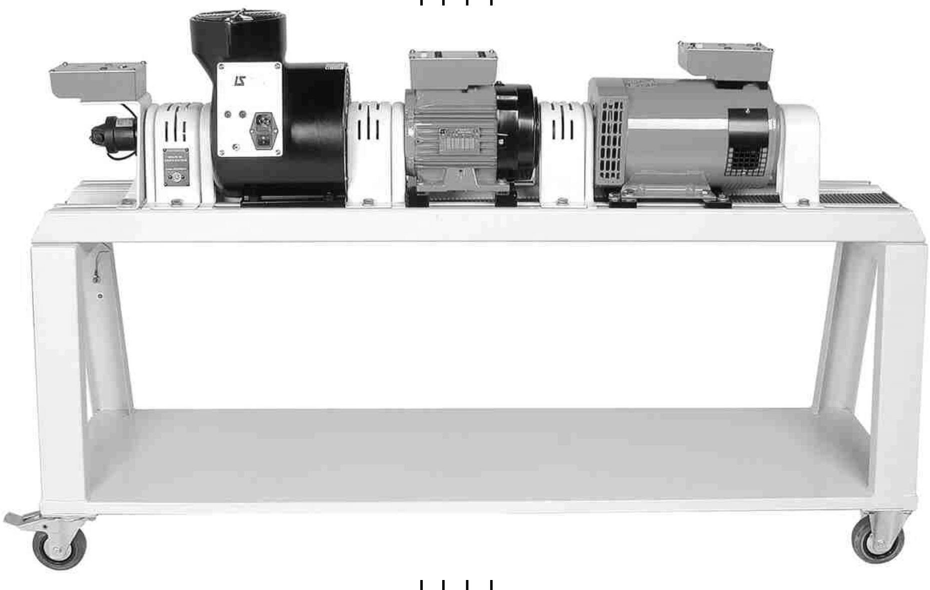


FP 10/15 8/10/2003

FP.10/15D2

TEST BENCH with POWDER BRAKE

for machine from 0,75 to 1,5 kW

Operating instructions

CE AUTOCERTIFICATION

According to "Machines" directive 89/392/CEE, modified 91/368/CEE and according to "Low voltage" directive 73/23/CEE modified 93/68/CEE

NOTE

LEROY-SOMER reserves the right to modify the specifications of its products at any moment in order to implement the latest technological developments. All information egiven in the present document may therefore change without notice.

WARNING ⚠

PRECAUTIONS BEFORE USE

- If a roller-mounted support is used, the brakes of the rollers should be locked.
- Check the alignment of all the machines mounted on the test bench and the correct fastening of the couplings.
- Check that the fastening screws of the machines are correctly tightened.
- Check thet the protective covers of the machines are correctly tightened.
- The training equipments are disigned to be modulable and quickly connectable : therefore particular care must be observed for earthing.

All sub-units must be connected by the user to the skid ground terminal with independant connections.

The user must then connect the ground terminal to the earth of the installation.

PRECAUTIONS FOR USE

- The electrical power supply sources of electric machines must be fitted with a 30 mA differential cutout and an emergency circuit breaker easily accessible and close to the test bench.
- The cables and protective fuses must correspond to the power given on the nameplate of each machine.
- It is necessary to fit thermal protections (usually of the OTP type) to the machines within the training equipment range ; these probes are inserted in the safety link of the power supplies in order to cut the supplies of the bench in case of fault.
- When a DC motor with series or separate excitation is mounted on the test bench, it is compulsory to fit an overspeed protection which cuts the main power supply of the machines in order to prevent any risk of racing.
- The calibration operation of the torque sensor will be carried out without removing the protective cover. A screwdriver should be used to drive home the threaded hole of the sensor coupling in order to fit the torque arm.

CE AUTOCERTIFICATION

According to "Machines" directive 89/392/CEE, modified 91/368/CEE and
according to "Low voltage" directive 73/23/CEE modified 93/68/CEE

PRECAUTIONS FOR INSTALLATION

- It is required to locate the test bench in a place lighted according to the Labour Code.
- The bench must be clearly visible fot the person manipulating the controls of the various concerned power supplies.
- This person must have within reach a cutout device for the power supply sources.
- Before displacing the test bench, it is necessary to check that all components are fastened with original screws and that tightening is correct. During the move, the skids must remain horizontal.
- If the bench has to be lifted, dismantle some components in order to limit maximum load to 50 kg. For motors heavier than 50 kg, it will be necessary to sling them by both shaft ends.
- The bench must be placed on a flat and smoorth ground.
- After any modification of the bench setup, for instance the replacement of a test machine by another one, it is necessary to check the correct alignment of the shaft line.

PRECAUTIONS DURING USE

- Make sure an emergency circuit breaking device is within reach.
- Before carrying out any operation, check that all power supply sources have been cut out and that the shaft line has completely stopped to rotate.
- Noise can reach a level of 75 dB(A), so the necessary measures in connection with the working space have to be taken.

MAINTENANCE OF THE BENCH

- Check every year that the different components are sufficiently tightened, that the alignment is correct and that the couplings are in good condition.
- Check periodically the condition of the brushes of the DC machines.
- Clean the air intake louvres of the ventilation systems.

LEROY-SOMER déclines any responsability whatever if these recommendations are not complied with.

TABLE OF CONTENTS

CONNECTION DIAGRAM

1 - INTRODUCTION

1.1 - MOTOR TEST BENCH

Asynchronous squirrel-cage motor linked to load bench.

The test bench includes the motor load (magnetic powder brake),a force meter (strain gauge meter) or a torque meter (in option)to measure the torque moment and a speedometer (tachometer generator) .Adaptable couplings avoid any problems that may be encountered with different alignments.

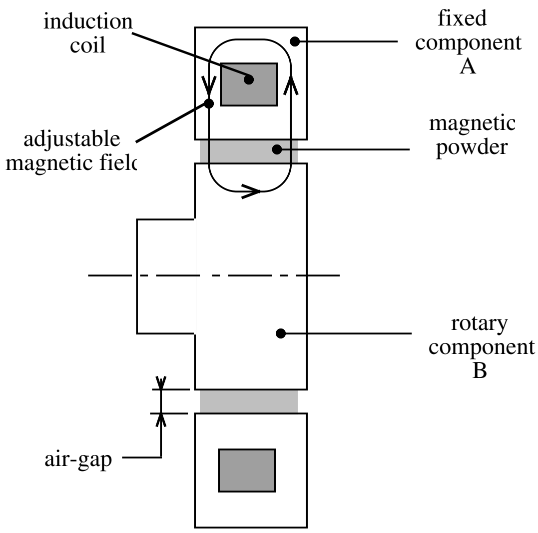
1.1.1 - Powder brake

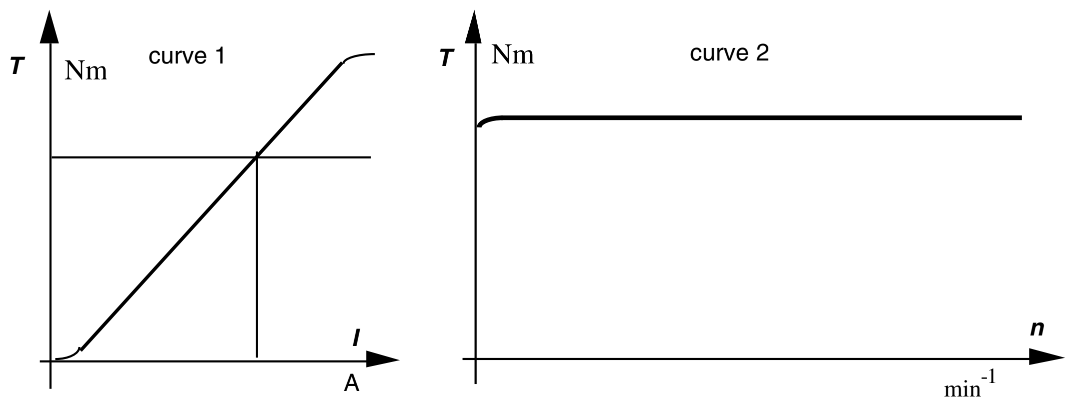
The **brake** is designed to act as a load for motors with a power of 1,5 kW .

