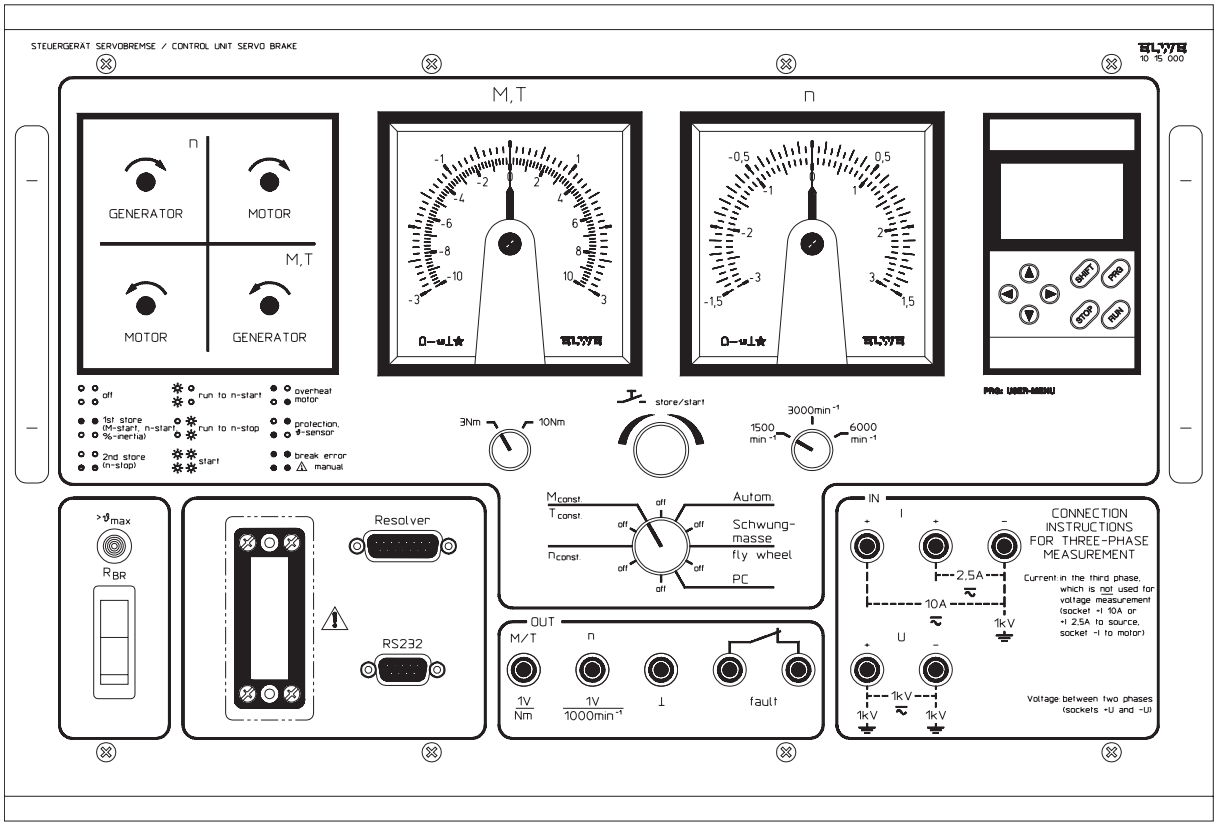
Operating Manual

Control Unit for Four-Quadrant (4-Q) Servo Load Machine in a 300-W System 10 15 000

Please read the operating instructions thoroughly before using this device. The guarantee and the manufacturer's possible liability does not cover defects which are caused by non-observance of these instructions. If this unit is passed on to others, than this manual must be, too.



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Contents

1. Safety Instructions

- ***The unit must not be put into operation if:***

– the cable is damaged.
– the equipment or the operating elements have visible damage.
– the connection cable is damaged.
– the casing cover is missing.
– the unit has been dropped.

- ***The unit must not be used***

– in damp or wet locations.
– in locations containing flammable gases, vapours or dust.
– in hazardous locations.

- ***Avoid***

– impact, shock and vibration.
– the ingress of liquids.
– heat concentration due to covered ventilation slots, ventilation holes and signal lamps – fire hazard!

- ***Make sure that***

– a residual-current device has been connected in series.
– you disconnect from the power supply unit before you connect the unit or change the connections of the experimental set-up.
– the unit will only be cleaned when it is off-circuit.
– only original spare parts are used if repair work has to be carried out.

- ***Only use***

– experimental cables with shockproof plugs.
– undamaged experimental cables.

Do not change the experimental set-up when the equipment is switched on.

- ***The equipment must only be repaired by our service team or by an electrician authorised by us.***

- ***Changes to the circuit or of any other kind are not permitted.***

2. Use as intended

The device/equipment is used in experimental set-ups for lessons and educational training according to the ELWE experimental manuals.

3. Application range

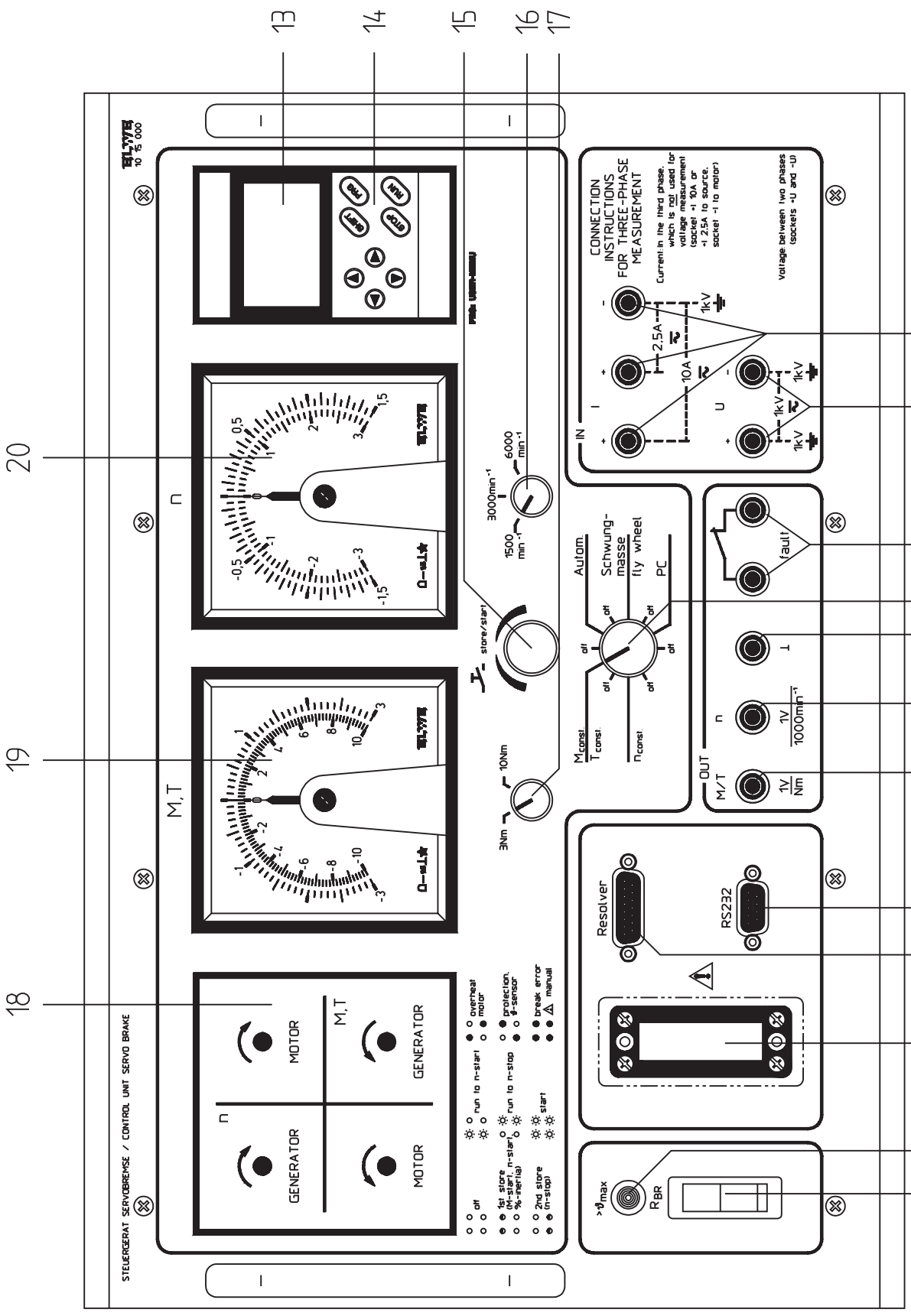
The control unit is exclusively used for operating the 4-Q servo load machine (Art. No. 30 17 001 01). With this combination it is possible to study the performance of electrical machines in the ELWE 300-W series in all of the four quadrants.

