MICRO DYNE

MOTOR TESTING SYSTEM

USER MANUAL

www.magtrol.com

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PURCHASE RECORD

Please record all model numbers and serial numbers of your Magtrol equipment, along with the general purchase information. The model number and serial number can be found on either a silver identification plate or white label affixed to each unit. Refer to these numbers whenever you communicate with a Magtrol representative about this equipment.

Model Number : ______________________

Serial Number : ______________________

Purchase Date : ______________________

Purchased From : ______________________

3rd English Edition | February 2022

SAFETY PRECAUTIONS

WARNING

WARNING! IN ORDER TO MINIMIZE RISKS, IT IS OF UTMOST IMPORTANCE TO RESPECT THE CURRENT SAFETY STANDARDS WHEN PLANNING, CONFIGURING AND OPERATING THE MICRO DYNE MOTOR TEST SYSTEM.

CAUTION

CAUTION! OPERATE THE MICRO DYNE MOTOR TEST SYSTEM WITH GREAT CAUTION! THE MICRO DYNE MAY BE IRREVERSIBLY DAMAGED IF IMPACTED MECHANICALLY (FALL), CHEMICALLY (ACIDS) OR THERMALLY (HOT AIR, VAPOR).

1. Make sure that all Magtrol electronic products are earth-grounded, to guarantee personal safety and proper operation.
2. Check line voltage before operating electronic equipment.
3. Make sure that all rotating parts are equipped with appropriate safety guards.
4. Periodically check all connections and attachments.
5. Always wear protective glasses when working close to rotating elements.
6. Never wear a necktie or baggy clothes when standing close to rotating elements.
7. Never stand too close or bend over the rotating drive chain.

QUALIFIED PERSONNEL

Persons in charge of installing and operating the MICRO DYNE Motor Test System must have read and understood this user manual, paying extra close attention to all safety-related information.

The MICRO DYNE Motor Test System is a high-precision product integrating the most recent measurement techniques. The MICRO DYNE can give rise to residual dangers if used and manipulated in a non-compliant way by unqualified personnel.

This MICRO DYNE must be handled by qualified personnel according to the technical requirements and the above-mentioned safety instructions. This is also true when using dynamometer accessories.

TABLE OF CONTENTS

PREFACE

PURPOSE OF THIS MANUAL

This manual contains all the information required for the setup, connection and general use of Magtrol's MICRO DYNE Motor Test System. To achieve maximum capability and ensure proper use, please read this manual in its entirety before operating the unit. Keep the manual in a safe place for quick reference whenever a question should arise.

WHO SHOULD USE THIS MANUAL

This is written for operators who are going to use the MICRO DYNE Motor Test System in order to determine the torque and power of a miniature/micro motor in relation to its speed. The operator is assumed to have the necessary technical knowledge in electronics and mechanical engineering enabling him to install the dynamometer without risk.

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 structure of the manual is as follows:

Chapter 1: INTRODUCTION – Contains the technical data sheets for Magtrol's MICRO DYNE Motor Test System, which describe the system and all of its components, and provides detailed technical characteristics. A complete parts list, along with unpacking instructions, is also included in this section.

Chapter 2: INSTALLATION / CONFIGURATION – Provides information needed for the setup of the MICRO DYNE Motor Test System, primarily electrical connections and power configuration.

Chapter 3: TESTING CONSIDERATIONS – Provides information on a number of factors that must be taken into consideration before running a test, including: safety, power dissipation, and influences that affect the apparent accuracy of the torque readout.

Chapter 4: TEST SETUP – Provides instructions on how to set up a motor test, including dynamometer setup, motor mounting and software configuration.

Chapter 5: OPERATING PRINCIPLES - Information pertaining to the theory of operation including torque measurement, speed measurement and the PID control loop.

Chapter 6: CALIBRATION - Step-by-step instructions for the calibration procedure.

Chapter 7: TROULBESHOOTING - Solutions to common problems encountered during setup, testing and calibration.

Appendix 1: MICRO DYNE COMMAND SET - Provides command reference tables for users who wish to write their own application.

Appendix 2: SCHEMATICS - Contains a core block diagram, main schematic and wattmeter schematic.

SEMANTICS

In this manual, different terminologies may be used to speak about the «MICRO DYNE Motor Test System». The primary purpose is to make this user manual useful and easy to read.

Different terminology used: «MICRO DYNE», «Dynamometer».

CONVENTIONS USED IN THIS MANUAL

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

NOTICE

Indicates information considered important but not hazard related.

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 function of the product.

CAUTION

INDICATES A HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN MINOR OR MODERATE INJURY.

THIS IS ALSO USED TO DRAW THE OPERATOR'S ATTENTION TO INFORMATION, DIRECTIVES, PROCEDURES, ETC. WHICH, IF IGNORED, MAY RESULT IN DAMAGE TO THE MATERIAL BEING USED. THE ASSOCIATED TEXT DESCRIBES THE NECESSARY PRECAUTIONS TO TAKE AND THE CONSEQUENCES THAT MAY ARISE IF THESE PRECAUTIONS ARE IGNORED.

WARNING

INDICATES A HAZARDOUS SITUATION THAT, IF NOT AVOIDED, COULD RESULT IN DEATH OR SERIOUS INJURY.

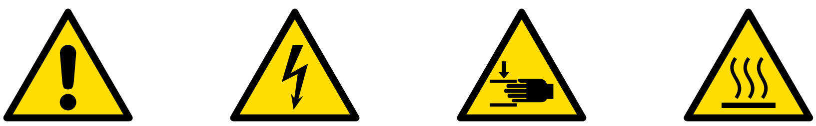
THIS INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH THE UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTY MAY BE AT RISK. THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AND ACT UPON IT, BEFORE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

DANGER

INDICATES A HAZARDOUS SITUATION THAT, IF NOT AVOIDED, WILL RESULT IN DEATH OR SERIOUS INJURY. THE SIGNAL WORD «DANGER» IS TO BE LIMITED TO THE MOST EXTREME SITUATIONS.

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

The safety symbol may subsequently vary depending on the source of the hazard. Below are examples:



Various safety pictograms according to ISO 7010

1. INTRODUCTION

1.1 UNPACKING THE MICRO DYNE

1.1.1 PACKING

Your Micro Dyne System was shipped in its own hard-sided carrying case with shock-resistant packing foam. The packaging is designed to protect the instruments during normal handling.

Inspect the contents for any evidence of damage in shipping. In the event of shipping damage, immediately notify the carrier and Magtrol's Customer Service Department.

NOTICE Save all shipping cartons and packaging material for reuse when returning the instrument for calibration or servicing.

1.1.2 PARTS LIST

Make sure the case contains all the following:

A. Dynamometer with attached motor fixture

B. Electronics unit

CAUTION THE DYNAMOMETER AND ELECTRONICS UNIT ARE SHIPPED ALREADY CONNECTED TO ONE ANOTHER BY A SERIES OF CABLES (BUNDLED TOGETHER). USE CAUTION WHEN LIFTING OUT OF THE CASE.

C. Media/USB Flash Drive

- C1. M-TEST 7 Media
- C2. Micro Dyne Supplemental Programs and Utilities

D. Bag of cables

- D1. USB cable
- D2. Three power supply cables with dual banana plugs on both ends
- D3. Main IEC power cord

E. A second bag of parts contains the following:

- E1. Circular weight and fastening (hex key) screw for torque configuration
- E2. Hardware for motor fixturing
  - E2a. Two motor fixture adapters
  - E2b. Small Allen wrench (hex key)
  - E2c. Two small hex screws
- E3. Three bags of rubber couplings
  - E3a. Ten pieces of 0.5 mm inside diameter tubing, each 25 mm in length
  - E3b. Ten pieces of 0.8 mm inside diameter tubing, each 25 mm in length
  - E3c. Ten pieces of 1.6 mm inside diameter tubing, each 25 mm in length
- E4. Two calibration weights, one 5 g and one 10 g, tagged and labeled.

E5. Calibration documentation

E5a. Calibration certificate for Micro Dyne

E5b. Calibration test report for wattmeter

E5c. Calibration test report for dynamometer

E6. Accessory tools

E6a. Tweezers

E6b. Medium Allen wrench

E6c. Large Allen wrench

E6d. Five cable ties

Fig.1-1 Micro Dyne Accessories

1.2 DATASHEET

MICRO DYNE
MOTOR TESTING SYSTEM

FEATURES

- Designed specifically for miniature and micro motors
- Torque: Easily convertible from 2.0 mN·m to 4.0 mN·m (0.28 oz·in to 0.57 oz·in)
- Speed: up to 100,000 rpm
- Power: 4 W
- Low inertia
- Sold as a complete, out-of-the-box motor testing system. Components include:
  - Hysteresis Dynamometer: provides precise torque loading independent of shaft speed
  - Motor Fixture: accommodates motors from 5 mm to 30 mm in diameter.
  - Dedicated Electronics: all-in-one dynamometer controller, DC wattmeter, power relay and USB interface
  - Comprehensive Motor Testing Software
  - Easy-to-use calibration software
  - All necessary connection cables
  - Calibration weights: 5 g and 10 g

Fig. 1: Micro Dyne Motor Testing System

DESCRIPTION

With over 50 years' experience in dynamometer design and torque measurement, Magtrol has revolutionized the industry. Magtrol's new Micro Dyne, capable of measuring extremely low torques (2.0 mN·m can be resolved to 0.0004 mN·m), is designed exclusively for testing miniature and micro (low-torque) motors.

For the utmost convenience, the Micro Dyne is packaged as a COMPLETE MOTOR TESTING SYSTEM. Everything that is needed to accurately and efficiently test miniature motors and micro motors is included with the purchase of a Magtrol Micro Dyne. The only component that needs to be supplied by the customer is a laptop or desktop personal computer and motor power supply.

Motor Characteristics Measured/Calculated:

- Torque
- Speed
- Amps
- Volts
- Horsepower
- Efficiency
- Input Watts
- Output Watts

APPLICATIONS

Magtrol motor test systems can be found in test labs, at inspection stations, and on the manufacturing floors of most of the world's leading motor manufacturers. The Micro Dyne system is used exclusively for closed-loop testing of miniature motors and micro motors used in low-torque/high-speed applications.

Motor sub-types include, but are not limited to, the following:

- Brushed and brushless DC motors
- Gearmotors
- Brushless DC servomotors
- Vibrator motors
- Miniature air motors

These mini/micro motors are used in a diverse range of industries and products, including:

- Medical and laboratory equipment
- Robotics and automation
- Toys
- Handheld communication devices
- Audio/video equipment
- Optics and photonics
- Aerospace and defense
- Security and instrumentation
- Industrial machinery

SYSTEM COMPONENTS

DYNAMOMETER

The Micro Dyne dynamometer absorbs power with Magtrol's unique Hysteresis Braking System. Because it does not require speed to create torque, the dynamometer can conduct a full motor ramp—from free-run to locked rotor.

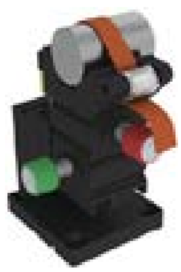
In addition to a dedicated motor fixture, the dynamometer base plate also includes leveling knobs and motor power terminals. The housing of the dynamometer protects all the moving parts of the brake.

ELECTRONIC UNIT

At the hub of the Micro Dyne system is a multifunctional electronic unit. The unit employs DSP technology for high-speed data acquisition and complete PC control of the dynamometer. A USB receptacle enables easy connection to a personal computer. An integrated DC wattmeter reads volts and amps, and calculates watts; and a built-in power relay controls motor power (on/off).

The front panel includes the terminals for motor power in/out and voltage sensing. LED system ready and torque range indicators are located on the front panel of the unit.

