DEFINING PRECISION

Technical Lexicon

Terms from

Force and torque measurement technology

and

GTM data sheets

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Introduction

In this technical lexicon, you will find explanations for terms used in force and torque measurement technology. Many of these terms have been taken from corresponding standards and directives. Since such documents are not always consistent in their usage of these terms, we have compiled this lexicon in order to provide you with easy-to-understand definitions of the terms you will find in GTM data sheets, calibration certificates, operating manuals and product descriptions.

The sources used for these definitions include the International Vocabulary of Metrology (VIM), DIN EN ISO 376, DIN 51309, and VDI/VDE/DKD 2638 and 2639. We have modified the definitions from these sources where appropriate.

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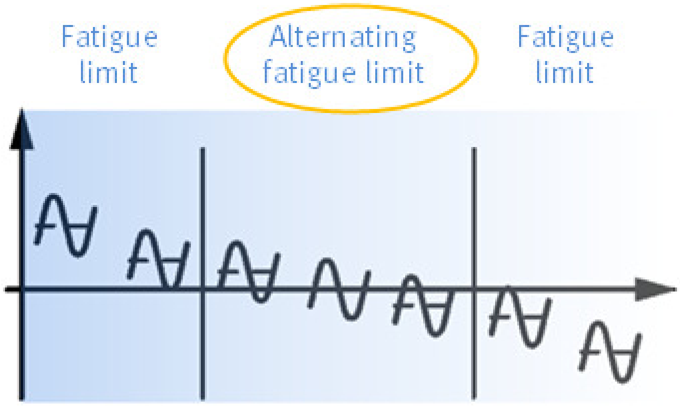
Accuracy class

The accuracy class allows a rough classification of certain GTM products. Unless specified otherwise, it represents the → linearity error for specifications based on a full scale value, and the → interpolation error for specifications based on an actual value. The term → classification is used to refer to accuracy classes defined in standards or directives.

Alternating fatigue limit

Amplitude of a stress with an overlaid average load that a transducer bears without breaking throughout a period of an infinite number of load applications. The average load is smaller than the amplitude of the stress, meaning that each stress application alternates between tensional and compressive force, or clockwise and anti-clockwise torque. The alternating fatigue limit can be determined using calculation aids or diagrams, depending on the transducer series in question. Data sheets specify the → permissible oscillation stress.



Anti-fatigue screws

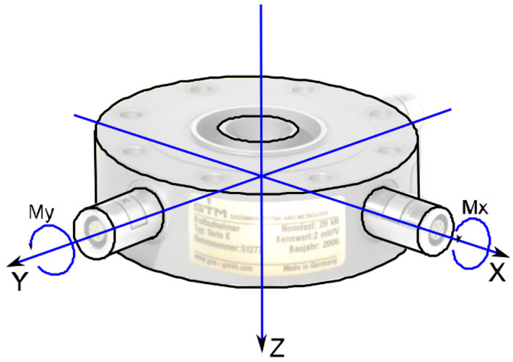
Anti-fatigue screws are special screws designed for dynamic applications. The waisted screws have much greater elasticity than rigid screws, and can offer advantages for pulsating or bending stresses.

Average load

The static portion of a dynamic load.

Bending moment

The specialist term for a → moment that generally leads to deformation along a specific axis. For example, a bending moment causes bending in an axis, while a → torque causes the axis to rotate.
In practice, bending moments frequently occur together with transverse or eccentric forces, though these do not constitute prerequisites for a bending moment.
The term "bending moment" indicates that this variable does not represent the main component of a transducer, but rather a secondary component or interference component that needs to be measured. Depending on their design, force and torque transducers can be equipped with additional bending moment measuring bridges.



Bending moment influence

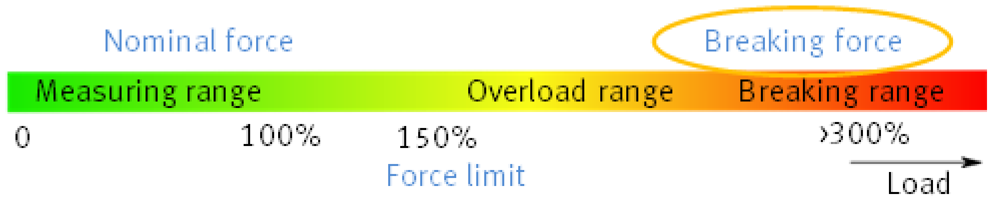
The deviation of the output signal of a transducer due to an applied bending moment. In torque transducers, for example, these would be moments generated during installation of the transducer and applied vertically to the torque axis. In force transducers, for example, these would be moments caused during tensional force measurements by a transducer not having been installed axially (→ eccentricity influence). The relative bending moment influence is based on the full scale value.

