstalk correction	
Correction range	±12.7% RO or less
Correction accuracy	±0.05%RO
Offset position correction	
Offset setting range	-100 ~ 200mm
Correction accuracy	±0.05%RO

CF card recording

MFT-306R 6-Component Force Analyzer



The CF card recording 6-Component Force Analyzer MFT-306R also uses the 6-Component Wheel Force Transducer to measure a 6-component force passed to the tires from the road surface, just like the MFT-306. After computation, the 6-component force measurement data and tire rotation count are output in voltage form and digitally recorded to the CF card. The USB port is used to connect to a PC for various settings, monitoring, and the importing/processing of recorded data. The CF card can perform recording with up to 4 analyzers synchronously and can also synchronize with our DC-204R and DC-204Ra.

- High-speed operation of crosstalk, rotation correction, etc.
- 6-component force data, tire rotation count signal output in voltage form
- Forward and backward measurement possible with this encoder
- 6-Component Wheel Force Transducer characteristics data set by PC
- Up to 4 controllable units
- Start-to-stop data recorded in a CF card
- Synchronous recording of up to 4 units and synchronous measuring of up to 8 units when combined with the DC-204R

Specifications MFT-306R

Interface	USB1.1
Status LD	Power status, Wheel position, Recording status
Operation	Recording START/STOP key
Recording area	
Media	Compact Flash memory card (specified by us) Supplied as standard 128MB Upto 512MB
Format	DADiSP™/2000 compliant
Speed	500μS, 1mS, 2mS, 5mS, 10mS, 20mS, 50mS, 100mS
Data	START-to-STOP or up to card-full measurements recorded
Power supply	DC 10~16V 1.2A MAX.
Operating environments	0 ~ +50°C, 85% RH or less (No condensation allowed)
Dimension	320(W)x60(H)x220(D)mm (excluding projections)
Weight	2kg

6-component force voltage output

Output	0~5V or -5~+5V (settable)
Output accuracy	±0.2%FS

Tire rotation speed output

Output	0~5V
Output accuracy	±0.5%FS

Calibration output

Output	-5V, 0V, +5V (when set to ±5V)
Output accuracy	±0.2%FS

Low-pass filter

Cutoff frequency	20, 50, 100Hz and PASS
Cutoff characteristics	Bessel type

6-Component Wheel Force Measurement

MFT-7306 Control Software

Setting of the 6-Component Wheel Force Transducer characteristics data

Type of transducer	Enter the name of the Force Transducer
Serial No.	Enter the serial number of the transducer
Capacity	Enter the capacity of the transducer
Rated Output	Enter the rate output of the transducer
Crosstalk	Enter the crosstalk correction value

MFT-306 measurement condition setting

Output voltage full scale	Set to 200×10^{-6} strain equivalent to capacity
Output voltage shift	Settable between + to - full scale
Low-pass filter	Select either 20, 50, 100Hz or PASS
Tire dynamic load radius	Enter the dynamic load radius of the tire
Wheel offset	Enter the offset value of the wheel

Monitor

Switching the number of monitors	Can display to any number of monitors from 1~24
Monitoring channel	Can monitor a desired wheel and channel
Monitoring contents	Fx, Fy, Fz, Mx, My, Mz, Speed monitor value \pm peak value shown

List

List	Shows the 6-Component Wheel Force Transducer's type, serial No., Rated output, Crosstalk correction value, Full scale, Shift, Low-pass filter tire dynamic load radius, Wheel offset
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Print

Print the list

System

Box number	Set the box number of the MFT-306 connected Check the box number of the MFT-306
Balance select	Select either rotation balance or no-rotation balance
Unit select	Select the unit of monitor display (SI unit/ Gravimetric unit)
Serial port select	Select the serial port of the PC

Other

Version information	Version information of MFT-306 and MFT-7306
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Balance

One-wheel balance	Balance operation of a desired wheel
All-wheel balance	Balance operation of all of the selected wheels

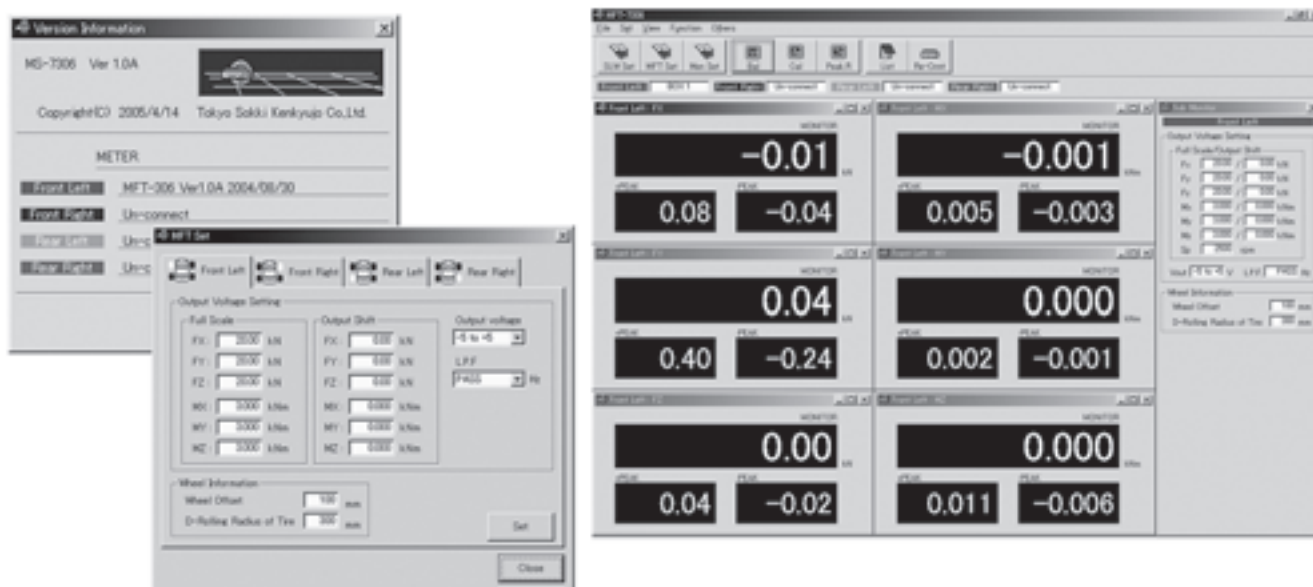
Calibration output

Output voltage	Select either + full scale output, - full scale output, or 0V output
One-wheel calibration	Calibration output of a desired wheel
All-wheel calibration	Calibration output of all of the selected wheels

Peak reset

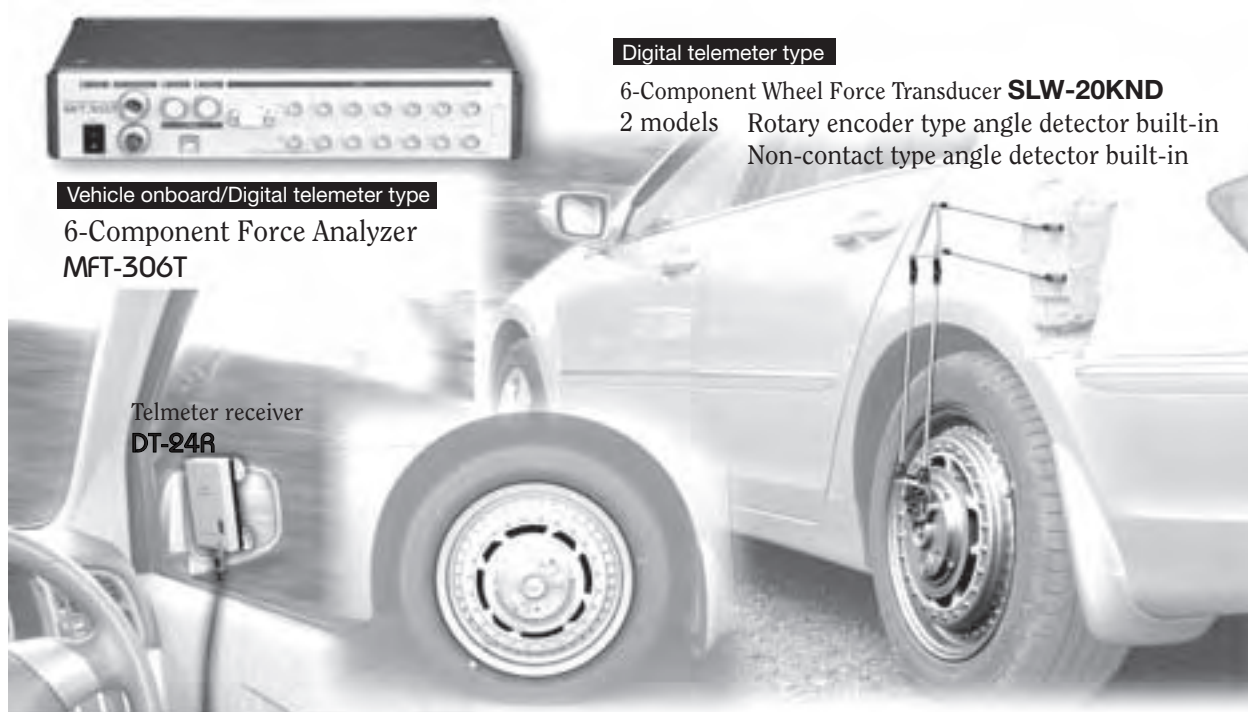
One-wheel peak reset	Reset the \pm peak value of all channels of a desired wheel
All-wheel peak reset	Reset the \pm peak value of all channels of selected wheels