4. Main features of the control unit

- Four modes: "$n_{const.}$", "$M_{const.}$", programmable ramps for automatic characteristic curve measurements, gyrating mass simulation
- Variable speed between ± 5000 rpm; 270° pointer instrument with centre zero, three measuring ranges, digital display
- Variable torque from 0 Nm to 10 Nm; pointer instrument with centre zero, two measuring ranges, digital display
- Variable start torque
- Variable gyrating mass of up to 10,000 $kgcm^2$
- 4-Q display for the indication of the mode and other information
- Internal isolating amplifier for measuring the current and voltage of the tested machine
- RS232 interface for the output of torque, speed and effective values for current and voltage of the tested machine (test object). Acceleration and load characteristics can be measured and loads can be simulated with the respective software packages. Additional measuring interfaces are not necessary.
- Analog outputs with standard signals for M and n for the connection of an XY-recorder or the external display panel with large indicating instruments (10 15 001)
- Control of temperature and protective measures on the 4-Q servo load machine and on the test object

5. Operating elements

(1) Mains switch with mode display
(2) Display for overheating of the brake resistor
(3) Connection for energy supply to the 4-Q servo load machine
(4) Connection for measuring signals from the 4-Q servo load machine
(5) Serial interface for PC connection
(6) Output socket for analog torque signal
(7) Output socket for analog rotational frequency signal
(8) Reference potential for the outputs (6) and (7)
(9) Mode switch
(10) Fault indicating contact
(11) Input sockets for measuring the voltage on the test object
(12) Input sockets for measuring the current on the test object
(13) Display
(14) Key pad
(15) Adjuster with touch function
(16) Changeover switch "rotational frequency range"
(17) Changeover switch "torque range"
(18) Quadrant display
(19) Torque display
(20) Rotational frequency display


13
14
15
16
17
20
19
18
12
11
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9
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3
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1
STEUERGERÄT SERVOBREMSE / CONTROL UNIT SERVO BRAKE
10 15 000
n
M, T
MOTOR
GENERATOR
GENERATOR
MOTOR
M, T
CONNECTION INSTRUCTIONS FOR THREE-PHASE MEASUREMENT
Current in the third phase, which is not used for voltage measurement (socket +I 10A or +I 2.5A to source, socket -I to motor)
Voltage between two phases (sockets +U and -U)
2.5A
10A
1kV
3000min⁻¹
6000 min⁻¹
1500 min⁻¹
store/start
10Nm
3Nm
Autom.
Schwung-masse
fly wheel
PC
Mconst.
Tconst.
nconst.
off
fault
OUT
M/T
1V/Nm
1V/1000min⁻¹
Resolver
RS232
>9max
RBR

6. Connection information

The equipment is connected to the 4-Q servo load machine and, if necessary, to the PC via sockets (3), (4) and (5).

After coupling the 4-Q servo load machine to the test object with the coupling collar, apply the protective cover. Also connect the thermostatic switch on the test object to the socket on the motor terminal box using the jack cable on the 4-Q servo load machine.

If necessary, connect the additional display panel with three safety cables to sockets (6), (7) and (8).

For possible connections for measuring the voltage and current of the test object at input sockets (11) and (12), please see the help texts in the optional software.

The control unit is connected to the three-phase system via a universal residual-current-operated circuit-breaker r.c.c.b. (EN 50178, IEC 755) and switched on with the mains switch (1).
If the r.c.c.b. trips when the equipment is switched on, disconnect other consumers from the r.c.c.b. and repeat the procedure.

When switched on or in the event of faults, the control unit is basically non-conducting, i.e. the connected 4-Q servo load machine is not activated. The quadrant display (18) is switched off after testing the four LEDs or indicates the fault (see fault messages). If the control unit was not switched to "off" position and a fault has not occurred, an input prompt or readiness to start, depending on the set mode, is indicated on the quadrant display (18).

When the max. brake power is exceeded (overheating of the brake resistor), the control unit is disconnected from the supply system for safety reasons. This state is indicated by display (2). However, after cooling down, the control unit switches on without the machine starting.

Note: The first few times the equipment is used at high brake power, smoke and a smell may develop at the brake resistor. This is normal and becomes less every time the equipment is used.

The fault indicating contact (10) acts as a break contact and can be integrated into a protective circuit for the test object.

7. Setting the modes

The measuring ranges for M are selected with switch (17) and for n with switch (16).

The mode is set with switch (9).

Every change of setting at mode switch (9) causes a controller inhibit, meaning that the power output stages are blocked and all controllers are reset, the 4-Q servo load machine stops free of torque. STP1 is indicated on display (13).

This function is also used as an emergency-off function.

At switch position "off" the controller inhibit acts statically, at the switch positions for the individual modes it is necessary to activate the key (15). An automatic restart is therefore not possible.

The function "off" can also be achieved with the STOP key on key pad (14). Display (13) indicates STP3, the red key is alight. Before activating key (15) for a restart, press key RUN on the key pad (14), otherwise a fault message is issued (see fault messages).

Display (13) and key pad (14) are active in all of the switch positions except at PC switch position.

7.1 $n_{const.}$ mode

The system control unit / 4-Q servo load machine acts as a drive and memorises the rotational frequency within the power limits of the test object, i.e. independent of the acting torque the rotational frequency remains constant. This method is mainly used for the measurement of start characteristics. It is also possible to drive generators with this method.

When switch position $n_{const.}$ is set, the four simultaneously flashing LEDs on the quadrant display (18) indicate the readiness to start.

If the key of the adjuster (15) is now operated, the 4-Q servo load machine is synchronised independently of the rotational frequency and the direction of rotation of the test object, meaning without developing a torque.

The speed can be changed with the adjuster (15). One rotation from notched position to notched position corresponds to the lowest possible speed change. When the rotation is slow, the change is small, and when the rotation is fast, the change is greater. (The sensitivity can be changed for special applications, see USER menu.)

The quadrant display (18) indicates the actual operating mode of the test object. The torque and the rotational frequency are indicated on the pointer instruments (19) and (20) and on the display (13). The indicated signs always relate to the test object. The percentage on the display (13) corresponds to the torque, i.e. % ≙ Nm, so that 4.0 % ≙ 4.0 Nm.

If, during synchronisation to zero torque, i.e. the test object is stationary and must be switched on later, it is necessary that the drive system reaches its max. torque straight away, the key on the adjuster (15) must be turned forward and then back by one notched position after it is activated. Then the test object can not start.

7.2 $M_{const.}$ mode

The system control unit/4-Q servo load machine loads the test object with a variable torque, independent of the rotational frequency of the test object. This can be compared with the features of a magnetic particle brake and is used for measuring load characteristic curves. The torque control generally occurs between no-load run and standstill, the direction of rotation cannot be changed and generator operation is not possible.

When switch position $M_{const.}$ is set, the simultaneous flashing of the top LEDs on the quadrant display (18) prompts the input of the start torque. A start torque of 0 to 10 Nm is set by turning the adjuster (15) clockwise. This is indicated on the torque display (19) and on the display (13). The percentage on display (13) corresponds to the torque, i.e. % ≙ Nm, so that 4.0 % ≙ 4.0 Nm.

The selected start torque is stored by pressing key (15). The displays are reset.

The four simultaneously flashing LEDs of the quadrant display (18) indicate readiness to start. If key (15) is now operated once more, the selected start torque is immediately adjusted and can be changed with the adjuster (15). When the rotation is slow, the change is small, and when the rotation is fast, the change is greater.

An impulse or start torque, depending on the order of switching on, acts upon the test object. If a start torque of 0 Nm has been stored, the synchronisation process takes place without developing a torque or the inertia torque of the 4-Q servo load machine becomes effective.

The quadrant display (18) indicates the motor operation of the test object. The torque and the rotational frequency are indicated on the pointer instruments (19) and (20) and on the display (13). The indicated signs always relate to the test object. The percentage on the display (13) corresponds to the torque, i.e. % ≙ Nm, so that 4.0 % ≙ 4.0 Nm.

7.3 Automatic mode

The system control unit / 4-Q servo load machine acts as a drive and memorises the rotational frequency within the power limits of the test object. The speed changes linearly within selectable limits. This method is used for the automatic measurement of characteristics.

When switch position "Autom." is set, the simultaneously flashing top LEDs on the quadrant display (18) prompt the input of the start rotational frequency. A start torque can be set within the value range of ±4000 rpm by turning the adjuster (15). It is indicated on the rotational frequency display (20) and on the display (13). The starting torque is stored by pressing key (15). The displays are reset.

The simultaneously flashing bottom LEDs on the quadrant display (18) prompt the input of the stop frequency. The procedure is the same as with the start speed.

The simultaneously flashing left LEDs on the quadrant display (18) indicate the readiness for reaching the start frequency. The test object can be switched on.

When the key on adjuster (15) is now pressed, the 4-Q servo load machine synchronises independently of the speed and direction of rotation with the test object and accelerates or brakes it until it reaches the start frequency.

When the start frequency is reached, the right LEDs flash simultaneously. It is still possible to switch on the test object. When key (15) is pressed again, the test object is reduced to stop frequency. This is done with a steady ramp time of 12 s (The specified ramp time of e.g. 12 s is related to a speed difference of 6000 rpm. This ramp time is variable (see also USER menu).

The quadrant display (18) indicates the current operating mode of the test object. The torque and the rotational frequency are indicated on the pointer instruments (19) and (20) and on the display (13). The indicated signs always relate to the test object. The percentage on the display (13) corresponds to the torque, i.e. % ≙ Nm, so that 4.0 % ≙ 4.0 Nm.

When the stop frequency is reached, the 4-Q servo load machine is switched off after approx. 2 s, i.e. the test object rotates at no-load rotational frequency. This is indicated by the simultaneously flashing left LEDs on the quadrant display (18).

Since the start and stop frequencies are still stored, this process can be repeated with the same values, start with key (15) ... see paragraph 5. This is useful for measuring characteristic curves with a motor that is warming up.

If you want to program other values for the start and stop frequency, the mode switch (9) must have been switched "off" once.