Bending moment limit / effect

The bending moment limit is the permissible static bending moment that can be used to load a force or torque transducer without significantly and permanently altering its properties. If the bending moment limit is exceeded, permanent alterations may occur. The effect of the bending moment can be defined by the → bending moment influence or → eccentricity influence, for example.
The specified bending moment limit applies solely to one applied bending moment, without further stress being applied to the transducer by forces or torques. A permissible combined load can be calculated for individual transducer series using → load diagrams or calculation aids.

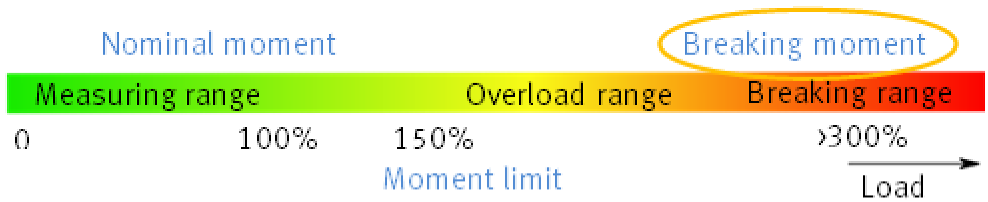
Breaking force

The breaking force is the force that is applied in the direction of the specified measurement axis of the transducer, and can cause irreparable damage on its own. The breaking load range for GTM transducers is more than 300% of the nominal force.



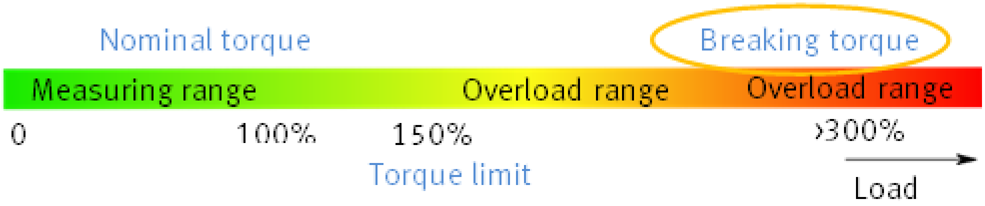
Breaking moment

The breaking moment is the moment that is applied around the specified measurement axis of a multi-component transducer, and can cause irreparable damage on its own.
When using a multi-component transducer, ensure that the breaking moments are specified for an individual effective breaking moment or for all simultaneously effective breaking moments.



Breaking torque

The breaking torque is the torque that is applied around the specified measurement axis of the transducer, and can cause irreparable damage on its own. The breaking load range for GTM transducers is typically more than 300% of the nominal torque.



Bridge resistance

The bridge resistance is the minimum resistance or the resistance range that an electronic measurement amplifier can be loaded with. As a rule, the bridge resistance is equal to the → input resistance of the connected transducer. If several transducers are connected in parallel, the bridge resistance is lower in accordance with the parallel circuit.

C

Calculation aids

→ Load diagrams

Calibration

The use of → standards to establish a relationship with the displays of calibration objects with their coordinated → measurement uncertainties.

Characteristic curve

Dependency of the transducer signal on the input variable force or moment, represented by a curve.

Characteristic value

→ Nominal characteristic value

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Characteristic value range

Range in which the characteristic value of the transducer can be found. The specification applies to transducers with unadjusted → nominal characteristic values.

Characteristic value tolerance

Tolerance in which the characteristic value of the transducer can be found. The specification applies to transducers with adjusted → nominal characteristic values. The relative characteristic value tolerance is based on the nominal characteristic value.

Classification

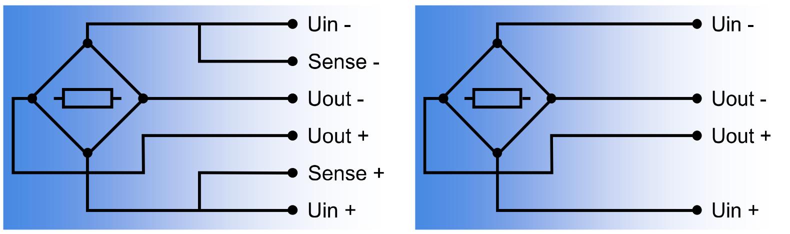
Classification specifies a class. Unlike the → accuracy class, the classification is always given based on a standard or directive, e.g. ISO 376 for force transducers, DIN 51309 for torque transducers or DKD-R 3-7 for torque transfer wrenches.

Clockwise/anti-clockwise torque characteristic value difference

Difference between the characteristic values for clockwise and anti-clockwise torque. The difference is only specified for specifications based on the full scale value if it is not covered by the → linearity error.

Connection technology

In terms of strain gauge sensors, connection technology refers to whether a six-wire connection with excitation voltage feedback or a four-wire connection is used.



Creep

Creep is the term used to refer to the change over time in the output signal with a constant load and stable ambient conditions following a prior load change. Unless stated otherwise, the specification refers to unloading creep (which is usually the same as loading creep). The relative creep is based on the difference in the load change, and is this a variable based on the actual value.

Crosstalk

The term crosstalk is often used to describe the effect of → secondary components when these are considered as → disturbance values. Crosstalk is usually specified as a relative value. Its basis is thus sometimes unclear, or physically and mathematically incorrect. As such, it is more useful to specify the → secondary component sensitivity.

