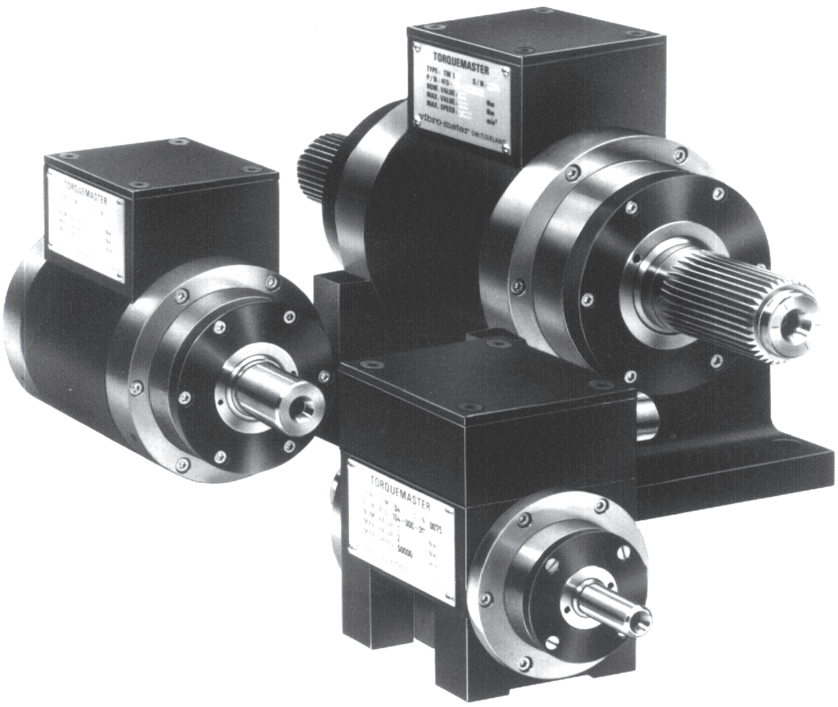
INSTRUCTION MANUAL

TORQUEMASTER
TM 200 SERIES

P/N 648.012 E

(MATM200/E)



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PREFACE

Purpose and Scope of This Manual

This manual provides reference information for the installation, calibration and use of torque transducers belonging to the TORQUEMASTER TM 200 series.

Who Should Use This Manual ?

This manual is written for operators of test rigs/monitoring systems using TORQUEMASTER TM 200 series transducers for torque and speed data acquisition.

The operator is assumed to have the necessary technical training in electronics and mechanical engineering to enable him to operate the TORQUEMASTER transducer, the associated electronics, driving element, driven element, calibration test bench, etc.

Manual Organization

This section gives an overview of the structure of the manual and the information contained within it. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The chapters of this manual are presented in a logical order. You should read those that are most relevant to you and then keep the manual at hand for future reference.

The structure of the manual is as follows :

Chapter 1 : **Safety** - Contains important information for your personal safety and the correct use of the equipment.

THIS CHAPTER SHOULD BE READ BEFORE ATTEMPTING TO INSTALL OR USE THE EQUIPMENT.

Chapter 2 : **System Overview** - Familiarizes the user with the overall system, i.e. the TORQUEMASTER unit with its complementary digital control unit (DCU 285) and the cable assembly linking the two.

Chapter 3 : **Installation, Connection and Operation** - The various transducer mounting possibilities are described here. Information is also given on maximum radial (bending) and axial (thrust) forces, as well as maximum shaft acceleration and velocity. Details on cabling the TORQUEMASTER transducer to the complementary DCU 285 digital control unit are also provided.

Chapter 4 : **Technical Description** - Describes the operation of the torque transducer and its integrated electronic circuitry. The ER 107 / ER 108 cable assembly is also described.

Chapter 5 : **Maintenance** - Informs the user what to do if the transducer bearings need to be replaced or if the entire system needs to be repaired and recalibrated.

Chapter 6 : **Specifications** - Lists the mechanical and electrical specifications of the TORQUEMASTER transducer.

Appendix A : **Drawings** - Contains diagrams showing the mechanical dimensions of the TORQUEMASTER transducer.

Appendix B **:** **Nomogram** - Can be used for quick and approximate torque-speed-power calculations.

Lexicon - Gives a definition of abbreviations and various specific terms used in this manual.

Product Defect Report - Allows the user to indicate problems observed on a module/system, thus enabling our After-Sales Service department to repair the unit as quickly as possible.

Documentation Evaluation Form - Allows the user to provide us with valuable feedback on our documentation.

Related Publications

For additional information relating to the use of the TORQUEMASTER system the reader is referred to the following publications and documents :

- TM 204 ÷ 208 Data Sheet P/N 250-019
- TM 210 ÷ 211 Data Sheet P/N 250-020
- TM 212 ÷ 213 Data Sheet P/N 250-017
- TM 214 ÷ 215 Data Sheet P/N 250-016
- TM 216 Data Sheet P/N 250-021
- DCU 285 Data Sheet P/N 202-010
- DCU 285 Quick Reference Guide P/N 648.013
- DCU 285 Instruction Manual P/N 648.014

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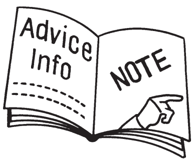
1 SAFETY

1.1 Symbols Used in This Manual

The following symbols and type styles may be used in this manual to highlight certain parts of the text :



*The **NOTE** symbol.* ☞

This is intended to draw the operator's attention to complementary information or advice relating to the subject being treated.
It introduces information enabling the correct and optimal functioning of the product to be obtained.

The CAUTION safety symbol. 

This is used to draw the operator's attention to information, directives, procedures, etc. which, if ignored, may result in damage being caused to the material being used.
The associated text describes the necessary precautions to take and the consequences that may arise if the precautions are ignored.

THE WARNING SAFETY SYMBOL. 

THIS INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTIES MAY BE PUT AT RISK.
THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AND ACT UPON IT, BEFORE PROCEEDING FURTHER.

1.2 Important Remarks on Safety

CAUTION

This instruction manual should be read carefully and the safety instructions observed before installing, calibration or using the material described herein.

1.2.1 Location of Safety Symbols in This Manual

The operator should also take note of the safety-related information found elsewhere in this manual :

This symbol is found on the following pages :
1-2 ; 5-1

This symbol does not appear in the manual

1.3 Additional Remarks on Safety

☞ *For the correct and safe use of this instrument, it is essential that both operating and servicing personnel follow generally accepted safety procedures in addition to safety precautions specified in this manual. Specific warning and caution statements, where they apply, will be found throughout the manual. These are highlighted by the corresponding warning and caution symbols (described above).*

The safety procedures should be communicated to all personnel who are liable to operate the equipment described in this manual.

No modifications, transformations or repairs should be made to the equipment without having first obtained the written permission of Vibro-Meter. Failure to observe this will invalidate the warranty.

2 SYSTEM OVERVIEW

2.1 General

The TORQUEMASTER TM 200 series constitutes Vibro-Meter's new generation of torque transducers having integrated electronic processing circuitry.

At present, the TORQUEMASTER TM 200 series encompasses transducers having the following torque ratings : 1 Nm, 2 Nm, 5 Nm, 10 Nm, 20 Nm, 50 Nm, 100 Nm, 200 Nm, 500 Nm, 1000 Nm, 2000 Nm and 5000 Nm.

Each transducer has a built-in temperature compensating circuit that assures the accuracy of the measured torque is maintained irrespective of the temperature of the transducer. The incorporated electronic circuitry also determines the direction of the shaft rotation and filters the torque signal. A built-in self test function is also present to test the measuring chain.

In addition, for most torque ratings, the customer has a choice of the transducer :

- mounting method ; suspended installation or pedestal installation

- shaft end ; smooth or splined.

2.2 Complementary Units

The TORQUEMASTER must be used in conjunction with a complementary signal processing unit and a cable assembly. The possible configurations are :

(i) TM connected to a processing unit supplied by the user (Fig. 2-1)

The user's unit performs the torque and speed signal processing.
An ER 107 cable assembly is recommended.

(ii) TM connected to a DCU 285 digital control unit (Fig. 2-2)

The DCU 285 unit (Fig. 2-3) performs the torque and speed signal processing. It also shows the measured torque and speed values and the calculated power value on a digital display.
An ER 108 cable assembly is recommended.

☞ *For further information on the DCU 285 digital control unit, please refer to its instruction manual.*

Information concerning the connection of a TORQUEMASTER transducer to a processing unit supplied by the user is given in Section 3.3.2.

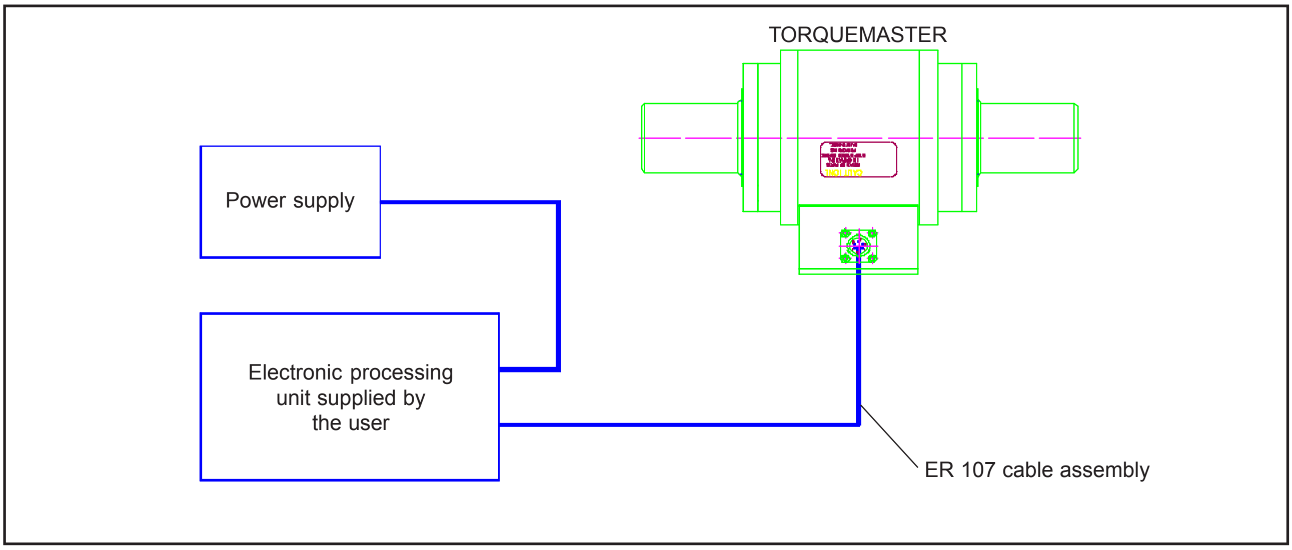


Fig. 2-1 : TM connected to a processing unit supplied by the user.