Monitor examples



Digital telemeter type

6-Component Wheel Force Measurement



Digital telemeter type

6-Component Wheel Force Transducer **SLW-20KND**2 models Rotary encoder type angle detector built-in
Non-contact type angle detector built-in

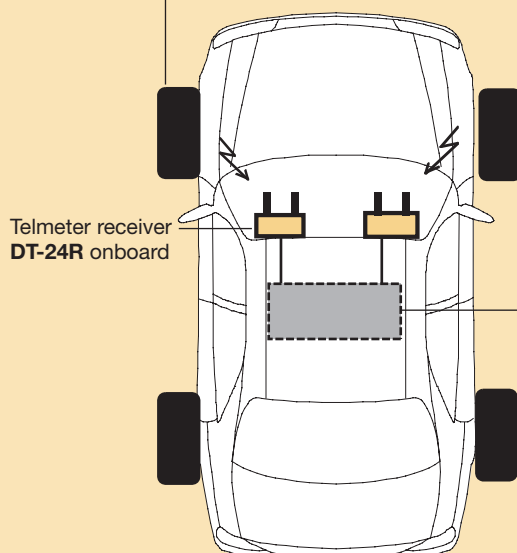
Vehicle onboard/Digital telemeter type

6-Component Force Analyzer
MFT-306TTelemeter receiver
DT-24R

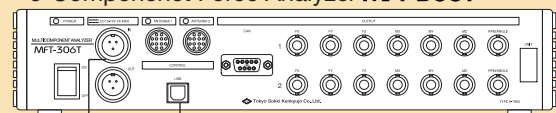
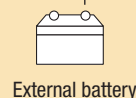
The 6-Component Wheel Force Measuring System is comprised of the 6-Component Wheel Force Transducer and the exclusive 6-component force analyzer. There are two types available, the slip-ring type and digital telemeter type, each using a different method to transfer the 6-component force information. The digital-telemeter 6-Component Wheel Force Measuring System is comprised of the 6-Component Wheel Force Transducer SLW-20KND into which a miniature transmitter is built, the 6-Component Force Analyzer MFT-306T, and the Telemeter

Receiver DT-24R. There are two 6-Component Wheel Force Transducer SLW-20KND models, one with a rotary encoder type angle detector and one with a non-contact type angle detector. The Receiver DT-24R is lightweight and so can be attached with suction holders. The 6-Component Force Analyzer has the voltage output built-in to output 6-component wheel force, tire rotation count, angle, and other data. The 6-Component Force Analyzer, which is controlled through a PC, comes standard with the control software MFT-7306T.

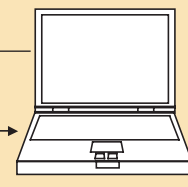
6-Component Wheel Force Transducer

SLW-20KND with built-in transmittermodel 1: Incorporates Rotary encoder type angle detector
model 2: Incorporates non-contact type angle detectorTelemeter receiver
DT-24R onboard

Vehicle onboard measurement

6-Component Force Analyzer **MFT-306T**Voltage output **F_x, F_y, F_z, M_x, M_y, M_z**
RPM (Angle)CAN output **F_x, F_y, F_z, M_x, M_y, M_z**
RPM

External battery

Control software
MFT-7306T

Personal computer

6-Component Wheel Force Measurement

Digital telemeter type

SLW-ND 6-Component Wheel Force Transducer

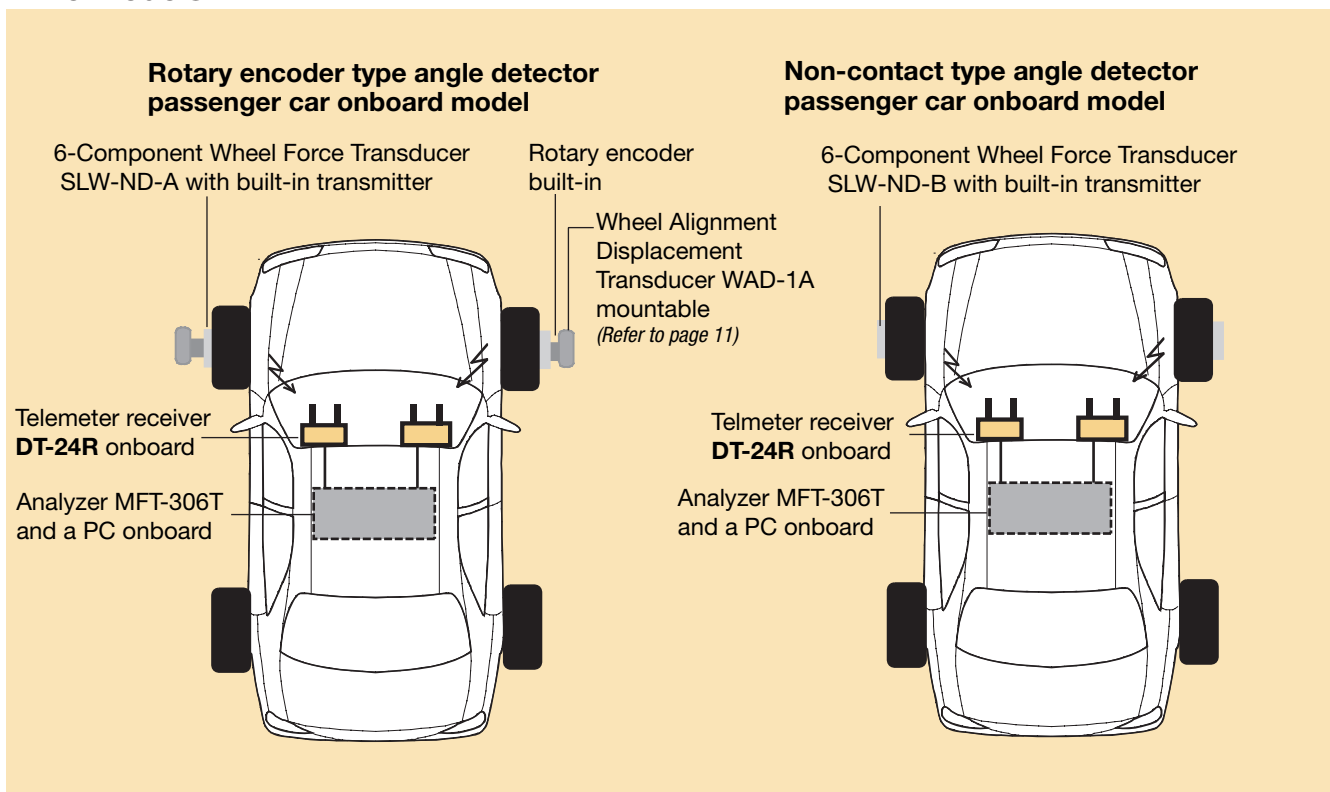


Rotary encoder type angle detector onboard model imaged

This digital-telemeter 6-Component Wheel Force Transducer is comprised of a load cell, which detects external forces passed to the tires from a road surface while driving as the orthogonal three-component force and the three moments around it, and the tire rotation angle detector. After digital conversion in the load cell, the detected three-component force, three moments, and tire rotation angles are wirelessly sent to onboard 6-Component Force Analyzer MFT-306T through the Telemeter Receiver DT-24R. The receiver, which can be installed in the passenger car, needs no cable routed from the outside of the car. There are two Transducer models in the line up differing in their tire rotation angle detector, one has a rotary encoder type and the other, a non-contact type. The former can be installed with the Wheel Alignment Displacement Transducer (WAD-1A) that is used to measure wheel alignment at the same time as the six-component forces. To support wheel sizes and around-hub dimensions that differ with each car type, using the "exclusive rim" and "hub adapter" can make installation possible into every passenger car type with a wheel size of 15 inches or larger.

- **No supporters and cables outside the passenger car - Safe car driving**
- **Signals from the 6-Component Wheel Force Transducer received wirelessly in the car, requiring no cables routed inside and outside the car**
- **Installable into every passenger car type using the exclusive rim and hub adapter**
- **AA batteries used. Use of secondary batteries also possible**