Deutsche Akkreditierungsstelle (DAkkS)

The DAkkS is Germany's national accreditation body. It is an independent agency that approves, confirms and monitors the professional competence of laboratories, certification bodies and inspection authorities. Up until 12/17/2009, Germany had several accreditation authorities for various fields. However, these powers had to be transferred to a single national accreditation authority in order to comply with a regulation by the European Parliament.

Deutscher Kalibrierdienst (DKD)

Association of accredited calibration laboratories in Germany whose expert committees support → metrology by drawing up directives, exchanging information and performing intercomparisons, among other things. Up until 12/17/2009, DKD was responsible not only for the creation, promotion and maintenance of metrological infrastructure, but also acted as the accreditation authority for calibration laboratories. The latter function has now been transferred to the → Deutsche Akkreditierungsstelle (DAkkS) due to a regulation issued by the European Parliament. Since then, the DKD has continued as an association under the aegis of the Physikalisch Technischen Bundesanstalt (PTB).

Disturbance value

On single-axis transducers: → parasitic loads; on multi-component transducers: → crosstalk.

Drift

Continuously changing sensitivity of a transducer or an electronic measurement amplifier. The term “zero point drift” is also commonly used; this refers to a continuously changing zero point.

Durability

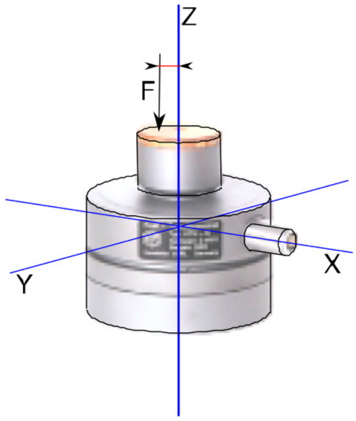
Amplitude of fluctuating stress that a transducer bears without breaking throughout a period of an infinite number of load applications. Overlaying a static → average load alters the durability; depending on the size of the average load, this leads to either the → fatigue limit or the → alternating fatigue limit. The durability can be determined using calculation aids or diagrams, depending on the transducer series in question. Data sheets specify the → permissible oscillation stress.

Eccentricity

→ Permissible eccentricity

Eccentricity influence

The eccentricity influence describes the change that occurs in the output signal of the transducer if the force input is offset against the measurement axis (→ bending moment influence).



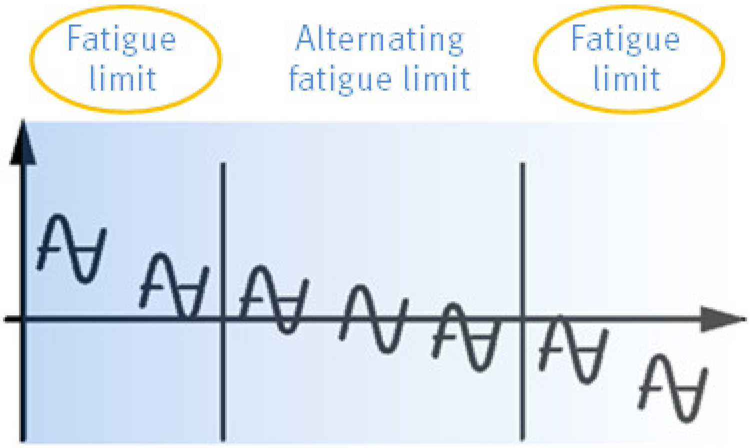
Excitation voltage

Voltage an electronic measurement amplifier supplies to the connected transducers.

F

Fatigue limit

Amplitude of a stress with an overlaid average load that a transducer bears without breaking throughout a period of an infinite number of load applications. The average load is equal to or greater than the amplitude of the stress. The fatigue limit can be determined using calculation aids or diagrams, depending on the transducer series in question. Data sheets specify the → permissible oscillation stress.



Finite time fatigue strength

Load in the fatigue endurance test that causes a breakage within around 10^7 load cycles. The → durability is above this threshold.

Force application

Refers to the way in which a force is properly applied in a transducer using various attachments. Proper application is when unwanted influences on the line-volatile → vector are minimised during single-axis force measurement.

Force measurement range

The force measurement range specifies the measurement range of a force transducer for which the technical measurement specifications are valid. Each measurement range has a start and end value.

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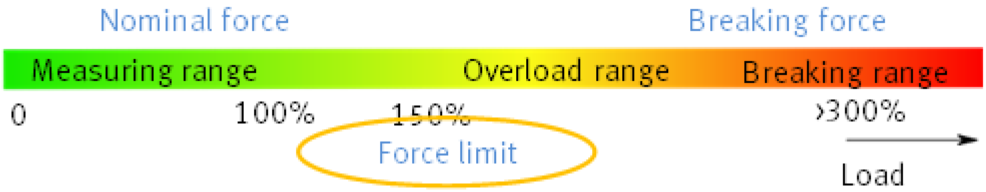
Force limit

The force limit is the largest force that can be applied to the transducer in the direction of its specified measurement axis without causing significant mechanical deformation or altering the zero signal. If the force limit is exceeded, this may result in permanent changes in the form of an alteration to the zero signal or mechanical deformation (offsetting of the characteristic curve).