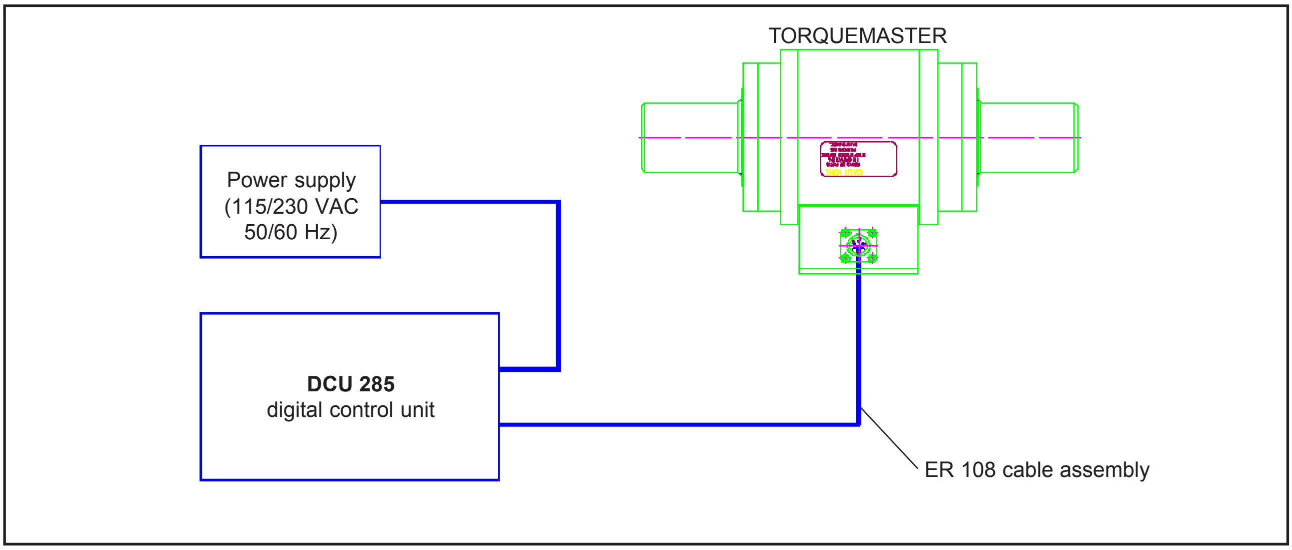


Fig. 2-2 : TM connected to a DCU 285 digital control unit.

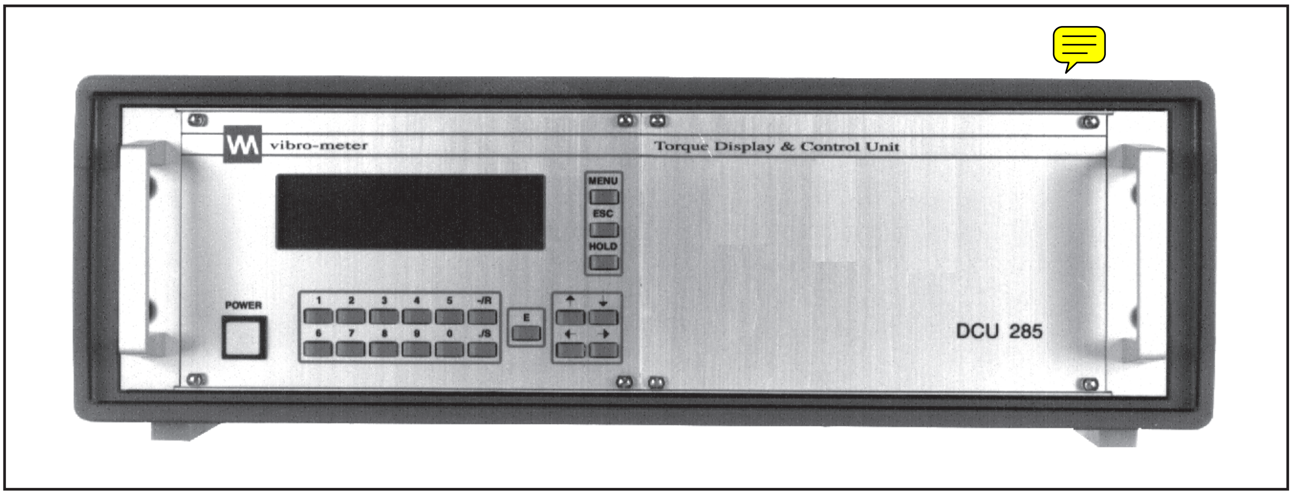


Fig. 2-3 : DCU 285 digital control unit.

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3 INSTALLATION, CONNECTION AND OPERATION

☞ *The TORQUEMASTER torque transducer should be considered as a precision measuring instrument and not only as a simple torque transmission element. The choice of coupling and quality of alignment influence considerably the measurement precision and the lifetime of the transducer and couplings.*

3.1 Standard Accessories

The transducer is normally delivered with :

- An aluminium support (for the TM 210 to TM 216 units)
- A 6-pole SOURIAU connector
- An instruction manual.

Depending on the type of mounting chosen, the aluminium support will be used to fix the transducer to the test bench (supported installation) or will be removed altogether (suspended installation).

The TM 204 - TM 208 transducers have a support integrated into the housing of the transducer. This support cannot, therefore, be removed.

The ER 107 and ER 108 cable assemblies must be ordered separately.

3.1.1 Mounting Possibilities

There are two different ways of mounting the torque transducers :

(i) Suspended Installation

In this configuration the measuring shaft and the TORQUEMASTER housing are supported by the driving and driven machine shafts via single couplings (see Fig. 3-1).

Advantages

- Cheaper (single-element couplings)
- Shorter drive train (resonant frequency in torsion of the drive train is higher than for double-element couplings)

Disadvantages

- Increased radial play as the TM is not directly secured to test bench (results in a lower critical speed than for supported installation)
- Rotational speed is limited

(ii) Supported Installation

In this configuration the measuring shaft is supported by the transducer housing, which can be bolted directly to the test bench (see Fig. 3-2).

Advantages

- Higher critical speed due to less shaft bending

Disadvantages

- Overall length of the installation is greater than it would be with suspended installation
- Higher price (double-element couplings required)

☞ *Supported installation is necessary once one has to cope with a larger misalignment between the elements and when the rotational speed is high.*

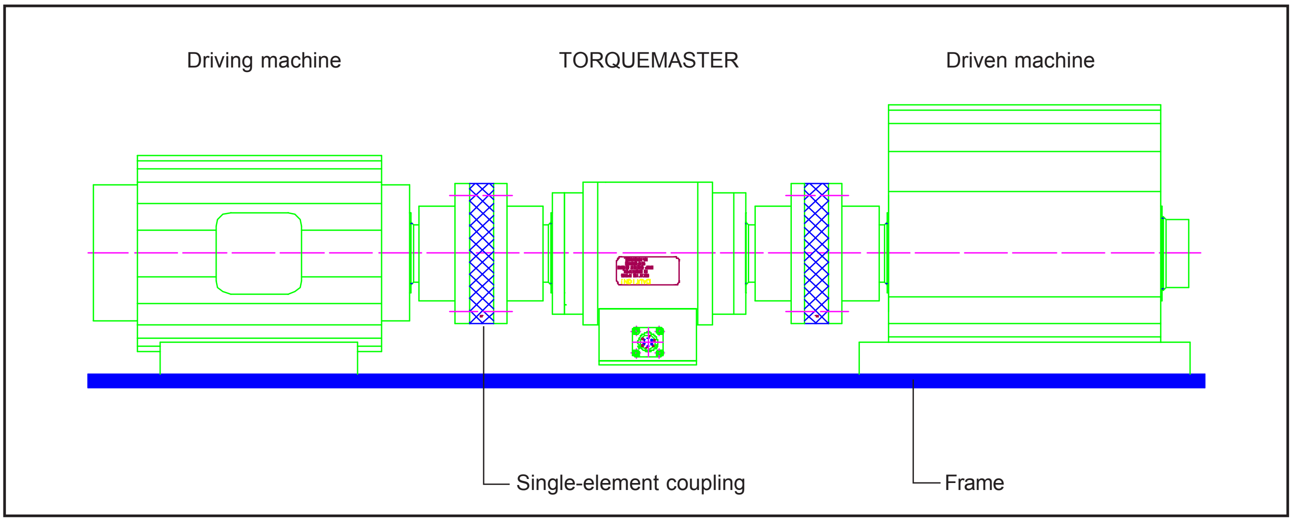


Fig. 3-1 : Suspended installation.

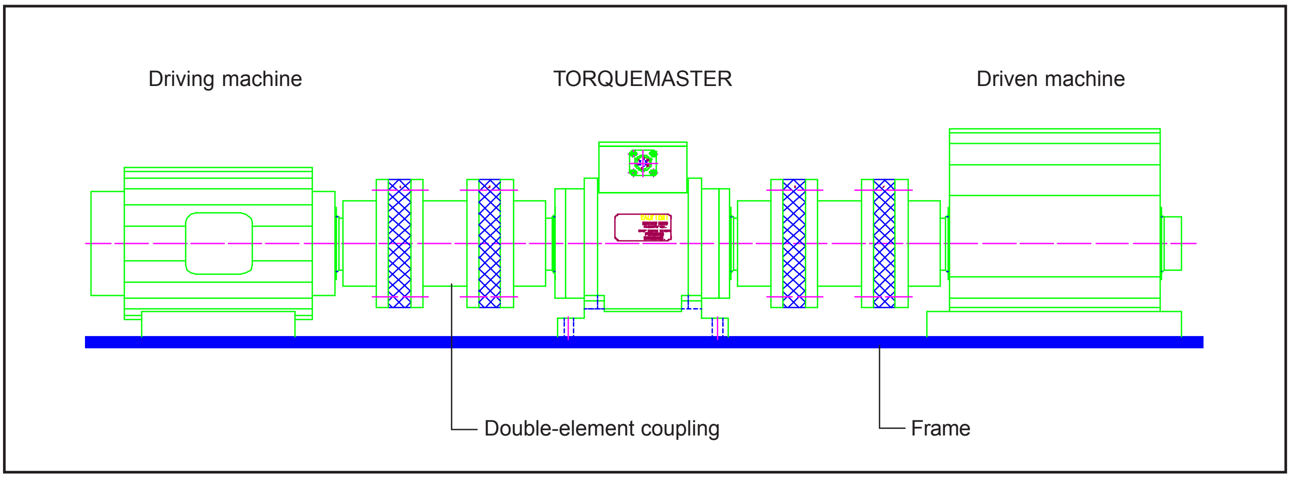


Fig. 3-2 : Supported installation.

3.2 Considerations During Transducer Installation

3.2.1 Radial (Bending) Forces

The existence of large bending forces (F_r in Figs. 3-3 and 3-4) will displace the rotational centre of gravity of the measuring shaft. This creates an imbalance which submits the shaft to a periodic load application, the frequency of which is related to the rotational speed. The effect is particularly noticeable at high speeds.