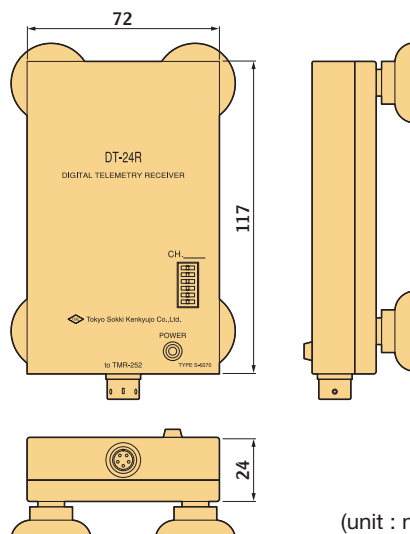
Two models



Digital telemeter type

6-Component Wheel Force Measurement**SLW-ND****Specifications**

Force Transducer		SLW-20KND-A	SLW-20KND-B
Applicable wheel size		15-in. or larger	
Applicable hub size		Various dimensions applicable using the hub adapter	
Capacity Fx, Fy, Fz Mx, My, Mz		±20kN (front/back force, right/left force, up/down force) ±4kN-m (camber moment, drive control torque, steering moment)	
Temperature range		-20 ~ +120 °C (temperature around hub)	
Compensated temperature range		-10 ~ +80 °C	
Temperature effect on zero		0.05%/°C	
Temperature effect on span		0.05%/°C	
Anti-vibration		498m/s ²	
Maximum RPM		2500 rpm	
Non-linearity		±1.0%R0	
Hysteresis		±1.0%R0	
Crosstalk		±5.0%R0 before the transducer computational correction	
Dimension		φ326mm×55mm	
Weight		4.5kg.	
6-Component Force Telemeter transmitter built in the transducer		SLW-6TA	SLW-6TB
Sensor input	Channels Bridge excitation Measuring range Frequency response	6 (Strain gauge type transducers) DC3.0V ±8000 x 10 ⁻⁶ strain (including balancing range) DC to 200Hz	
ADC	Resolution Sampling speed Stability	16-bit 1mS on zero ±1 x 10 ⁻⁶ strain/°C on span ±0.02%/°C	
Data transfer	Method Carrier frequency	Direct spectrum diffusion 2402.0~2482.0MHz	
Angle detection	Method	Rotary encoder	Non-contact detection
	Resolution Maximum RPM	1° 2500rpm	
Power supply	Type Supply voltage Current consumption	4 AA batteries (Use of secondary batteries possible) DC4.8~6.0V 300mA MAX	
Dimension		φ196mm x 99mm (excluding projecting parts)	φ196mm x 60mm (excluding projecting parts)
Weight		1.7 kg. (including batteries)	2 kg. (including batteries)

DT-24R Telemeter Receiver

* The above is a conceptual installation photo. Actual installation may differ.

(unit : mm)

Specifications

Communication	
Type	Direct spectrum diffusion
Carrier frequency	2402.0 ~ 2482.0 MHz
Dimension	72(W) x 24(H) x 117(D) mm (excluding projecting parts)
Weight	200 g.

6-Component Wheel Force Measurement

MFT-306T Digital-telemeter type 6-Component Force Analyzer



The Digital-telemeter 6-Component Wheel Force Transducers SLW-ND attached to the axle shafts allow the external forces passed to the tires from the road surface to be input as an orthogonal three-component force and the three moments around them. After being amplified and converted digitally in the force transducer, an input signal is wirelessly sent to MFT-306T through the Receiver DT-24R. Received data is used to digitally operate the crosstalk correction between each component force and the rotation correction (X and Y components only). 6-component force data, tire rotation count signal are output in voltage form through the output connector of front panel. Monitoring is done through a PC, controlling 6-Component Force Analyzers up to 4 units. The control software MFT-7306T comes standard with the device. After being set up, the analyzer can perform measurement by itself with the PC disconnected.

- Small and lightweight - Reduction of installation area
- High-speed operation of crosstalk, rotation correction, etc.
- 6-component force data, tire rotation count signal output in voltage form
- Measurement data transferred wirelessly by built-in telemeter
- Up to 4 controllable units

Specifications

Computation	
Operations	Crosstalk, Rotation, Offset position Rotation correction (Fy)
Crosstalk correction range	$\pm 12.7\%$ RO or less
Offset setting range	-100 ~ +200mm
Output	
Wheel 6-component force, tire rotation (Angle)	
Output voltage	0 ~ +5V, or -5 ~ +5V (changeable)
6-component force	+5V/2500rpm
RPM	+3.59V/359 degrees
Angle	1mA (at 5K Ω)
Output currency	$\pm 0.2\%$ FS
Output accuracy	20, 50, 100Hz, PASS (Bessel type)
Low-pass filter	
Calibration	
Output voltage	0, 2.5, 5V or -5, 0, +5V
Output accuracy	$\pm 0.2\%$ FS
Interface	
USB standard	USB1.1
Function	Setting of measuring condition, Monitor
CAN standard	Conforms to ISO-11898-2
Function	6-component wheel force, tire rotation transmitter, battery voltage
Status LED	
Power condition	
Anti-vibration	
20m/s ² (50Hz, 0.6mmp-p)	
100m/s ² (shock)	
Operating environment	
0 ~ +50°C, 85%RH or less (no condensation allowed)	
Power supply	
Supply voltage	DC 10~16V
Current consumption	2A MAX.
Dimension	
320(W) x 60(H) x 220(D) mm (excluding projecting parts)	
Weight	
3 kg.	

NB: Output voltage of RPM and angle is switchable according to condition set.

Control software MFT-7306T

Specifications

Setting of 6-Component Wheel Force Transducer characteristics data

Manufacture model	Enter type name of the Force Transducer
Manufacture number	Enter serial number of the transducer and transmitter
Capacity	Enter capacity of the transducer
Rated output	Enter the rated output of the transducer
Crosstalk	Enter crosstalk correction value of the transducer
Speed correction	Enter speed correction value of the Transducer

Measurement condition setting

Output voltage full scale	Set to "200x10 ⁻⁶ strain equivalent to capacity"
Output voltage shift	Settable between + full scale to - full scale
Output voltage	± 5 V. Select between 0 and 5 V
Low-pass filter	Select either 20, 50, 100 Hz, or PASS
Rpm/angle voltage output	Select tire rpm/angle
Tire dynamic load radius	Enter the dynamic load radius of the tire
Wheel offset	Enter the offset value of the wheel

CAN setting

CAN ID setting	CAN ID setting of the transducer
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Monitor

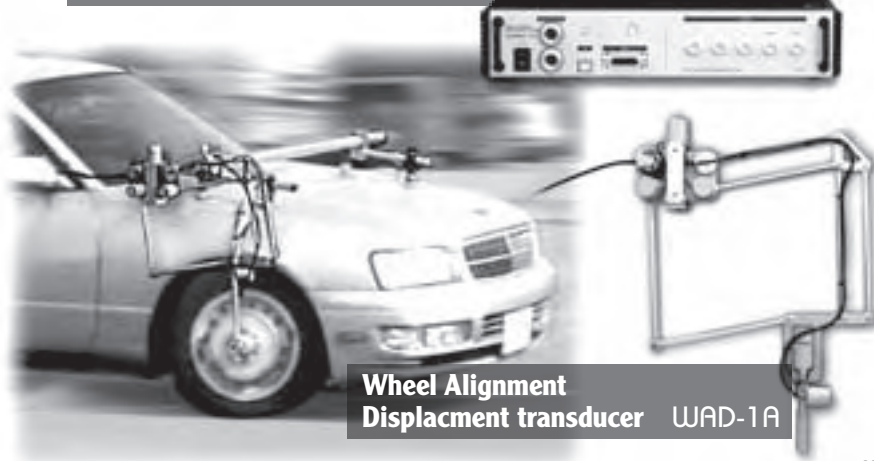
Sub-monitor display	Select the sub-monitor display ON/OFF and the wheel position
View channel	View the desired wheel and desired channel
View contents	Fx, Fy, Fz, Mx, My, Mz, Speed monitor values, \pm peak value shown

List

Contents	Shows the transducer's type, serial number, capacity, rated output, crosstalk correction value full scale, shift, low-pass filter, tire dynamic load radius, wheel offset, speed correction, and CAN ID Print list
Printout	
System	
Box number	Set the box number of the analyzer Check the box number of the analyzer
Analyzer-set wheel	Select the wheel position
Balance select	Select either rotation or no-rotation balance
Unit select	Select display unit (SI unit/Gravimetric unit)
Balance	
One-wheel balance	Balance operation of a desired wheel
All-wheel balance	Balance operation of all of the selected wheels
Calibration output	
Output voltage	Select either + full scale output, - full scale output, or zero output
One-wheel calibration	Calibration output of a desired wheel
All-wheel calibration	Calibration output of all of the selected wheels
Peak reset	
One-wheel peak reset	Reset the \pm peak value of all channels of a desired wheel
All-wheel peak reset	Reset the \pm peak value of all channels of selected wheels

Wheel Alignment Measuring System WAD/WAM

Vehicle onboard measurement

Wheel Alignment Analyzer WAM-1A**Wheel Alignment Displacement transducer WAD-1A**