Fundamental resonance frequency

The frequency at which the unloaded transducer without attachments vibrates, following an impact in the direction of the measurement axis.

Geometry matrix

The geometry matrix describes the geometrical arrangement of the individual transducers in a multi-component system, and forms the first calculation stage. For example, the columns in the matrix may contain the forces and moments in the Cartesian coordinate system, while the rows represent seven individual transducers. The values are scaled or subjected to unit conversion. The elements in the matrix can take values between -1 and 1.
The results of the calculation stage are unscaled measurements based in the desired coordinate system, e.g. the three forces and three torques in the Cartesian coordinate system in mV/V. The next calculation stage is characterised by the → main characteristic value matrix.

Head mass

→ Proportional moving mass

Hysteresis

Specifies the maximum difference between the values displayed at the same load level when the load is increasing and decreasing, if a load cycle is performed up to the nominal load. The relative hysteresis is based on the full scale value. In principle, the relative → reversibility error is the same physical property, but based on the actual value.

I

Input resistance

Ohmic resistance of the transducer, measured at the connection lines for the excitation voltage.

Input signal range

Permissible input voltage of an electronic measurement amplifier.

Insulation resistance

The insulation resistance is the ohmic resistance between the connection lines of the transducer and the metal transducer body.

Integration time

Active time of a filter, e.g. the time over which an average is taken from regularly sensed measurements.

Interpolation error

The interpolation error defines the maximum deviation of the display value from an interpolation value whose interpolation equation is determined using the least-squares method. Unless otherwise specified, a third-order interpolation equation is used whereby the zero value of the function is congruent to the coordinate origin (polynomial without constant element). The relative interpolation error is based on the actual value.

L

IP-code

The IP-code specifies the prevailing conditions under which the transducer can be operated. The protection classification is based on DIN EN 60529.

Linearity error

In case of increasing load, the linearity error is the maximum error of the display value of a reference straight line whose gradient is determined using the least-squares method. In transducers with only one load direction (e.g. only compression force transducers), the straight line runs through the coordinate origin. In transducers with an alternating load direction, the reference straight line equation contains a constant element. Accordingly, the same definition applies for electronic measurement amplifiers. The linearity error is based on the full scale value.

Load diagrams

Load diagrams or calculation aids provide information on the permissible load limits for force or torque transducers when multiple forces and moments are applied in different load directions. When compared to static load limit values, this offers the advantage of being able to select the best transducers for each specific load case. The load diagrams are available for selected transducer series.

Load level

Force or torque value that is applied during a measurement in the transducer and maintained at a constant level for a certain period of time.

Longitudinal force limit

The longitudinal force limit is the largest permissible static force that can be applied to a torque transducer in the direction of its specified measurement axis without causing significant, permanent changes to its properties. If the longitudinal force limit is exceeded, permanent alterations may occur.
The specified longitudinal force limit applies solely to one applied longitudinal force, without further stress being applied to the transducer by forces or torques. A permissible combined load can be calculated for individual transducer series using → load diagrams or calculation aids.

Main characteristic value matrix

The main characteristic value matrix is the second stage (after the → geometry matrix) in the calculation of multi-component systems, and is used for linear scaling and unit conversion. As a rule, the forces and moments are scaled on a linear basis in the Cartesian coordinate system with the input unit mV/V using the least-squares method, and output as forces and moments with the units ‘N’ and ‘N·m’. The main characteristic value matrix thus contains parts of the geometrical relations (e.g. lever arm lengths) and the sensitivities of the individual transducers, and is in many cases sufficient for the purpose of characterising multi-component systems.
If demands are more stringent, the next stage in the calculation can be completed using a → sensitivity matrix.

Main component

The main component is the component determined by the corresponding multi-component measurement circuit. For example, the load F_z is the main component for the F_z measurement circuit. All other loads are → secondary components.

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Main component sensitivity

Characterising values of the quotients of output signal change and input variable change in multi-component systems, based solely on the main components. In Cartesian coordinate systems, for example, there are up to six main component sensitivities for the measurement circuits F_x, F_y, F_z, M_x, M_y, M_z.
The transfer behaviour from the → secondary components is described by the →secondary component sensitivity.

Mass

Total mass of the transducer, generally without attachments. The masses of the attachments are included if a mass specification without attachments would not be useful for design purposes (e.g. transfer standards with bolt-on compression plates).

Measurement uncertainty

Parameter indicating the value distribution of a measurement variable, taking into account systematic effects, static distribution of the measurements under defined conditions, experience and other information.