☞ *In extreme cases, a high bending force may cause permanent deformation of the measuring shaft, leading to false measuring results being obtained.*

The tables in Figs. 3-3 and 3-4 list the maximum bending force (F_r) allowed for TM 204 - TM 216 transducers in suspended, respectively supported, installation.

3.2.2 Axial (Thrust) Forces

In suspended installation, pure thrust forces (F_a in Figs. 3-3 and 3-4) have practically no effect on the measurement results, as they do not provoke any deformation of the shaft that could influence the measurement.

In supported installation, axial thrust forces produce a strain on the bearings. This leads to premature wear of the bearings and an increase in the residual torque. In this case, the maximum allowed axial force for the transducer is lower than that allowed for the transducer in suspended installation.

☞ *Note that transducers in supported installation have a much lower permitted value of F_a than transducers in suspended installation.*

It is important to avoid the simultaneous application of bending and thrust forces on the transducer shaft.

The tables in Figs. 3-3 and 3-4 list the maximum thrust force (F_a) allowed for TM 204 - TM 216 transducers in suspended, respectively supported, installation.

TYPE	Fa max [N]	Fr max [N]
TM 204	1'100	20
TM 205	1'500	40
TM 206	2'500	70
TM 207	3'500	60
TM 208	4'000	80
TM 210	6'000	120
TM 211	10'000	200
TM 212	20'000	300
TM 213	30'000	500
TM 214	*	*
TM 215	*	*
TM 216	*	*

* These values are not yet available

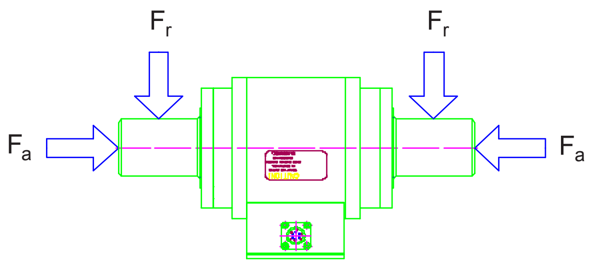


Fig. 3-3 : Maximum allowed axial and radial forces for TM in suspended installation.

TYPE	Fa max [N]	Fr max [N]
TM 204	100	50
TM 205	100	80
TM 206	100	150
TM 207	100	150
TM 208	100	150
TM 210	120	200
TM 211	120	250
TM 212	150	350
TM 213	150	500
TM 214	200	*
TM 215	200	*
TM 216	*	*

* These values are not yet available

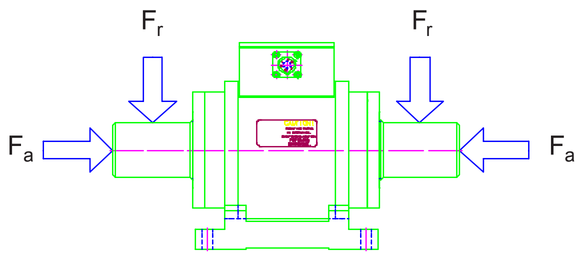


Fig. 3-4 : Maximum allowed axial and radial forces for TM in supported installation.

3.2.3 Permitted Shaft Acceleration and Velocity

The presence of misalignment (particularly radial) in the configuration will give rise to a periodic radial displacement of the torque measuring shaft. Associated with this displacement are a vibration velocity and a vibration acceleration. These values are functions of the radial displacement and the rotational speed of the torque measuring shaft. The formulae used to calculate the velocity and acceleration are given in Fig. 3-5. The shaft acceleration is shown in graphic form in Fig. 3-6.

The TM transducers have been qualified by Vibro-Meter under the following test conditions :

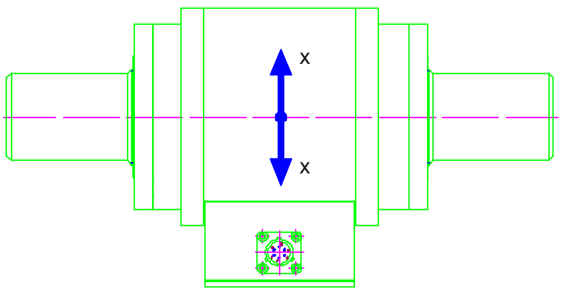
(i) Random vibration

Power spectral density 0.05 g^2 / Hz between 20 and 500 Hz.
Applied for 90 minutes along each of the 3 axes (x, y, z).

(ii) Sinusoidal vibration

Sweep between 10 and 500 Hz at a rate of 1 octave / minute.
Cycle performed for 90 minutes along each of the 3 axes.
From 10 to 60 Hz : amplitude 0.35 mm peak-peak
From 60 to 500 Hz : amplitude 5 g peak

☞ *You should ensure that the acceleration value in (ii) is not exceeded in everyday use.*



Relationships

(1) Acceleration

$$a = 4 \cdot \pi^2 \cdot n^2 \cdot x \quad [m/s^2]$$

(2) Velocity

$$v = 2 \cdot \pi \cdot n \cdot x \cdot 1000 \quad [mm/s]$$

Where :
x = radial displacement [m]
n = rotational speed [Hz]

Fig. 3-5 : Calculating the shaft acceleration and velocity.

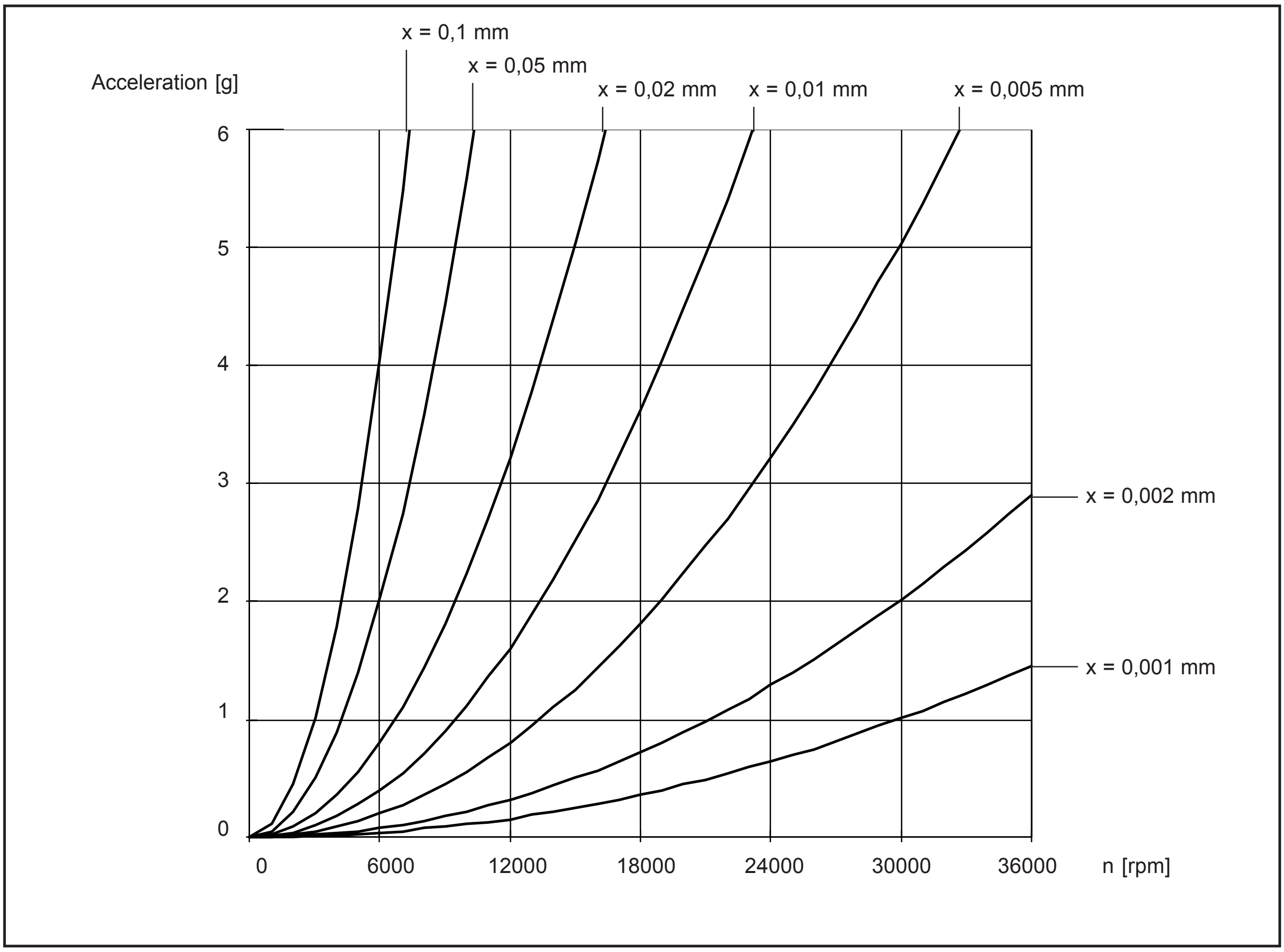


Fig. 3-6 : Graph showing the shaft acceleration (g) as a function of the axial displacement (x) and rotational speed (n).

3.2.4 Natural Frequency of Torsional Oscillations

3.2.4.1 Static and Dynamic Measurements

The distinction between static and dynamic measurements does not concern the rotation or absence of rotation of the measuring shaft, but rather the evolution of torque with time. The term "static measurement" is used when the torque remains virtually unchanging with time. The term "dynamic measurement" is used when there are more rapid variations of torque (due to transient phenomena). Examples of the latter may be encountered when investigating clutch engagement/disengagement characteristics and in drive systems consisting of an AC motor and a frequency converter.

3.2.4.2 Calculating the Natural Frequency of the Drive Train

When considering the use of a torque transducer for dynamic measurements, it is essential to calculate the natural frequency (or resonant frequency) of the torsional oscillations of the whole drive train. Here, the measuring section of the torque measuring shaft is frequently the "weakest link in the chain" (torsional spring) which, together with the rotating masses of the drive train, represents a torsional oscillator.

Even an everyday drive train arrangement may be rather complex and determination of its natural frequency demands considerable calculation effort when the rotor set as a whole is to be considered, with several torsional springs and intervening masses. For a detailed analysis of dynamic response, the reader should consult textbooks on the subject. However, the measurement analysis can sometimes be reduced to the simplified model shown in Fig. 3-7.

The torsional spring consists only of the measuring section of the torque measuring shaft. The torsional stiffness Kt is stated in Section 6.1. J1 and J2 are the resulting flywheel masses acting on each side of the measuring section. Their moments of inertia can be calculated by adding the moments of inertia of the individual elements. Refer to Section 6.1 for the moment of inertia of the measuring shaft ('Moment of inertia of rotor'), to the manufacturers' data sheets for the moment of inertia of the coupling element, driving and driven machines.