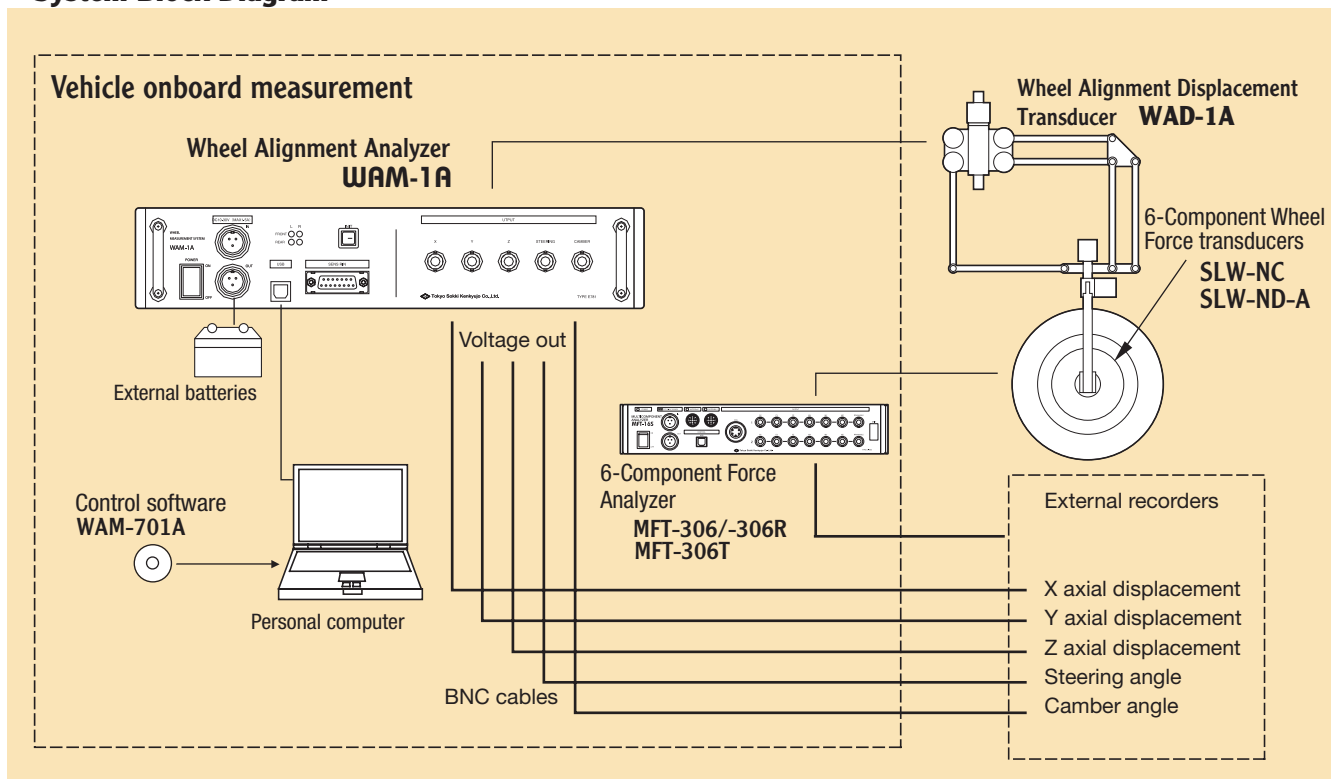
- *Wheel center orthogonalized three-direction displacement*
- *Steering angle*
- *Camber angle*
- *Control up to 4 units simultaneously*

Vehicle onboard measurement
Multi-Recorder TMR-200

The Wheel Alignment Measuring System is composed of the Wheel Alignment Displacement Transducer WAD-1A and the exclusive analyzer WAM-1A. The Wheel Alignment Measuring System can also measure the steering angle and camber angle simultaneously in addition to the three-direction displacement of the wheel center by being installed to the 6-Component Wheel Force Transducer that measures the orthogonal three-direction load and the three moments around it that are passed to the tires from the road surface.

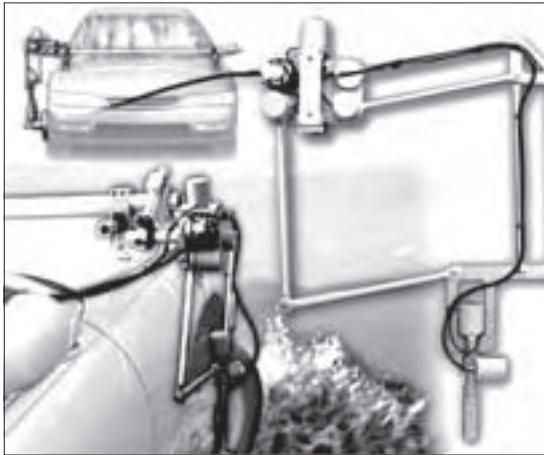
Measurements are output in voltage format in real time through the car-mountable analyzer. The exclusive Wheel Alignment Analyzer WAM-1A, which is USB-connected to a PC, is responsible for everything from settings to measurement. Control up to 4 units simultaneously with the included control software WAM-701A. Voltage output is also supported by the optionally-available Multi Recorder TMR-200, which allows waveform monitoring using the display unit TMR-281.

System Block Diagram

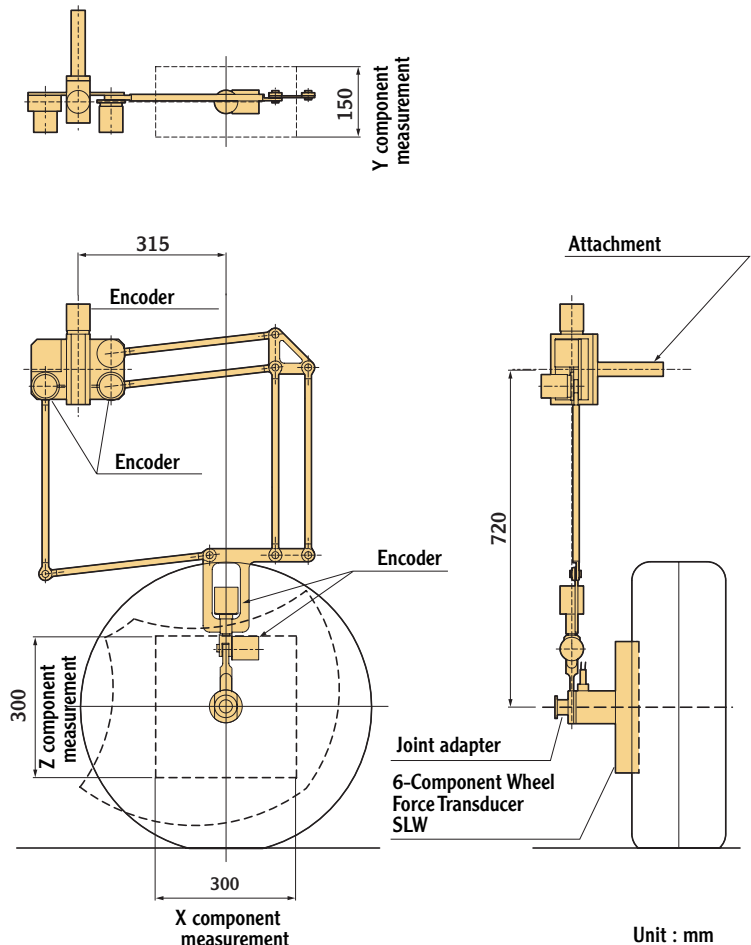


Wheel Alignment Measuring System WAD/WAM

Wheel Alignment Displacement transducer WAD-1A



The Wheel Alignment Displacement Transducer is combined with the Wheel Alignment Analyzer WAM-1A to measure each displacement in the wheel center's X, Y, and Z axes while driving, as well as the changes in steering angle and camber angle. After the Wheel Alignment Displacement Transducer is installed to a fixed point on the car, the end of the displacement transducer is linked to the head of the wheel (6-Component Wheel Force Transducer SLW) to make it follow the movement, which allows the rotary encoder to measure the angle changes of the link corresponding to the wheel movement. The Wheel Alignment Analyzer WAM-1A outputs displacements and angles in voltage form in real time. The displacement transducer is also equipped with the slip-ring support function required to maintain the reference position of the 6-Component Wheel Force Transducer (SLW) in a constant position.



Protection ratings : IP 54 equivalent

Specifications

WAD-1A			
Displacement component*1	X axis (front/back)	Y axis (right/left)	Z axis (up/down)
Measurement range	±150mm	±75mm	±150mm
Measurement accuracy*2	±1mm	±2mm	±1mm
Angle component*1	Steering angle		Camber angle
Measurement range	±30°		±10°
Measurement accuracy*2	±0.3°		±0.3°
Temperature range	-10 ~ +80 °C		
Input/output cable	φ9mm Multi-conductor shielded polyurethane cable 5m		
Weight	4.2 kg. Unsprung weight : 2 kg		
Accessory	Joint adapter for SLW force transducer		
Peripherals	Attachment Mount bar		

*1: Movement of the slip-ring case head of the 6-Component Wheel Force Transducer SLW-NC

*2: Depends on how it is combined with Wheel Alignment Analyzer WAM-1A

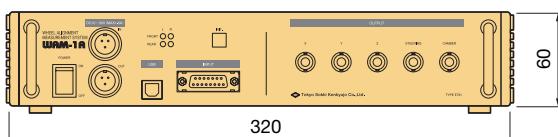
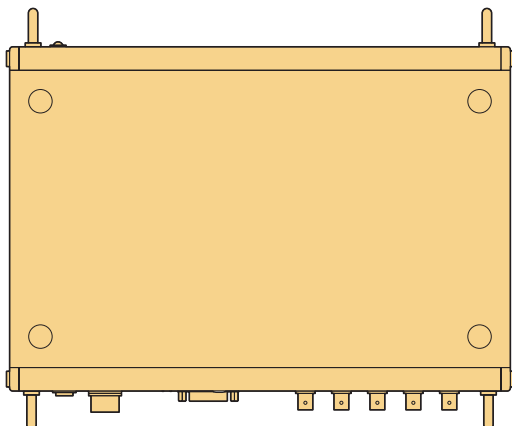
Wheel Alignment Measuring System WAD/WAM

Wheel Alignment Analyzer WAM-1A



The Wheel Alignment Analyzer is combined with the Alignment Displacement Transducer (WAD-1A) to measure each displacement in the wheel center's X, Y, and Z axes while driving, as well as the steering angle and camber angle. Measurements are output in voltage form in real time.