MOTOR FIXTURE



Attached to the dynamometer base plate is a motor fixture designed expressly for micro/miniature motors. The base of the fixture features an XYZ stage with 3-axis positioning for excellent adjustability and motor centering. With the included adapters, motors from 5 mm to 30 mm in diameter can be easily mounted. The fixture is keyed to help secure the motor under test and a rubber strap with knurled cam grip provides motor clamping.

MOTOR TESTING SOFTWARE

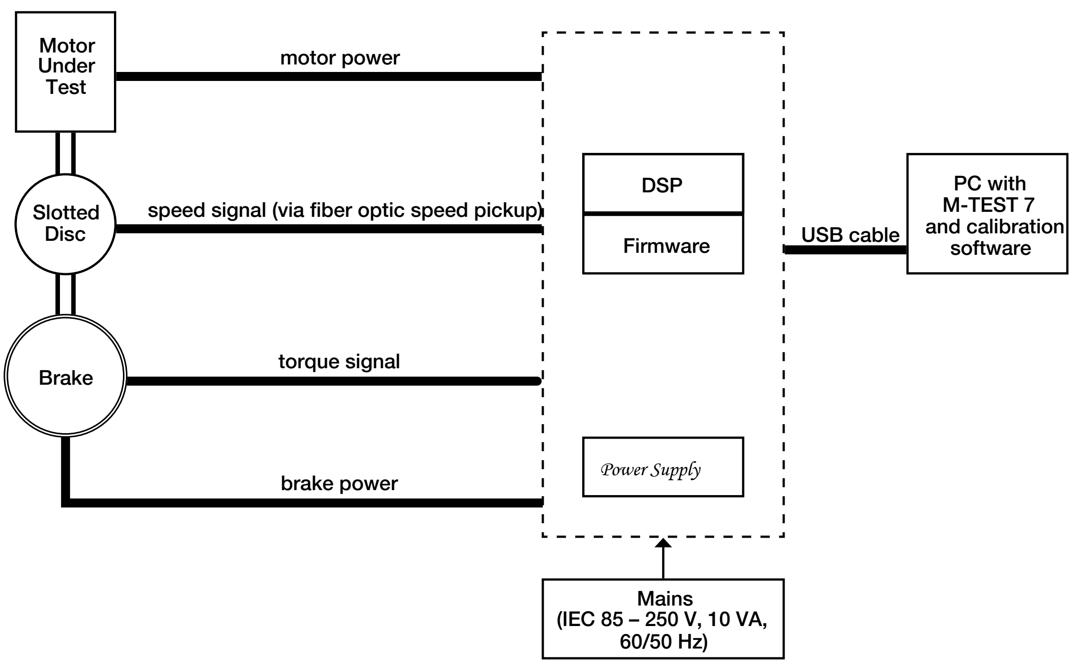
Magtrol's M-TEST 7 is a state-of-the-art comprehensive motor testing program designed for use with Windows® operating systems for PC-based data acquisition. The software measures and calculates a motor's performance characteristics by employing these user-configurable testing methods:

- **Ramp:** Select from average ramp down/up or ramp down with inertia correction factor. Also allows extrapolation of free-run and locked-rotor motor data, plus interpolation of specific speed or torque data points.
- **Curve:** Test speed, torque, amps, watts input, watts output and open loop parameters. Capable of adjusting sampling rate and using step or ramp from one load point to the next.
- **Pass/Fail:** Checks amps, input watts, speed, torque and output watts against user-defined limits.

The data generated can then be stored, displayed and printed in tabular or graphic formats, and is easily imported into a spreadsheet.

SYSTEM CONFIGURATION

BLOCK DIAGRAM



OPERATING PRINCIPLES

SPEED MEASUREMENT

The Micro Dyne contains a reflective fiber optic speed pickup. Each rotor slot that passes by the sensing end of the fiber optic generates an electronic pulse, which is then converted to a speed reading (in rpm).

TORQUE MEASUREMENT

A hysteresis brake is used to develop a resistance to rotation of a mechanical shaft. A torsional force is produced by the test motor and applied to the brake's rotor-shaft assembly. Reaction torque is measured by the angle of the brake pendulum assembly and is interpreted by the Micro Dyne system software (M-TEST 7).

SPECIFICATIONS

DYNAMOMETER

The Micro Dyne offers two different torque configurations in one unit. Depending on the motor's maximum torque rating, the user can easily switch between the 2.0 mN·m and 4.0 mN·m torque settings via the dynamometer's rear access panel. The ratings are the same for either configuration.

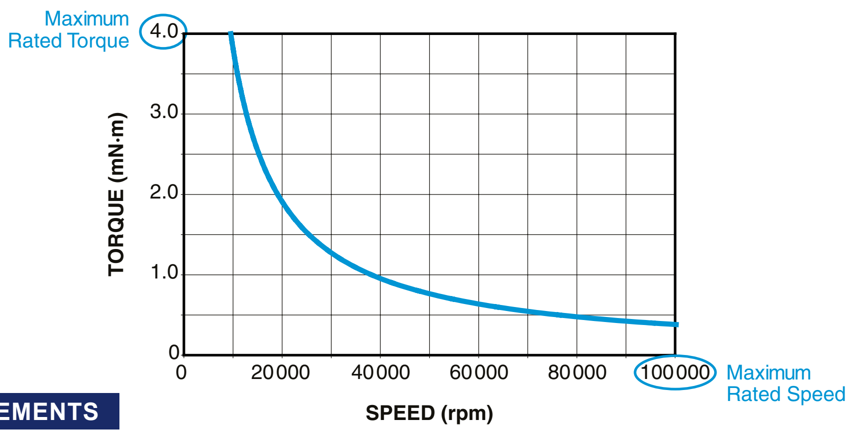
MAXIMUM TORQUE	NOMINAL INPUT INERTIA	MAXIMUM KINETIC POWER	MAXIMUM KINETIC POWER	MAXIMUM SPEED a)	ACCURACY	ACCURACY
mN·m	kg·cm^2	W - 5 min	W - continuous b)	rpm	torque	speed
4.0 or 2.0	5.43×10^{-4}	4	4	100 000	< 1% of full scale	< 0.02% of reading

a) Because the MicroDyne is optimized for high speeds, the lowest measurable speed is 50 rpm. If a motor is operating at less than 50 rpm, the speed measurement will read zero.

b) NOTE: Operating at the continuous power rating for periods of up to 4 hours is acceptable. However, operating for extended periods at high temperatures will result in premature component and bearing failure. Limiting the length of the cycle and the component temperatures will guard against premature failure. Where continuous duty is desired for longer time intervals, component temperatures should be maintained less than 100°C.

POWER ABSORPTION CURVE

Based on the maximum kinetic power ratings, the curve below represents the maximum power (heat) that the dynamometer can dissipate over time. The area under the curve equals the maximum speed/torque combinations for both a motor test of less than 5 minutes (intermittent duty), and a continuous-duty motor test.



DYNAMOMETER ENVIRONMENTAL REQUIREMENTS

Operating Temperature	0 °C to +70 °C
Relative Humidity	< 60% without condensation
EMC	In accordance with IEC 61326:2002

SPECIFICATIONS

ELECTRICAL UNIT

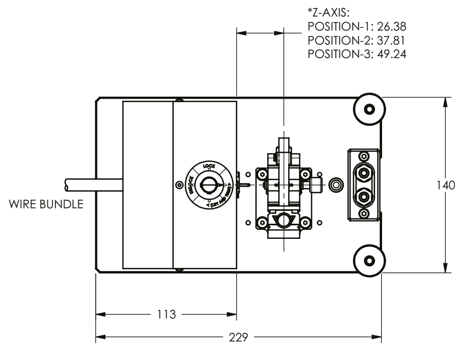
GENERAL ELECTRICAL CHARACTERISTICS	
Fuse (5 × 20 mm)	IEC 500 mA 250 V T
Power Requirements	10 VA
Voltage Requirements	85 – 250 VAC, 50/60 Hz
ENVIRONMENT	
Operating Temperature	0 °C to +70 °C
Relative Humidity	< 60% without condensation
POWER MEASUREMENT (DC)	
Current Input (isolated)	± 5 A ±(0.1% Reading + 0.2% Range)
Voltage Input (isolated)	± 30 VDC ±(0.1% Reading + 0.2% Range)
Conversion Rate	15/second
Power Accuracy	0.4% of VA range
Isolation, to earth	50 VDC
Isolation, channel-to-channel	100 VDC

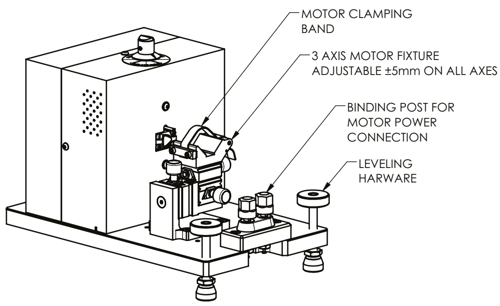
MOTOR FIXTURE

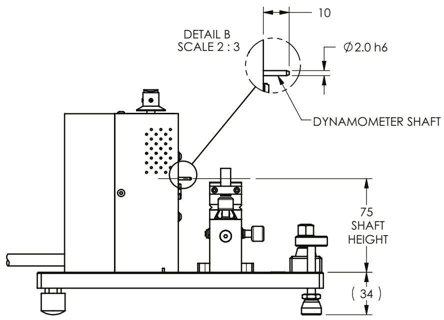
MOTOR ACCOMMODATION	
Motor Diameter	5 mm – 30 mm
Motor Length	5 mm – 50 mm
Motor Shaft Diameter	0.75 mm – 3 mm
Maximum Load	100 g
ADJUSTABILITY	
X/Y/Z Adjustable Range	±5 mm (all axes)
Controllable Motion	0.005 mm
Travel per Knob Revolution	0.318 mm