The mechanical load used is a balance-mounted magnetic powder brake. The part of the brake coupled to the motor is a disc. This disc "A" rotates in a chamber containing magnetic powder. The powder is magnetized when exposed to a magnetic field.

It builds up on the disc when the magnetic field is produced. The disc finds it harder and harder to rotate as the powder accumulates (i.e. as the strength of the magnetic field increases) : the resistive torque therefore increases.

When the brake and the motor are coupled, magnetizing the powder exerts a resistive torque on the shaft of the motor.





BRAKE CHARACTERISTICS

Power supply : - brake coil - forced ventilation - VF (single phase)	 direct current with : - GCL 0,8 (generator) - MOD'SIM (simulation module) - INTERMECA (measurement interface) - MODMECA (measurement module) 230V (2P + PE - 0,35A - 50Hz)
Coil resisting at 20 ° C	20 Ohms
brake max rotation speed	3000 min^{-1}
excitation current and torque moment	In = 0,22A Tn = 10 Nm I max = 0,65 A T max = 25 Nm Io = 0 A To ≤ 0,4 Nm
dissipated power at 20 ° C, 1500 min^{-1} with forced ventilation	1500 W during 45 min 2000 W during 15 min 3000 W during 5 min
brake protection - coil cut - current -on again	Thermal probe T > 95 ° C T < 85 ° C
	In case of powder brake dismantling, a new calibration may be done before another use

1.1.2 - Option 1 : Forcemeter (for more details see"operating instructions"réf.CAP.FOR)

The brake, which is balance mounted, is equipped with a force meter (fig.1). It is placed at a fixed distance "d" from the shaft of the motor, and is used to measure the moment of the braking torque .

The force meter is a strain gauge device (i.e. a device in which the resistance of a fine wire varies as its length changes under strain).

The signal conditioner and the display unit are built into the Mechanical Module.

A removable torque arm is provided to calibrate the system.

The forcemeter is connected to the Mechanical Module by a 1.5m lead with a 7-pin DIN plug connector.

1.1.3 - Option 2 : Torquemeter (for more details see"operating instructions" réf. CAPCOL)

1.1.4 - Speedometer

The speedometer is a tachometer generator that supplies a voltage that varies proportionally with the rotational speed.

TACHOMETER CHARACTERISTICS

Speed constant :	0.02 V per rev.	E.m.f at 1,000 min^{-1} :	20 V
Max. current :	0.20 A	Max. speed :	15,000 min^{-1}

Armature resistance : 51 Ω

The tachometer is connected to the Mechanical Measurement Module by a 1.5m lead with a 5-pin DIN plug connector.

1.2 - MEASUREMENT MODULES

1.2.1 - Mechanical measurements

1.2.1.1 - General remarks

The module (fig.2) comprises the following components:

. the device for measuring and reading the rotational speed *(n)* of the machine being driven, from the voltage supplied by the tachometer generator.

. the force or torquemeter conditioner-display for powering,measuring and displaying the torque(*T).*

. the device for measuring the mechanical power*(P)* from the speed and torque moment data.

. the powder brake power supply, control system.

1.2.1.2. FRONT

The following are on the front of the module

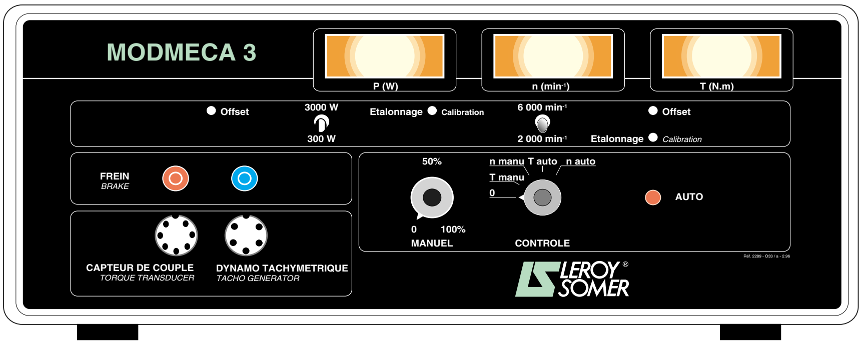
.the "On - Off" switch.

. the large size (13mm) LED's displays indicate respectively :

- the *MECHANICAL POWER P* m in watts. Cal.: 1 or 4kW.Accuracy ≤ 3%.

- the *ROTATIONAL SPEED n* expressed in revolutions per minute. Cal.: 2,000 or 6,000 min^{-1} according to position of selector switch. Accuracy ≤ 1%.

fig.2



- the *TORQUE MOMENT T* on the brake shaft expressed in N.m. Cal.: 10 or 40N.m Accuracy ≤ 2%.

. the potentiometer used to calibrate the speed *n.*

. the speed selector switch (2,000 or 6,000 min^{-1}) used to modify the voltage from the analog output and the internal speed servo-control.

. the power selector switch : 0.3 or 3 kW to adapt the module with the force or torque meter used on the test bench with 0.3 kW motor or 1.5/3 kW motors

. the potentiometer used to reset the torque measurement to zero.

. the potentiometer used to calibrate the torque measurement.

. the 6-way switch used to select the operating mode of the brake.

1st	position	- zero control	: 0
2nd	position	- "manual" torque control	: *T*.m
3rd	position	- "manual" speed control	: *n*.m
4th	position	- "automatic" torque control	: *T*.a
5th	position	- "automatic" speed control	: *n*.a
6th	position	- torque control by external voltage	: *T*.exter

. the control knob on the potentiometer used for "manual" mode control.

. a pushbutton contact switch used to control the braking gradient -speed or torque-in"automatic" mode

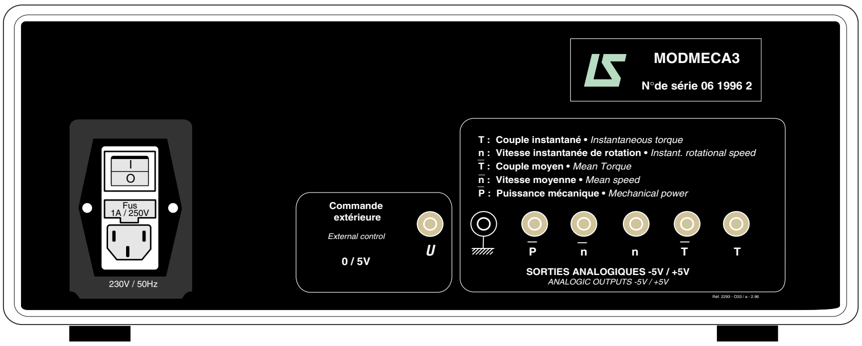
. the two 7 and 5 pin DIN connectors, for connecting the leads from the force meter and from the tacho meter generator.