Note: The values of the start and stop frequencies should be within a range that is appropriate (safe) for the respective test object.

7.4 Flywheel mode

The system control unit / 4-Q servo load machine loads the test object with a variable moment of inertia, i.e. with a variable flywheel of 200 to 10,000 kgcm^2. This is the simulation of a load with constant torque or proportional relation between power and speed.
It is possible to determine starting times at different moments of inertia.

For the purpose of illustration: "Real" flywheels (art. no. 31 17 010 and 31 17 011) have a moment of inertia of 200 and 400 kgcm^2.

Or another illustration: On its shaft end the test object has a 2 cm wide steel disk, whose diameter of 19 cm (4.4 kg) can be altered to a max. of 50 cm (31.4 kg).

When switch position "flywheel" is set, the simultaneously flashing top LEDs on the quadrant display (18) prompt the input of the moment of inertia. A moment of inertia between 200 and 10,000 kgcm2 can be set by turning adjuster (15) clockwise. It is indicated on torque display (19) and on display (13). The Nm display corresponds to 1,000 kgcm^2 and the percentage on display (13) correspond to the moment of inertia, i.e. % ≙ 1000 kgcm^2, so that 5 % ≙ 5000 kgcm^2. The selected start torque is stored by pressing key (15). The displays are reset.

The four simultaneously flashing LEDs on the quadrant display (18) indicate readiness to start. If key (15) is now operated again, the selected moment of inertia is set immediately.

The test object is affected by an impulse or a start torque depending on the order in which it is switched on.

The quadrant display (18) indicates the actual operating mode of the test object. The torque and the rotational frequency are indicated on the pointer instruments (19) and (20) and on the display (13). The indicated signs always relate to the test object. The percentage on the display (13) corresponds to the torque, i.e. % ≙ Nm, so that 4.0 % ≙ 4.0 Nm.

7.5 PC mode

The system control unit / 4-Q servo load machine is controlled with a PC. The equipment is connected to the PC via the RS232 serial interface (5) and a standard cable.

The display (13), the key pad (14), the torque display (19) and the rotational frequency display (20) are switched off. The quadrant display (18) is only used for fault indication.
The adjuster with key (15) is ineffective.

8. Fault indication

○ ● The protective cover is not applied,
● ○ the temperature sensor for the test object is not applied or
the 4-Q servo load machine is not connected to the control unit (3).

Reaction: The control unit is blocked, display (13) indicates STP1 (not with PC).
After the fault has been eliminated, the control unit can be cleared with key (15).

● ○ The temperature of the test object is too high.

○ ● Reaction: The control unit is blocked, display (13) indicates STP1 (not with PC).
After cooling down, the control unit can be cleared with key (15).

● ● Fault in the system control unit/4-Q servo load machine.

● ● Reaction: The control unit is blocked, display (13) indicates the fault. The most common faults are STP3, Sd2, OH, OH3, OH4 and OH7. The OH faults indicate an overloading of the control unit or the 4-Q servo load machine. After a certain cooling down period, the fault can be reset (see below). The fault message Sd2 is an indication for a wrongly or non-connected resolver cable. The fault message OH3 can have the same indication. Message STP3 is indicated when the control unit was stopped with the STOP key on key pad (14) and not cleared again with the RUN key or when a PC program was not exited correctly.

When the fault is eliminated, the fault indicator can be reset by once switching to "off" position or by pressing the STOP/RUN keys. The control unit is cleared with key (15).

9. USER menu

In the operating modes "$n_{const.}$" and "automatic" it is possible to change two parameters each for special requirements. These changes are only effective until the mode is changed or the system is switched off. The switch position "off" does **not** reset the changed parameters. Only these two parameter pairs can be changed. The parameters are changed with the key pad (14) and indicated on display (13).

Driving or loading synchronous machines

In "$n_{const.}$" mode it is possible to change over to torque control with speed bracketing during the operation. The torque can be increased or reduced by pressing a button.

Switching from frequency control to torque control during operation can, for example, be useful for synchronous generators after synchronisation, when the input of the drive machine (e.g. steam turbine) must be increased. The synchronous machine then operates as generator with effective power output.

Or the synchronous machine operates as a motor and is loaded with a torque (of the driven machine). When there is a sudden loss of load (the test object is disconnected), the 4-Q servo load machine keeps on rotating with the set rotational frequencies (speed bracketing at ± 1% of the rotational frequency when switching over from frequency control to torque control). The following steps are necessary to switch over from frequency to torque control:

		Display		
		Line 1	Line 2	Line 3
1.	PRG	Code 0953 00		
2.	◀	USER MENU		
3.	▶	Code 0953 00	xxxx rpm	DIS: IN
4.	▲	Code 0250 00	0	FCODE 1 Bit
5.	PRG	Para 0250 00	0	FCODE 1 Bit
6.	▲	Para 0250 00	1	FCODE 1 Bit

Now, the control is switched over, the adjuster with pushbutton function is ineffective. This setting can be undone with ▼. Carry out the steps 1 – 5 before the synchronisation using adjuster (15) and connecting to the network.

		Display		
	Key	Line 1	Line 2	Line 3
7.	PRG	0953 00	xxxx rpm	x.xx % (Nm)
8.	PRG	Code 0250 00	1	FCODE 1 Bit
9.	▲	Code 0473 10	0	FCODE abs
10.	PRG	Para 0473 10	0	FCODE abs
11.	▲	Torque is increased		
	▼	Torque is reduced		
	SHIFT ▲	Torque is quickly increased		
	SHIFT ▼	Torque is quickly reduced		

Apart from the sign, the indication on the display does not relate to the torque; the torque display (19) is correct.

		Display		
	Key	Line 1	Line 2	Line 3
12.	PRG	Initial display		
13.	PRG	Code 0473 10	xx	FCODE abs
14.	▼	Code 0250 00	1	FCODE 1 Bit
15.	PRG	Para 0250 00	1	FCODE 1 Bit
16.	▼	Para 0250 00	0	FCODE 1 Bit
17.	PRG	Initial display		

The frequency control is switched on again; the adjuster (15) is effective.

Automatic linear frequency adjustment

In the automatic mode, ramp times are specified. The basic setting is 12 s, i.e. 2 s are required for a frequency change of 1000 rpm. The following steps are necessary for further times:

		Display		
	Key	Line 1	Line 2	Line 3
1.	PRG	Code 0953 00		
2.	◀	USER MENU		
3.	▶	Code 0953 00		
4.	▲	Code 0101 01	12.000s	Tir (acc)
5.	PRG	Para 0101 01	12.000s	Tir (acc)
6.	3 x ◀	Para 0101 01	12.000s	Tir (acc)
7.	▼ ▲ *)	Para 0101 01	xx.000s	Tir (acc)
8.	2 x PRG	Code 0101 01	xx.000s	Tir (acc)
9.	▲	Code 0103 01	12.000s	Tif (dec)
10.	PRG	Para 0103 01	12.000s	Tif (dec)
11.	3 x ◀	Para 0103 01	12.000s	Tif (dec)
12.	▼ ▲ *)	Para 0103 01	xx.000s	Tif (dec)
13.	PRG	Initial display		

*) Every time the key is pressed, the ramp time is increased or reduced by one second.

10. Specifications

Mains voltage:	3 x 400 V – 20%, + 30%, 45 - 65 Hz
Power:	4.8 kW
Output current:	7 A, 10.5 A for a short time
Fault indicating contact:	250 V AC; 0.2 A
Max. input current at the sockets +/– I:	13 A
Max. input voltage at the sockets +/– U:	1000 V
Display accuracy for n:	± 2.5 %
Display accuracy for M:	± 5 %
Output voltage for M-signal:	1 V/Nm
Output voltage for n-signal:	1 V/1000 rpm
Mains fuse:	3 x M 10 A (6.3 x 32)
Fuse for power supply unit:	80 mA M (5 x 20)
Dimensions in mm:	190 x 440 x 297 (Length x Width x Height)
Mass	13 kg

Note:
All specifications are subject to change. The specified dimensions and the mass are approximate values.