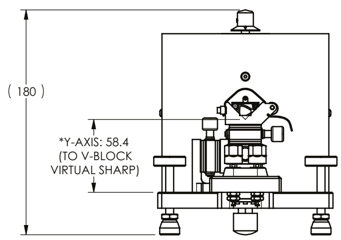
DIMENSIONS

DYNAMOMETER





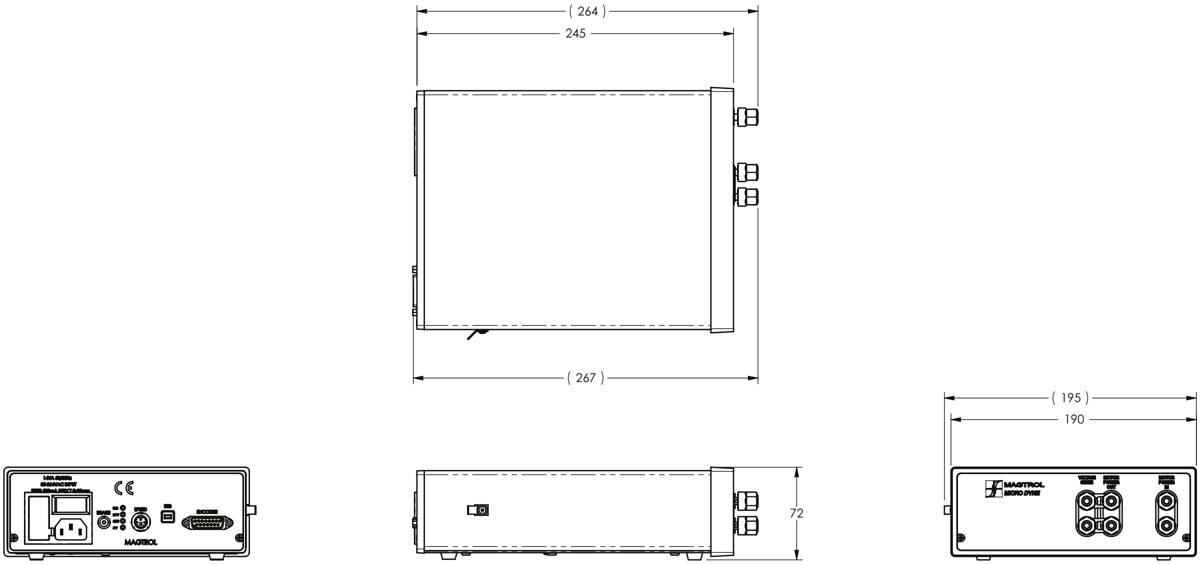




Weight	4.2 kg	9.3 lb

DIMENSIONS

ELECTRONIC UNIT



Weight	1.5 kg	3.2 lb

2. INSTALLATION / CONFIGURATION

2.1 DYNAMOMETER SETUP

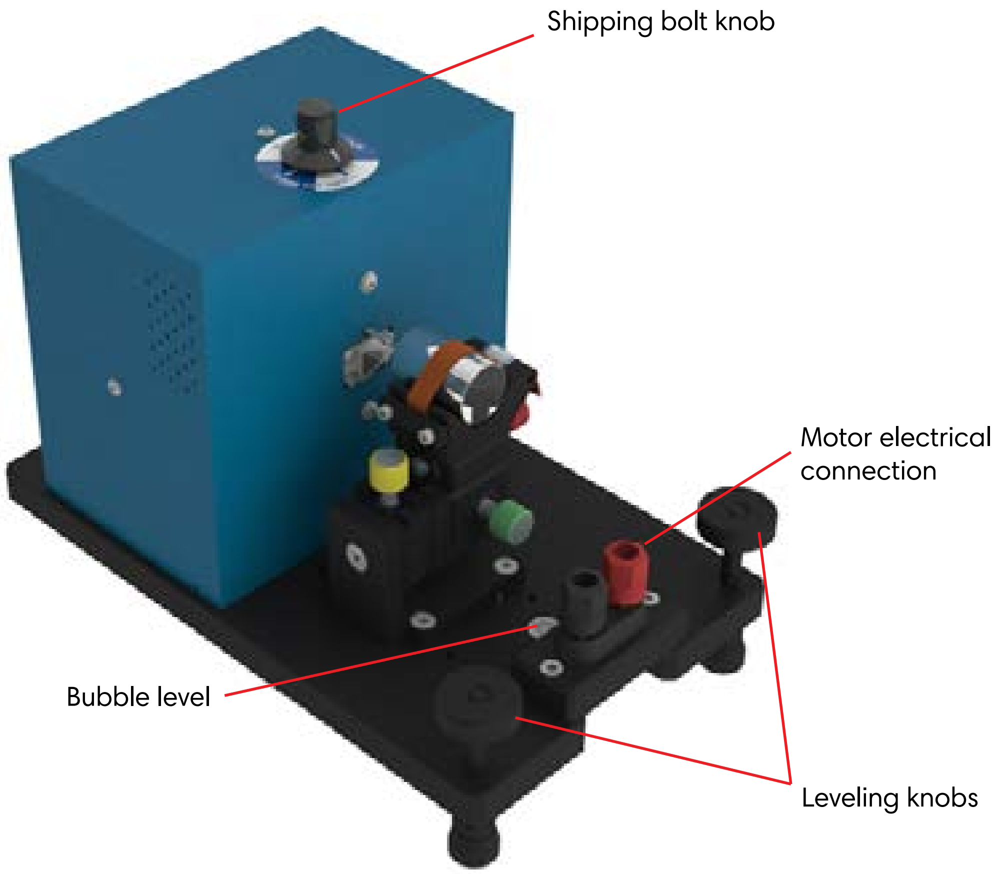


Fig.2-1 Micro Dyne Dynamometer

2.1.1 UNLOCKING THE SHIPPING/RESTRAINING BOLT

Before dynamometer operation, the shipping/restraining bolt must be unlocked. A knob attached to the bolt is located on the top of the dynamometer housing, as shown in Figure 2–1. To unlock, lift up on the knob and turn it 90° to the "Unlock" position.

2.1.2 DYNAMOMETER LEVELING

Simply level the dynamometer with the two leveling knobs at the front of the base plate, using the embedded bubble level as a guide.

2.2 ELECTRICAL CONNECTIONS

The Micro Dyne is shipped with the dynamometer and the electronics unit already connected to one another by a set of cables. These four cables are bundled together at the dynamometer end, and branch out into the following for connection to the electronics unit:

CONNECTION CABLE	ATTACHES TO	DESCRIPTION
Earth ground	Mounting plate of speed pickup	Provides safety against electric shock.
Dynamometer brake cable	BRAKE Output	Delivers power from electronics unit to dynamometer brake.
15-pin instrument cable	ENCODER Input	Quadrature encoder; reads torque measurement.
3-pin DIN cable	SPEED Input	Speed pickup; reads speed measurement.

2.2.1 EARTH GROUND

For your safety, the dynamometer has been earth grounded and shipped with the ground strap already in place. This protective wire provides an alternate path to ground in case of short circuits or heavy electrical currents.

The other end of the ground strap should be connected to the metal tab attached to the speed pickup mounting plate, located on the Micro Dyne Electronics Unit.

The complete earth ground path is as follows:

Dynamometer —> Electronics unit —> Main power cord —> Earth

2.2.2 REAR PANEL CONNECTORS

Fig.2-2 Electronics Unit Rear Panel

The rear panel connectors, from left to right, are:

CONNECTOR	ATTACHES TO	CONNECTION CABLE
POWER Input	Power source	Main power cord
BRAKE Output	Dynamometer	Dynamometer brake cable
SPEED Input	External speed sensor	3-pin sensor cable
USB Port	Personal computer	USB cable
ENCODER Input	Dynamometer	15-pin instrument cable

Using the table above, make the necessary connections with the cables provided. As noted in Section 2.2 – Electrical Connections, some of the cables have been installed prior to shipping.

2.3 MOTOR POWER

NOTICE For detailed instructions on motor mounting, refer to Section 4.2.

Using the three power supply cables provided, make the following basic connections. Other power configuration options are shown in Section 2.2.

CAUTION PAY ATTENTION TO WHICH PIN ON THE BANANA PLUG IS POSITIVE AND WHICH ONE IS NEGATIVE. CONNECT TO THE RED (+) AND BLACK (–) TERMINALS ACCORDINGLY.

TERMINAL ON ELECTRONICS UNIT	CONNECTED TO	DESCRIPTION
Motor Power In	User's power supply	Allows power measurement and on/off switching from electronics unit.
Motor Power Out	Motor connection point on dynamometer	Outputs power to the motor. Controlled by relay inside electronics unit which turns motor power on/off.
Voltage Sense	Motor connection point on dynamometer	Measures voltage directly at the motor, thus compensating for voltage drop. Results in increased power measurement accuracy and efficiency.

Fig.2-3 Electronics Unit Front Panel

Figure 2–4 illustrates the internal wattmeter and relay layout, showing the complete basic power circuit from power supply to motor.

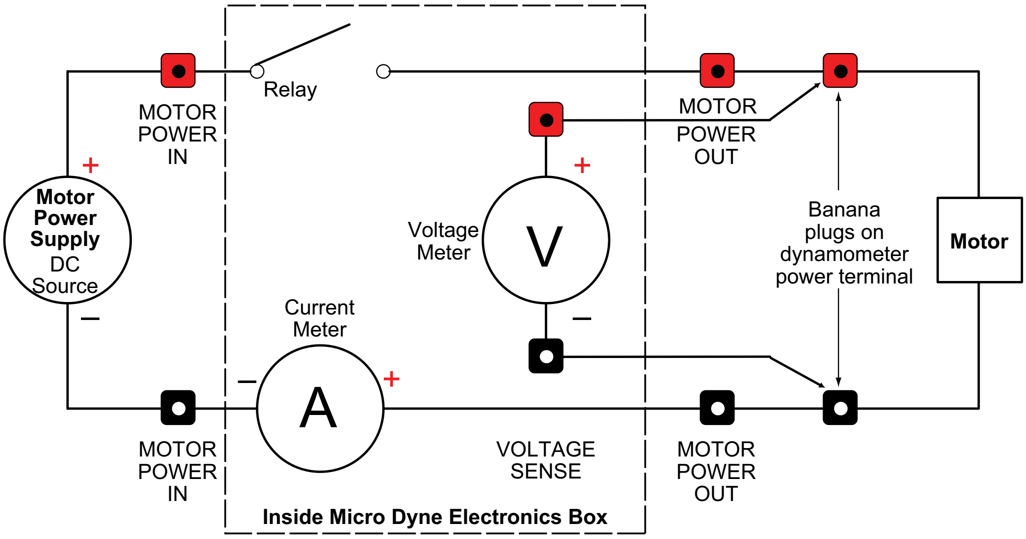


Fig.2-4 Basic Motor Power Circuit

2.3.1 POWER CONFIGURATION OPTIONS

2.3.1.1 BASIC CONFIGURATION

This standard Micro Dyne setup shows a (customer-provided) motor power supply wired to the Micro Dyne Electronics Unit. This setup allows the Micro Dyne's electronics to control on/off power to the motor under test, and to monitor input power.

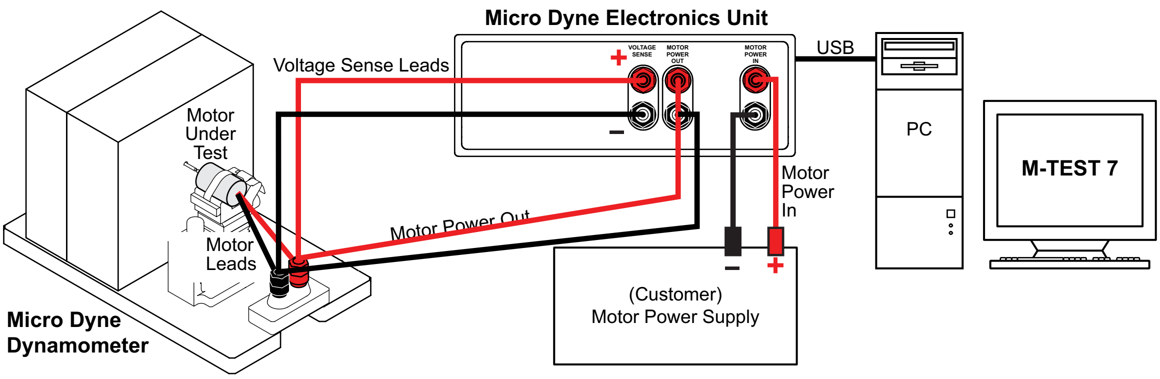


Fig.2-5 Basic System Configuration

2.3.1.2 RELAY CONFIGURATION

To run a motor in both clockwise and counter-clockwise directions, without having to rewire during the middle of a test, a relay card is required. A National Instruments™ relay card (available for purchase from Magtrol) allows for the automatic reversing of motor leads when the motor power supply is connected to the relay card. Like the basic system configuration, the Micro Dyne controls on/off power to the motor under test and monitors motor input power. For more information regarding motor reversal, refer to Section 4.3.1.