1.2.1.3 - Back

The following are on the back of the module:

. the electrically insulated ± 5V analog outputs, corresponding to the following parameters:

-*SPEED*: 2 outputs : mean value and instantaneous value.
5V/2,000 min^{-1} or 5V/6,000 min^{-1}, according to position of selector switch.



-*POWER* 1 mechanical POWER output 5V/1kW or 5V/4kW

-*TORQUE MOMENT* 2 outputs :
mean value and instantaneous value,
5V/10 N.m or 5V/40 N.m

. a 0 to + 5 V DC analog input for external torque control.

. the module power supply safety fuse (1.5A time-delay fuse).

. the 230 V single-phase 50 Hz mains power lead connector. The lead has a 2P + E plug.10/16 A

N.B.: the connection terminals on the back of the module are adapted to 4 mm diameter plugs.

1.2.1.4 Operation

A - PREPARATION

A.1 - SPEED MEASUREMENT

The tachometer generator is connected to the mechanical measurement module by the 5 pin DIN plug lead. The speed is expressed in revolutions per minute.

Calibration: a potentiometer is used to calibrate the speed measurement sequence. (One possible method: use synchronous motor ref.: A23.S).

2,000 or 6,000 min^{-1} Switch: this only modifies the speed signal from the analog output on the back of the module, i.e. 5 V at 2,000 min^{-1} and 5 V at 6,000 min^{-1} and modifies the internal servo control system.

A.2 - TORQUE MEASUREMENT with the FORCE METER OPTION

The force meter is connected to the mechanical measurement module by a 7 pin DIN plug lead. The torque is expressed in N.m.

Reset to zero: : a potentiometer is used to reset the torque measurement sequence to zero.

Calibration: : a potentiometer is used to adjust the gain of the torque measurement sequence.

A removable torque arm is provided with the module for recalibrating the system.

- To recalibrate see the " opérating instructions " concerning the force meter CAP.FOR or the torque meter CAP.CO.

A.3 - MECHANICAL POWER MEASUREMENT

The mechanical power is measured with an analog multiplier that gives the product of *T* and *w* Power is expressed in watt.

A.4 - MECHANICAL LOAD CONTROL

The mechanical load is a magnetic powder brake. This load is controlled by the mechanical module, to which it is connected by the 7 pin DIN plug lead.

A 6-way switch is used to select the operating mode of the device.

Position 1 0 the magnetic brake is not powered, so the motor is only subjected to the residual torque.

Position 2 *T* m manual torque control. The mechanical load control is used to adjust the torque. The torque is adjusted by the control potentiometer.

Position 3 *n* m manual speed control. The current powering the powder brake is controlled to adjust the rotational speed of the motor.

A P.I.. - type regulator is incorporated in the control loop to stabilize the device.
Controlling the current in this way makes it possible to read the characteristic *T(n)* of the asynchronous motor as a whole, even during the "unstable" part.
For a speed of > 2,000 min^{-1}, switch to the 6,000 min^{-1} position.

The speed is adjusted using the control potentiometer.

Position 4 *Ta* automatic torque control. The mechanical load control is used to adjust the torque.
The push-button sets the following cycle:
data are analyzed and the characteristics of the motor being studied are plotted during the start-up phase.
For a speed of > 2,000 min^{-1}, switch to the 6,000 min^{-1} position.

Position 5 *na* automatic speed control. The current is controlled in the mechanical load to adjust the rotational speed of the motor.
The push-button sets thefollowing cycle:

To plot the characteristic *T (n)* of the asynchronous motor, select "speed control".

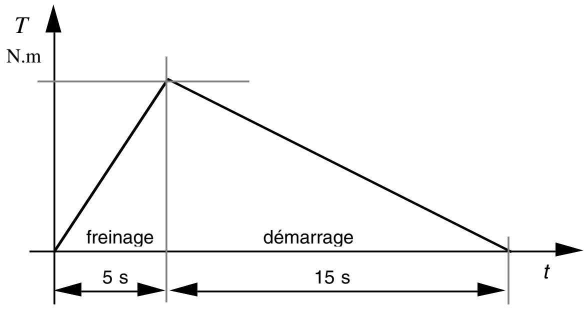
In this control mode the"zero speed"is detected,the load is progressively reduced and the motor start up slowly.

N.B.: the braking and start-up times are given as an indication only and may vary from one apparatus to another.

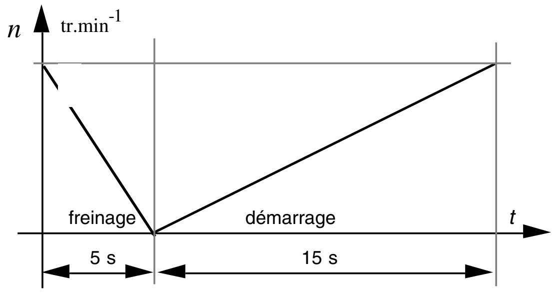
Position 6 *ext.T* torque control via external voltage (0-5V)

This external control enables the user to exert the torque,he requires on the motor shaft (load simulation).

The external torque control input terminals are on the back of the module.



braking start-up



braking start-up

1.2.2 - ELECTRICAL MEASUREMENTS

1.2.1.1 General remarks

The module (Fig.7) comprises the following components:

. Apparatus for measuring and reading:

- *direct current* — mean value. 1 rating 2 A.

- *direct current* or *alternating current* — mean value. 2 ratings: 2 and 20 A.
  RMS* value. 2 ratings: 2 and 20 A.
  Reading modified by 4-way switch.

- *DC voltage* or *AC voltage* — mean value .2 ratings: 50 and 500 V.
  RMS* value .2 ratings: 50 and 500 V.
  Reading modified by 4-way switch.

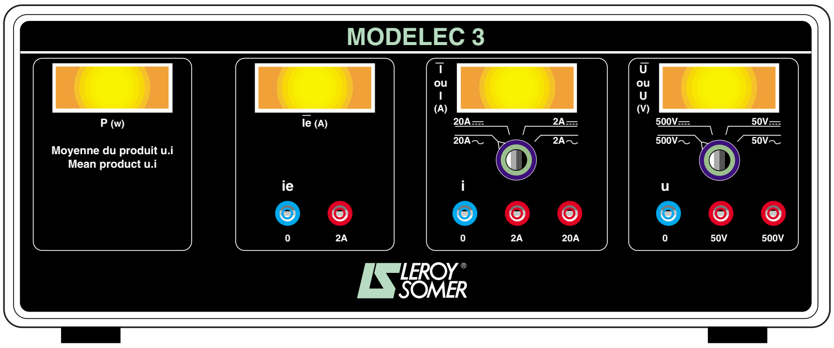
- *DC* or *AC* power. — Ratings: 100 W / 1 kW and 10 kW.

1.2.2.2 Front

The following are on the front of the module:

. the "On-Off" switch.

. the four 2,000 point LED displays, H = 13 mm, corresponding to:



- *the direct current*, rating 2 A.
Accuracy ≤ 1%.(for DC or synchronous machine, excitation circuit)
2 connection terminals.

-*the direct or alternating current:*
3 connection terminals.
. DC, rating 2 and 20 A.
Accuracy ≤1%.
. AC, rating 2 and 20 A.
Accuracy ≤1%.Peak current 4 or 40 A.