Outer view



Unit : mm

- *Small and lightweight - Reduction of installation area*
- *Alignment Displacement Transducer data and analyzer settings can be set using a PC*
- *Control software (WAM-701A) included*
- *Control up to 4 units simultaneously*

Specifications

Applicable transducers	Wheel Alignment Displacement Transducer WAD-1A
Sampling frequency	100Hz
Measurement range	
X/Y/Z displacement	Select either $\pm 250\text{mm}$ or $\pm 125\text{mm}$
Steering/Camber angle	Select either $\pm 50^\circ$ or $\pm 25^\circ$
Offset	$-100 \sim +200\text{mm}$
Voltage output	
Output	$0 \sim 5\text{V}$, or $\pm 5\text{V}$
Accuracy	0.3%FS
Stability on span	0.03%FS/ $^\circ\text{C}$
Stability on zero	Displacement: $\pm 50\mu\text{m}/^\circ\text{C}$ Angle : 0.01 deg./ $^\circ\text{C}$
S/N ratio	46dBp-p or more
Calibration	
Output	When set to 5V : -5V , 0V , $+5\text{V}$ When set to $0 \sim 5\text{V}$: 0V , $+2.5\text{V}$, $+5\text{V}$
Accuracy	0.3%FS
Low-pass filter	20Hz, PASS
Interface	USB 1.1
Power supply	DC10~30V, 1.5A MAX.
Operating environment	$0 \sim +50^\circ\text{C}$, 85%RH or less (no condensation allowed)
Dimension	320(W) x 60(H) x 220(D) mm (excluding projecting parts)
Weight	2.5 kg.
Standard accessory	Operational manual Control software WAM-701A DC power cable CR-10 USB cable CR-6182

Wheel Alignment Measuring System WAD/WAM

Wheel Alignment Analyzer Control Software WAM-701A

This control software is used for the Wheel Alignment Analyzer to set various measurement conditions and to control the monitor display, initial operation, calibration output, etc.

Specifications

File operation	
Displacement transducer data read	Read the displacement transducer dimension data from a file
Analyzer setting file read	Read the analyzer's settings from a file
Analyzer setting file save	Write the analyzer's settings to a file
Software exit	Exit the control software
Setting	
Displacement transducer data setting	Set the displacement transducer dimension data
Measurement range	X, Y, and Z axis displacement: Select either ± 250 or ± 125 mm Steering angle, camber angle: Select either 50 deg. or 25 deg.
Voltage output	± 5 V. Select between 0 and 5 V
Low-pass filter	Select either 20 Hz or PASS
Offset	Input the offset value manually Setting range: -100 ~ +200 mm
Wheel position	Set the box No. and axle shaft position (FL, FR, RL, RR)
Box number	Set the box No. to the analyzer
Monitor display	Select either one-wheel monitor, two-wheel monitor, four-wheel monitor
Initialization	Initialize
Calibration/Voltage output	Select either + full scale output, - full scale output, or zero output
List	List of the displacement transducer manufacture number, analyzer manufacture number, displacement transducer dimension data, full scale, voltage output, low-pass filter, and offset
Reconnection	Reconnect the analyzer
Version information	Display version information of the control software and analyzer's firmware

Digital telemeter type

Wheel Torque Measurement

Digital telemeter type

LTW-ND Wheel Torque Transducer

The Digital telemeter type Wheel Torque Measuring System is composed of a torque transducer LTW-ND to measure drive torque and braking torque, and onboard telemeter receiver DT-24R, while passenger car driving. In the torque transducer, a miniature telemeter transmitter is built in to pick up the digital output from the receiver installed in the passenger car. This system is small with very small projection dimensions and so can perform measurements without disturbing driving conditions; it is also cordless and so can be organized compactly. The use of the exclusive rim and hub adapter allows installation into any type of passenger car.

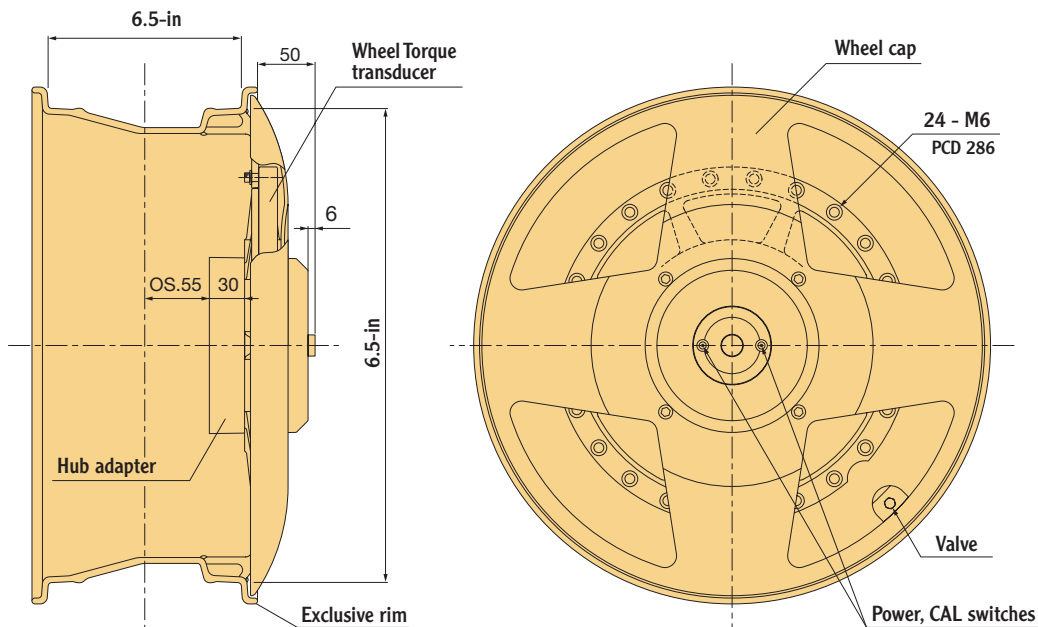
Protection ratings : IP 54 equivalent

- **Small - Regular wheel size or equivalent**
- **Small projection dimensions**
- **Measurement in rain possible because of the waterproof structure**
- **Open structure helps release braking heat**
- **Wireless data reception possible in the car, requiring no cables routed from outside to inside the passenger car**
- **Easily make the change to slip-ring measurement as well**
- **Measurement with the standard offset possible for any car type using the special rim and hub adapter**

Specifications

	LTW-2.5KND	LTW-5KND
Sensing system	Digital telemeter	
Capacity	2.5 kN-m	5 kN-m
Rated output	2000 x 10 ⁻⁶ strain	3000 x 10 ⁻⁶ strain
Non-linearity	±0.3%RO	
Hysteresis	±0.3%RO	
Temperature range	-30 ~ +100 °C (around hub)	
Compensated temperature range	-20 ~ +80 °C	
Temperature effect on zero	0.01%RO/°C	
Temperature effect on span	0.01%/°C	
Over load	150%	
Wheel load allowable	20kN	
Bending moment allowable	3.5 kN-m	5 kN-m
Effect of side load	Less than 0.5%RO at a side load of 3 kN	Less than 0.5%RO at a side load of 5 kN
Effect of wheel load	Less than 0.5%RO at a wheel load of 5 kN	Less than 0.5%RO at a wheel load of 10 kN
Input/output resistance	700Ω±5%	
Zero balance	10%RO or less	
Applicable wheel size	14-in. or larger	
Applicable hub size	Supports various dimensions using the hub adapter	
Weight	2.9 kg.	3 kg.

Wheel Torque Measurement



Unit : mm

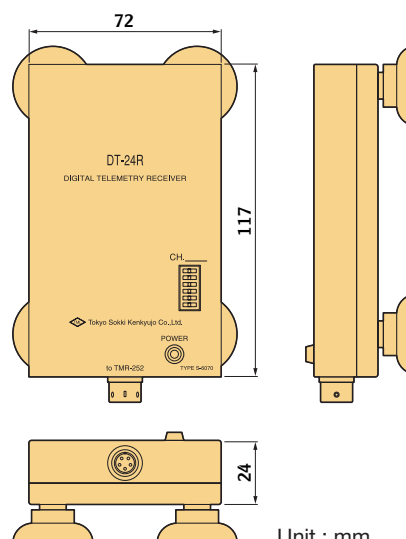
LTW-1TA Built-in telemeter transmitter

Specifications

Number of measurement	1 point (strain gauge type transducer)
Bridge excitation	DC3V
Measuring range	$\pm 8000 \times 10^{-6}$ strain
Frequency response	DC to 200Hz
Sampling speed	500 μ S
Sability	Zero
Accuracy	$\pm 1 \times 10^{-6}$ strain/ $^{\circ}$ C
Communication	
Method	Direct spectrum diffusion
Carrier frequency	2402.0 ~ 2482.0MHz

Power supply	Voltage	DC4.2 ~ 7.6V
	Applicable battery	3 alkaline AA batteries
	Repetition use	6 hours or more
Weight		600 g.

DT-24R Telemeter receiver



Specifications

Receiving data	
Data	6-component wheel force, tire rotation number (angle)
Method	2.4GHz PCM system
Dimension	72(W) x 24(H) x 117(D) mm (excluding projecting parts)
Weight	200 g.

Applicable measuring instrument is Multi-Recorder TMR-200. For measuring system, refer to page 19.

* The above is a conceptual installation photo. Actual installation may differ.