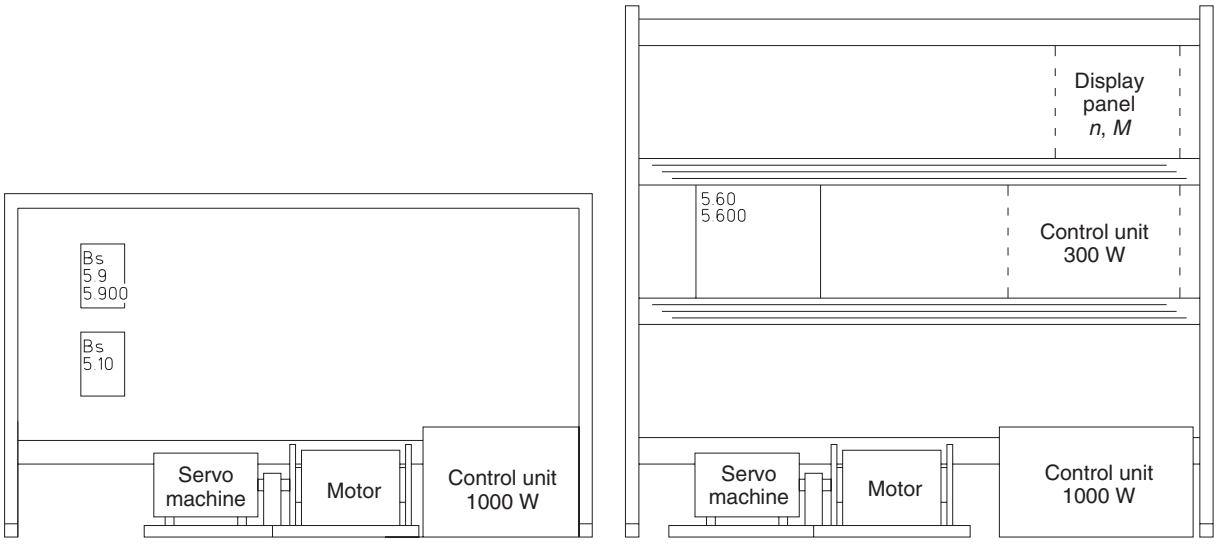
	Experimental module system		Experimental panel system	
Equipment	**100 W**	**300 W**	**300 W**	**1000 W**
Voltage supply	—	—	P 5.60	P 5.600
Circuit breaker	BS 5.9	BS 5.900	—	—
On/Off switch, 3-polar	BS 5.10	BS 5.10	—	—
Control unit	10 05 000 *	10 15 000 *	10 15 000	24 05 000
Speed/torque display	—	—	10 15 001	10 25 001
4-Q servo load machine	30 07 001 01	30 17 001 01	30 17 001 01	30 27 001 01
Three-phase squirrel-cage induction motor	MSA 06/065	MSA 6/65	MSA 6/65	MSA 600/650
Connection mask	31 05 601/651	31 15 601/651	31 15 601/651	31 25 601/651
Coupling collar	31 00 000	31 00 000	31 00 000	31 00 000
Coupling cover	31 00 002	31 00 003	31 00 003	31 00 003
Shaft end cover	31 00 004	31 00 005	31 00 005	31 00 005

* in portable housing

Arrange the instruments according to the illustration.

When setting up tests care must be taken that

– the coupling cover
– the shaft end cover
– and the Cinch connector for the thermal monitor for the motor is plugged in.

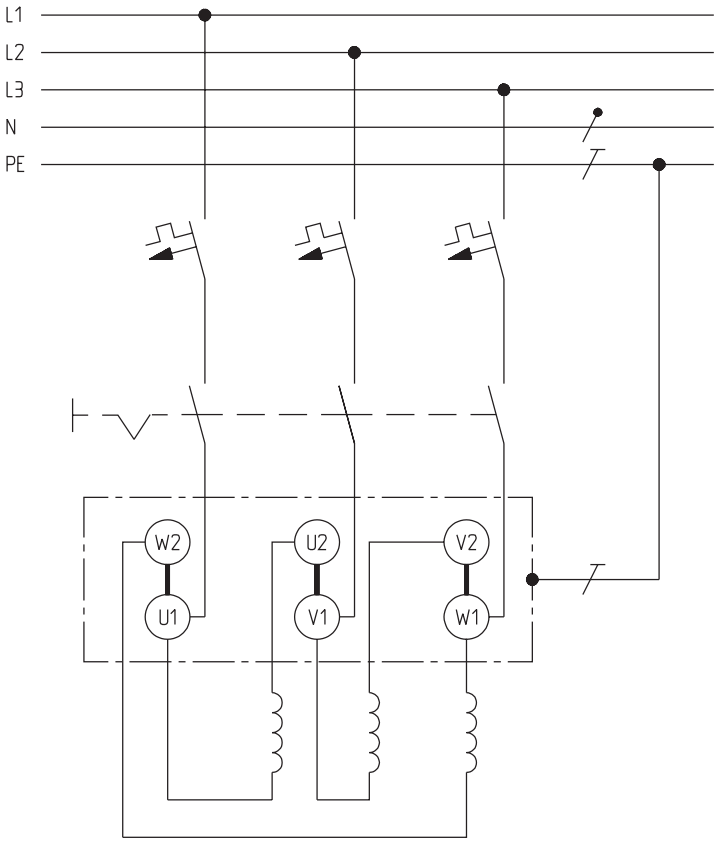


Exercise 1:

Practice adjusting the control unit to record the characteristic input n = f (M) for the range between no-load and about 1.5 times the rated load.

Procedure:

1.1 Connect the cables as shown on the circuit diagram.



1.2 Before starting the unit adjust the operating elements on the control unit as follows.

Power rating	**100 W**	**300 W**	**1000 W**
Operating switch on	M_{const} / T_{const}		
Changeover switch "Torque" on	1,5 Nm	3 Nm	10 Nm
Changeover switch "Speed" on	1500		

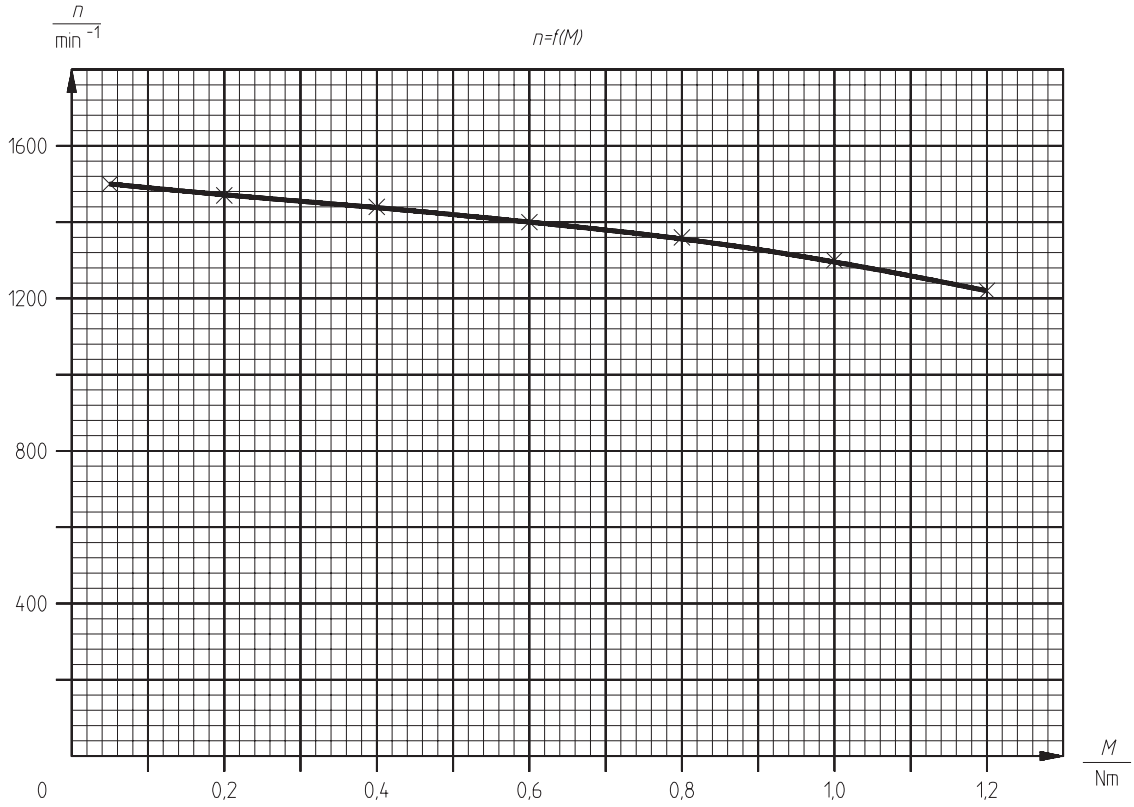
Turn-on the control unit at the mains. Wait for both of the top LEDs on the quadrant indicator to flash simultaneously.

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	0.2	0.4	0.6	0.8	1.0	1.2
$\frac{n}{\text{min}^{-1}}$	1495	1470	1440	1400	1360	1300	1220

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



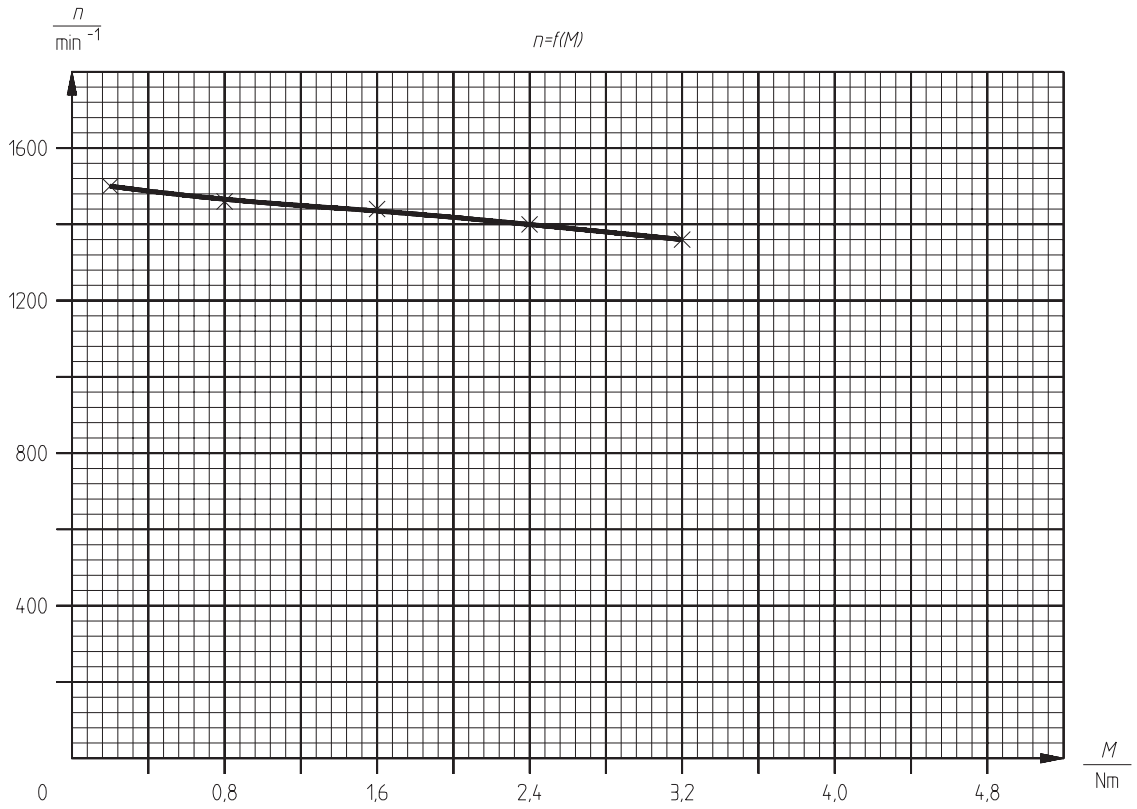
Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	0.8	1.6	2.4	3.2
$\frac{n}{\text{min}^{-1}}$	1495	1467	1438	1400	1359