-*the DC or AC voltage*: 3 connection terminals.
. DC voltage, rating 50 and 500 V. Accuracy ≤ 1%.
. AC voltage, rating 50 and 500 V. Accuracy ≤ 2%. Peak allowable voltage:1,000V.

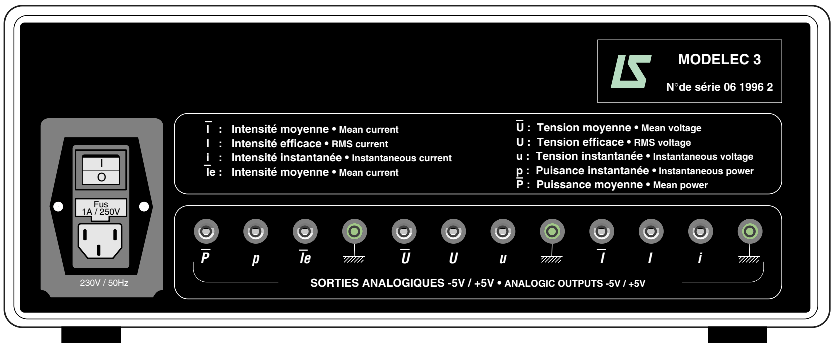
-*the DC or AC power*.
. DC. Accuracy ≤ 2%.
. AC. Accuracy ≤ 3% at a frequency of < 200 Hz. Band pass : 5 kHz at -3dB.
Rating: 100 W / 1 kW and 10 kW according to current and voltage ratings used.

. the 4-way current switch, used to select the type and rating of the current.

. the 4-way voltage switch, used to select the type and rating of the voltage.

N.B.: the connection terminals are safety-type protected terminals.
They accept 4 mm-diameter "safety" jacks or "banana" plugs.

1.2.2.3 Back



The following are on the back of the module:

.*The electrically insulated* ± 5V analog outputs,corresponding to the following measured parameters:

- *DC CURRENT* - Mean value - rating 2 A
- *DC CURRENT* - Mean value - ratings 2 or 20 A
- *AC CURRENT* - Real RMS value - ratings 2 or 20 A
- *DC VOLTAGE* - Mean value - ratings 50 or 500 V
- *AC VOLTAGE* - Real RMS value - ratings 50 or 500 V
- *POWER* - Mean value - rating 0.1/1/10 kW

. the peak ± 10 V electrically *insulated signal* outputs can also be used:

- *CURRENT*: 1 INSTANTANEOUS CURRENT output, with a peak value of 4 or 40 A according to the rating.
- *VOLTAGE*: 1 INSTANTANEOUS VOLTAGE output, with a peak value of 100 or 1,000 V according to the rating.
- *POWER*: 1 INSTANTANEOUS POWER output, 0.2 / 2 / 20 kW according to the rating.

. the module power supply safety fuse (1.5A time-delay fuse).

. the 230 V single-phase 50 Hz mains power lead connector. The lead has a 2P + T plug. 10/16 A. (1.5 m lenght)

N.B.: the connection terminals on the back of the module are adapted to 4 mm Ø plugs.

1.2.2.4 Operation

A - POWER UP

The apparatus must be connected to the mains (230 V single-phase 50 Hz).
Press the red switch (I/O) to power up.

B - VOLTAGE MEASUREMENT : MEAN VALUE

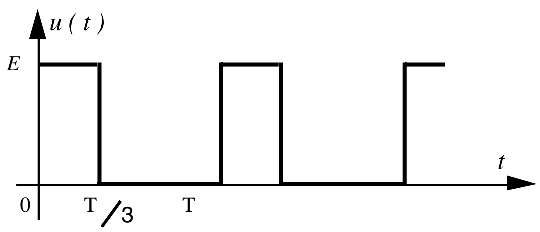
. Select the right rating by turning the rotating switch to 50 V -- or 500 V --

. Connect the black lead to the black terminal (shared) and the red lead to the red terminal, 50 V or 500 V according to the rating selected.

. For the measurement to be correct, the peak voltage must not exceed twice the value of the rating selecting.

<u>Example</u>: the voltage delivered by a chopper.
The 50 V -- rating is selected.

(It is assumed that the frequency is low enough for the main harmonics to be detected by the apparatus).



1st case: E = 90 V ====> u = 30 V with E less than 2 x 50 = 100 V, the measurement displayed is correct.

2nd case: E = 120 V ===> u = 40 V with E greater than 2 x 50 = 100 V, the measurement displayed is incorrect.

N.B.: for DC voltages and for the 500 V -- rating, voltages of up to 1,000 V can be measured.

C - CURRENT MEASUREMENT : MEAN VALUE

. For currents of less than 2 A (e.g. the excitation current for a DC machine), use the black terminal and the red terminal marked by the symbol Ie.

. For currents of 2 A or over (e.g. the armature current of a DC machine), use the red and black terminals linked to the rotating switch.

. Select the right range by turning the rotating switch to 2 A -- or 20 A --

. Incorporate the ammeter in the circuit via the black terminal (shared) and the red terminal, 2 A or 20 A according to the range selected.

. If a peak factor of 2 is kept to at the end of the range, the measurement is correct. If not, the value displayed is incorrect.

D - VOLTAGE MEASUREMENT : RMS VALUE

. The electrical module measures the RMS value of the input voltage. This measurement includes the direct component.

. Select the right range by turning the rotating switch to 50 V ~ or 500 V ~.

. Connect the voltage to be measured across the black terminal and the red terminal, 50 V or 500 V according to the range selected.

. If a peak factor of 2 is kept to at the end of the range, the measurement is correct. If not, the value displayed is incorrect.

N.B.: For sinusoidal voltages at a rating of 500 V, voltages with a maximum RMS value of up to 700 V can be measured.

E - CURRENT STRENGTH MEASUREMENT : RMS VALUE

. The electrical module measures the RMS value of the current. This measurement includes the direct component.

. Select the right range by turning the rotating switch to 2 A ~ or 20 A ~.

. Incorporate the ammeter in the circuit via the black terminal (shared) and the red terminal, 2 A or 20 A according to the range selected.

. If a peak factor of 2 is kept to at the end of the range, the measurement is correct. If not, the value displayed is incorrect.

F - POWER MEASUREMENT

F.1 - GENERAL REMARKS

. The electrical module has an analog multiplier that gives the product *u(t)* x*(t)*, there the direct component corresponding to the mean power (Wattmeter) received or supplied by a dipole is extracted via a band-pass filter.

. As the voltage drop caused by the ammeter is negligible (owing to the use of a HALL current probe), the upline set-up must be designed to minimize any errors that might be caused by incorporating measurement apparatuses in the circuit.

. Select the right range on the voltmeter by turning the rotating switch to 50 V or 500 V and connect the voltage circuit across the black terminal (shared) and the red terminal, 50 V or 500 V according to the range selected.

. Select the right range on the ammeter by turning the rotating switch to 2 A or 20 A and connect the current circuit across the black terminal (shared) and the red terminal, 2 A or 20 A according to the range selected.

. The wattmeter works with direct or alternating currents and voltages.

F.2 -MEASUREMENT of THREE-PHASE ELECTRICAL POWER.

. The electrical power absorbed by a three-phase motor is expressed by : $P = UI\sqrt{3}\cos Ø$ where *U* : voltage between phases. *I* : line current.