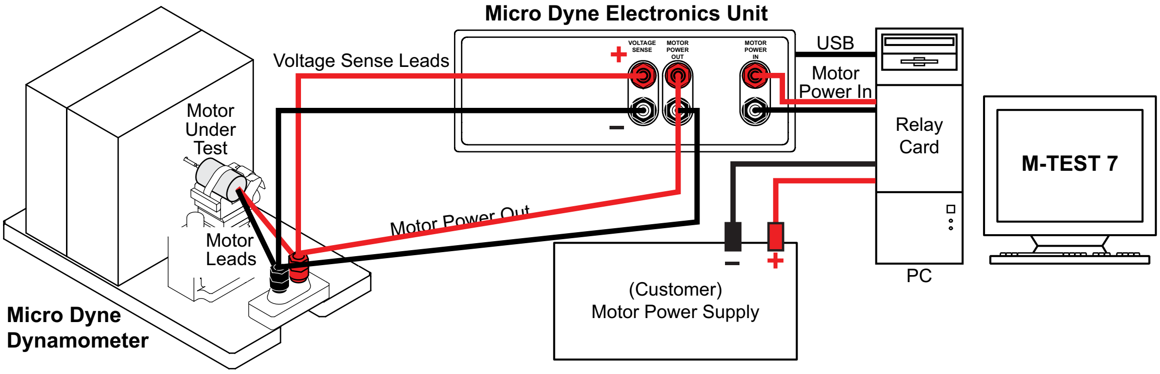


Fig.2-6 Relay Configuration

2.3.1.3 MOTOR DRIVE CONFIGURATION

This setup allows for the addition of a motor drive unit. The advantage to this is that the Micro Dyne is now measuring the drive/motor efficiencies, instead of the just the motor alone. This is especially beneficial when the motor is dependent on the motor drive for operation. With the power supply unit attached to the Micro Dyne relay, the power to the motor drive can be controlled through M-TEST 7.

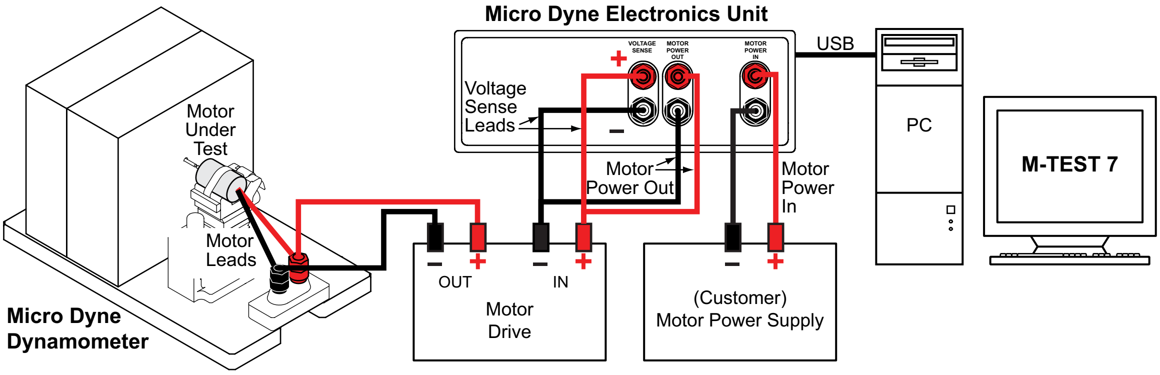


Fig.2-7 Motor Drive Configuration

2.4 MOTOR TESTING SOFTWARE

2.4.1 SOFTWARE INSTALLATION

For detailed installation instructions, refer to Magtrol's M-TEST 7 User's Manual.

M-TEST 7 COMMUNICATION

In order to use M-TEST 7 with the Micro Dyne, the COM port to which the USB interface is connected must first be determined.

1. Power up the Micro Dyne.
2. Find the COM port.

For Windows 7 and higher: Go to Start menu > Control Panel > Device Manager > Ports. Look for the USB Serial Port and note the COM port number in parenthesis.

NOTICE To configure M-TEST 7 for the Micro Dyne, refer to Section 4.3 – Software Configuration.

2.5 COMMUNICATION CHECK

When powering up the Micro Dyne, check to make sure that the READY LED and one of the torque range LEDs on the front panel of the electronics unit (see Figure 2–3) are illuminated.

Using a serial terminal program such as Tera Term or HyperTerminal, send the identification query "*IDN?" to the Micro Dyne. The returned response should be "Magtrol,MicroDyne,(serial number),(firmware revision)".

NOTICE All commands should use a carriage return-line feed as the terminator.

2.6 INITIAL CALIBRATION

After communication is verified, it is highly recommended to calibrate the dynamometer before performing any tests. Refer to Chapter 6 – Calibration for a detailed procedure.

3. TESTING CONSIDERATIONS

A number of factors must be taken into consideration before running a test, including: safety, power dissipation, and influences that affect the apparent accuracy of the torque readout (such as shaft alignment, windage, friction, vibration, dynamometer leveling, cogging, Eddy currents and temperature rise). The following sections describe these factors, and their effects, in further detail.

NOTICE If you have not already done so, please take a moment to familiarize yourself with the Micro Dyne System's technical specifications. See Section 1.2 – Data Sheet.

3.1 SAFETY

WARNING FOR GENERAL SAFETY CONSIDERATIONS, PLEASE FOLLOW THESE FEW COMMON-SENSE RULES:

- Make sure all wiring and connections have been properly made.
- Secure all grounding wires to the appropriate locations to reduce the chance of shock and damage to the equipment.
- Always wear safety glasses when working around Micro Dyne equipment.
- Do not wear loose clothing or ties when operating the Micro Dyne equipment.
- Ensure motor under test is properly mounted to the motor fixture.

3.2 POWER DISSIPATION

All Magtrol dynamometers are power absorption instruments. As a dynamometer loads a test motor, it is absorbing power from the motor into the hysteresis brake. The brake is converting this mechanical energy into heat.

There are finite limits to the amount of energy and resulting temperature rise that any absorption brake can withstand. Excessive power over extended periods of time may result in more obscure damage including breakdown of bearing lubricants and degradation of magnetic coil insulation. Extreme temperatures due to inappropriate operation can not only warp the rotor and surrounding housings, but also alter the magnetic characteristics. Absolute best-case scenario under such circumstances would be a reduced torque output from the brake assembly, if complete dynamometer failure were not realized.

3.2.1 POWER ABSORPTION CURVE

Based on the maximum kinetic power ratings, the curve represented in Figure 3–1 illustrates the maximum power (heat) that the dynamometer can dissipate over time. The area under the curve equals the maximum speed/torque combinations for both a motor test of less than 5 minutes (intermittent duty), and a continuous-duty motor test.

CONDITIONAL ENVIRONMENTAL PARAMETERS	
Maximum brake temperature	100 °C (212 °F)
Ambient temperature	25±5 °C (77±9 °F)

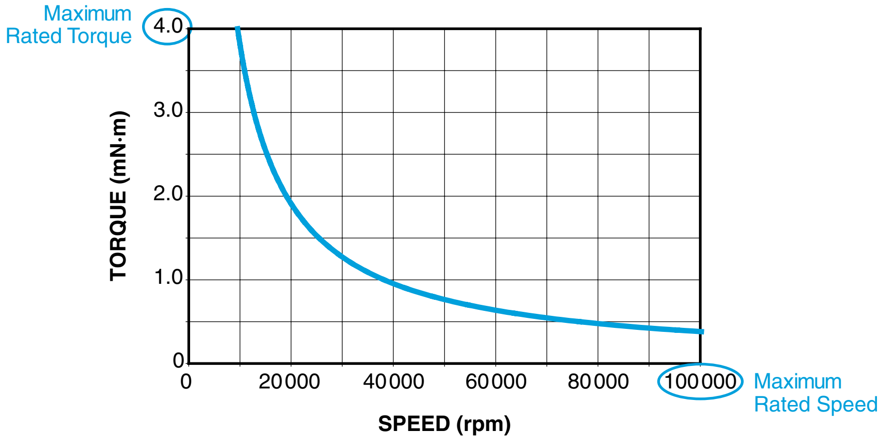


Fig.3-1 Micro Dyne Power Absorption Curve

3.3 SHAFT ALIGNMENT

In motor testing, shaft alignment is one of the most important factors to consider. An improper coupling and/or shaft alignment can lead to unwanted side loads and vibration, damaging both the test equipment and motor. To accommodate micro motor sizes, while preventing side loading on the dynamometer shaft, a coupling of small flexible rubber tubing should be used. The friction of the rubber tube on the shaft alone suffices as a clamping agent. Several pieces of rubber tubing, in various diameters, are included with the Micro Dyne for this purpose. Refer to Section 4.2.1 – Shaft Coupling for detailed coupling instructions.

3.4 WINDAGE

Windage is proportional to the square of speed. The air friction is tangential to the surface and impinges upon the stationary field assembly. This acts as viscous drag and becomes part of the motor load and torque reading. There is also a small amount of air dissipated as pumping loss. Since this appears as a load on the motor, not measured by the dynamometer, it becomes a source of error. Considering the size of the parts affected by windage in the Micro Dyne, this source of error will be less pronounced than if similar speeds were seen on larger dynamometers.

3.5 FRICTION

Friction of the carrier bearings is not a measurable load. When correctly loaded and lubricated, the friction is insignificant. During actual motor testing there is usually enough system vibration to "settle" negating frictional effects. If excessive drag is present, mechanical realignment may be required. In the design of the Micro Dyne, careful attention was paid to carrier bearing friction for the proper operation of the pendulum assembly; mainly in ensuring the pendulum returned to the zero position within the published error bands.

NOTICE Friction is the largest source of error in the Micro Dyne but it is relatively small in comparison to the overall range and accuracy (< 1%) of the dynamometer.

3.6 VIBRATION

All rotating dynamometer assemblies are precision balanced. At high speeds, some vibration and noise are inevitable but not necessarily harmful. however, excessive resonant vibrations caused by bent shafts and poor alignment will produce data errors and are a safety hazard.

CAUTION SEVERE VIBRATION LEFT UNATTENDED COULD ULTIMATELY LEAD TO PERMANENT DAMAGE TO THE TEST EQUIPMENT OR THE MOTOR UNDER TEST.

3.7 DYNAMOMETER LEVELING

An improperly leveled dynamometer will alter the torque calculations in proportion to the deviation from a true level surface. The base plate of the Micro Dyne is equipped with two leveling knobs and an embedded bubble level for easy leveling.

3.8 COGGING

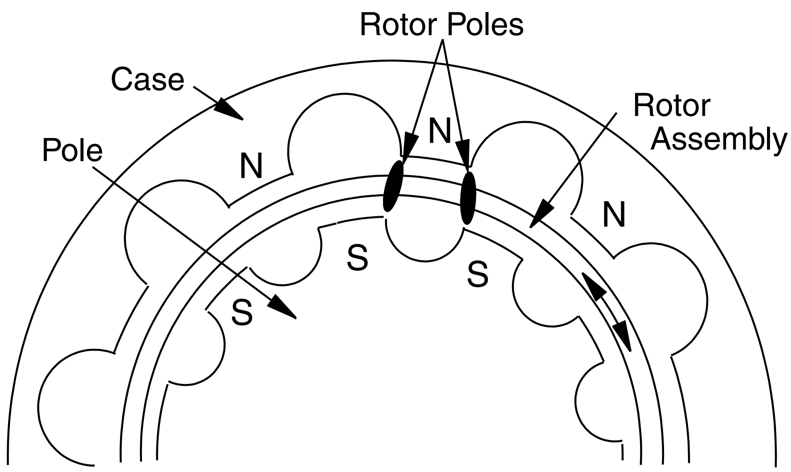


Fig.3-2 Hysteresis Brake Cross Section

This cross-section shows (by one tooth) the magnetic relationship of the hysteresis brake elements. If the dynamometer shaft is at rest with the (brake) current applied, and if the current control is then reduced to zero, a magnetic salient pole will be temporarily imposed on the rotor of the brake.

If the shaft is then rotated slowly, the magnetic poles on the rotor will attempt to align with the adjacent case-pole tooth form. This is often referred to as “cogging”. The action is sinusoidal. First it tries to resist rotation and then, as the rotor passes through the tooth form, it subsequently supports rotation.

The most obvious results of cogging are uncontrolled oscillations within the torque/speed curve. It will become difficult for the motor under test to tune in the PID loop, along with a possible increase in resonant noise from the dynamometer and motor.

3.8.1 AVOIDING COGGING

To avoid magnetic cogging, before the shaft comes to rest, slowly reduce the current control to zero.

3.8.2 REMOVING COGGING

To most effectively remove cogging, once established, reapply current on the dynamometer. Then, slowly ramp the current to zero while maintaining a very low speed (only a few rpms). The current ramp to zero can be increased slightly in speed when the dynamometer rotation is sped up during this process.