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



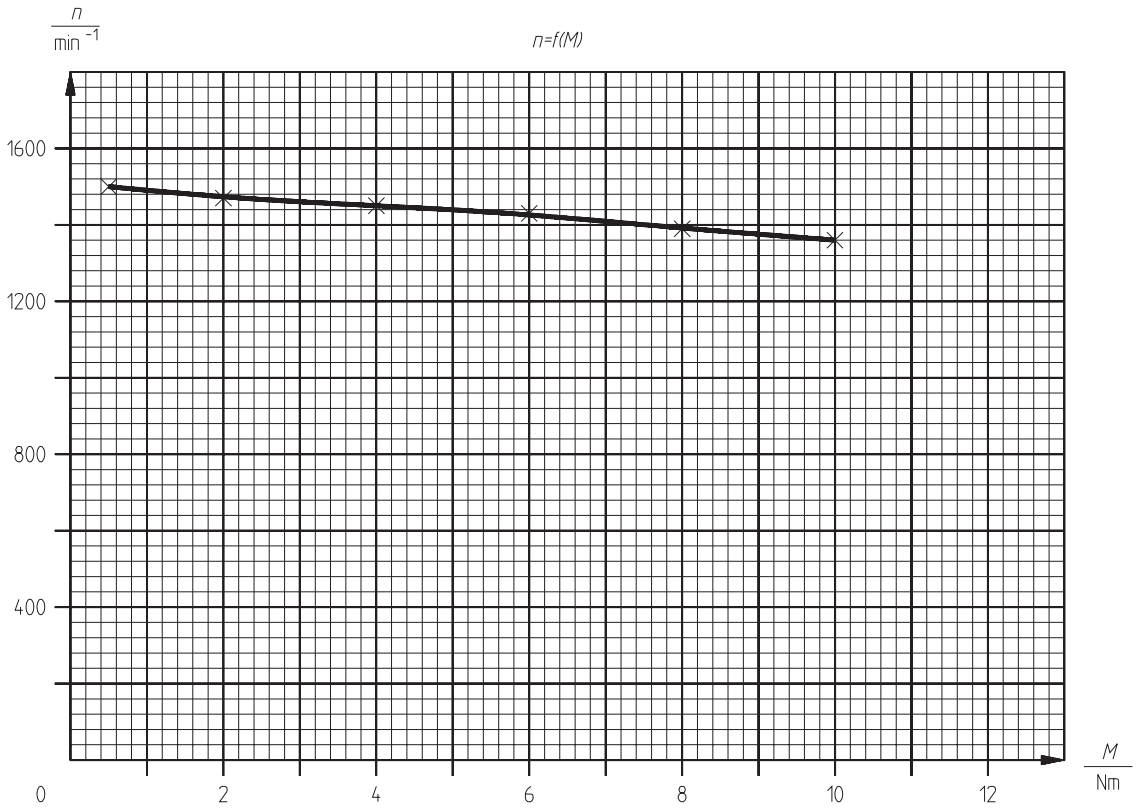
Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	2	4	6	8	10
$\frac{n}{\text{min}^{-1}}$	1495	1475	1453	1428	1395	1362

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

Exercise 2:

Practice adjusting the control unit to record the characteristic $M = f(n)$. (Starting characteristic for induction machines)

Note: Nominal voltage collector machines (e.g. direct-current machines) may not be slowed down by low speed or reverse rotation, as allowed with induction machines (e.g. short-circuit rotor motor). Direct-current machines can be overloaded for a short time up to a maximum of 50 % ... 80 %.

2.1 Before starting the unit adjust the operating elements on the control unit as follows:

Power rating	**100 W**	**300 W**	**1000 W**
Operating switch on	n_{const}		
Changeover switch "Torque" on	3 Nm	10 Nm	30 Nm
Changeover switch "Speed" on	1500		

Turn-on the control unit unit at the mains. Readiness to start is indicated by the four LEDs on the quadrant display flashing simultaneously.

2.2 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed and the torque. Enter the values in the table.
Press the "store/start" adjuster once.

Adjust the speed, as required in the table, by turning the "store/start" adjuster anti-clockwise and read off the relevant torque. Switch the motor (test object) off. Insert the measured torque value in the table.

Adjust the speed to the next value given in the table. Switch the motor on again and proceed with the next measurements accordingly.

Note: With starting characteristics the motor becomes overloaded. Therefore you must switch off after each measurement. With very long measuring times in the lower speed range, the motor becomes overheated. The thermostatic switch in the motor winding switches the servo machine off automatically.

to 2.2

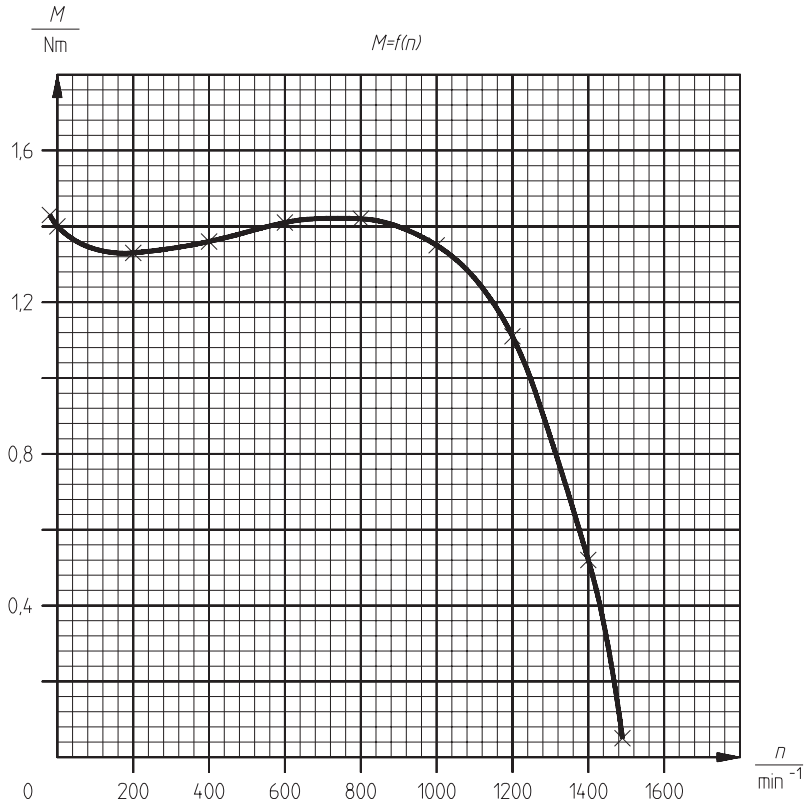
$\frac{n}{\text{min}^{-1}}$	n no load 1495	1400	1200	1000	800	600	400	200	0 [1)]	-20 [2)]
$\frac{M}{\text{Nm}}$	0.05	0.52	1.10	1.35	1.42	1.41	1.36	1.33	1.4	1.43

Note:

1) To adjust the speed to 0 min^{-1}, it is advisable to only observe the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).

2.3 Draw the dependency of the torque on the speed M = f (n) (Starting characteristic).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

to 2.2

$\frac{n}{\text{min}^{-1}}$	n no load 1495	1400	1200	1000	800	600	400	200	0 [1)]	-20 [2)]
$\frac{M}{\text{Nm}}$	0.05	2.7	5.2	5.7	5.8	5.6	5	4.8	5	5

Note:

1) To adjust the speed to 0 min^{-1}, it is advisable to only observe the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).