Ø : phase difference between the current flowing through 1 winding and the voltage across the terminals of the winding.

. Ø is never the phase difference between *U* and *I*. Measuring *P* with a single apparatus would give : either $P=UI\cos(Ø+30)$ or $UI\cos Ø - 30)$

To obtain a correct power measurement, a phase switch must be linked to the wattmeter so that the 2 wattmeter method can be used : $P = P1 + P2.$

Another method is to use an artificial neutral point.

. Using a neutral point means that *P* can be measured directly and recorded with a single apparatus.

If the motor is in star configuration, the neutral point will be used. In delta configuration, shown the diagram below.

. *Active power:*

The set-up below enables the active power to be read directly on the *Pu* display of the Electrical Measurement Module.

The wattmeter reading must be multiplied by 3 (assuming that the 3 phases are balanced).

Similarly, the voltage obtained on the analog output must be multiplied by 3.

. *Reactive power:*

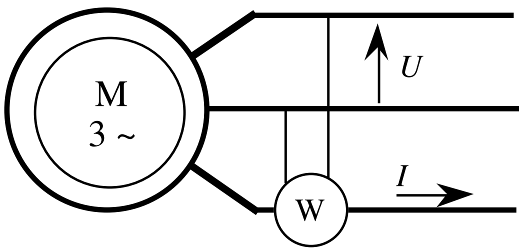
The set-up below enables the reactive power to be read directly on the *P u* display of the Electrical Measurement Module.

The wattmeter reading must be multiplied by √3 (assuming that the 3 phases are balanced).

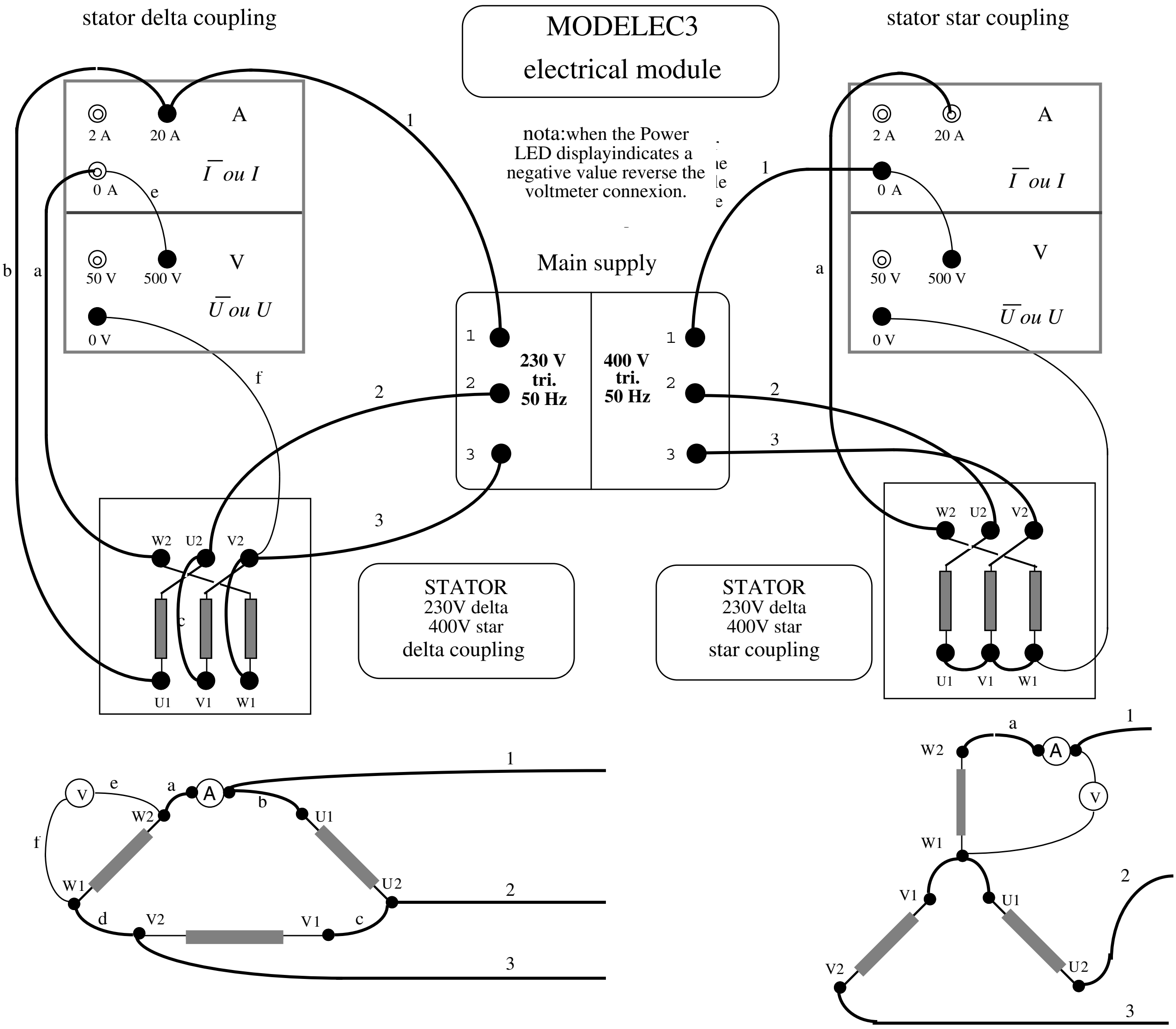
Remember: where kØ is the reading on the wattmeter W in watts, the reactive power absorbed by the motor is : $Q = \sqrt{3}.kØ$, in vars.

MEASUREMENT OF THREE-PHASE

REACTIVE POWER.



MEASUREMENT OF THREE-PHASE ACTIVE POWER



2 - USE

2.1 - CONVENTIONAL USE

The operator manually controls the strength of the current powering the magnetic brake.
He thus exerts a resistive torque on the shaft of the motor.
He takes the readings on the measurement apparatuses for different braking strengths and can then plot the machine characteristics.