3.9 EDDY CURRENTS

There is some Eddy current generation within the brake rotor. These magnetically-induced currents cause an increase in braking torque proportional to speed. While more pronounced in larger dynamometers (which exhibit higher rotor surface velocities), in a pure loading system it becomes a benefit of the dynamometer. Since the Eddy currents affect the rotor surface, this torque is measured by the torque pendulum and becomes another load source (and not a source of error).

3.10 TEMPERATURE RISE

Temperature rise has a more complex effect on hysteresis brake load torque and is difficult to quantify. As the temperature of the brake increases, differential expansions cause dimensional changes that tend to increase torque. Conversely, electrical resistance in the rotor increases with temperature, resulting in decreased Eddy current generation and load, all in a variable frame.

CAUTION UNDER NO CIRCUMSTANCES SHOULD THE MAXIMUM WATTAGE RATINGS FOR THE DYNAMOMETER BE EXCEEDED. THE RESULTING RISE IN TEMPERATURE CAN CAUSE PERMANENT DAMAGE TO THE ROTATING ASSEMBLY, INCLUDING ALTERING THE MAGNETIC PROPERTIES OF THE ROTOR ITSELF.

4. TEST SETUP

4.1 TORQUE CONFIGURATION

The Micro Dyne can be configured to either a 4 mN·m or 2 mN·m torque scale. The Micro Dyne is shipped as the 2 mN·m configuration. To convert it to 4 mN·m, follow the procedures below.

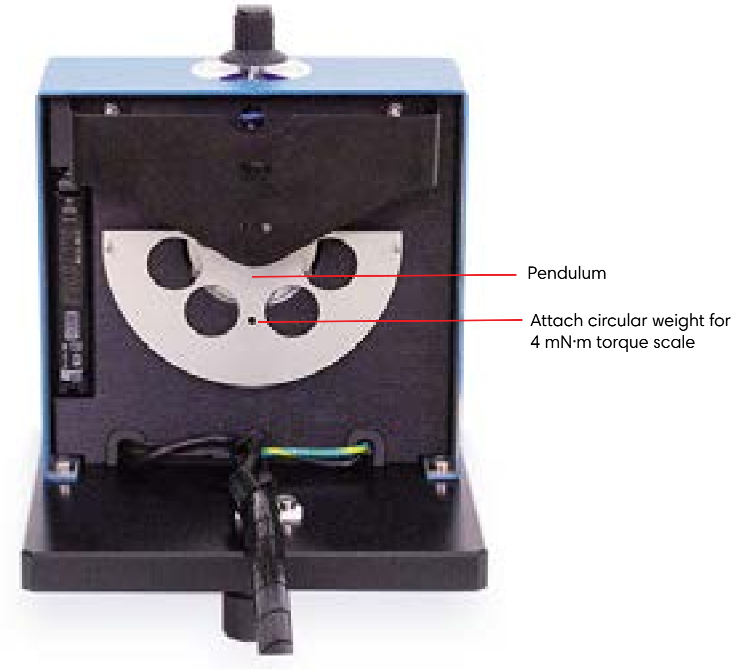


Fig.4-1 Dynamometer, Inside View

1. Locate the small parts bag labeled 4 m·Nm configuration components.
2. Attach the circular weight with the provided flat head cap screw, using the provided Allen wrench included with the 4 m·Nm configuration components.
3. Calibrate the dynamometer with the 10 gram calibration weight. Refer to Chapter 6 for complete calibration instructions.

NOTICE Re-calibration is necessary after every conversion between the 2 mN·m and 4 mN·m torque configurations.

4.2 MOTOR MOUNTING

Fig.4-2 Micro Dyne Motor Fixture

4.2.1 SHAFT COUPLING

If the motor shaft diameter is 0.5 mm to 1.6 mm, it is highly recommended to use one of the provided rubber couplings to adapt the motor shaft to the 2.0 mm Micro Dyne Dynamometer shaft.

1. Trim the tubing to allow about 2 mm of tubing over the dynamometer shaft and 3 mm of tubing over the motor shaft.
2. Place the tubing snugly around the dynamometer shaft, being careful not to bend the shaft.
3. After the motor is mounted, as described in Sections 4.2.2, 4.2.3 and 4.2.4, place the other end of the rubber tubing around the motor shaft.

4.2.2 ADAPTERS

When testing motors with diameters less than 20 mm, the appropriately-sized adapter must be used.

MOTOR DIAMETER	ADAPTER
5 mm – 10 mm	V-Adapter I
10 mm – 20 mm	V-Adapter II
20 mm – 30 mm	No adapter necessary

Attach the adapters to the fixture using the provided hex screws and Allen wrench. The threaded holes are found in the groove of the v-adapters.

NOTICE The adapter should be secured in place but be careful not to overtighten.

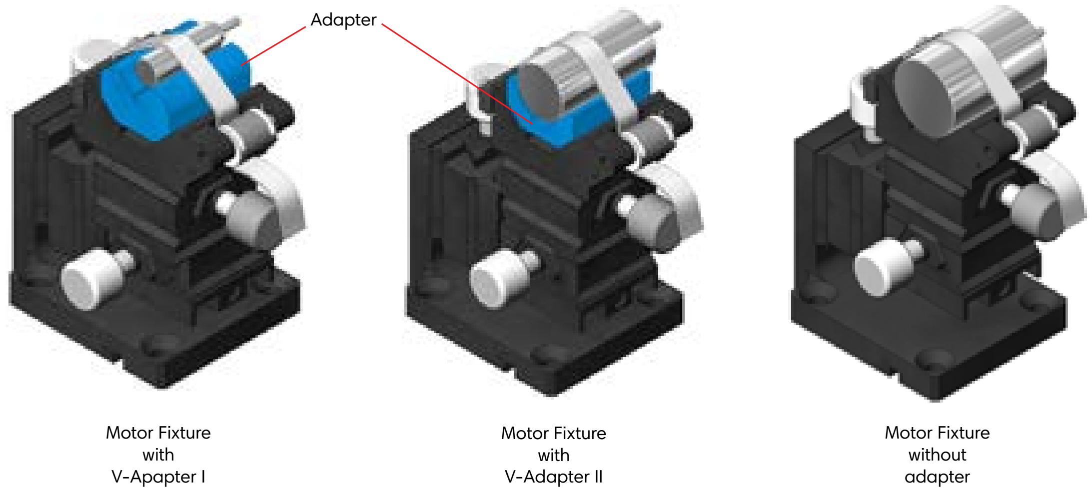


Fig.4-3 Motor Fixture Adapters

4.2.3 CLAMPING STRAP

1. Place the motor under the rubber strap.
2. Tighten by pulling on the strap. A knurled cam will lock the strap in place when the strap is let go.
3. To release the motor, rotate the cam upward and the strap will loosen.

NOTICE Ideally, the clamping strap should be secured at the middle of the motor.

4.2.4 STAGE ADJUSTMENT

For precise motor alignment, the stage of the motor fixture may be axially adjusted using the three colored adjustment knobs.

KNOB COLOR	AXIS	ADJUSTMENT DIRECTION
Red	X	Horizontal (side-to-side positioning)
Yellow	Y	Vertical (shaft height)
Green	Z	Depth (of motor to input shaft of dynamometer)

NOTICE The entire motor fixture can also move (as one unit) along the length of the dynamometer base plate, in line with the bolt pattern. The fixture is locked in place by screwing into the tapped holes with the provided hex key screws.

4.3 SOFTWARE CONFIGURATION

This section only provides very basic instructions for setting up M-TEST 7 to run with the Micro Dyne. For detailed information about selecting, configuring and running a test, refer to Magtrol's M-TEST 7 User's Manual.

1. Power up the Micro Dyne.
2. Start M-TEST 7.
3. Open the Configure hardware window.

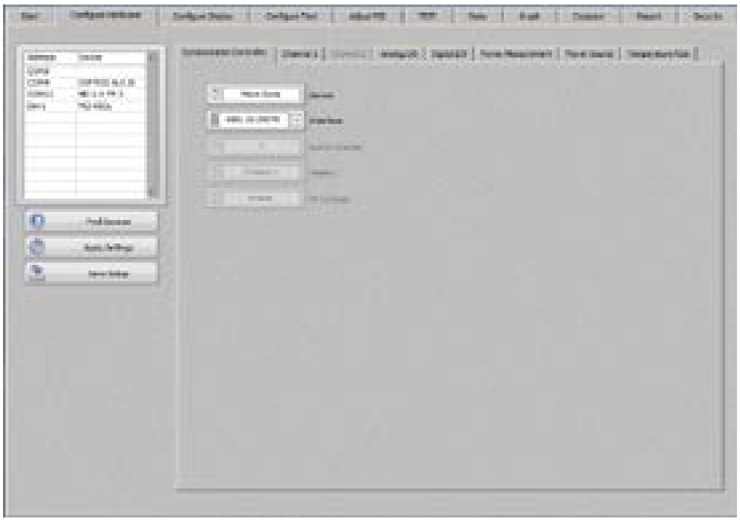


Fig.4-4 M-TEST 7 Configure Hardware Window

4. Enter the following settings:

   4a. Under Dynamometer Controller, select "Micro Dyne" for the Model.

   4b. For the Interface, select the COM port where the USB interface is connected (as determined in Section 2.4.2 – M-TEST 7 Communication). The COM port may show as ASRlx::INSTR, where x is the COM port number.

   4c. Under Power Measurement, select "Micro Dyne" as the Device.

NOTICE For increased power measurement capabilities, other power analyzers (such as Magtrol's 7510 or 7530) may be used in conjunction with the Micro Dyne. If applicable, the supplemental power analyzer should be selected as the "Device." If using a third-party measurement device not found on the list, by selecting "None", M-TEST 7 will no longer be responsible for measuring the input power.

4.3.1 MOTOR REVERSAL

If it is desired to perform a motor test in both clockwise and counter-clockwise directions, a programmable relay is required. See Appendix B for a simplified schematic. Motor direction is configured in M-TEST 7 and requires a power supply supported by M-TEST 7. Supported power supplies are found in the Device text box, under the Power Source options in the Configure hardware window. See Figure 4–5.

4.3.1.1 REVERSING MOTOR DIRECTION BEFORE TEST IS RUN

To reverse the motor direction and keep the direction of rotation constant throughout the entire test, use the Configure hardware window for motor reversal setup.

1. Open the Configure hardware window.
2. Under Power Source, click on the Device text box and scroll through for a list of supported power supplies.
3. After selecting a power supply, set the voltage and current output for that voltage supply. If a negative voltage is entered, M-TEST 7 switches relays to change the polarity of the motor voltage and, in turn, reverses the direction of rotation (for a DC motor).

Fig.4-5 M-TEST 7 Power Source Configuration

4.3.1.2 AUTOMATIC REVERSAL OF MOTOR DIRECTION DURING TEST

Curve tests and Pass/Fail tests allow for reversing the motor direction during a test.

NOTICE

Because Ramp tests do not allow reversing direction, the motor must ramp up and down in the same direction for the entire test. To reverse the direction of rotation for a ramp test, after running the first test, enter a negative power supply voltage in the Configuration hardware window (as described in Section 4.3.1.1) and then run the test a second time.

1. If not already done so, select a Power Source supported by M-TEST 7 in the Configure hardware window.
2. Open the Configure Test window. If Curve Test or Pass/Fail Test is selected, an extra column in the Control Data table, under Test Parameters, labeled "Volts" should appear.