2.3 Draw the dependency of the torque on the speed M = f(n) (Starting characteristic).

Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

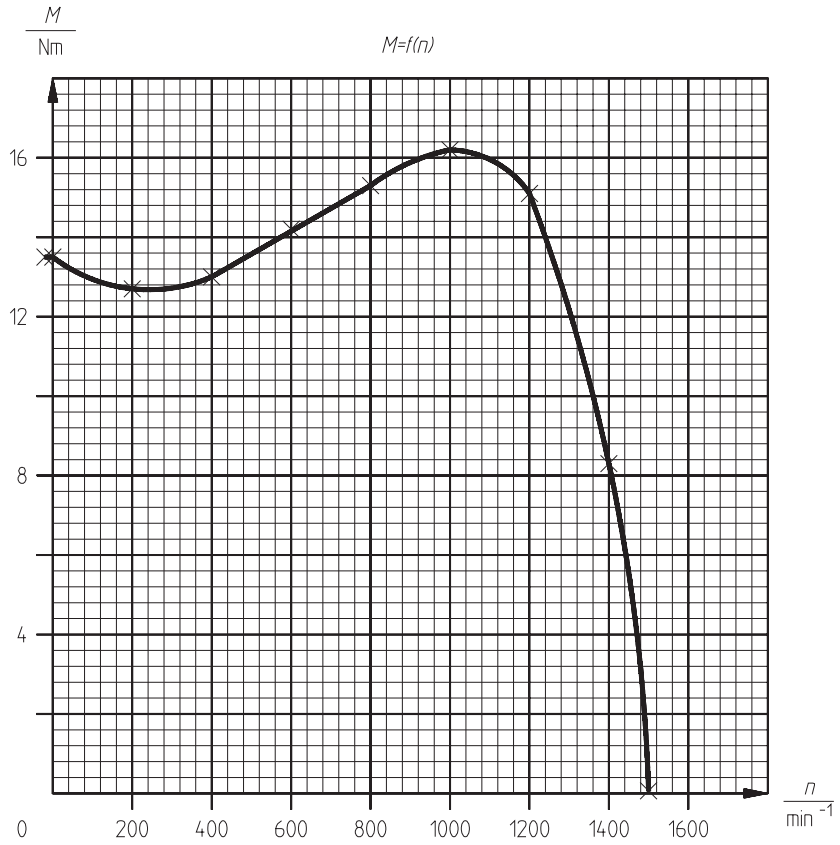
to 2.2

$\frac{n}{\text{min}^{-1}}$	n no load 1495	1400	1200	1000	800	600	400	200	0 [1)]	-20 [2)]
$\frac{M}{\text{Nm}}$	0.05	8.3	15.1	16.2	15.3	14.2	13.0	12.7	13.5	13.5

Note:

1) To adjust the speed to 0 min-1, it is advisable to watch only the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).



2.3 Draw the dependency of the torque on the speed M = f(n) (Starting characteristic).

Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

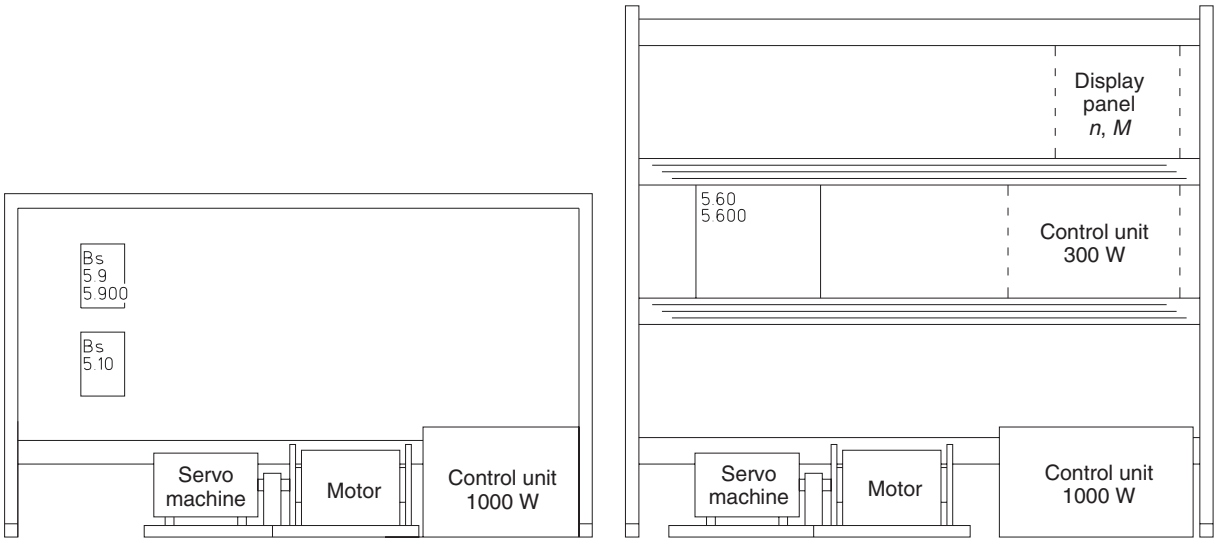
	Experimental module system		Experimental panel system	
Equipment	**100 W**	**300 W**	**300 W**	**1000 W**
Voltage supply	—	—	P 5.60	P 5.600
Circuit breaker	BS 5.9	BS 5.900	—	—
On/Off switch, 3-polar	BS 5.10	BS 5.10	—	—
Control unit	10 05 000 *	10 15 000 *	10 15 000	24 05 000
Speed/torque display	—	—	10 15 001	10 25 001
4-Q servo load machine	30 07 001 01	30 17 001 01	30 17 001 01	30 27 001 01
Three-phase squirrel-cage induction motor	MSA 06/065	MSA 6/65	MSA 6/65	MSA 600/650
Connection mask	31 05 601/651	31 15 601/651	31 15 601/651	31 25 601/651
Coupling collar	31 00 000	31 00 000	31 00 000	31 00 000
Coupling cover	31 00 002	31 00 003	31 00 003	31 00 003
Shaft end cover	31 00 004	31 00 005	31 00 005	31 00 005

* in portable housing

Arrange the instruments according to the illustration.

When setting up tests care must be taken that

– the coupling cover
– the shaft end cover
– and the Cinch connector for the thermal monitor for the motor is plugged in.



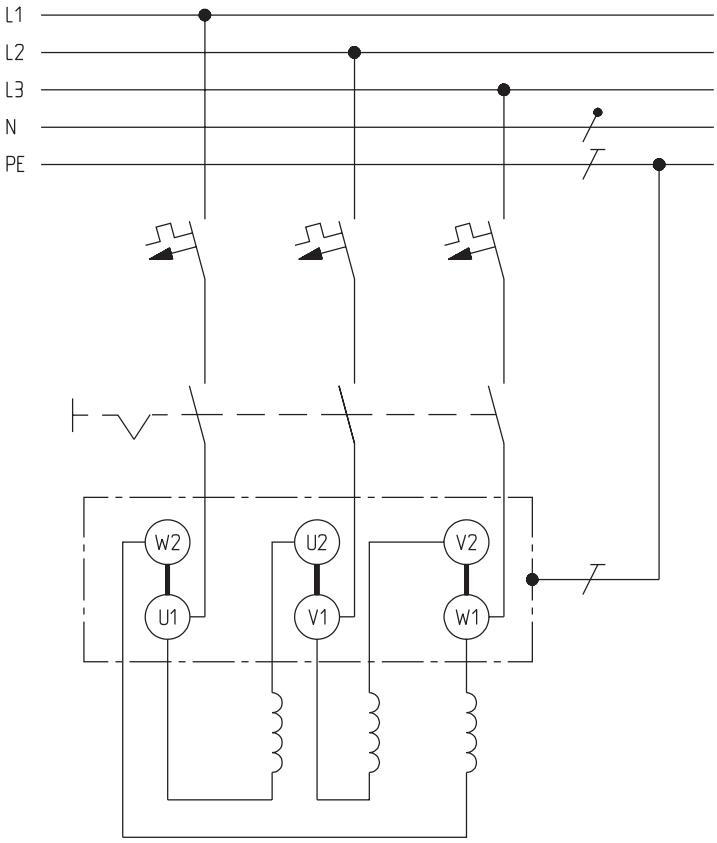
Name | Class | Date

Exercise 1:

Practice adjusting the control unit to record the characteristic input n = f (M) for the range between no-load and about 1.5 times the rated load.

Procedure:

1.1 Connect the cables as shown on the circuit diagram.



1.2 Before starting the unit adjust the operating elements on the control unit as follows.

Power rating	100 W	300 W	1000 W
Operating switch on	M_{const} / T_{const}		
Changeover switch "Torque" on	1,5 Nm	3 Nm	10 Nm
Changeover switch "Speed" on	1500		

Turn-on the control unit at the mains. Wait for both of the top LEDs on the quadrant indicator to flash simultaneously.