2.2 - USED WITH PLOTTER

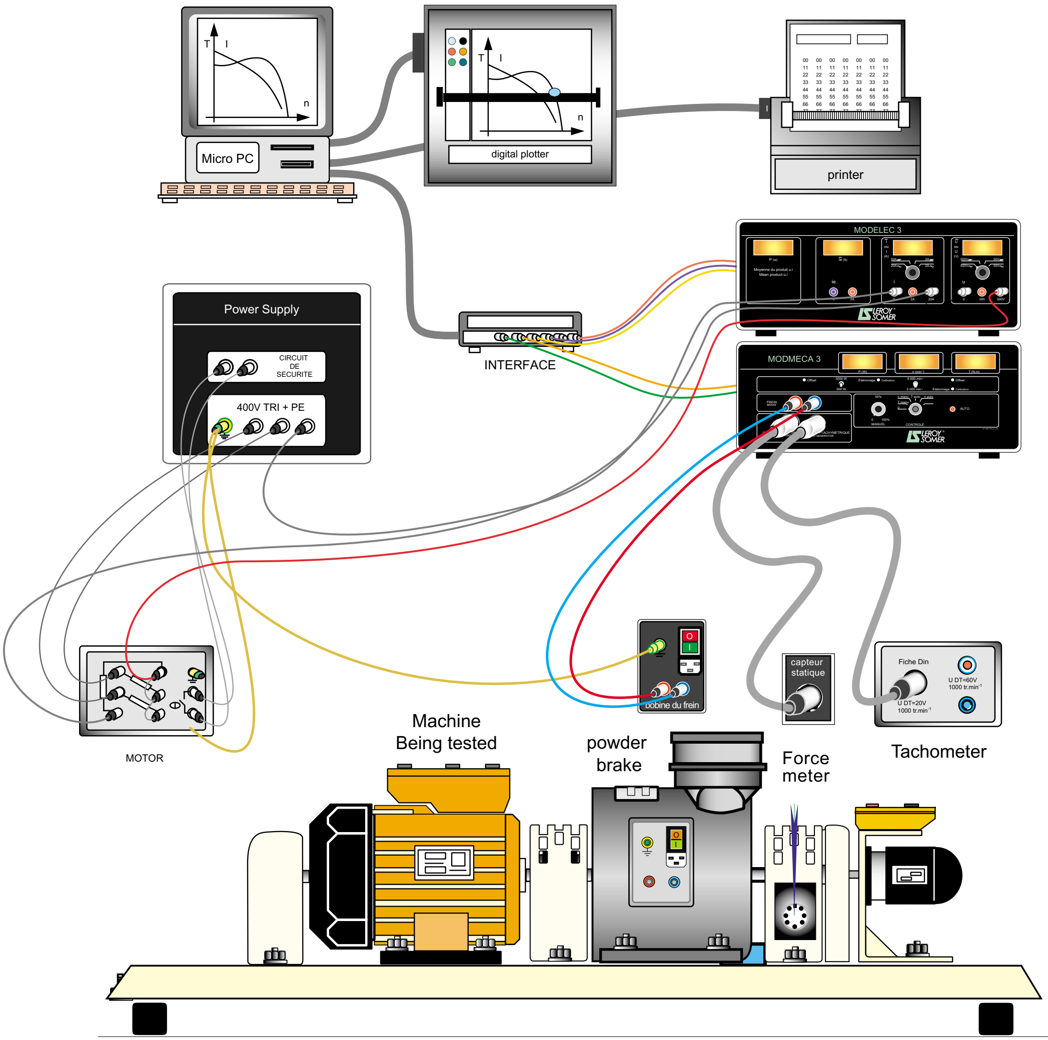
The analog outputs enable a **plotter** and an **oscillograph** to be used.
By automatically controlling the machine load, all the characteristics of the rotating machine can be plotted . See the system flow diagram overleaf.

2.3 - USED WITH DATA PROCESSING SYSTEM

The operator is aided considerably by a system in which the plotter is replaced by an **interface** linked to a **computer**, as the computer performs all the time-consuming tasks such as calculations, the choice of scales, the plotting of graphs, etc...

2.3.1. SET-UP.The computer is linked to the Mechanical (MOD'MECA) and Electrical (MOD'ELEC) Measurement Module meters and to an interface, thus replacing a whole range measurement apparatuses: ammeter, voltmeter, wattmeter, cosØ-meter, speedometer, torquemeter, etc..

See the system flow diagram overleaf.



2.3.2- COMPUTERS

Types of computer that can be used : compatible PCs AT with graphics boards : EGA or VGA.

2.3.3 - INTERFACE

The interface transmits data between the measurement modules and the computer.

2.3.4 - USE

. The operator has full control. The effects of any change in one of the motor parameters are immediately displayed on the screen.

. Floppy disk programs are used to plot the characteristics of DC motor and AC motor.

DC motor as : separate, shunt ,compound and series excitation motor

AC motor as : asynchronous and synchronous motor

With two Electrical Measurement Modules available, the transformer can be studied.

. It is also possible to:

- highlight the influence of one of the parameters on the running of the machine (power supply voltage, winding resistances, field current, etc...),

- study start-up problems : * at a constant voltage
  * at an adjustable voltage ...

- illustrate the stable and unstable states of an asynchronous motor,

- study a motor with his drive where variable speeds are required,

- take readings during transient states...

NOTE: for further details refer to the specific Software Instruction Manual.

3. OPERATING EXAMPLE

THE THREE-PHASE ASYNCHRONOUS MOTOR

Any type of conventional readings can be taken with this equipment.
This paragraph deals with the type of experiments that are normally impossible to perform.

3.1 - STABLE AND UNSTABLE OPERATION

3.1.1. Speed control

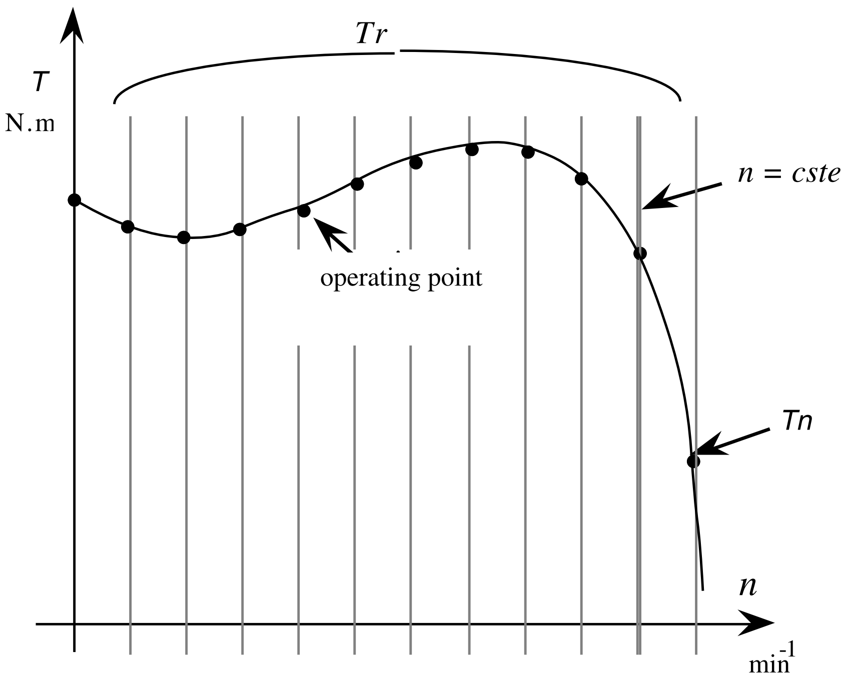
3.1.1.1 EXPERIMENT

. With the motor "wired up" and the data processing system on line, turn the brake switch to position *n*m : manual speed control.

. Power up the motor **at a reduced voltage** by starting it up off load.

. Adjust the brake control potentiometer and display the characteristic *T (n)* of the machine on the screen by reducing its speed (until it locks) and then acceleratingagain ; we only record the acceleration curve, i.e. up until the moment at which maximum speed is reached.

This gives the characteristic shown in the figure below.



3.1.1.2 INTERPRETATION

Controlling the speed in fact means setting the speed of the rotating unit. For this type of control, the characteristic $T_r(n)$ of the load at a given speed is a vertical straight line.