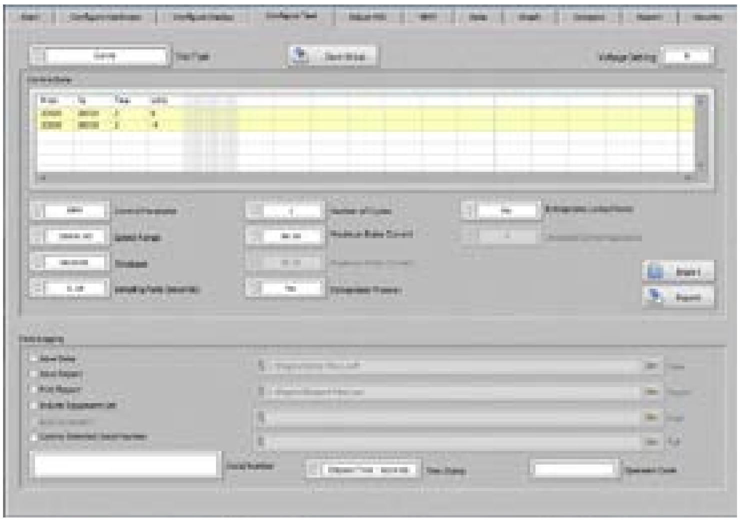


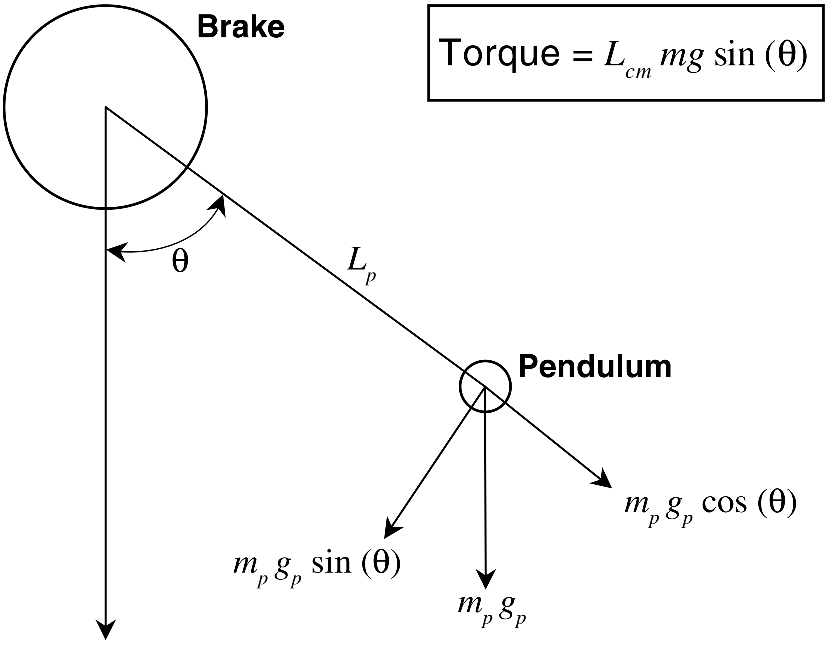
Fig.4-6 Curve Test Parameters with Motor Reversal

3. To have the motor direction reversed during a test, simply enter a negative voltage, as shown in Figure 4-6.

5. OPERATING PRINCIPLES

5.1 TORQUE MEASUREMENT

An innovative approach to measuring small torques is implemented in the Micro Dyne. The design employs a very small pendulum and brake assembly hung in a precision-machined carrier. The basic concept, a textbook physics problem, is described below.



SYMBOL	REPRESENTS
L_p	the length to the center of mass of the pendulum
$m_p g_p$	the force applied by the mass and gravity
$m_p g_p \sin(\theta)$	the force in the radial direction

Fig.5-1 Illustrated Torque Principle

5.1.1 TORQUE CALCULATION

At calibration time, a known mass at a known distance is applied to the pendulum system and a precise calibration is accomplished.

$$L_p m_p g_p \sin(\theta) = L_c m_c g_c \cos(\theta)$$

SYMBOL	REPRESENTS
L_c	the length from the center to the calibration weight
$m_c g_c$	the force applied by the known mass and gravity

The coefficient $L_p m_p g_p$ is calculated and stored. Torque data is calculated using this coefficient, along with position data.

5.2 SPEED MEASUREMENT

The Micro Dyne contains a reflective fiber optic speed pickup. As each rotor slot passes by the sensing end of the fiber optic, an electronic pulse is generated, which is then converted to a speed reading (in rpm). The incoming pulses from the speed pickup can be resolved down to 5 Hz or 5 pulses per second. With 6 slots on the rotor, this results in a minimum speed setting of 50 rpm. (The speed reading will drop to zero at 50 rpm.)

NOTICE The rotor/speed measuring mechanism of the Micro Dyne has been optimized for motors running from 10,000 rpm to 100,000 rpm.

Fig.5-2 Micro Dyne Rotor

5.3 CONTROLLER AND THE PID LOOP

The Micro Dyne has PID adjustment capability for both the speed and torque modes to provide the best system response. The PID loop comprises the following three variables:

P = proportional gain

I = integral

D = derivative

other important variables include:

- Set point - desired load or speed
- Error - difference between the set point and the actual measurement
- Additional scaling – used to broaden the range of the control loop

5.3.1 P (PROPORTIONAL GAIN)

With proportional gain, the controller output is proportional to the error or to a change in measurement. Deviation from the set point is usually present. Increasing the proportional gain will make the PID loop unstable. Increasing the integral value will eliminate this instability. For best loop control, set the proportional gain as high as possible without causing the loop to become unstable.

5.3.2 I (INTEGRAL)

With integral, the controller output is proportional to the amount of time the error is present. Increasing the integral value eliminates the offset from the set point. If the response becomes oscillatory, increase the derivative value.

5.3.3 D (DERIVATIVE)

With derivative, the controller output is proportional to the rate of change of measurement or error. Derivative can compensate for a changing measurement. Derivative takes action to inhibit more rapid changes of the measurement than proportional gain.

5.3.4 ADDITIONAL SCALE FACTOR

The Additional Scale Factor (PS, IS and DS) is a multiplier of the P, I or D term. Due to the fact there are so many different motor combinations, this multiplier is needed to extend the range of the PID. The letters represent the following values:

A = 0.001	D = 0.05	G = 1
B = 0.005	E = 0.10	H = 5
C = 0.010	F = 0.50	I = 10

Using the multiplier, PID values from 0.001 (0.001 × 1%) to 990 (10.0 × 99%) may be inputted.

5.3.5 HOW THE PID LOOP WORKS

The following diagram demonstrates the correlation between the variables in the PID loop.

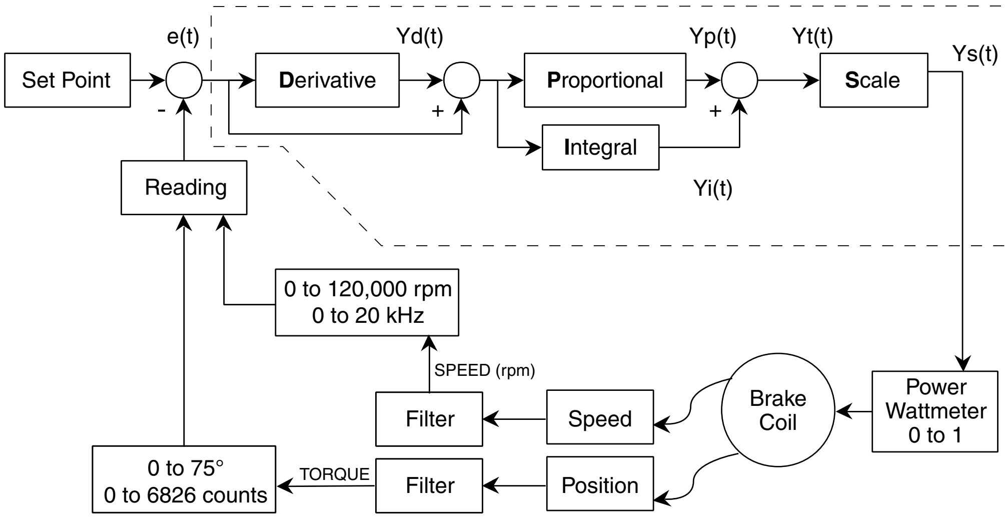


Fig.5-3 Control Loop and PID System Block Diagram

5.3.6 PID EQUATIONS

Where Skp, Ski and Skd are factory-determined system coefficients…

yd(t) = (e(t) - e(t-3) + 3 * [e(t-1) - e(t-2)]) * (10/*Skd*) * D% * DS

yp(t) = (e(t) + yd(t)) * (10/*Skp*) * P% * PS

yi(t) = yi(t-1) + [e(t) + yd(t)] * (10/*Ski*) * I% * IS

yt(t) = yp(t) + yi(t)

ys(t) = Scale * yt(t)

5.4 DC WATTMETER

The data acquisition stage in the hardware of this DC power measurement instrument is very simple. The input voltage is divided by an amplifier circuit and applied directly to a ITC2515 A/D converter. The input is differential and isolated from the amps circuitry. The input current is applied through a shunt resistor and the resulting voltage is amplified and applied directly to a ITC2515 A/D converter. The input is differential and isolated from the voltage circuitry. The wattage presented is a multiplication of the amps and voltage. See Section B.3 – DC Wattmeter Schematic.

6. CALIBRATION - DYNAMOMETER

6.1 CALIBRATION SOFTWARE AND DRIVER INSTALLATION

6.1.1 MICRO DYNE CALIBRATION SOFTWARE

1. Insert the "Micro Dyne Calibration and Driver Disk" into your CD-ROM drive.
2. The calibration software installer will start automatically.
3. If the software does not start installing, open Windows File Explorer and run setup.exe from the DVD (Windows XP only).

6.2 CALIBRATION PREPARATION

A detailed description of the electrical, mechanical and software setup for calibration is conveniently located within the Calibration Software. In the calibration software setup window (next to Setup help), click INSTRUCTIONS.

CAUTION READ AND FOLLOW THE ON-SCREEN INSTRUCTIONS CAREFULLY BEFORE CONTINUING WITH THE CALIBRATION PROCEDURE.

6.3 CALIBRATION PROCEDURE

The Micro Dyne Calibration Software walks the user through every step in the calibration process. Simply follow the instructions and prompts that appear on the screen.

6.3.1 SETUP

Start the Micro Dyne Calibration Software by opening the **Micro Dyne Calibration** software from the Start menu. The calibration setup window will appear.

Fig.6-1 Calibration Setup Window

Open/Print Button	Access previously saved calibration data with option to reprint calibration report.
Calibrate Button	Perform calibration
Model	Enter model; default is “Micro Dyne”
Serial Number	Enter serial number; default is blank
Condition	Select from list; options are “New Unit” (default), “Recal after repair” and “Recal as received” Selection will appear on calibration report.
Nominal Torque	Select torque value in mN·m from “2.000” (default) or “4.000”
Cal Weight Exact Masst	Enter mass of calibration weight (in grams) as printed on tag. Required for calibration to proceed.
VISA Resource Name	Selectable from all detected COM ports of PC. To identify Micro Dyne COM port, click Setup Help INSTRUCTIONS. The COM port may show as ASRLx::INSTR, where x is the COM port number
Initialize Communication button/indicator	Click to initialize communication with Micro Dyne. Unit information will be displayed (see Detected Unit Info) and indicator will turn green.
Setup Help Instructions button	Provides a detailed description of the electrical, mechanical and software setup required for calibration.
Technician	Enter calibration technician’s name
Date	Current date is automatically entered.
Remarks	Entered remarks will appear on calibration report.
Detected Unit Info	Displays data about Micro Dyne unit after communication is successfully initialized. (*See Initialize Communication button/ indicator.*)
Yellow Message Box	A note reminding which calibration weight to use will be displayed, depending on the nominal torque value selected: • For 2 mN·m range, use 5 g weight • For 4 mN·m range, use 10 g weight

6.3.2 RUN

1. After completing all required setup data, click **calibrate** to begin calibration. Carefully follow the instructions given in the bar at the top of the screen. The Reset ZERO dialog box will appear.