The fact that the drive train has a natural frequency f_0 (for torsional oscillations) has the following consequence; it determines the frequency response of the measuring system and governs whether rapid variations in torque can be accurately sensed or if the torque signal is amplified or attenuated due to the dynamics of the drive train. The transfer response is illustrated in Fig. 3-7 for various values of Q, quality factor, which is dependent upon the amount of damping in the torsional system. The graph shows the factor by which the torque is amplified as a function of the frequency of the torsional oscillations.

☞ *The system should be configured and operated in a manner such that the natural frequency is avoided in everyday running. The transfer function should be as close to 1 as possible, therefore the frequency of the torsional oscillations should not exceed about $0.5f_0$.*

Note that the natural frequency of a drive train will normally be reduced by the inclusion of a torque transducer. The natural frequency of a system should be recalculated to determine the effect of the transducer.

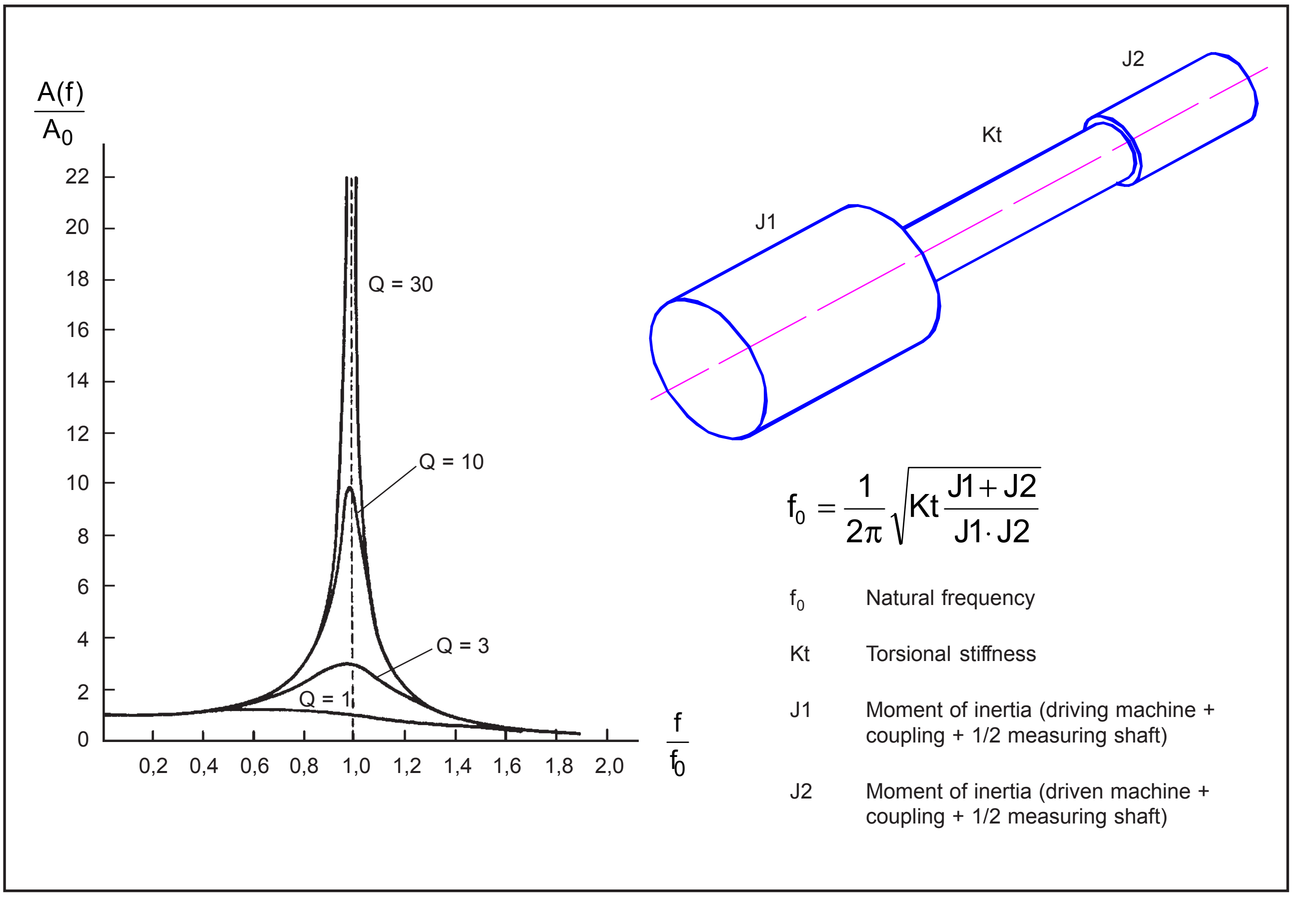


Fig. 3-7 : Simplified model of the drive train to calculate the natural frequency.

3.2.4.3 Natural Frequency of the TORQUEMASTER's Measuring Shaft

The natural frequency of the TORQUEMASTER's measuring shaft is given in Fig. 3-8. Note that a torsional resonance can also occur at this frequency.

Torque transducer	Natural frequency for torsional oscillations [Hz]
TM 204	460
TM 205	630
TM 206	960
TM 207	1'340
TM 208	1'500
TM 210	1'250
TM 211	1'550
TM 212	1'550
TM 213	2'050
TM 214	*
TM 215	*
TM 216	*

* These values are not yet available

Fig. 3-8 : Natural frequency of the TORQUEMASTER's measuring shaft.

3.3 Electrical Connections

3.3.1 Earthing of all Elements

☞ *To assure the correct operation of the TORQUEMASTER it is important to ground its housing.*
It is recommended that the TORQUEMASTER housing, the test rig chassis as well as the housings of the driving machine and driven machine are all connected to a common earth.

When the TORQUEMASTER is mounted on the test rig using an aluminium support, the housing will normally be in electrical contact with the test rig. This should, however, be checked during installation.

When the TORQUEMASTER is in suspended installation it will be necessary to run a wire from the housing to the common earth point (Fig. 3-9).

3.3.2 Transducer Supply and Signals

The supplying of the transducer, the reading of the signals (torque, speed, rotational direction) and the activation of the test function are effected via a 6-pole connector mounted on the transducer housing.

The various input and output signals corresponding to the connector pins are as follows (see also Fig. 3-10) :

A : Supply; 20 to 32 VDC (100 mA max.)
B : Maximum torque 0 to ±10 VDC (impedance 500 Ω)
C : Rotational direction, open-collector output (max. 30 VDC)
D : 0 V
E : Test input (high impedance)
The test function is active when this input is connected to 0 V;
if not connected to 0 V, the test function is inactive.
F : Speed output, pulse train on open-collector output (max. 30 VDC)

☞ *All outputs are protected against short-circuits.*
The supply input (A) can withstand an inversion of polarity.

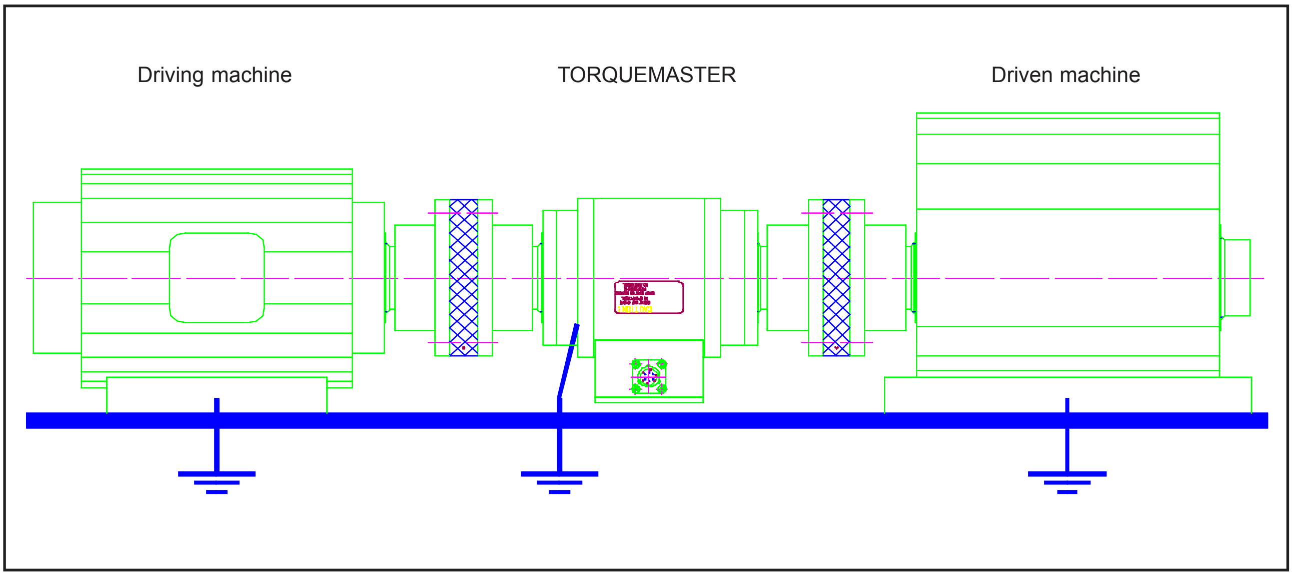


Fig. 3-9 : Connecting the TORQUEMASTER unit and other elements to a common earth.