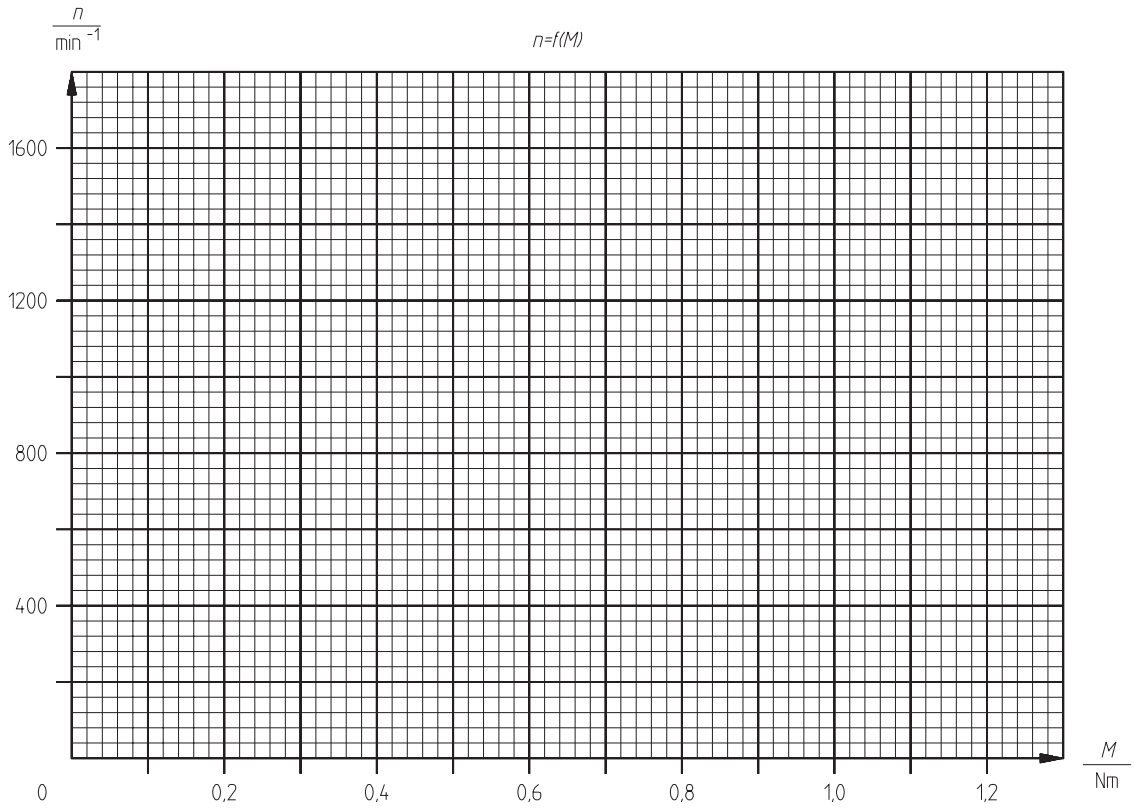
Name		Class	Date

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	0.2	0.4	0.6	0.8	1.0	1.2
$\frac{n}{\text{min}^{-1}}$							

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



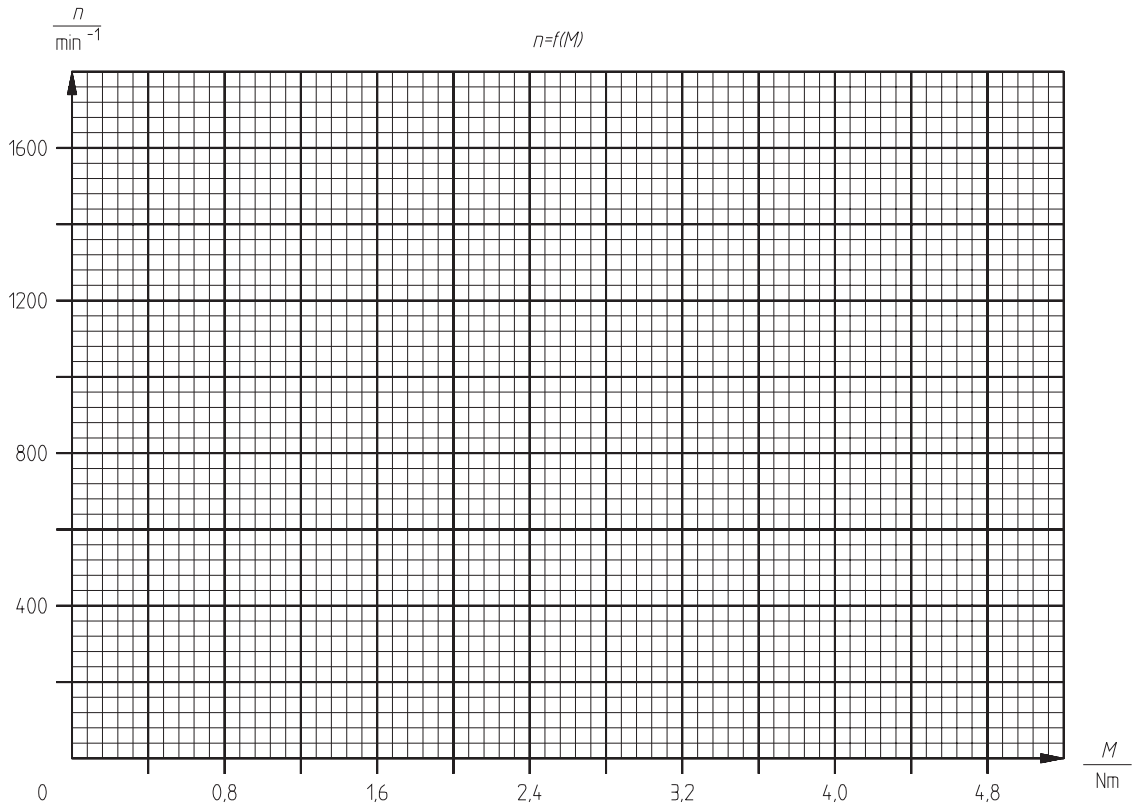
Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	0.8	1.6	2.4	3.2
$\frac{n}{\text{min}^{-1}}$					

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



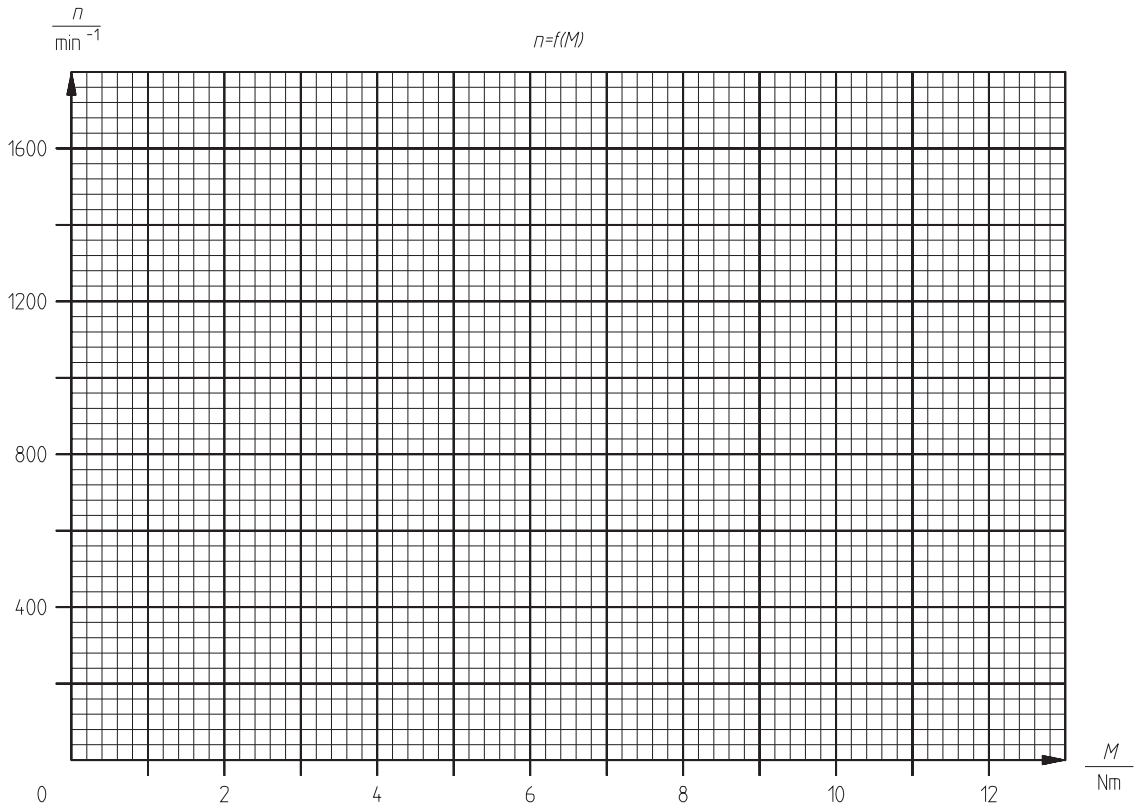
Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

1.3 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed at the torque of 0 Nm and fill in the table below.
Press the "store/start" adjuster twice. Increase the load by turning the "store/start" adjuster clockwise until the torque required in the table is reached. Read the value of the relevant speed and insert it into the table.

$\frac{M}{\text{Nm}}$	0	2	4	6	8	10
$\frac{n}{\text{min}^{-1}}$						

Take the following measurements as well.

1.4 Using the measured values, draw the function of speed on the torque n = f (M).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

Exercise 2:

Practice adjusting the control unit to record the characteristic $M = f(n)$. (Starting characteristic for induction machines)

Note: Nominal voltage collector machines (e.g. direct-current machines) may not be slowed down by low speed or reverse rotation, as allowed with induction machines (e.g. short-circuit rotor motor). Direct-current machines can be overloaded for a short time up to a maximum of 50 % ... 80 %.

2.1 Before starting the unit adjust the operating elements on the control unit as follows:

Power rating	**100 W**	**300 W**	**1000 W**
Operating switch on	n_{const}		
Changeover switch "Torque" on	3 Nm	10 Nm	30 Nm
Changeover switch "Speed" on	1500		

Turn-on the control unit unit at the mains. Readiness to start is indicated by the four LEDs on the quadrant display flashing simultaneously.

2.2 Start the motor. Use the speed indicator to check that the motor rotates forward.
Read off the idling speed and the torque. Enter the values in the table.
Press the "store/start" adjuster once.

Adjust the speed, as required in the table, by turning the "store/start" adjuster anti-clockwise and read off the relevant torque. Switch the motor (test object) off. Insert the measured torque value in the table.