Measurement uncertainty matrix

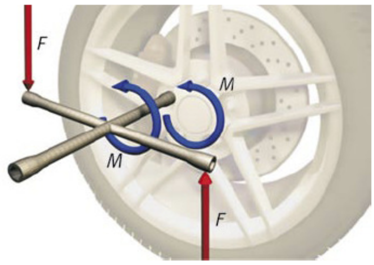
Expansion of the measurement uncertainty specification for multi-component systems, developed by GTM. The measurement uncertainty matrix has four matrices that contain the parameters for calculation of the measurement uncertainty when the multi-component system is under any load, even for zero-crossings of the individual components.

Metrology

The science of measurement and its application, taking into account theoretical and practical points of view.

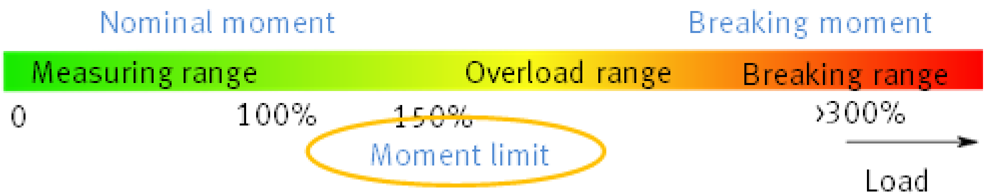
Moment

General term used to describe the effect of force vectors on radius vectors. Moments are space-volatile → vectors. The general term "moment" is used for specifications for multi-component transducers.
→ torques and → bending moments, on the other hand, are special definitions for specific transducer applications.



Moment limit

The moment limits are the largest moments that can be applied to a multi-component transducer in the direction of its specified measurement axis without causing significant mechanical deformation or altering the zero signal. If the moment limits are exceeded, this may result in permanent changes in the form of an alteration to the zero signal or mechanical deformation (offsetting of the characteristic curve).
When using a multi-component transducer, ensure that the moment limits are specified for an individual effective moment limit or for all simultaneously effective moment limits.



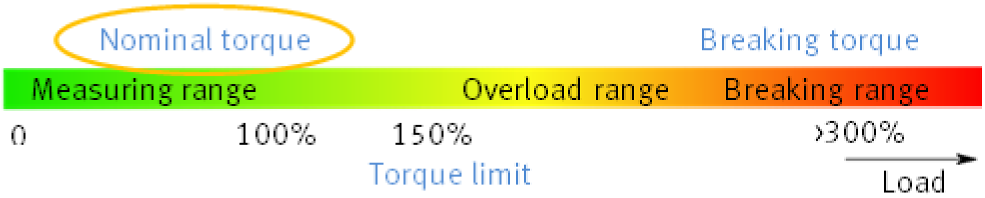
N

Nominal acceleration

The nominal acceleration is the greatest acceleration for which the acceleration transducer is nominally designed. The transducer will maintain its technical measurement specifications up to its nominal acceleration.

Nominal torque

The nominal torque is the greatest torque for which the torque transducer is nominally designed. The transducer will maintain its technical measurement specifications up to its nominal torque.



Nominal bending moment

The nominal bending moment is the greatest moment for which a force or torque transducer is nominally designed. The transducer will maintain its technical measurement specifications for bending moment measurement up to its nominal bending moment.

Nominal sensitivity

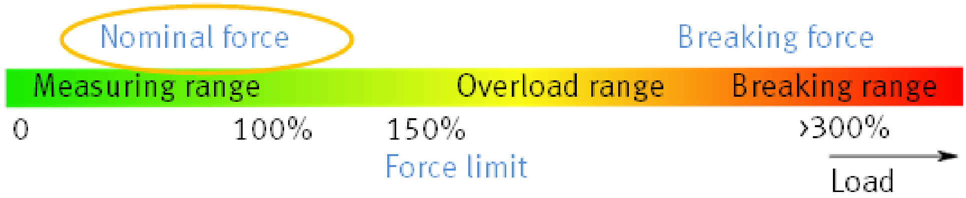
Characteristic target value of the quotient for output signal change and input variable change.

Nominal characteristic value

Characteristic target value of the output signal under nominal load, reduced by the zero point for unloaded transducers. The → characteristic value tolerance applies to adjusted nominal characteristic values, and the → characteristic value range applies to unadjusted nominal characteristic values.

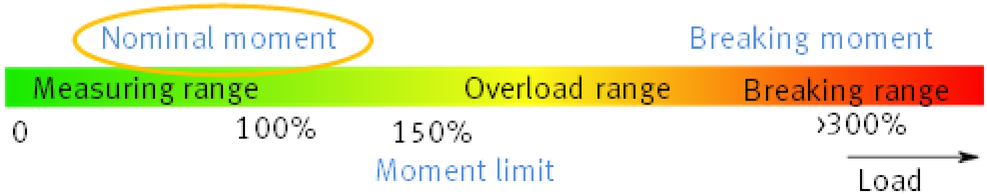
Nominal force

The nominal force is the greatest force for which the force transducer is nominally designed. The transducer will maintain its technical measurement specifications up to its nominal force.