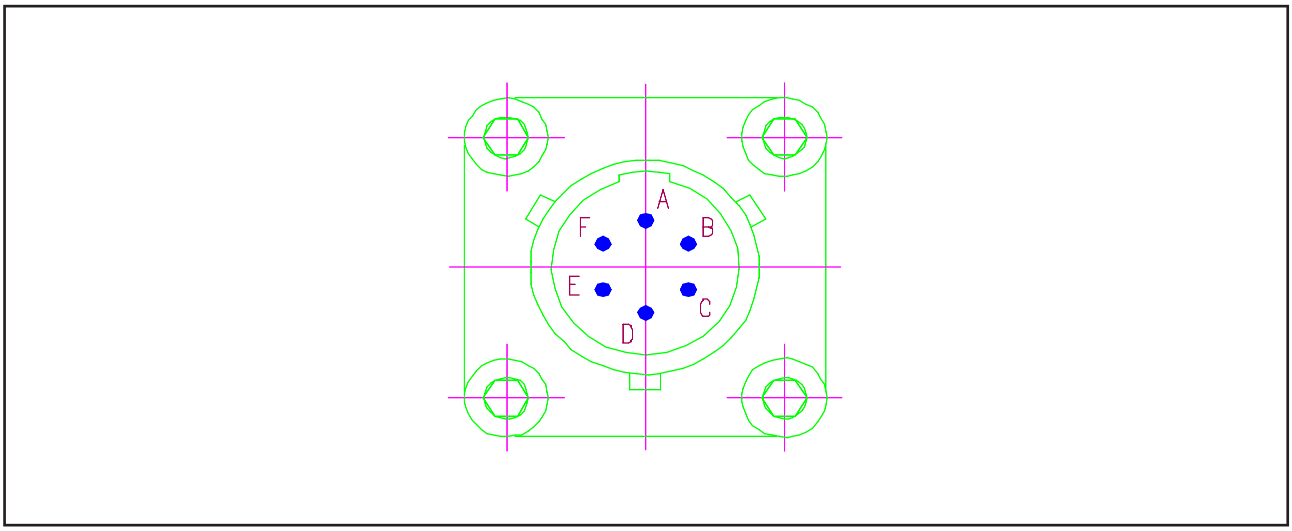
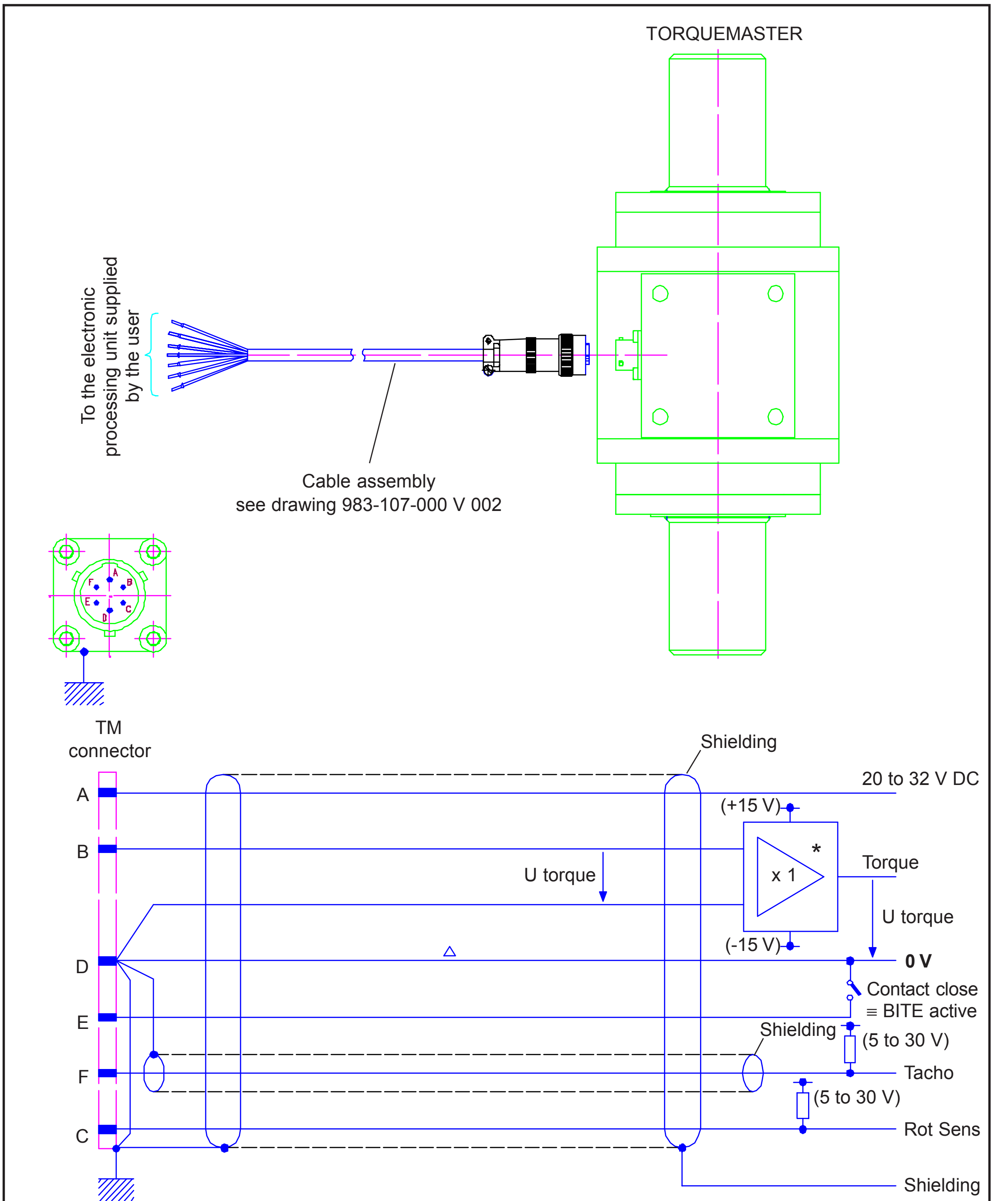


Fig. 3-10 : 6-pole connector mounted on the TORQUEMASTER housing.

3.3.3 Connecting the TORQUEMASTER to an electronic processing unit supplied by the user

The connection of the TORQUEMASTER transducer to an electronic processing unit supplied by the user (refer to Figs 3-11 and 3-12) can be made using a ready-made ER 107 cable assembly. Alternatively, the connector delivered with the transducer may be fitted to a cable supplied by the user. In the latter case, the user must use an 8-core cable. The lead used for the speed signal (tacho output) should be shielded separately. Make sure that the supply and the torque signal each have their own 0 V lead.



* Differential amplifier necessary to reject the DC voltage present in the 0 V lead (Δ). If there is no differential amplifier, an offset in the zero value of the torque signal will be present. This offset will depend on the resistance and the length of the cable.

Fig. 3-11 : Connecting the TORQUEMASTER to an electronic processing unit supplied by the user.

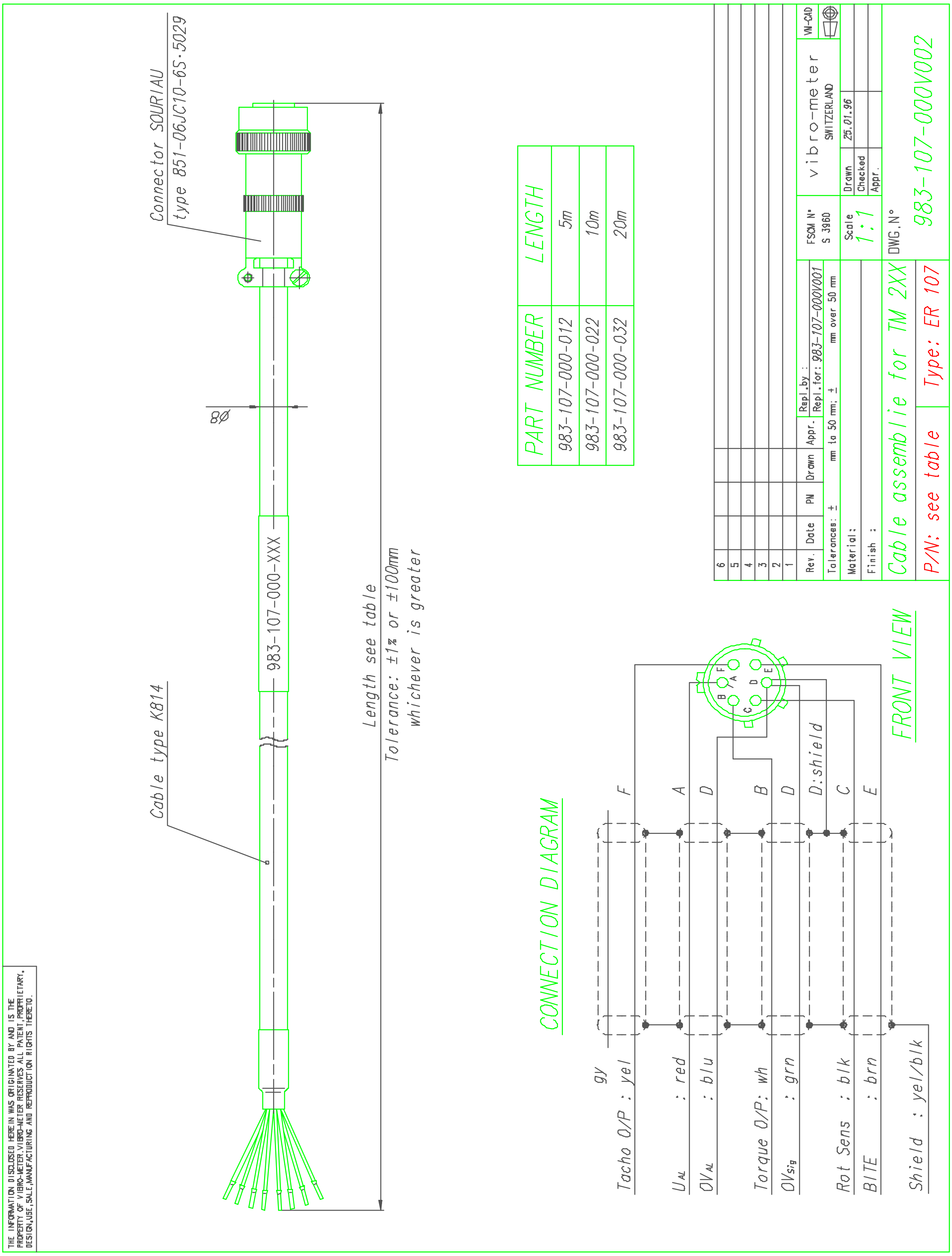


Fig. 3-12 : ER 107 cable assembly used to connect the TM to an electronic processing unit supplied by the user.

3.3.4 Connecting the TORQUEMASTER to a DCU 285 digital control unit

The TM transducer should be connected to the DCU 285 unit using an ER 108 cable assembly (refer to Fig. 3-13). For further information on this cable assembly, refer to Fig. 3-14 (drawing 983-108-000 V 002).