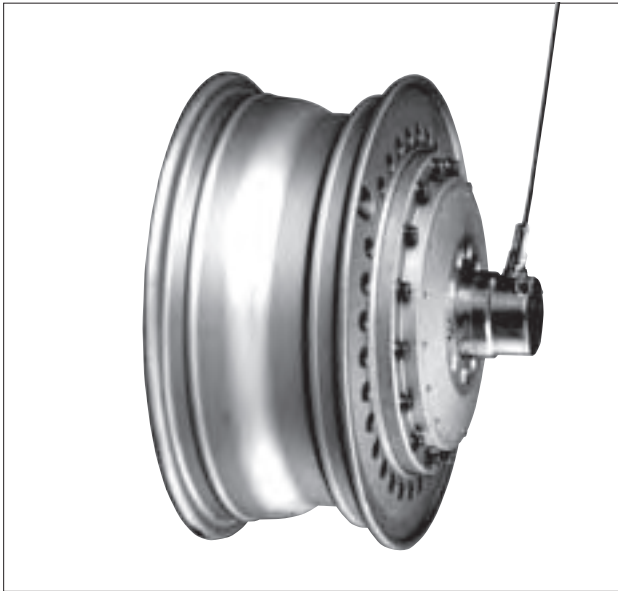
Unit : mm

Slip-ring type

Wheel Torque Measurement

Slip-ring type

LTW-NA Wheel Torque Transducer

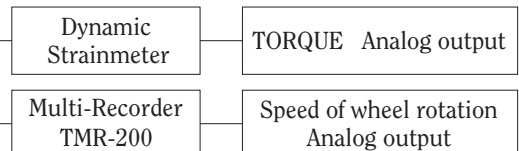
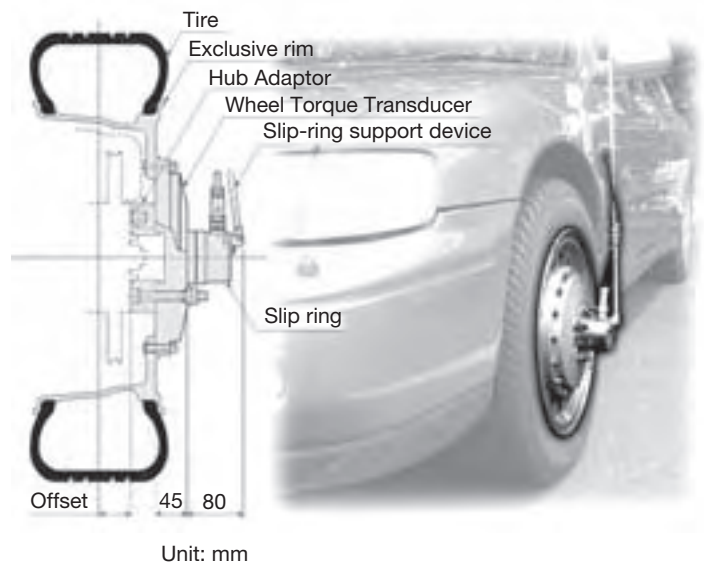


The Slip-ring type Wheel Torque Measuring System, which is composed of the Wheel torque transducer LTW-NA to measure drive/braking torque, and Dynamic strainmeter, Multi-Recorder, can measure torque with analog output by being connected to the included slip-ring and Dynamic Strainmeter. The slip-ring, which incorporates an encoder, allows rotation speed to be measured if connected to a F/V converter to count output pulses. The use of the exclusive rim and hub adaptor allows installation into any type of passenger car.

Protection ratings : IP 54 equivalent



- **Lightweight, almost the same weight as ordinary passenger car wheel**
- **Watproof construction making running in the rain possible**
- **Possible installation to various vehicles using exclusive rim and hub adaptor**



Specifications

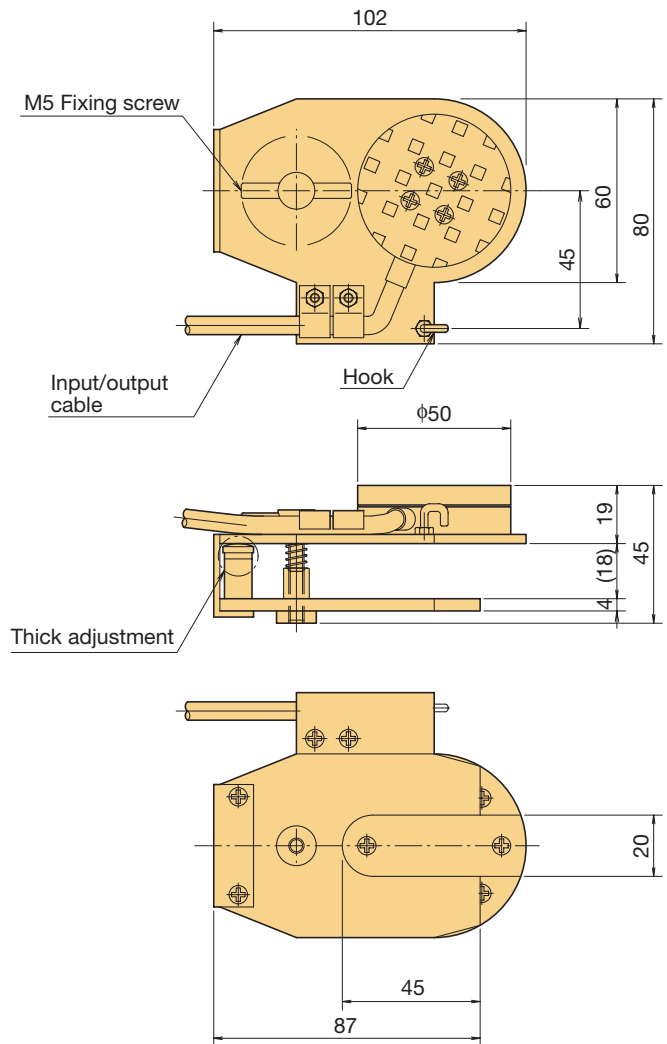
	LTW-2.5KNA
Sensing system	Slip-ring and encoder built-in
Capacity	2.5kN-m
Rated output	1mV/V (2000 x 10 ⁻⁶ strain) ±10%
Non-linearity	0.3%RO
Hysteresis	0.3%RO
Temperature effect on zero	0.01%RO/°C
Temperature effect on span	0.01%/°C
Compensated temperature range	-20 ~ +80 °C
Temperature range	-30 ~ +100 °C
Over load	150%
Bending moment allowable	3.5kN-m
Wheel load allowable	20kN-m
Allowable exciting voltage	20V
Input/output resistance	700Ω±5%
Effect of wheel load	Less than 0.5%RO at a wheel load of 5kN
Effect of side load	Less than 0.5%RO at a side load of 3kN (with a tire of 300mm in radiation)
Applicable wheel size	12-in. or larger in various type
Applicable hub size	100-4, 100-5, 114.3-4, 114.3-5 holes
Weight	15 kg. with 15x6J wheel mounted
Supplied cable	CT6-8P5/SWP-N+SNP (φ6mm 8-core shielded polyurethane cable 5m)

Pedal Force Transducer MLA-NA



The Pedal Force Transducer, which is a load cell to measure the pressure applied to the passenger car's brake pedal, can be installed easily without modifying the pedal. Cables do not break easily even when handled roughly.

Protection ratings : IP 51 equivalent

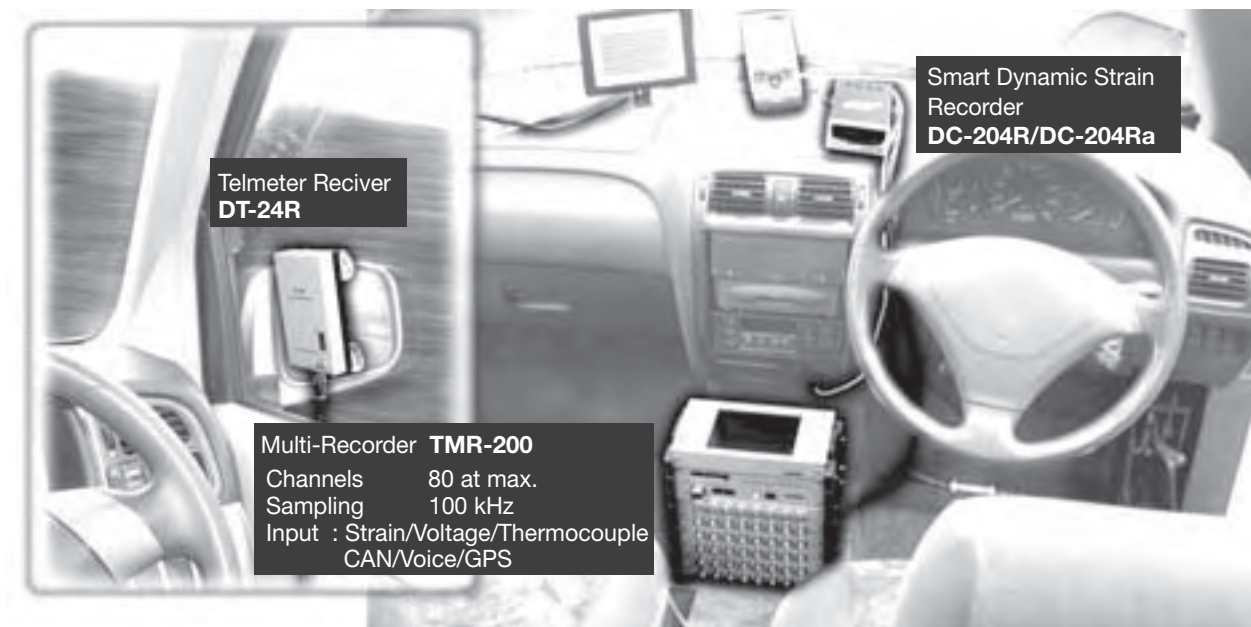


Unit: mm

Specifications

	MLA-1KNA
Capacity	1kN
Rated output	1mV/V (2000 x 10 ⁻⁶ strain) ±10%
Non-linearity	0.3%RO
Hysteresis	0.3%RO
Temperature effect on zero	0.1%RO/°C
Temperature effect on span	0.05%/°C
Compensated temperature range	-10 ~ +60 °C
Temperature range	-10 ~ +60 °C
Over load	150%
Input/output resistance	350Ω±1%
Recommended exciting voltage	5V or less
Allowable exciting voltage	10V
Zero balance	10%RO
Input/Output cable	φ6mm 0.08mm ² 4-core shielded polyurethane cable 4m
Weight	250 g.