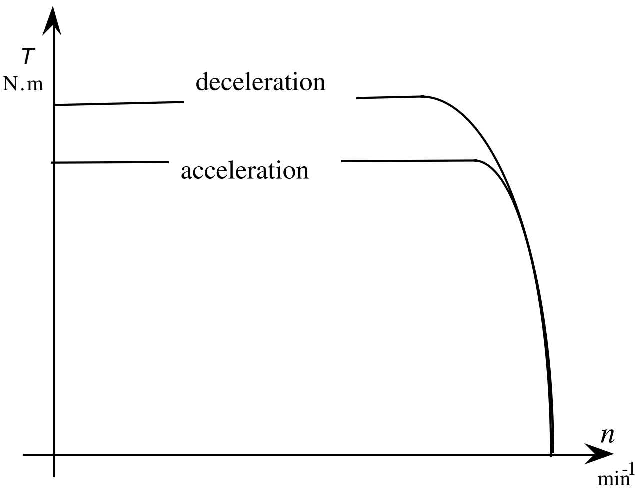
By varying the speed, a range of characteristics *Tr(n)* is obtained, whose points of intersection with the characteristic *T(n)* give the different operational states of the unit.

All the operational states are displayed on the screen. By drawing a line through all the points,we can plot the characteristic *T(n)* of the motor.

3.1.2 - Torque control

3.1.2.1 - EXPERIMENT

. Turn the brake switch to position T_m: manual torque control.



. Power up the motor at its rated voltage by starting it up off load.

. Adjust the brake control potentiometer and display the characteristic *T (n)* of the machine by increasing the resistive torque.

When the resistive torque reaches a certain value, the motor suddenly seizes.

. Reduce the motor load; when the resistive torque is changed, the machine unlocks as quickly as it seized and soon reaches the steady speed previously attained.

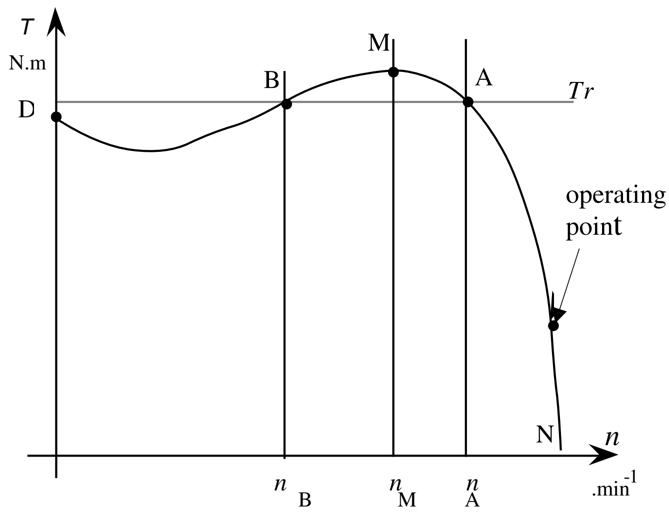
3.1.2.2 - INTERPRETATION

Let us look at the shape of the curve of the characteristic *T(n)* of the motor shown overleaf.

Controlling the torque means exerting a specific torque moment on the unit. For this type of control, the characteristic T_r *(n)* of the load for a given moment is a horizontal straight line.

Trace a horizontal straight line on the graph.

It intersects the curve of the characteristic *T(n)* at points **A** and **B**.



- **Analysis of point A.**

- As the speed increases the motor torque *T* decreases.

As the resistive torque *Tr* is constant,the difference between them, *T - Tr* , is negative:
the rotating unit tends to slow down to a steady speed n_A.

- As the speed decreases the motor torque *T* increases.

As the resistive torque *Tr* is constant the difference between them, *T - Tr* is positive : the rotating unit tends to accelerate up to a steady speed n_A.

A *is a stable operating point. All points on the line segment NM of the characteristic T(n) are stable operating points.*

- **Analysis of point B.**

- As the speed increases the motor torque *T* increases. As the resistive torque *Tr* is constant the difference between them, *T -Tr* is positive:the rotating unit tends to accelerate up to a steady speed n_A.
- As the speed decreases the motor torque *T* decreases. As the resistive torque *Tr* is constant, the difference between them, *T - Tr* , is negative : the rotating unit seizes.

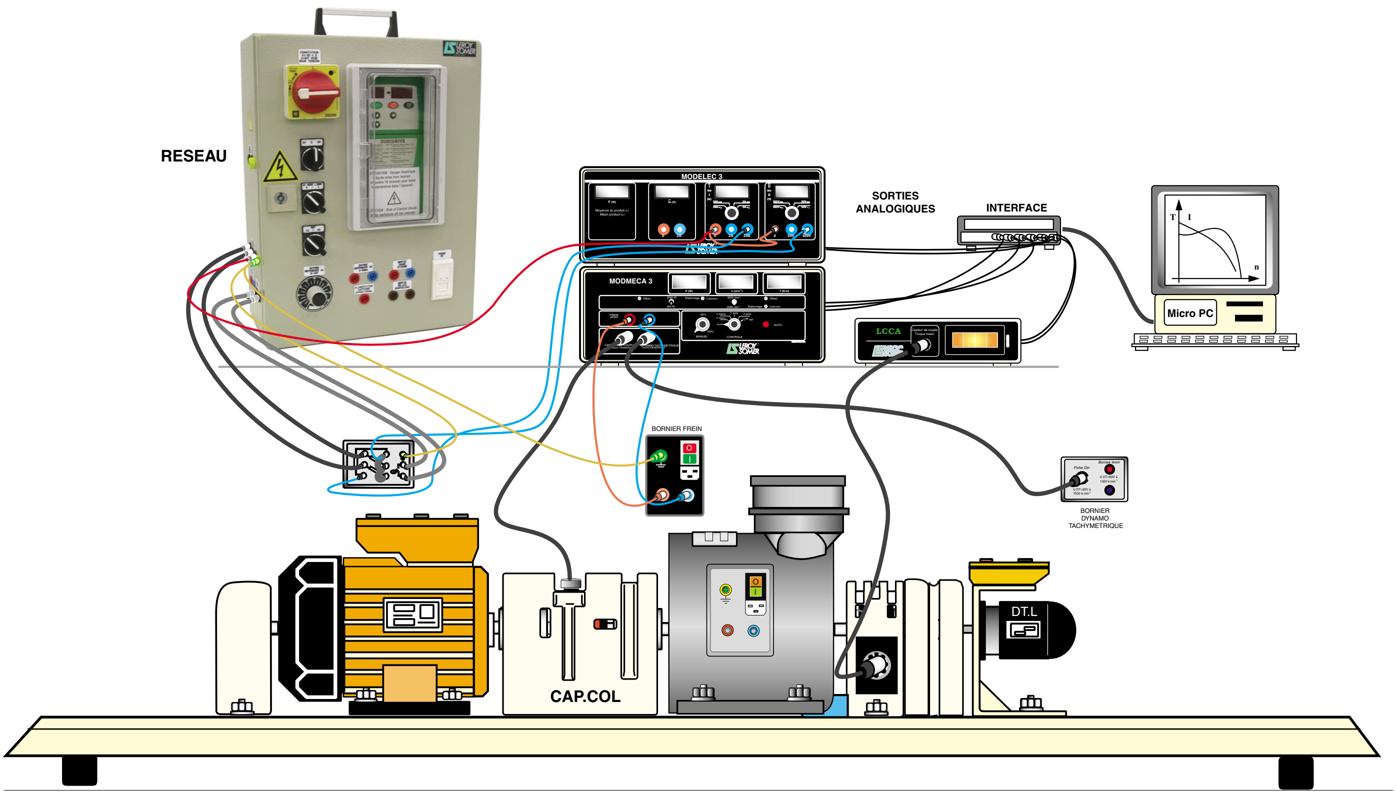
***B** is an unstable operating point. All points on the line segment MD of the characteristic T(n) are unstable operating points.*

- During operation, starting with a resistive torque of zero and then gradually increasing it, we have described the stable part NM of the characteristic.When the speed corresponding to point M is reached, the motor is running in an unstable state and seizes.