The following signals are available on the pins of the D-SUB 15 Pol P connector :

Pin 2	:	Speed output (Tacho o/p)
Pin 3	:	BITE input (activate test function)
Pin 4	:	0 V for power supply
Pin 5	:	Transducer power supply
Pin 7	:	Torque output
Pin 10	:	Rotational direction output (Rot Sens)
Pin 14	:	0 V for signals

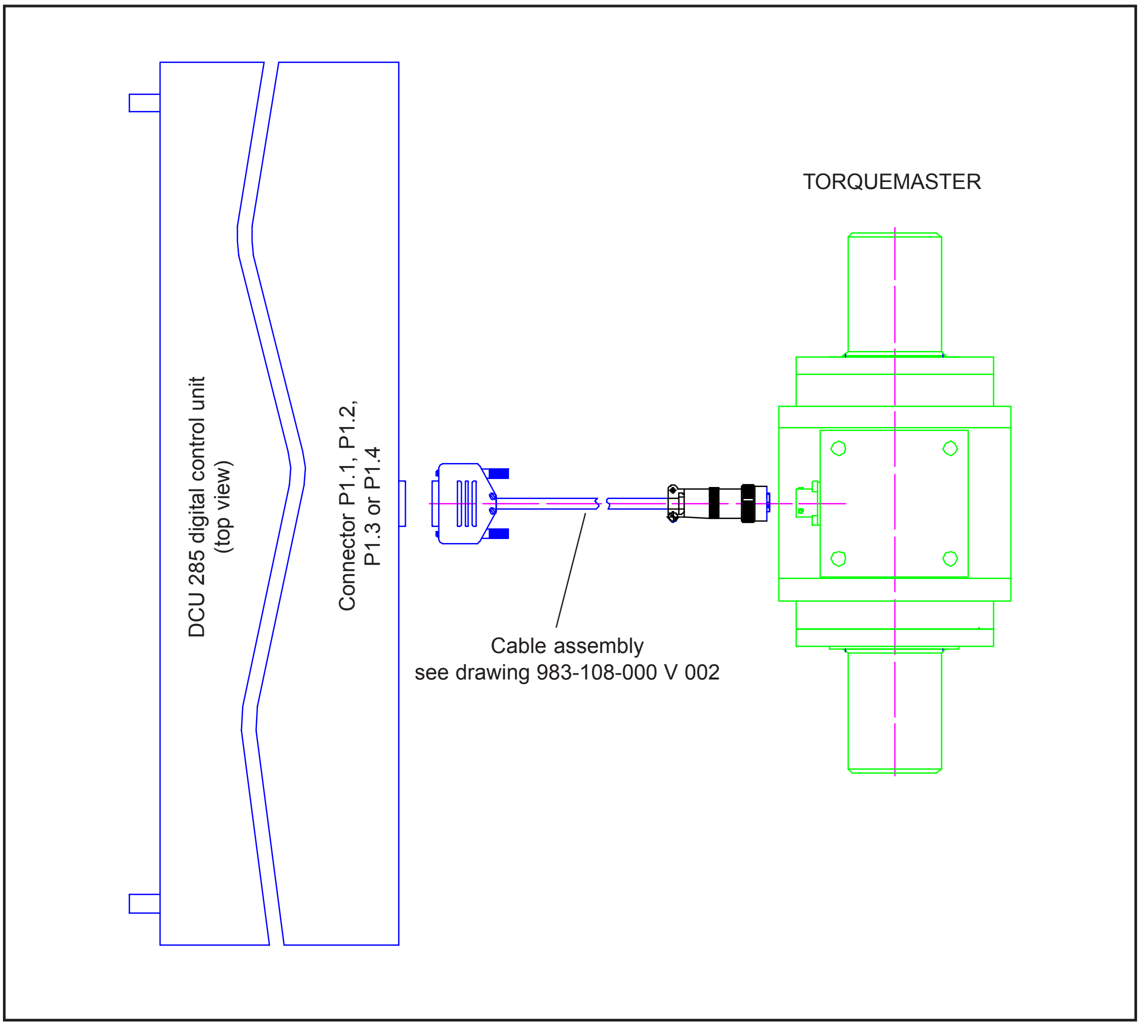


Fig. 3-13 : Connecting the TORQUEMASTER to a DCU 285 digital control unit.

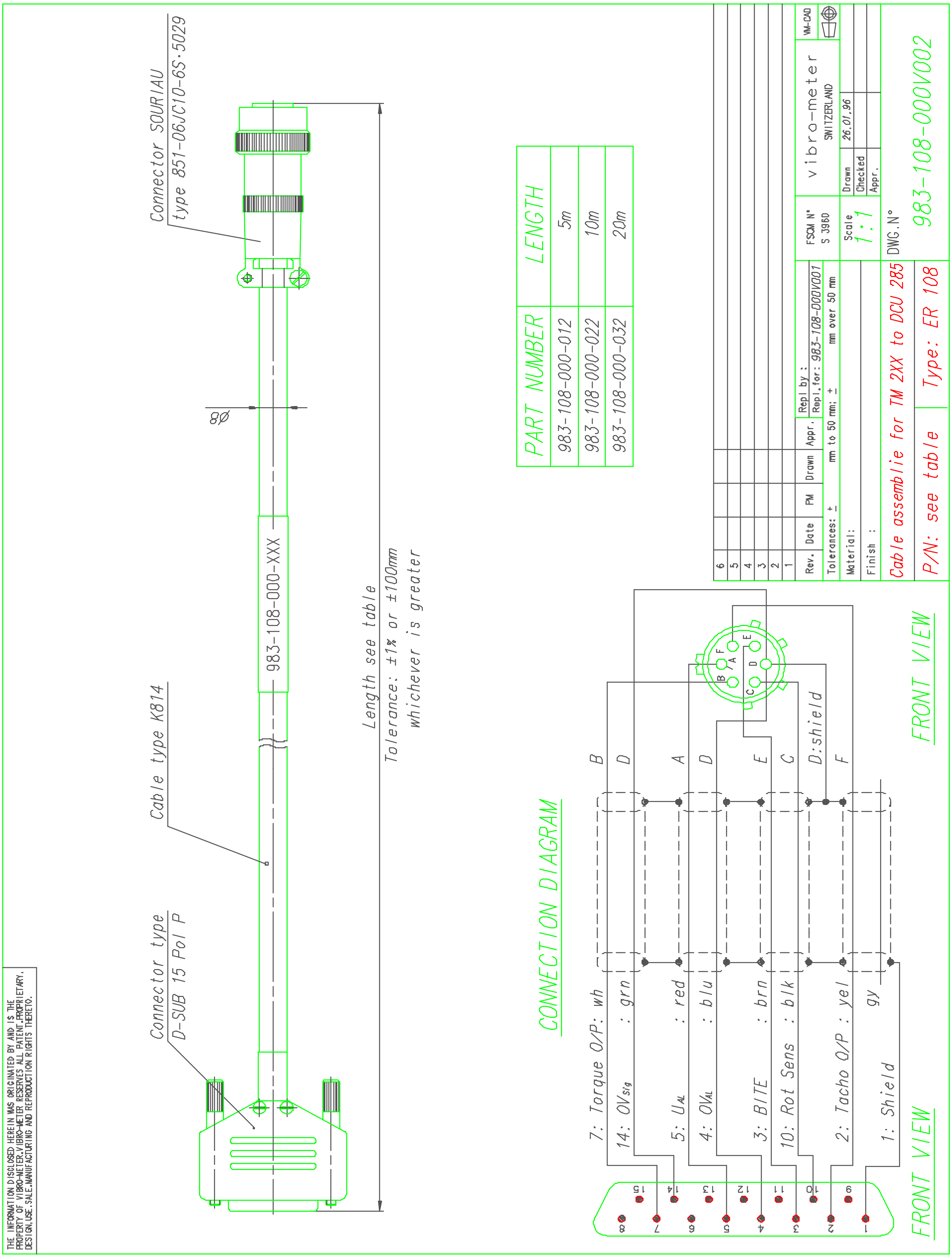


Fig. 3-14 : ER 108 cable assembly used to connect the TM to the DCU 285.

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4 TECHNICAL DESCRIPTION

4.1 Description of the TORQUEMASTER Unit

The TORQUEMASTER unit consists of the torque measuring shaft, the torque transducer and the built-in electronics. These are all contained in an aluminium housing. The unit also contains two sealed bearings having lifelong lubrication.

The upper part of the unit contains the built-in electronics. This part is sealed according to the IP44 standard to offer protection against water. A SOURIAU connector is present to allow the unit to be connected to a complementary signal processing unit via an ER 107 / ER 108 cable assembly.

The TORQUEMASTER unit performs the following three functions :

(i) Measurement of the static or dynamic torque, with detection of the torque direction.

(ii) Measurement of the shaft's rotational speed, with detection of the rotational direction.

(iii) Self-check.

The torque, speed and temperature are processed by the unit's built-in electronics. This also performs the temperature compensation.

4.1.1 Torque Transducer Principle

The transducer can be defined as an inductive torque transducer operating on the basis of a voltage transformer having a variable coupling factor.

The primary and secondary coils of the transformer (Fig. 4-1, Refs A and B) are separated by two concentric cylinders (Fig. 4-1, Refs C and D), each cylinder having finely positioned slots (Fig. 4-1, Ref. E). The cylinders are connected to the torque measuring shaft; the external cylinder to one side of the shaft's deformation zone (Fig. 4-1, Ref. F) and the internal cylinder to the other side of the deformation zone. When no torque is applied to the shaft the slots in both cylinders fail to overlap and there is therefore total screening (no induction) between the primary and secondary coils. As the torque applied to the shaft is increased, the deformation zone undergoes increasing angular deformation. This causes an increasing overlap between the slots in the cylinders and hence an increasing induction between the two transformer coils. In this way, when the primary coil is excited by a sinusoidal voltage signal, the transformer secondary coil produces a voltage signal whose magnitude is dependent on the applied torque.

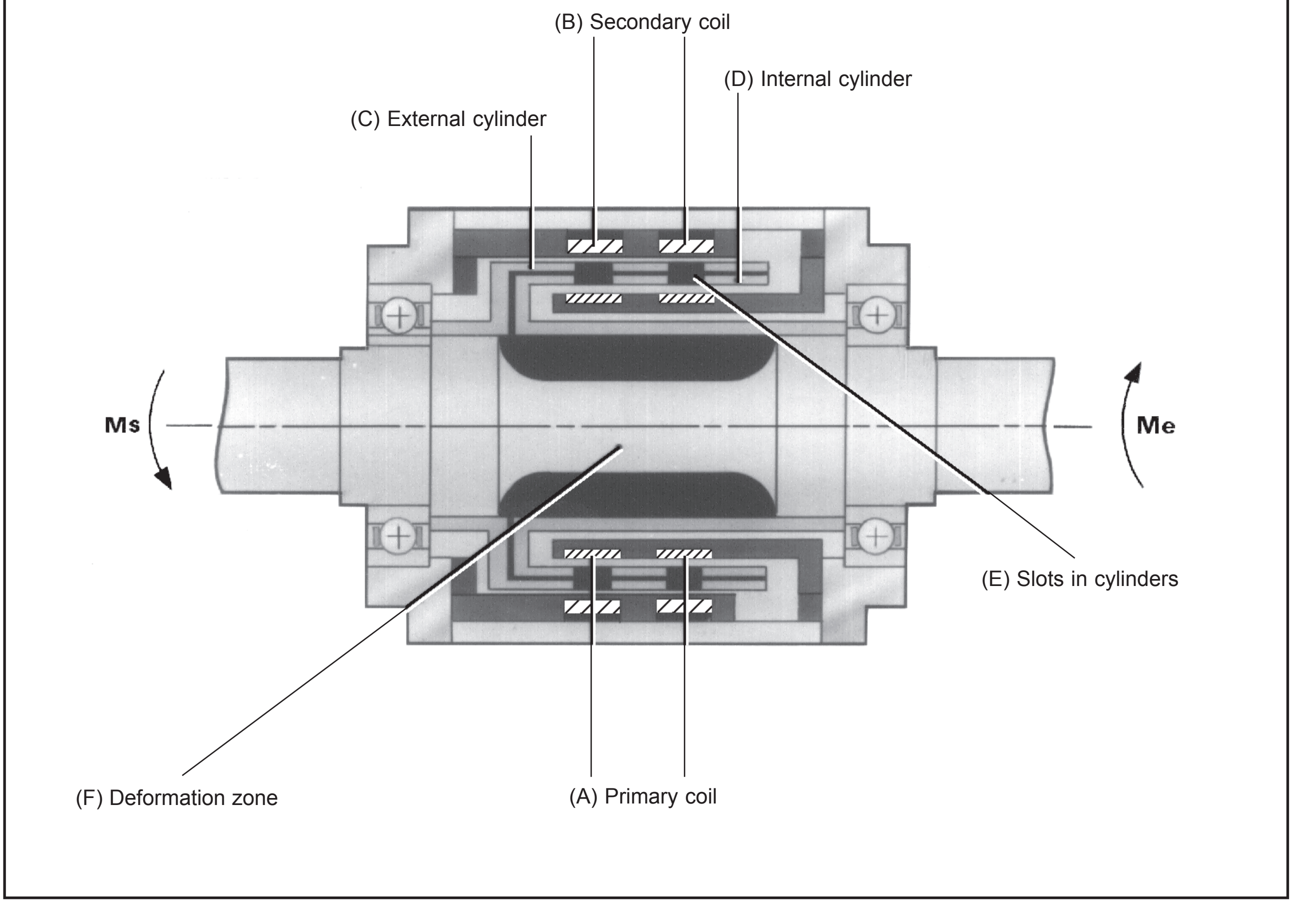

Fig. 4-1 : Principal elements of the torque transducer.