Vehicle onboard measurement with Multi-Recorder TMR-200



The above is a conceptual photo of taking vehicle onboard measurements using the telemeter. The actual installation position of the Receiver DT-24R may differ.

Measuring system used: Multi-Recorder TMR-200
Smart Dynamic Strain Recorder DC-204R/-204Ra

The system to measure wheel torque using the Multi Recorder TMR-200 series is comprised of the Digital-Telemeter Wheel Torque Measuring System LTW-ND as the measurement sensor, the Receiver DT-24R and the Telemeter I/F Unit TMR-252 for receiving radio waves, the Control Unit TMR-211 for recording measurements, and a computer for waveform processing. The Wheel Torque Measuring System in which a transmitting unit

is built-in wirelessly sends measurements after digitally converting them. The receiver can be installed in the passenger car, requiring no cables to be routed from the outside of the car. Using the Display Unit TMR-281 allows touch-panel operation. Additionally, combining a strain measuring unit and a thermocouple unit would build a system that meets your needs.

- **Wirelessly receive data in the car, requiring no cable from outside to inside the passenger car**
- **Easy installation into the passenger car**
- **Easy to change between the telemeter unit and slip-ring unit**
- **Even installs into passenger car types with wheels 14 inches diameter or more using the special rim and hub adapter**
- **The waterproof structure allows it to be used in the rain**
- **Telemeter I/F Unit TMR-252 is connected to the Multi-Recorder TMR-200 series - Excellent expandability**

SYSTEM

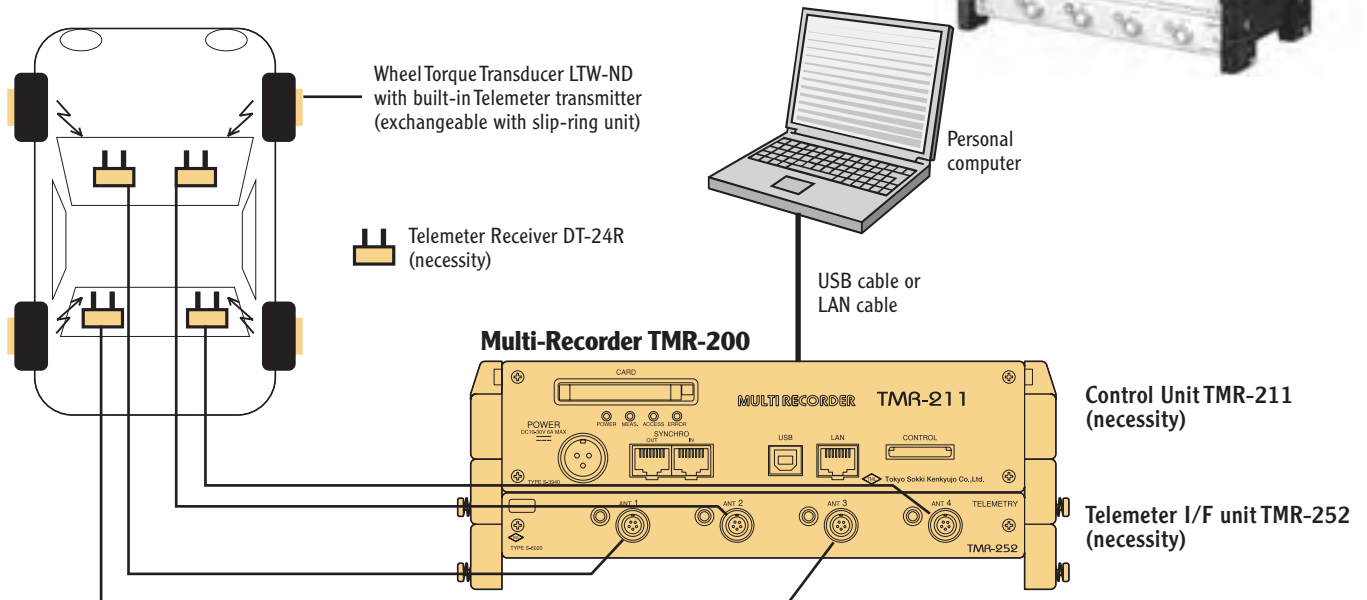
The necessary reception units are the Control Unit TMR-211, Telemeter I/F Unit TMR-252, and Telemeter Receiver DT-24R. Additionally, connecting other units such as the Multi-Recorder TMR-200 series can expand the system into a setup that meets users' needs.

The next page introduces onboard measuring system examples. Other combinations than those shown in these examples are available; a strain 4-gauge unit and a voltage/thermocouple unit can also be used together.

Vehicle onboard measurement with Multi-Recorder TMR-200

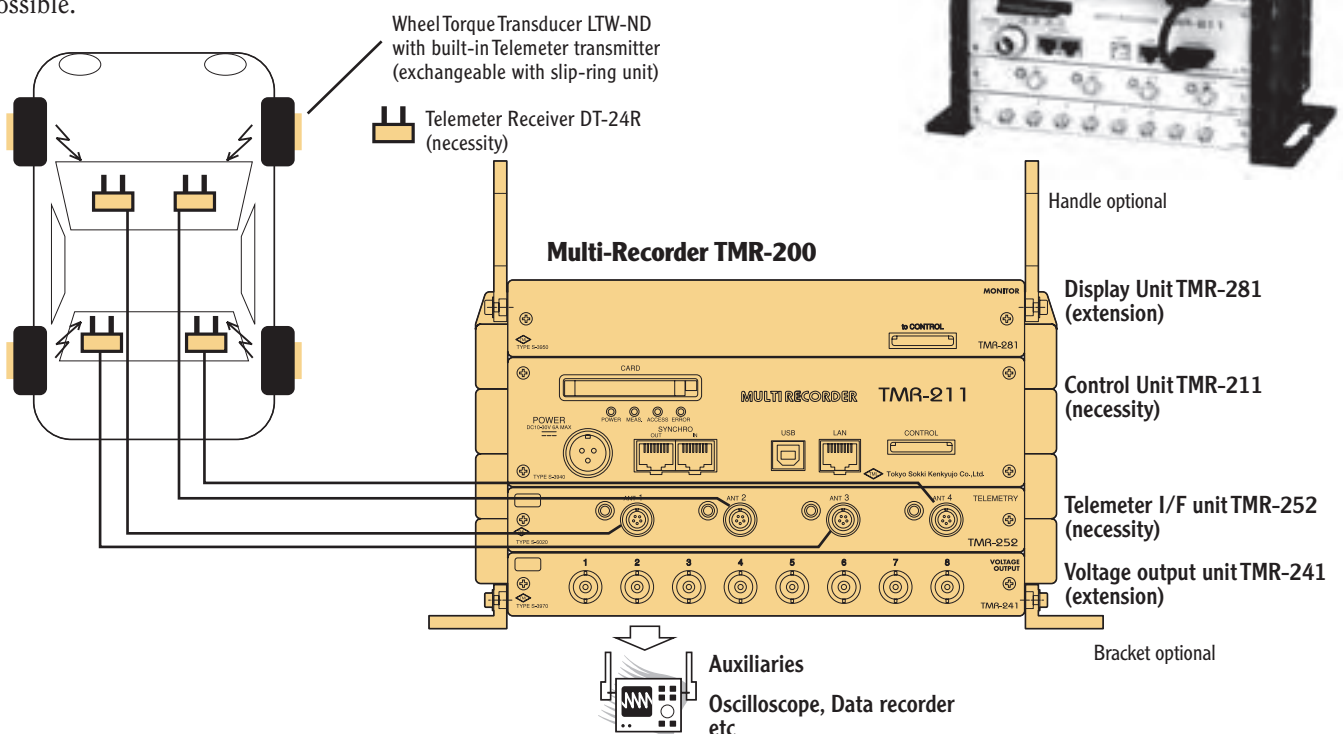
(Example 1) Bare-bones structure using a PC

- User interfaces are controlled through the exclusive PC software on a separately prepared PC.
- The minimum-required structure allows for a low initial installation cost.
- Digital data can be recorded to the Control Unit's CF card and to the PC.