Nominal moment

The nominal moment is the greatest moment for which multi-component transducer is nominally designed. The transducer will maintain its technical measurement specifications up to its nominal moment.



Nominal temperature range

The nominal temperature range defines the ambient temperature range within which the transducer maintains the technical specifications and error limits.

Noise

In terms of an electronic measurement amplifier, noise refers to the overlay of disturbance values with an unspecific frequency spectrum. In the GTM data sheets, noise is defined with a triple standard error, so 99.7% of the measurements are within the noise band.

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Operating range of the excitation voltage

The excitation voltage range within which the transducer can be operated and the specified technical data is observed. For calibrated transducers, the excitation voltage selected during calibration should always be used.

Operating temperature range

The operating temperature range defines the ambient temperature range that permits operation of the transducer within larger limits of error without causing significant alterations to its properties that may be detected when it is later used within the nominal temperature range.

Oscillation stress

→ Permissible oscillation stress

Output resistance

Ohmic resistance of the transducer, measured between the connection lines for the measuring voltage.

Parasitic loads

For single-axis transducers, the term parasitic loads refers to all forces and moments that are applied in addition to the specified measurement axis (→ bending moment influence, → torque influence, → eccentricity influence, → transverse force influence).

Permissible eccentricity

The permissible eccentricity for a force transducer is the permissible parallel offset of the force line of action from the measurement axis without significantly and permanently altering the properties. The effect of the eccentricity is described by the → eccentricity influence or the → bending moment influence, for example.

Permissible oscillation stress

Stress range of a sinusoidal pulsating or alternating load borne by the transducer over more than 10^7 load cycles without causing a significant change in its technical measurement properties. The stress range is based on the full scale value.

Proportional moving mass

Portion of the transducer's mass whose movement in dynamic use generates additional forces of inertia (synonym for head mass). The GTM data sheets specify a theoretically calculated value for initial orientation; this may differ from practically calculated values. Practically calculated values do not always match, either. Different proportional moving masses may result after each test, e.g. impact or periodic load.

R

Rated displacement

The rated displacement is the movement of the force application surfaces of the transducer when the nominal load is applied in the direction of the measurement axis.

Rated torsion angle

The rated torsion angle is the torsion angle of a torque transducer covered by the contact surfaces of the transducer when the nominal load is applied vertical to the measurement axis.

Reference coordinate system

A coordinate system that is referred to by the output variables of a multi-component system during a calibration. Since the coordinates in the multi-component calibration standard and the calibration object usually have different origins, the coordinates must be transformed in order to calculate the true forces and moments. The agreed coordinate system is the reference coordinate system. This is usually done using the coordinate system of the calibration object. The reference coordinate system is thus not automatically the coordinate system of the calibration standard.

Reference transducer

Transducer that embodies the measurement in a measuring device (usually stationary). The transducer is normally fixed in place, or can be easily replaced with other reference transducers with other measurement ranges.

Repeatability

Synonym for → repeatability in unchanged mounting position

Repeatability in unchanged mounting position

The maximum difference in the display values under the same load level, determined using several subsequent series of measurements in the same mounting position. The relative repeatability in unchanged mounting position is based on the actual value. However, the → relative reproducibility, which is defined in a similar way, is based on the full scale value.

Reproducibility

Synonym for → reproducibility in different mounting positions

Reproducibility

The maximum difference in the display values under the same load, determined using several subsequent series of measurements under the same conditions. The relative reproducibility is based on the full scale value. However, the → repeatability in unchanged mounting position, which is defined in a similar way for transducers, is based on the actual value.

Reproducibility in different mounting positions

The maximum difference in the display values under the same load level, determined using several series of measurements in different mounting positions. The different mounting positions are achieved by rotating the transducer to three or four positions on the measurement axis. The relative reproducibility in different mounting positions is based on the actual value.

Resolution

Resolution is the smallest difference between two digital measurements. It is mainly, though not exclusively, determined by the resolution of the A/D conversion. On measurement amplifiers with digital displays, the limiting parameter is often the resolution of the digital display. The resolution values specified in the data sheets differ from the physical resolution, which must be obtained using the → noisy signal.

Reversibility

Specifies the maximum difference between the values displayed at the same load level when the load is increasing and decreasing, if a load cycle is performed up to the nominal load. The relative reversibility is based on the actual value. In principle, the relative → hysteresis is the same physical property, but based on the full scale value.

S

Sampling rate

The sampling rate is the fastest possible scanning of a digital electronic measurement amplifier via a digital or analogue interface. It serves as an indication of how quickly measurements from a measurement chain are made available at the output. The internal sampling rate of the measurement amplifier is usually large by more than one power of ten. For dynamic measurements, the sampling rate specified in the data sheets must be at least twice as high as the frequency of the input variable expected for the measurement.