4.1.2 Transformer

The primary coil of the transformer consists of two equal windings mounted in series. It is excited by a signal having a frequency of 20 kHz which is produced by the transducer's built-in electronics. In addition, a constant current is supplied the primary coil. This allows the temperature of the unit to be determined.

The secondary coil consists of two windings in phase opposition. This allows the mechanical phase shift between the two cylinders to be determined. The secondary coil produces a torque-proportional (dynamic) voltage signal.

4.1.3 Torque Signal Conditioning Chain

The torque conditioning chain is based on a carrier frequency system containing a synchronous demodulator. This chain also contains a low-pass filter (second order Butterworth type) which can be set by the user by positioning micro-switches that are accessible by removing the cover of the transducer's built-in electronics (see Fig. 4-2). This filter is used to eliminate resonances and other forms of interference coming from the chain of mechanical elements (driving machine, couplings, etc) and the torque measuring shaft.

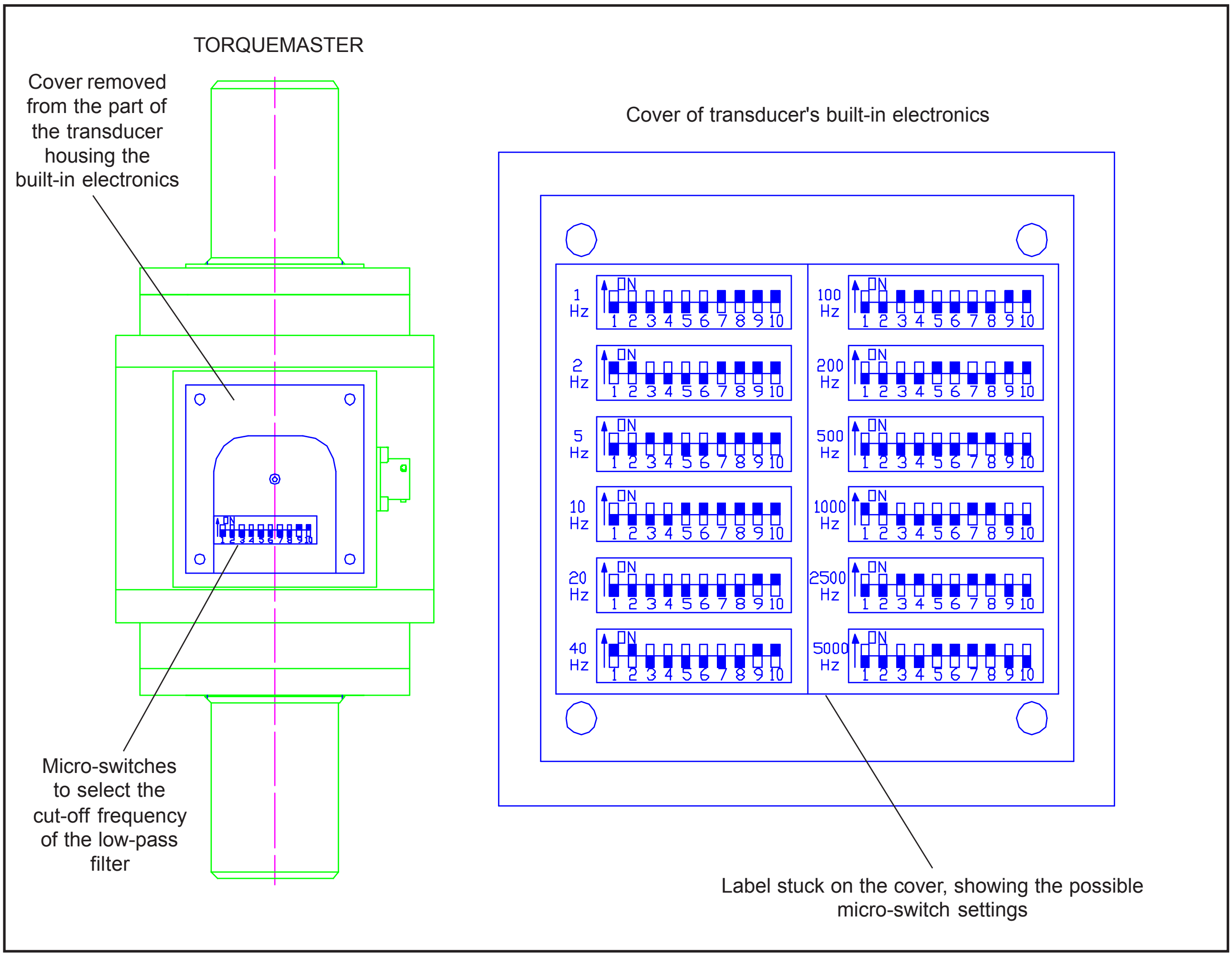

Fig. 4-2 : Location and configuration of micro-switches used to select the cut-off frequency of the low-pass filter.

4.1.4 Speed Conditioning Chain and Detection of Rotational Direction

A speed transducer is incorporated in the TORQUEMASTER housing to measure the rotational speed. This transducer is mounted so as to face a toothed part of the rotor and produces 30 pulses per revolution. The same transducer is used to determine the rotational direction of the shaft.

4.1.5 Built-In Self-Test Function (BITE Input)

The TORQUEMASTER's connector has a pin allocated for activating a test signal. When this pin is held low (logic 0) the test circuit simulates a torque signal (equivalent to +5 VDC) and this replaces the measured torque signal. The test function may be activated remotely and while the transducer is in use.

The test function checks the correct functioning of the torque signal conditioning circuitry. This function, however, does not in any way obviate the need for a static calibration of the transducer.

4.2 ER 107 / ER 108 Cable Assembly

The ER ... cable assembly is used to connect the TORQUEMASTER transducer to an electronic processing unit :

- ER 107 is used to connect it to a processing unit supplied by the user.
  Refer to drawing 983-107-000 V 002 in Section 3.3.3.

- ER 108 is used to connect it to a DCU 285 digital control unit.
  Refer to drawing 983-108-000 V 002 in Section 3.3.4.

The cable assembly is made from 8 leads that are shielded in pairs. The casing of the SOURIAU connector and the TORQUEMASTER housing are in electrical contact with the shieldings. The speed signal (TACHO O/P) must be shielded by itself.

The ER ... cable assemblies are available in standard lengths of 5, 10 and 20 m.

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5 MAINTENANCE

The TORQUEMASTER transducers are virtually maintenance-free. This is a consequence of the following aspects of their construction :

- Lifelong lubrication of the bearings, obviating the need for periodic attention.

- Transmission of the torque signal from the rotating measuring element to the processing electronics by a process of induction rather than by using sliprings. This eliminates mechanical wear.

However, it may be necessary to change the bearings after a while. The Lh10 parameter quoted in the transducer specifications (table in Section 6.1) gives the theoretical lifetime of the bearings in hours. The Lh10 value is in fact the number of hours after which 10 % of the bearings may begin to show signs of wear. It assumes that the transducer is running at its maximum speed and that the maximum permissible axial and radial forces are applied. Vibro-Meter recommends that the bearings be changed after this amount of use. Note, however, that when the normal running speed is reduced the lifetime Lh10 is increased.

You should not attempt to change the bearings yourself. The TORQUEMASTER transducer should be returned to Vibro-Meter for this operation.

Similarly, you should not attempt to carry out revisions or repairs of any kind on the mechanical or electronic components making up the TORQUEMASTER unit. If a problem is suspected, Vibro-Meter should be contacted so that arrangements can be made to effect any repairs in our factory.

Failure to observe the above may lead to the transducer being serious damaged.

☞ *Note that the TORQUEMASTER housing is sealed. Any evidence that the housing has been opened and unauthorized modifications have been attempted will invalidate the warranty.*

When returning a defective system to us, please complete and also return to us the Product Defect Report which can be found at the end of this instruction manual.

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6 SPECIFICATIONS

6.1 General

Torque Transducer	Nominal torque [Nm]	Total mass [kg]	Mass of rotor [kg]	Moment of inertia of rotor [kg.m^2]	Torsional stiffness (Kt) [Nm/rad]
TM 204	1	1,2	0,18	$30 * 10^{-6}$	145
TM 205	2	1,2	0,19	$30{,}6 * 10^{-6}$	290
TM 206	5	1,2	0,20	$31{,}4 * 10^{-6}$	725
TM 207	10	1,2	0,21	$31{,}8 * 10^{-6}$	1450
TM 208	20	1,2	0,23	$32{,}1 * 10^{-6}$	2900
TM 210	50	2,5	0,69	$142 * 10^{-6}$	5700
TM 211	100	2,5	0,73	$145 * 10^{-6}$	11400
TM 212	200	4,1	1,57	$425 * 10^{-6}$	38200
TM 213	500	4,4	1,8	$455 * 10^{-6}$	95800
TM 214 vers. 01	1000	9,9	4,9	$1730 * 10^{-6}$	328000
TM 214 vers. 02	1000	9,2	4,2	$1550 * 10^{-6}$	328000
TM 215 vers. 01	2000	10,8	5,8	$2030 * 10^{-6}$	656000
TM 215 vers. 02	2000	10,1	5,1	$1850 * 10^{-6}$	656000
TM 216	5000	20	10,2	$8000 * 10^{-6}$	$1{,}94 * 10^{6}$