(Example 2) All-in-one structure with voltage output

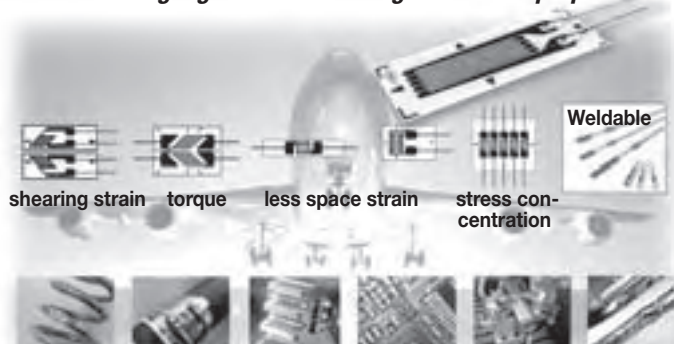
- The Display Unit TMR-281 and the Voltage Output Unit TMR-241 are additionally connected to the system shown in (Example 1) to establish a system allowing user-interface operation and waveform recording to be controlled all at once.
- The use of the Voltage Output Unit allows connection to external devices such as an oscilloscope or recorder.
- Even in this setup, digital data recording to the Control Unit's CF card is possible.



Miniature strain gauge application

The need for the measurement of strength in test and research fields wherein miniature and light weight is an important factor has been growing. TML strain gauges have been used as a means of measuring directly the strength of a specimen. The strain gauges introduced below have much demand in automobile, aircraft and industrial machinery fields.

Various strain gauge series according to versatile purposes



Ultra-miniature strain gauge measurement in less space area

F series	-20 ~ + 80 °C
UF series	-20 ~ +150 °C
EFLK/EFLX	-20 ~ +300 °C

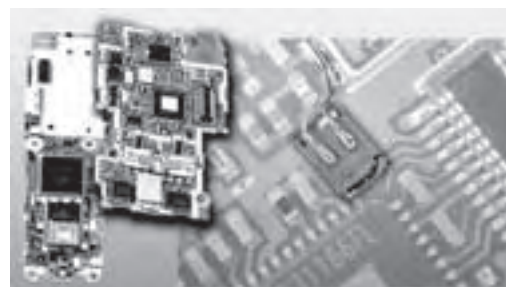
Printed circuit boards and surface mounting parts of automobile, computers and industrial machinery have become small. The following miniature strain gauges can be installed in a very limited gauge installation area.

Compensated temperature range

F series	+10 ~ + 80 °C
QF series	+10 ~ +100 °C
ZF series	+10 ~ +300 °C

Bonding adhesive applicable

CN	(-20 ~ +120°C)
EB-2	(-20 ~ +150°C)
C-1	(-20 ~ +200°C)
NP-50	(-20 ~ +300°C)



Gauge patterns	Configuration	Gauge type name	Active gauge(mm) length width	Backing (mm) length width	Resistance (Ω)
FLA-03 UFLA-03 (x3)	Single axis	FLA-03	0.3 1.4	3.0 2.0	120
EFLK-02 (x3)		UFLA-03	0.3 1.4	3.0 2.0	120
EFLX-02 (x3)		EFLK-02	0.2 0.8	1.6 1.2	120
		EFLX-02	0.2 0.8	1.8 1.2	120

Shearing strain/Torque measurements

QFLT [QF series] -20 ~ +200 °C

The gauges measure strains in 45-degree direction generated by shearing stress. The narrow gauge size is suitable for fine spring. The polyimide resin backing makes the use in temperatures up to 200°C possible. Standard self-temperature-compensation is for materials with a linear expansion coefficient of $11 \times 10^{-6}/^{\circ}\text{C}$, but self-compensated strain gauges for other materials can be manufactured to order.

Compensated temperature range
+10 ~ +100 °C

Bonding adhesive applicable

CN	(-20 ~ +120°C)
C-1	(-20 ~ +200°C)
NP-50	(-20 ~ +200°C)



Gauge patterns	Configuration	Gauge type name	Active gauge(mm) length width	Backing (mm) length width	Resistance (Ω)
QFLT-05A (x3)	Single axis Shearing strain	QFLT-05A-11	0.5 0.66	4.0 1.3	120
QFLT-05B (x3)		QFLT-05B-11	0.5 0.66	4.0 1.3	120
QFLT-1A (x3)		QFLT-1A-11	1 1.1	5.7 2.0	120
QFLT-1B (x3)		QFLT-1-350A-11 -002LE*	1 1.1	5.7 2.0	350
		QFLT-1B-11	1 1.1	5.7 2.0	120
		QFLT-1-350B-11	1 1.1	5.7 2.0	350
		*Gauge lead -002LE : Polyimide cable 2 cm attached			

Miniature strain gauge applications

Special specimen materials



Strain gauges can be used for composite materials such as CFRP and special materials such as ceramics, glass and plastics as well as metallic materials. The following strain gauges and adhesives are recommended for such applications.



Applicable specimen	Gauge series	Applicable thermal expansion (ppm/°C)	Operating temperature	Bonding adhesive
Composite	BF series	3, 5, 8	-20 ~ +200°C	CN, NP-50
	UF series	3, 5, 8*	-20 ~ +150°C	CN, NP-50, EB-2
	QF series	3, 5, 8*	-20 ~ +200°C	CN, NP-50, C-1
Glass	F series	8	-20 ~ + 80°C	CN, NP-50, EB-2
Plastics	GF series	50, 70	-20 ~ + 80°C	CN
Ceramic	QF series	3, 5, 8*	-20 ~ +200°C	CN, NP-50, C-1
	F series	3, 5, 8*	-20 ~ + 80°C	CN, NP-50, EB-2
	CF series	3, 5, 8*	-269 ~ + 80°C	CN, EA-2A, C-1
Magnesium alloy	QF series	28	-20 ~ +200°C	CN, NP-50, C-1

* Operating temperature depends on bonding adhesive.

* For the type of strain gauge and specifications, please consult us or TML distributors.

Axial force measurements

FLK type [F/QF/ZF series]

F series -20 ~ + 80°C

QF series -20 ~ +200°C

ZF series -20 ~ +300°C

The FLK type strain gauge with narrow gauge width is adequate for installation in an axial direction of bolt screw, fine pipe and round bar. The F, QF and ZF gauge series can be selected according to usage environments. Standard temperature compensation for the QF and ZF series is for materials with a linear expansion coefficient of $11 \times 10^{-6}/^{\circ}\text{C}$, but self-temperature compensation for other materials is available on request.

Compensated temperature range

F series +10 ~ + 80°C

QF series +10 ~ +100°C

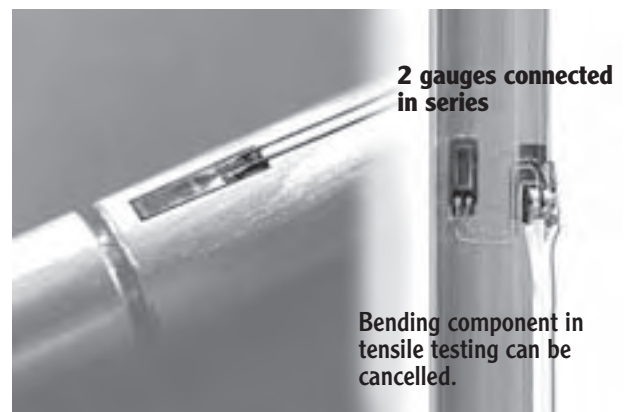
ZF series +10 ~ +100°C

Bonding adhesive applicable

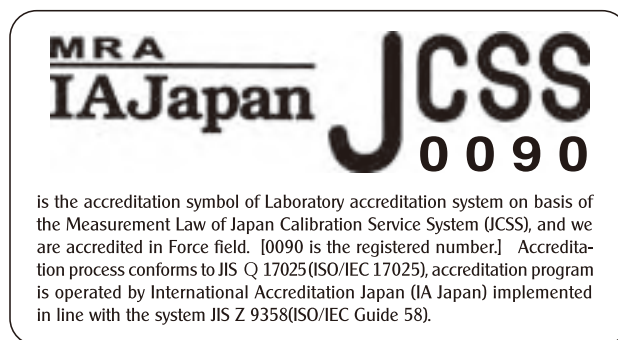
NP-50 (-20 ~ +300°C)

C-1 (-20 ~ +200°C)

CN (-20 ~ +120°C)



Gauge patterns	Gauge series	Gauge type name fundamental	Active gauge(mm) length width	Backing (mm) length width	Resistance (Ω)
 FLK-1 QFLK-1 (x3)	F series	FLK-1	1 0.7	4.5 1.4	120
		FLK-2	2 0.9	5.5 1.5	120
		FLK-6	6 1.0	11.2 2.2	120
 FLK-2 QFLK-2 (x3)	QF series	QFLK-1	1 0.7	4.5 1.4	120
		QFLK-2	2 0.9	5.5 1.5	120
		QFLK-6	6 1.0	11.2 2.2	120
 ZFLK-2 (x3)	ZF series	ZFLK-2	2 0.5	5.4 1.4	120



Tokyo Sokki Kenkyujo Co., Ltd.
www.tml.jp/e

8-2, Minami-Ohi 6-Chome, Shinagawa-Ku, Tokyo 140-8560, JAPAN
TEL: Tokyo 03-3763-5611 FAX: Tokyo 03-3763-5713

e-mail address: sales@tml.jp