It will only restart when the value of the resistive torque falls below that of the starting torque. As the motor is in an unstable state, it accelerates abruptly until it reaches a stable operating point and thus a steady speed.

APPENDIX

Connection diagram " test bench -MODMECA & MODELEC modules".



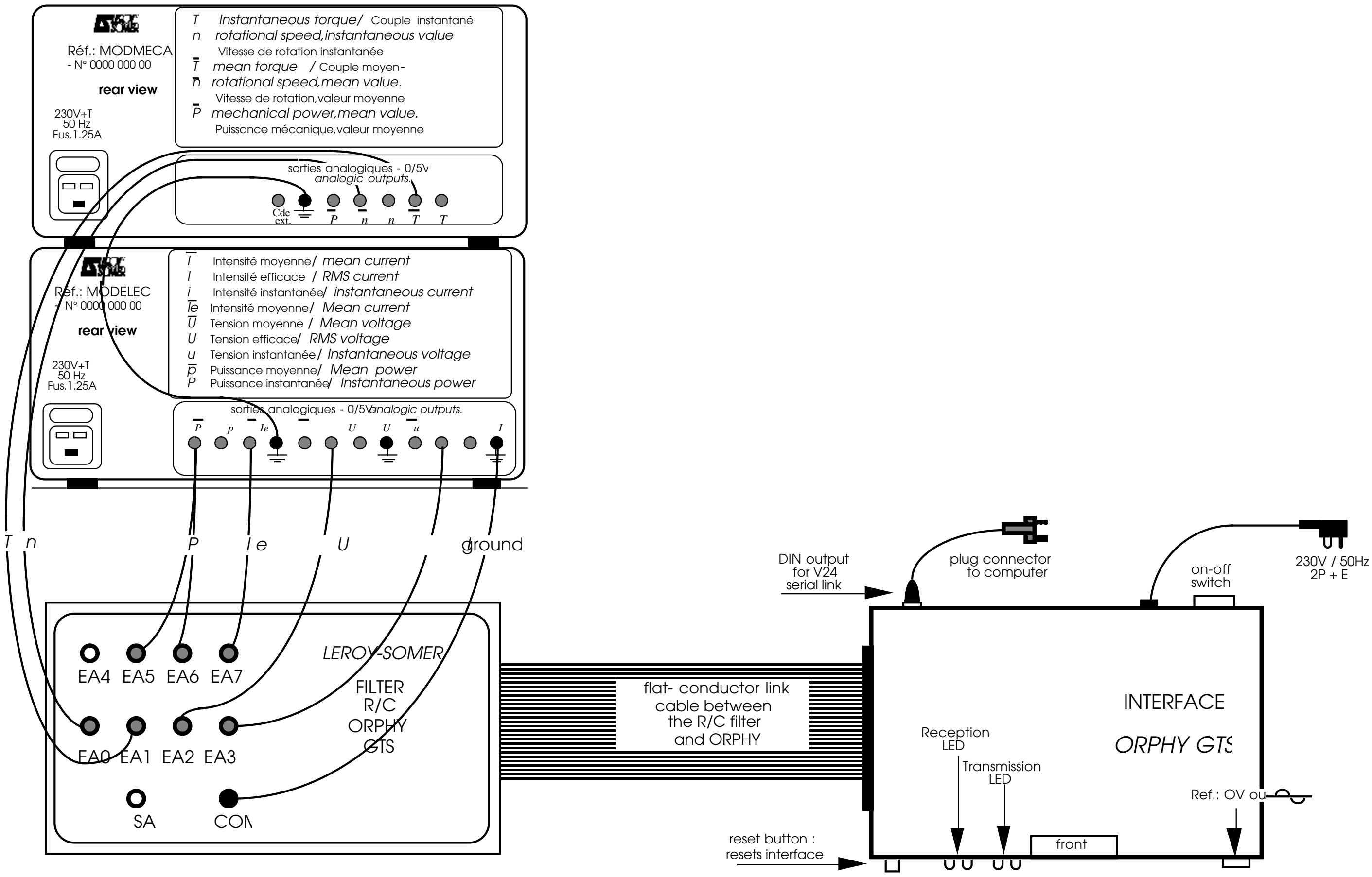
APPENDIX N°2

CONNECTION DIAGRAM : analog outputs from MODELEC and MODMECA modules to RC filter and ORPHY GTS interface.

Exemple : voltage and current measurement on AC motor.

$\overline{T}$ resistive torque (mean value) $\overline{n}$ rotational speed (mean value)	channel EA0<----> $\overline{n}$	- speed	yellow
$\overline{P}$ mecanical power (mean value)	channel EA1<----> $\overline{T}$	- torque	red
T resistive torque (instant.* value) n rotational speed (instant.* value)	channel EA2<----> U or $\overline{U}$	- mean or RMS voltage	blue
$\overline{I}$ mean current	channel EA3<----> I or $\overline{I}$	- mean or RMS current	white
I RMS current i instantaneous current	channel EA4<---->	- not used	----
$\overline{U}$ mean voltage	channel EA5<----> $\overline{P}$	- electrical power (mean value)	grey
U RMS voltage u instantaneous voltage	channel EA6<----> $\overline{P}$	- electrical power (mean	brown
$\overline{P}$ electrical power (mean value) p electrical power (instant.* value)	channel EA7<----> $\overline{Ie}$	- mean field current	green
$\overline{Ie}$ mean current *instantaneous	COM <----->	grounding lead to be connected to ground terminals at the rear of the modules.	black

the $\overline{I}$ and $\overline{U}$ analog outputs are used to measure direct currents (mean value)
the I and U analog outputs are used to measure alternating currents (RMS value)



APPENDIX N°3

CONNECTION DIAGRAM : analog outputs from MODELEC and MODMECA modules
to RC filter and ORPHY GTS interface.

Exemple : voltage and current measurement on DC motor.

$\overline{T}$ resistive torque (mean value) $\overline{n}$ rotational speed (mean value)	channel EA0<----> $\overline{n}$	- speed	yellow
$\overline{P}$ mecanical power (mean value)	channel EA1<----> $\overline{T}$	- torque	red
T resistive torque (instant.* value) n rotational speed (instant.* value)	channel EA2<----> U or $\overline{U}$	- mean or RMS voltage	blue
$\overline{I}$ mean current	channel EA3<----> I or $\overline{I}$	- mean or RMS current	white
I RMS current i instantaneous current	channel EA4<---->	- not used	----
$\overline{U}$ mean voltage	channel EA5<----> $\overline{P}$	- electrical power (mean value)	grey
U RMS voltage u instantaneous voltage	channel EA6<----> $\overline{P}$	- electrical power (mean	brown
$\overline{P}$ electrical power (mean value) p electrical power (instant.* value)	channel EA7<----> $\overline{Ie}$	- mean field current	green
$\overline{Ie}$ mean current *instantaneous	COM <----->	grounding lead to be connected to ground terminals at the rear of the modules.	black

the $\overline{I}$ and $\overline{U}$ analog outputs are used to measure direct currents (mean value)
the I and U analog outputs are used to measure alternating currents (RMS value)