Secondary component

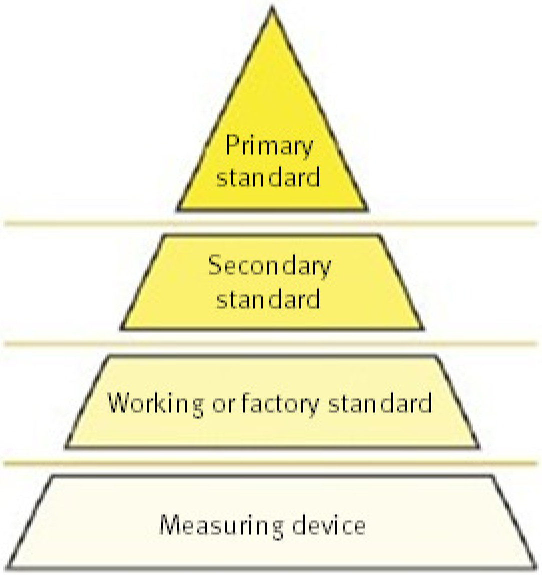
Secondary components are all components that cannot be recorded using a corresponding multi-component measurement circuit. For example, the loads F_x, F_y, M_x, M_y, M_z are the secondary components for the F_z measurement circuit. The load F_z is the→ main component.

Secondary component sensitivity

Characterising values of the quotients of output signal change and input variable change in multi-component systems, based on the secondary components. In Cartesian coordinate systems, for example, there are up to 30 secondary component sensitivities for the measurement circuits F_x, F_y, F_z, M_x, M_y, M_z.
Specification of the secondary component sensitivities offers an advantage over specification of the → crosstalk in terms of the clarity of the unit based specifications, and the ability to minimise measurement uncertainty by taking into account the secondary component sensitivities.
The transfer behaviour from the → main components is described by the → main component sensitivity.

Secondary standard

Standard in a location or at an organisation from which measurements can be derived there. A secondary standard can generally be traced back to a → primary standard, and is monitored by an accreditation authority.



Sensitivity

→ Nominal sensitivity

Sensitivity matrix

For definition, see distinctions in → geometry matrix, → main characteristic value matrix and → susceptibility matrix.

Signal propagation time

The signal propagation time specifies how long an electronic measurement amplifier needs under favourable conditions in order to supply a measurement signal that is present at the input as an output variable at the digital or analogue output.

Span with different lever arms

Part of the specification for torque transfer wrenches. The span with different lever arms refers to the influence of the transverse force, and defines the maximum difference between the display values with the same torque but different lever arms, and thus different transverse forces. The relative span in with different lever arms is based on the actual value.

Spring rigidity

Relationship between the force and axial deformation in force transducers.

Standard

Physical realisation of a variable definition with specified variable value and co-ordinated measurement uncertainty. A distinction is made between international standards (approved by international agreement for worldwide use) and national standards that embody the value definition for a country or economy. Together, → transfer standards, → secondary standards and → working standards form a broad metrological infrastructure.

Temperature influence on the characteristic value (TK_C)

The temperature influence on the characteristic value is the change in transducer sensitivity caused by a 10 K change in the temperature. Essentially, this is the result of a change in the modulus of elasticity of the spring material. The relative temperature influence on the characteristic value is based on the actual value, and only applies to stationary, gradient-free temperature conditions.

Temperature influence on the zero signal (TK_0)

The temperature influence on the zero signal is the change in transducer zero signal caused by a 10 K change in the temperature. The largest influencing factor are changes in the electronic resistance within the measuring bridge. The relative temperature influence on the zero signal is based on the full scale value, and only applies to stationary, gradient-free temperature conditions.

Tensile/compressive force characteristic value difference

Difference between the characteristic values for tensile and compressive forces. The difference is only specified for specifications based on the full scale value if it is not covered by the → linearity error.

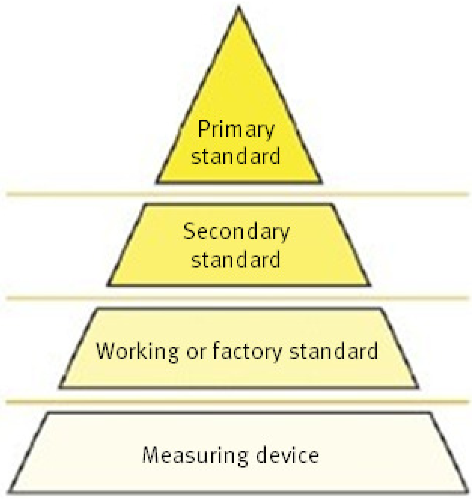
Transducer

Force, torque and multi-component transducers supply an output variable which relates specifically to the input variable (force or moment). Strain gauge based transducers usually excitation voltage as the output variable. This is specified in relation to the → excitation voltage [mv/V].