Torque transducer	Nominal torque [Nm]	Minimum rotational speed		Maximum rotational speed		Lifetime of bearings (Lh 10) [hours]
		Mesurable [rpm]	Det. of rot. dir. [rpm]	Standard [rpm]	High speed [rpm]	
TM 204	1	10	20	20000	50000	5000
TM 205	2	10	20	20000	50000	5000
TM 206	5	10	20	20000	50000	5000
TM 207	10	10	20	20000	50000	5000
TM 208	20	10	20	20000	50000	5000
TM 210	50	10	20	10000	32000	5000
TM 211	100	10	20	10000	32000	5000
TM 212	200	10	20	10000	24000	5000
TM 213	500	10	20	10000	24000	5000
TM 214	1000	10	20	7000	16000	5000
TM 215	2000	10	20	7000	16000	5000
TM 216	5000	10	20	5000	12000	5000

* This value is not yet available

6.2 Torque Measuring System

Torque output

- Max. range	:	±10 VDC ≡ ±200 % of Mn
- Output impedance	:	≤500 Ω (0 Hz to 5 kHz)
- Overvoltage protection	:	±33 VDC

BITE input

- Input impedance	:	10 kΩ
- Rest voltage of BITE control line	:	+6 VDC to +32 VDC
- Active voltage of BITE control line	:	≤ +4 VDC
- Overvoltage protection	:	±33 VDC

Measurement accuracy
The measuring range (MR) corresponds to the rated value of the physical quantity measured (Mn = rated torque)

- Zero calibration	:	≤ ±0.1 % of MR
- Sensitivity calibration	:	≤ ±0.1 % of MR
- Combined error at 100 % of Mn (1)	:	≤ ±0.1 % of MR
- Combined error at 200 % of Mn (1)	:	≤ ±0.2 % of MR

Temperature drift

- Temperature range 1	:	+10 °C to +60 °C
Zero	:	<0.1 % of MR / 10 K
Sensitivity	:	<0.1 % of MR / 10 K
BITE signal	:	<0.1 % of MR / 10 K
- Temperature range 2	:	-25 °C to +80 °C
Zero	:	<0.2 % of MR / 10 K
Sensitivity	:	<0.2 % of MR / 10 K
BITE signal	:	<0.1 % of MR / 10 K

Influence of speed on torque signal

- On zero	:	≤ ±0.01 % of MR / 1000 rpm
- On sensitivity	:	≤ ±0.01 % of MR / 1000 rpm

☞ *Mn corresponds to the rated (nominal) torque*
MR corresponds to the measuring range

Note

(1) The combines error corresponds to the sum of the hysteresis and linearity errors.

6.3 Speed Measuring System

Min. speed measurable	:	10 rpm
Min. speed for detection of rotational speed	:	20 rpm
Number of pulses per revolution (z)	:	30
Measuring range	:	5 Hz to 30 kHz
TACHO and ROT. SENS outputs		
- Type of output	:	open-collector output (protected against short-circuits)
- Internal resistance (collector-emitter short-circuit)	:	15 Ω (TACHO) 500 Ω (ROT. SENS)
- Overvoltage protection	:	±33 VDC

6.4 Power Supply

Supply voltage	:	20 to 32 VDC ±0.5 VDC
Current consumption	:	Max. 100 mA

6.5 Mechanical and Environmental

Balancing quality according to VDI 2060	:	Q1
Torque		
- Rated static torque	:	±100 % of rated torque
- Max. measurable static torque	:	±200 % of rated torque
- Rated dynamic torque	:	±100 % of rated torque
- Max. dynamic torque	:	±200 % of rated torque
- Max. dynamic torque without damage	:	±500 % of rated torque
Temperature		
- Compensated temperature range 1	:	+10 °C to +60 °C
- Compensated temperature range 2	:	-25 °C to +80 °C
- Operating temperature range	:	-40 °C to +85 °C
- Storage temperature range	:	-40 °C to +100 °C
Mechanical shock acc. to IEC 68.2.27 standard	:	Class D3 according to QAT-PTE 001/86
Vibration acc. to IEC 68.2.6 and IEC 68.2.35 standards	:	Class D3 according to QAT-PTE 001/86
Housing protection class acc. to IEC 529	:	IP44

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A DRAWINGS

This appendix contains the following drawings :

Designation	Drawing Number
- Torque Transducer TM 204 - TM 208 smooth shaft ends	415-204-000 V 011
- Torque Transducer TM 210 - TM 211 smooth shaft ends	415-209-000 V 011
- Torque Transducer TM 212 - TM 213 smooth shaft ends	415-212-000 V 011
- Torque Transducer TM 212 - TM 213 splined shaft ends	415-212-000 V 021
- Torque Transducer TM 214 - TM 215 smooth shaft ends	415-214-000 V 011
- Torque Transducer TM 214 - TM 215 splined shaft ends	415-214-000 V 021
- Torque Transducer TM 216 splined shaft ends	415-216-000 V 021

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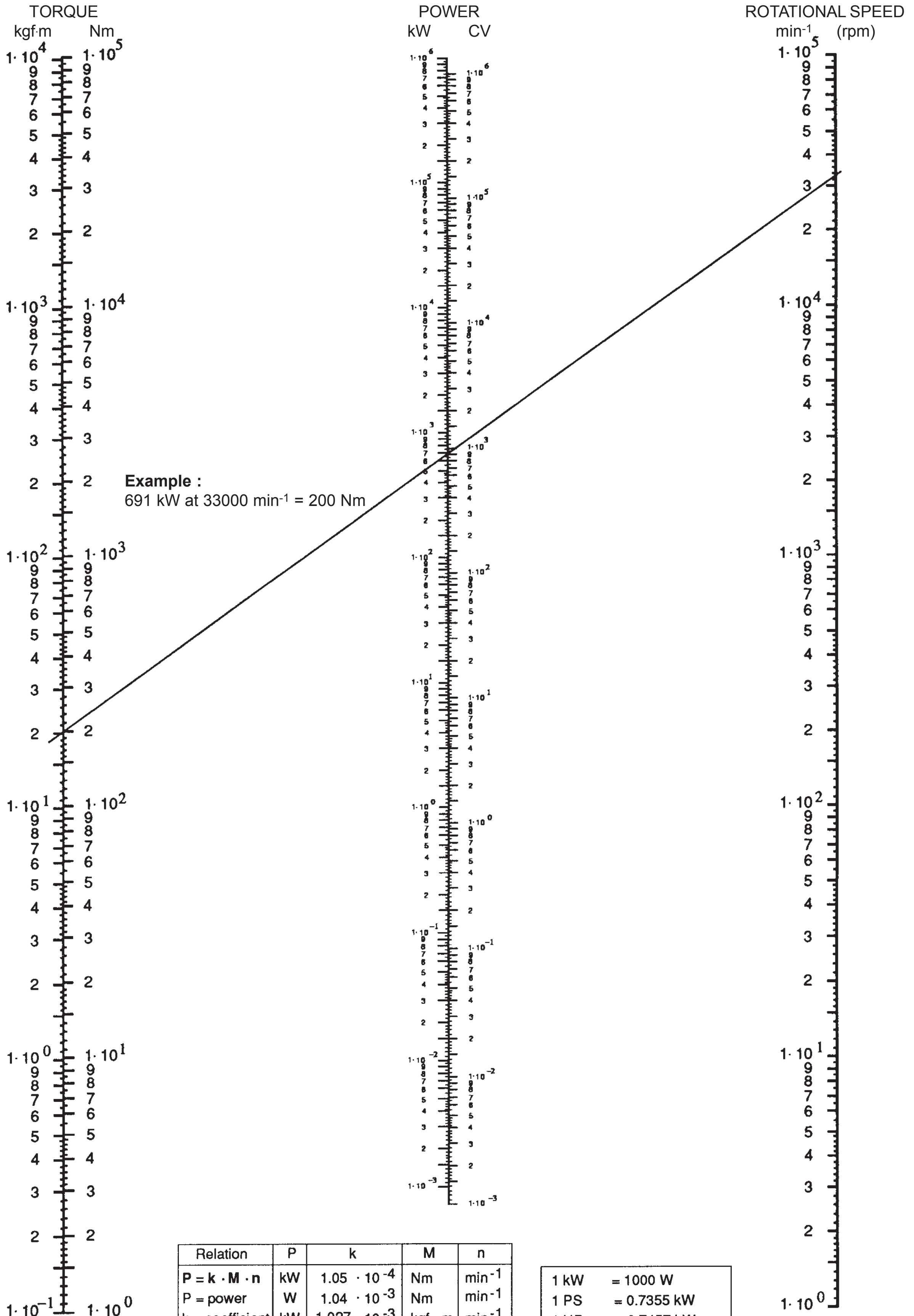
B NOMOGRAM



Relation	P	k	M	n
P = k · M · n	kW	$1.05 \cdot 10^{-4}$	Nm	min^{-1}
P = power	W	$1.04 \cdot 10^{-3}$	Nm	min^{-1}
k = coefficient	kW	$1.027 \cdot 10^{-3}$	kgf · m	min^{-1}
M = torque	W	1.027	kgf · m	min^{-1}
n = speed	HP	$8.42 \cdot 10^{-3}$	Nm	min^{-1}
	kW	$6.30 \cdot 10^{-3}$	Nm	s^{-1}

1 kW	= 1000 W
1 PS	= 0.7355 kW
1 HP	= 0.7457 kW
1 kgf · m	= 9.8067 Nm
1 lbf · ft	= 1.356 Nm
1 ozf . in	= $7.062 \; 10^{-3}$ Nm

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LEXICON

Auto taring	A function present in the DCU 285 to automatically calibrate its display to show zero torque when no torque is applied to the measuring shaft of the TORQUEMASTER unit.
Calibration	A process to precisely define the transfer characteristics between the torque applied to the TORQUEMASTER unit and the resulting output signal.
Coupling	(i) Mechanical connection between the driving machine and the TORQUEMASTER unit and between the TORQUEMASTER unit and the driven machine. These enable the elements in the drive train to be connected and compensate for minor errors in the alignment of the elements. (N.B. During installation you should nevertheless attempt to keep the misalignment to an absolute minimum.) (ii) Mutual induction between primary and secondary coils of a transformer.
Drive train	The entire rotor unit, comprising the rotor of the driving machine, the first coupling, the measuring shaft of the TORQUEMASTER unit, the second coupling and the rotor of the driven machine.
Limit torque	The limit torque is a value which must not be exceeded, to avoid damage to the measuring shaft leading to a change of calibration and a loss of accuracy. A specification is given for both static and dynamic limit torques.
Measuring shaft	The rotor in the TORQUEMASTER unit. This has a specially designed section (the measuring section) having a lower torsional stiffness which allows even small torque values to be detected easily.
Overrange	The range lying between the rated torque and the limit torque. The overrange can be used for torque measurement, provided that the dynamic signal amplitude (peak-to-peak) remains smaller than the rated torque.
Rated torque	The rated (or 'nominal') torque is the upper limit of the normal operating range. See also 'overrange' and 'limit torque'.
Transducer	A device that converts a physical quantity such as acceleration, force, pressure, temperature, torque, etc. into an electrical signal.

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