Adjust the speed to the next value given in the table. Switch the motor on again and proceed with the next measurements accordingly.

Note: With starting characteristics the motor becomes overloaded. Therefore you must switch off after each measurement. With very long measuring times in the lower speed range, the motor becomes overheated. The thermostatic switch in the motor winding switches the servo machine off automatically.

to 2.2

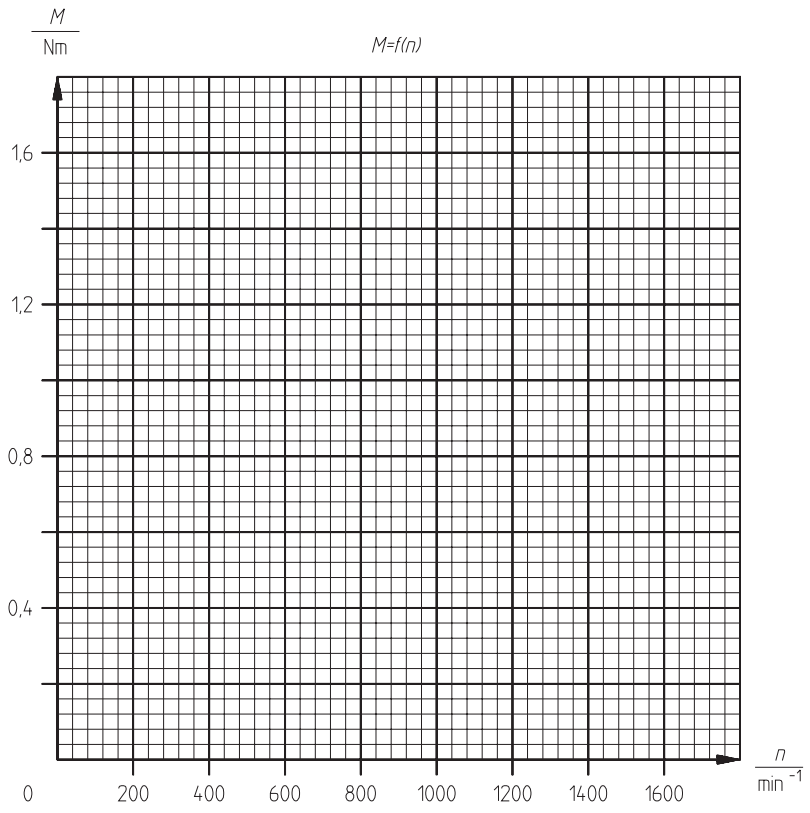
$\frac{n}{\text{min}^{-1}}$	n no load	1400	1200	1000	800	600	400	200	0[1)]	-20[2)]
$\frac{M}{\text{Nm}}$										

Note:

1) To adjust the speed to 0 min^{-1}, it is advisable to only observe the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).

2.3 Draw the dependency of the torque on the speed M = f (n) (Starting characteristic).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

to 2.2

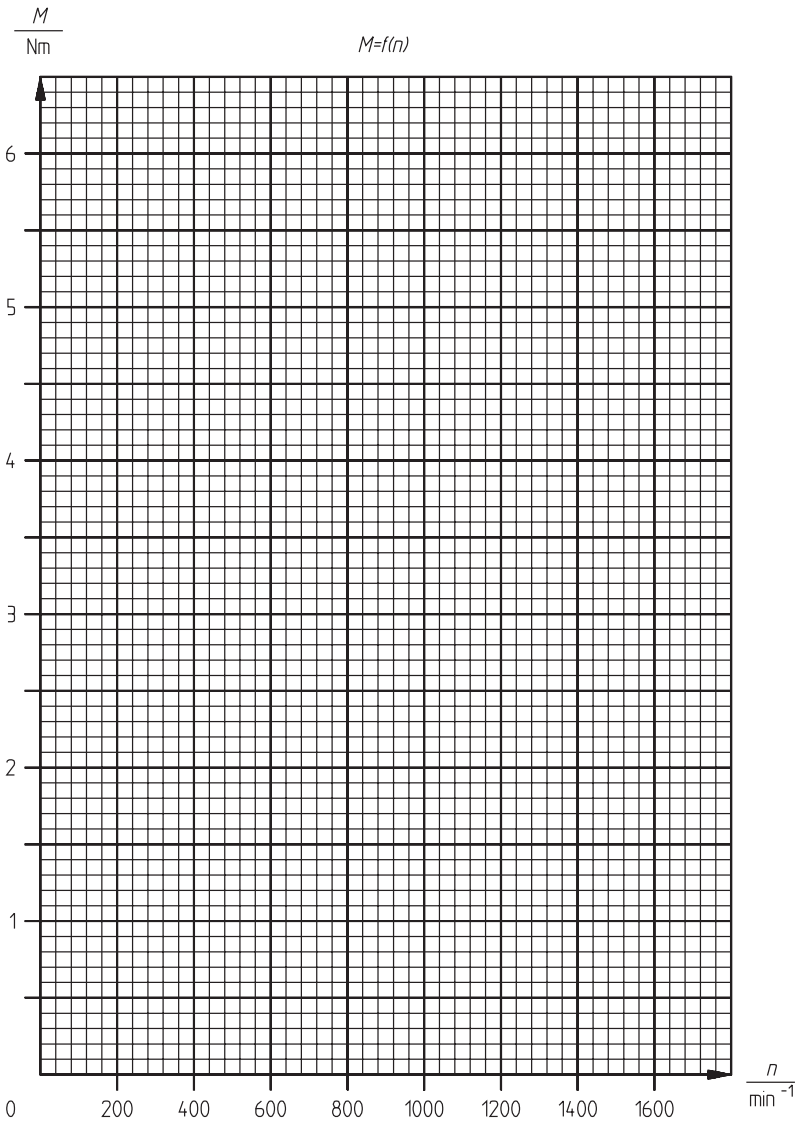
$\frac{n}{\text{min}^{-1}}$	n no load	1400	1200	1000	800	600	400	200	0 [1)]	-20 [2)]
$\frac{M}{\text{Nm}}$										

Note:

1) To adjust the speed to 0 min^{-1}, it is advisable to only observe the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).

2.3 Draw the dependency of the torque on the speed M = f(n) (Starting characteristic).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.

Name		Class	Date

to 2.2

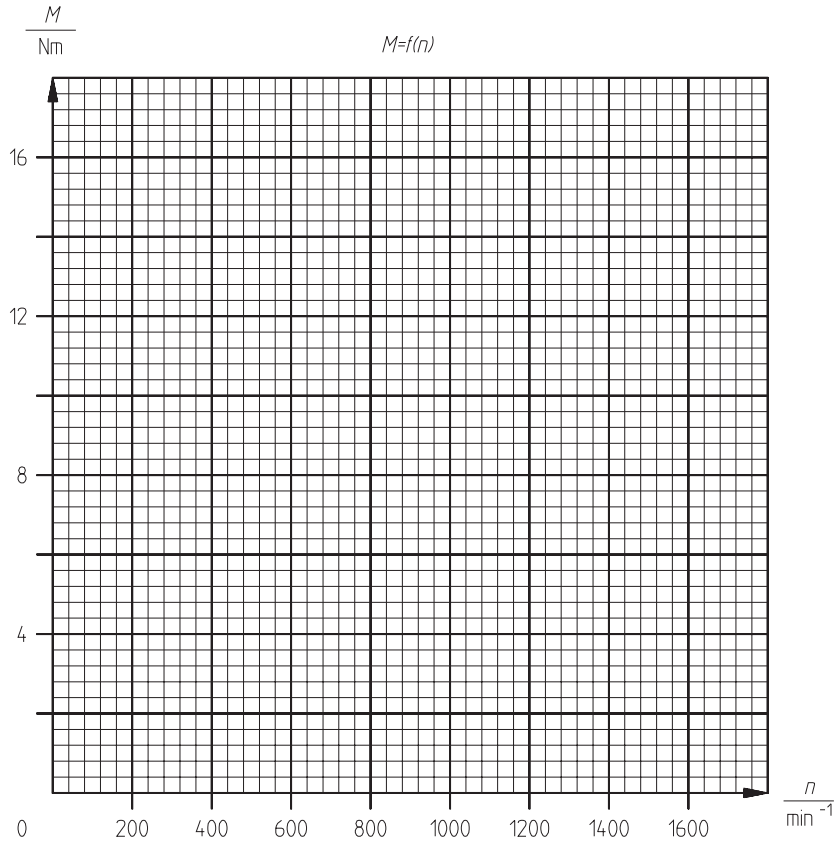
$\frac{n}{\text{min}^{-1}}$	n no load	1400	1200	1000	800	600	400	200	0[1)]	-20[2)]
$\frac{M}{\text{Nm}}$										

Note:

1) To adjust the speed to 0 min-1, it is advisable to watch only the coupling at a very low speed.

2) When you record the characteristic it is possible that a high dispersion of the starting torque may occur. The starting torque depends on the notching-position of the roller to the stand. To get an almost exact value of the starting torque the ELWE-servo machine offers the measurement of the starting torque at a slow reversal rotation (about -20 min^{-1}).

2.3 Draw the dependency of the torque on the speed M = f(n) (Starting characteristic).



Note: Depending on the manufacturing variations of the machines, fluctuations in the main voltage, the tolerance of the measuring devices and the temperature of the machines, a variation between the measured values and the shown values may occur.