NOTICE Calibration Constants are displayed for units with firmware version 2.4 or later.

Fig.6-2 Reset ZERO

2. To zero the pendulum at its current rest state (without weights), click **send Zero**.

NOTICE If reading in dialog box is more than a few counts away from zero (after clicking "Send zero" once), click **send Zero** again before continuing.

3. The next prompt asks the user to hang the calibration weight, starting with the right side. Carefully hang the appropriate calibration weight from the calibration peg, as show in Figure 6–3. Tweezers have been included in the accessory tool bag for your convenience.

Fig.6-3 Dynamometer Calibration

4. Continue to follow the instructions in the bar at the top of the screen, alternating between hanging the weight on opposite sides of the pendulum and removing the weight. An example of the screen display during this process is shown in Figure 6–4. This entire cycle will be performed a total of ten times. After each cycle, the message/ instruction bar will display the status of the calibration routine. The progress bar will also update.

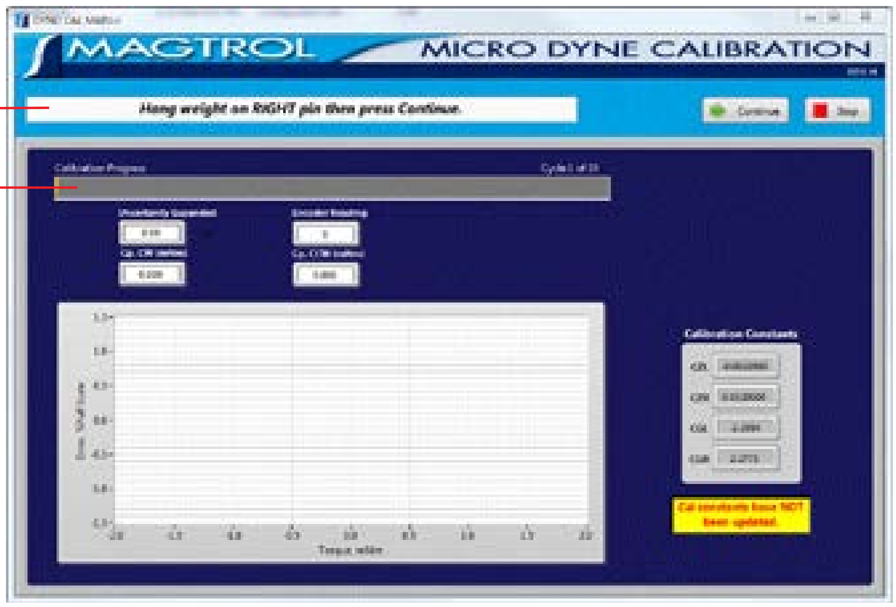


Fig.6-4 Calibration Instruction and Progress Bars

5. When the calibration is complete, a dialog box appears prompting the user to write calibration constants to the unit (to be saved in the Micro Dyne's internal firmware).

Fig.6-5 Calibration In-Process

6. After calibration, the obtained data will be displayed as passed or failed.

Fig.6-6 Final Calibration Window

7. If calibration passed:

   To view/print a calibration report or save calibration data, click continue and proceed to Section 6.3.3.

   To quit the Micro Dyne Calibration program without printing the results or saving the data, click stop.

   If calibration failed:

   Click stop or continue to quit program.

6.3.3 PRINT REPORT OR SAVE DATA

After clicking "Continue" at the completion of a calibration procedure, the calibration report will be displayed in the window and a dialog box will appear with the option of printing the report.

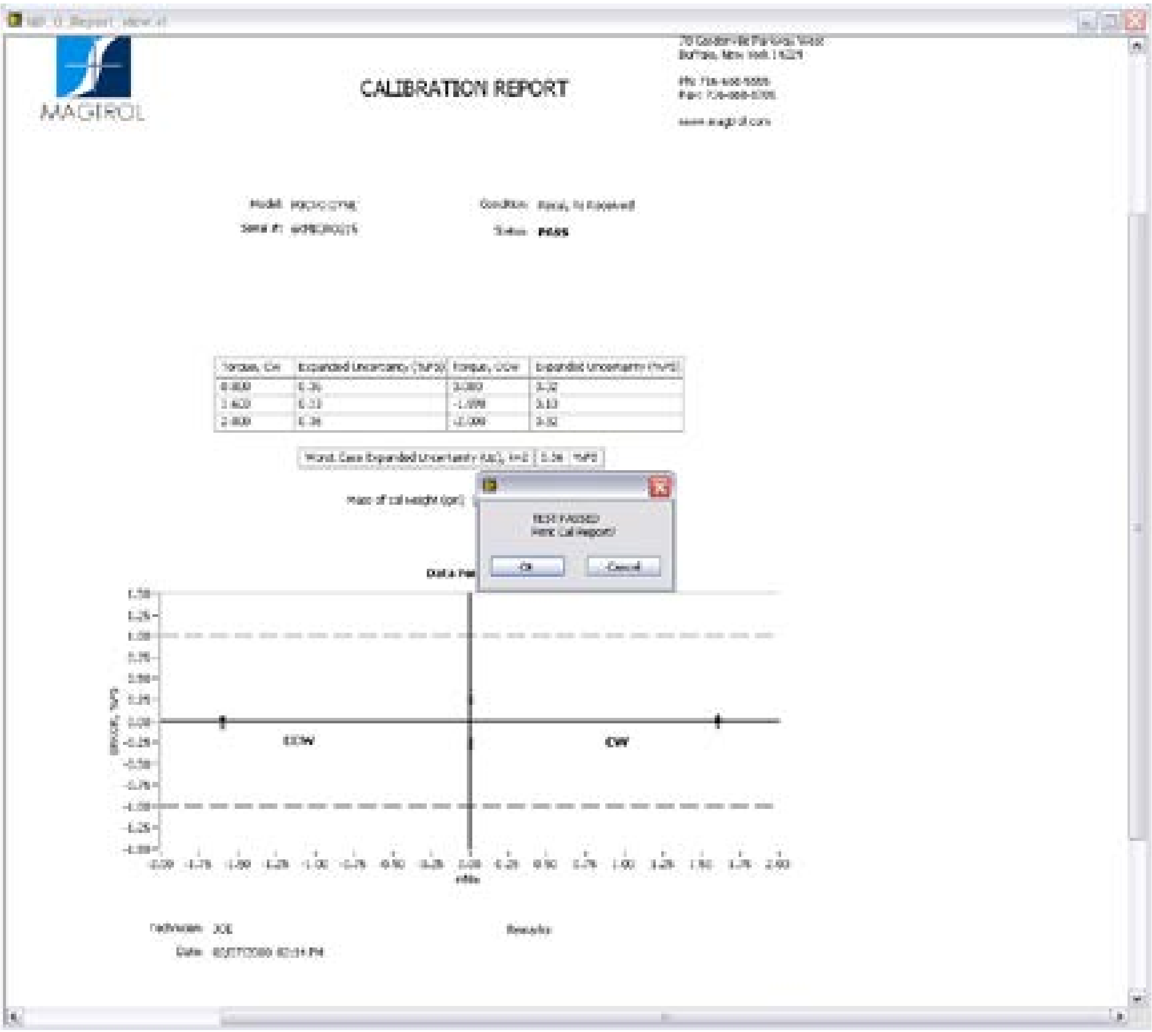


Fig.6-7 Calibration Report

Whether "ok" is selected, or "Cancel", the Save As dialog box will appear next in order to save the calibration data

7. CALIBRATION - WATT METER

7.1 CLOSED-BOX CALIBRATION

The Micro Dyne features closed-box calibration. The advantage of closed-box calibration is that the user does not have to disassemble the case or make mechanical adjustments.

The unit can be calibrated using external reference sources. Correction factors for offset and gain are stored in nonvolatile memory. They remain in effect until the user or the calibration house updates them.

7.2 CALIBRATION SCHEDULE

Calibrate the Micro Dyne:

- After any repairs are performed.
- At least once a year; more frequently to ensure required accuracy.

7.3 BASIC CALIBRATION PROCESS

The basic calibration process consists of two procedures which must be performed in the following order:

1. Initial Procedure
2. Zero for both Volts and Amps
3. Volts gain
4. Amps gain

Items needed for calibrating the Micro Dyne:

- External voltage reference of 0 to 30 volts DC
- Current reference of 0 to 5 amps DC
- Digital multimeter (DMM)

Both measuring instruments should have a accuracy of 0.005% or better.

7.3.1 INITIAL CALIBRATION PROCEDURE

1. Allow the Micro Dyne to stabilize in an environment with:
   - An ambient temperature of 18°C to 25°C.
   - Relative humidity less than 80%.
2. Turn on the Micro Dyne.
3. Allow the Micro Dyne to warm up for at least 30 minutes.

7.3.2 VOLTS AND AMPS ZERO AND GAIN

1. Send the command CAL to the unit via the USB port.
2. The response will be ZERO.
3. Apply 0.0000 volts to the volts input and 0.0000 amps to the amps input.
4. Send the command ZERO.
5. The response will be FSV=X.XXXX
6. Apply 30 volts to the input (this can vary a few mv but must be measured accurately).
7. Send the command FS=X.XXXX (where X.XXXX is your meter reading).

8. The response will be FSA=X.XXXX.
9. Apply 5 amps to the amps input (this can vary few mA but must be measured accurately).
10. Send the FSA=X.XXXX (where X.XXXX is your meter reading).
11. Unit will respond CAL COMPLETE.

8. TROUBLESHOOTING

PROBLEM	REASON	SOLUTION
SPEED MEASUREMENT		
Speed is erratic or there is no speed reading.	Speed pickup is in incorrect mode.	Switch speed pickup to SHS Mode.
CALIBRATION		
Micro Dyne revision is not displayed in the calibration software window.	Lost communication with electronics unit.	Check USB connections.
Calibration Error message appears at completion of calibration procedure.	Pendulum not fully returning to zero after the weight is removed.	Make sure the dynamometer is level and restart calibration procedure.

If you require additional assistance, please contact Magtrol Customer Service at 1-716-668-5555.

APPENDIX A. MICRO DYNE COMMAND SET

A.1 DATA FORMAT

Speed-torque data is a fixed-length string in ASCII format with a floating point decimal. Use the following string format:

SddddTdddd.R(cr)(lf)

or

SddddTdddd.L(cr)(lf)

Where…

S = Speed in rpm. (No leading zeroes are used.)

d = Decimal digit 0 through 9.

T = Torque in mN·m. (The torque value always contains a decimal point.)

L = Counterclockwise dynamometer shaft rotation (left).

R = Clockwise dynamometer shaft rotation (right).

. = Decimal point. (The decimal point location depends on the specific dynamometer and torque range in use.)

NOTICE The (cr) and (lf) characters will not display.

EXAMPLE

If a motor is running at 1725 rpm clockwise, with the dynamometer loading the motor to 2.26 mN.m, the Micro Dyne will return:

S 1725T2.260R

By manipulating the string, the speed-torque and shaft direction (if required) can be extracted. Then separate numerical variables can be assigned to them for data processing.

A.1.1 CODES FOR CR - LF

	BASIC	HEX	DEC
CR =	CHR$(13)	0D	13
LF =	CHR$(10)	0A	10

A.2 MICRO DYNE COMMAND SET

When entering a command code:

1. Type all characters in uppercase ASCII format.
2. End all commands with a CR-LF (hex 0D-0A).
3. Do not string multiple commands together in one line.

The character # represents a floating-point numerical value following the command. Leading zeroes are not required.