Transfer standard

Transducer that is used as an intercarrier for the comparison of standards. The requirements for transfer standards increase with the hierarchy of the standard. A distinction is made between the following comparisons:

- Standard - standard (requirement: VN class),
- Reference standard - standard (requirement e.g. class 00 in accordance with ISO 376),
- Working standard - standard (requirement e.g. class 0.5 in accordance with ISO 376)

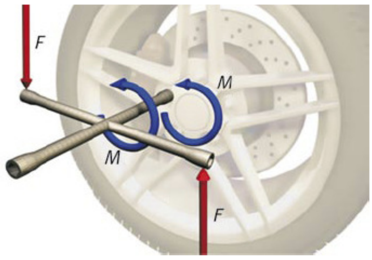


Transverse force influence

The error of the output signal caused by the application of a transverse force. In torque transducers, for example, such transverse forces may be generated by non-volatile axes. This usually also causes another bending moment. In the case of torque transfer wrenches, the presence of transverse forces is intrinsic to the system. However, the influence should preferably be kept as low as possible (→ span with different lever arms). In force transducers, transverse forces are often generated by deformations in the adjacent test constructions. The relative transverse force influence is based on the full scale value.

Torque

The specialist term for a → moment that generally leads to rotation along a specific axis, as opposed to a → bending moment, which bends the axis.
In the field of torque measurement technology, a distinction is made between "pure" torques (e.g. rotating torque transducers) and torques under the effect of a transverse force (e.g. torque transfer wrenches).
The term "torque" indicates that this variable represents the main component of a (usually single-axis) torque transducer.

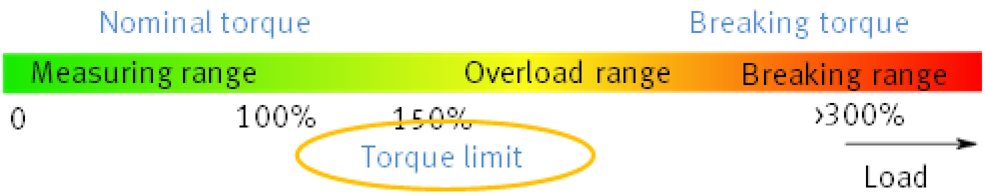


Torque influence

The error of the output signal of a force transducer due to a torque being applied around the measurement axis. The relative torque influence is based on the full scale value.

Torque limit

The torque limit is the largest torque that can be applied to the transducer in the direction of its specified measurement axis without causing significant mechanical deformation or altering the zero signal. If the torque limit is exceeded, this may result in permanent changes in the form of an alteration to the zero signal or mechanical deformation (offsetting of the characteristic curve).



Torque measurement range

The torque measurement range specifies the application range of torque transducers for which the technical measurement specifications are valid. Each measurement range has a start and end value.

Torsional rigidity

The relationship between the torque and torsion angle of a torque transducer.

Transverse force limit

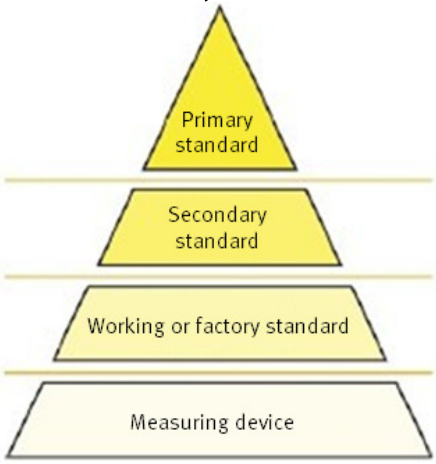
The transverse force limit is the largest permissible static force that can be applied to a force or torque transducer vertical to its specified measurement axis without causing significant, permanent changes to its properties. If the transverse force limit is exceeded, permanent alterations may occur.
The specified transverse force limit applies solely to one applied transverse force, without further stress being applied to the transducer by forces or torques. A permissible combined load can be calculated for individual transducer series using → load diagrams or calculation aids (www.gtm-gmbh.com).

Vector

What differentiates traditional force and torque measurement technology from modern multi-component measurement technology is the way in which the vector character of the physical variable is taken into account. In traditional measurement technology, → force applications and alignments must be optimised. The aim is to measure only the absolute value of the vector variable. All other components of the vector are considered → disturbance values. The aim of multi-component measurement technology, on the other hand, is to obtain not only the absolute value but also information on the alignment of the vector variables. All cases differentiate between → main components and → secondary components.
Forces are line-volatile vectors with five degrees of freedom. They can only be moved along their intended force line of action without altering the corresponding mechanical system.
Moments are space-volatile vectors with three degrees of freedom. They can be moved spatially as long as their axial directions are not altered. This means that moments can be moved either along the axis or parallel together with the axis.
Accelerations are position vectors, and apply with their alignment only in the one position.

Working standard

Standard routinely used to calibrate or verify measuring devices or systems. A working standard can generally be traced back to a → secondary standard.



Z

Zero error

The zero error is the difference between the zero points before and after a load. The relative specification is based on the full scale value.

Zero signal tolerance

The zero signal tolerance refers to the electrical detuning of the zero signal when there is no load on the transducer, without additional attachments. The relative zero signal tolerance is based on the full scale value.

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