A.2.1 COMMUNICATION COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
*IDN?	Returns Magtrol Identification and software revision.	Example: “MD 1.4 FP 2” Micro Dyne REV 1.4 and FPGA REV 2
B0	Brake Off.	---
B1	Brake On.	---
OD	Returns speed-torque value.	Output Data prompt to return data string with this format: SxxxxxTxxxxxRcrlf or SxxxxxTxxxxxLcrlf R or L is the shaft direction indicator, as viewed looking at the dynamometer shaft where: R = right; clockwise (CW) L = left; counterclockwise (CCW)

A.2.2 RAMP COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
DILXX.XX	Sets dynamic "I" scale coefficient.	When using dynamic scaling, XX.XX is multiplied by the I term to give the end I value.
DPLXX.XX	Sets dynamic "p" scale coefficient.	When using dynamic scaling, XX.XX is multiplied by the P term to give the end P value.

DS#	Enable or disables dynamic scaling.	Values for # are:
		0 = disable
		1 = enable

PD#	Program Down: Sets ramp down rate to #rpm per second and starts ramp.	Specify speed range (F#) AND a stop speed (S#) before using this command. This command programs a decreasing shaft speed at a rate of #rpm per second.
PR	▪ Resets ramp up or down. ▪ Sets speed to maximum speed. ▪ Turns brake off.	This command resets the ramp function, halting the ramp’s progress, and returns the motor to free run.
PU#	Program Up: Sets ramp up rate to #rpm per second and starts ramp.	Specify speed range (F#) AND a start speed (S#) before using this command. This command increases the shaft speed at a rate of #rpm per second.
S#	Sets start or stop speed for ramp to #RPM.	When this command is used with the PD command, the controller will ramp down to this speed and halt. When this command is used with the PU command, the controller will load immediately to this speed and ramp up to free- run.

A.2.3 SETUP COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
R	Resets as follows: ▪ Brake OFF.	Use this command to cancel any previous commands.
RQ1	Resets quadrature counter.	Use this command to reset torque count to zero.

A.2.4 SPEED COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
F#	Sets maximum speed to # rpm.	Sets a speed range for the controller. Must be specified before using the speed or ramp mode. Sets the range of the PID calculation.
N	▪ Resets speed point to maximum speed. ▪ Sets speed mode OFF. ▪ Sets brake OFF.	Use this command, sent alone, to reset any previous speed-stabilized setting to the maximum speed range.
N#	▪ Sets speed point to #. ▪ Sets brake ON.	Use this command to load the motor under test to a specific speed value #. Issue a speed range command (F#) first for best dynamic response. The controller is functioning with the dynamometer as a closed loop system. Adjust the speed PID values to tune the response.
ND#	Sets speed derivative to #.	Derivative value (#) can be any number from 0 to 99.
NDS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
NI#	Sets speed integral to #.	Integral value (#) can be any number from 0 to 99.
NIS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
NP#	Sets speed proportional to # gain.	Proportional gain value (#) can be any number from 0 to 99.
NP#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)

A.2.5 TORQUE COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
Q	▪ Resets torque to 0.0. ▪ Turns torque mode OFF. ▪ Turns brake OFF.	Resets any previous torque-stabilized command, and returns the motor to free run.
Q#	▪ Sets torque point to #. ▪ Turns brake ON.	Closed-loop command with its own set of PID parameters. Units are in mN·m.
QD#	Sets torque derivative to #.	Derivative value (#) can be any number from 0 to 99.
QDS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
QI#	Sets torque integral to #.	Integral value (#) can be any number from 0 to 99.
QIS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
QP#	Sets torque proportional gain to #.	Proportional gain value (#) can be any number from 0 to 99.
QPS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)

A.2.6 POWER ANALYZER AND RELAY COMMANDS

COMMAND CODE	FUNCTION	EXPLANATION
OA1,0	Reads amps.	---
OV1,0	Reads volts.	---
OW1,0	Reads watts.	---
PWR0	Switches off the power relay.	---
PWR1	Switches on the power relay.	---

A.2.7 MISCELLANEOUS COMMANDS

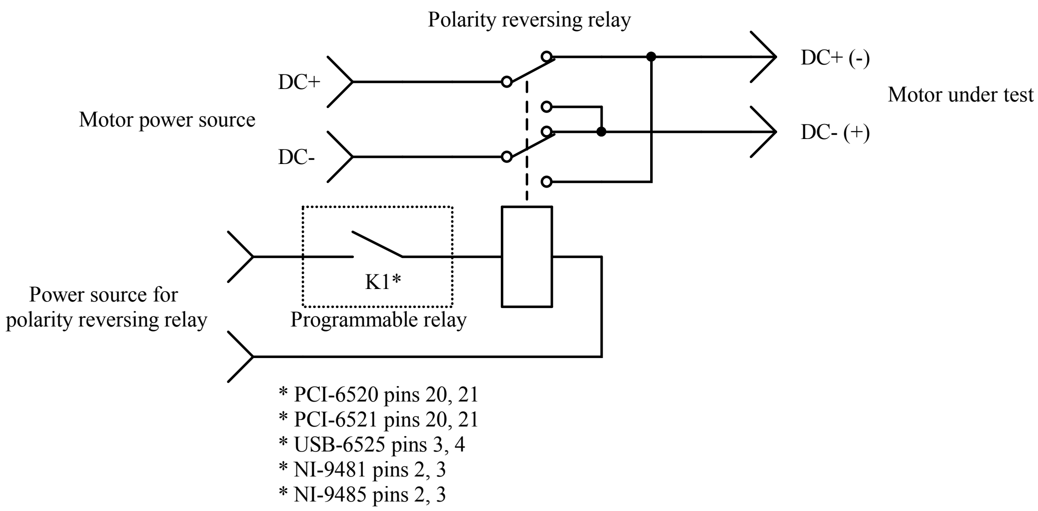
COMMAND CODE	FUNCTION	EXPLANATION
I#	Sets current output to #.	The Micro Dyne power supply outputs a fixed value of current. Use any value (#) between 0 and 99.99%. (99.99% = FS).
SAVE	Saves present configuration of unit to non-volatile memory.	---

A.2.8 CALIBRATION COMMANDS

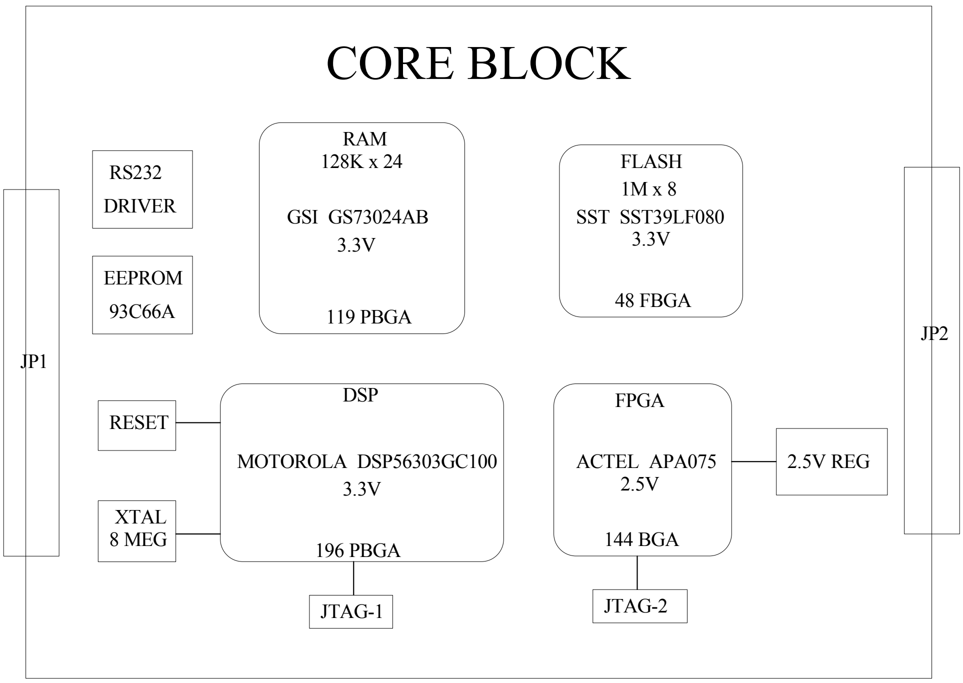
COMMAND CODE	FUNCTION	EXPLANATION
CAL	Sets unit into calibration mode.	See Chapter 6 - Calibration - Dynamometer and Chapter 7 - Calibration - Watt Meter
CGL	Returns average gain after calibration on left side. (Available with firmware revisions 2.4 and above.)	Output, floating point
CGR	Returns average gain after calibration on left side. (Available with firmware revisions 2.4 and above.)	Output, floating point
CZL	Returns average of zero calibration reading on left side. (Available with firmware revisions 2.4 and above.)	Output, floating point
CZR	Returns average of zero calibration reading on right side. (Available with firmware revisions 2.4 and above.)	Output, floating point
FSA=X.XXX	Calibrate full scale amps to this value.	See Chapter 6 - Calibration - Dynamometer and Chapter 7 - Calibration - Watt Meter
FSV=X.XXX	Calibrate full scale volts to this value.	See Chapter 6 - Calibration - Dynamometer and Chapter 7 - Calibration - Watt Meter
ZERO	Sets the offset to the value at the input.	See Chapter 6 - Calibration - Dynamometer and Chapter 7 - Calibration - Watt Meter
GL=xxxx	Sets average gain after calibration on left side.	Input, floating point
GR=xxxx	Sets average gain after calibration on right side.	Input, floating point
ZL=xxxx	Sets average of Zero calibration reading on left side.	Input, floating point
ZR=xxxx	Sets average of Zero calibration reading on right side.	Input, floating point

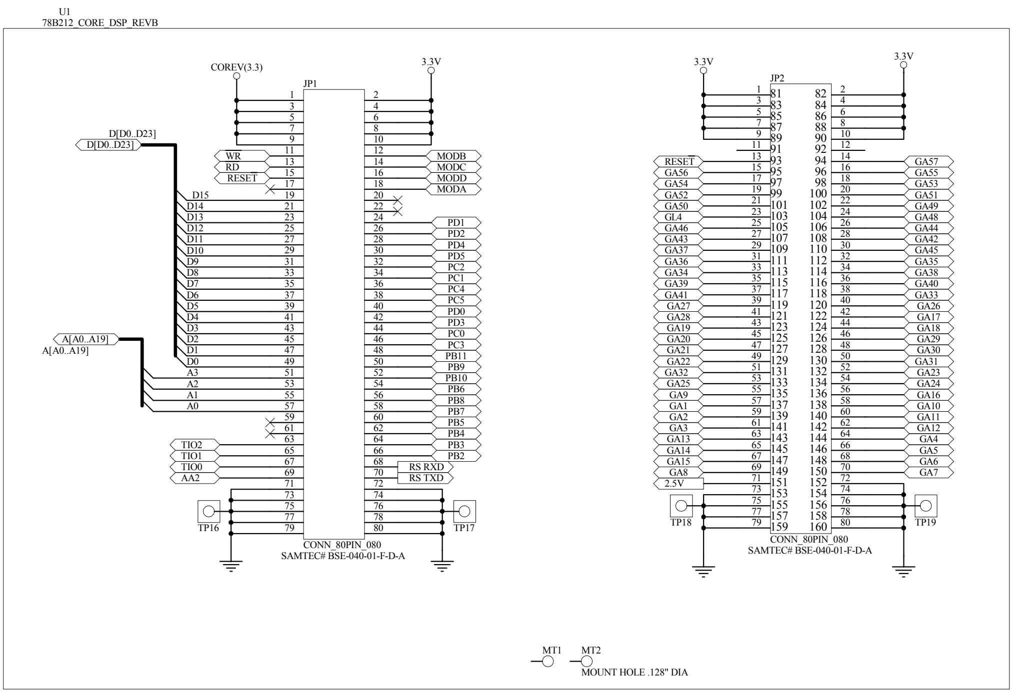
APPENDIX B. SCHEMATICS

B.1 POLARITY REVERSING CIRCUIT



B.2 CORE BLOCK DIAGRAM





SERVICE INFORMATION

RETURNING MAGTROL EQUIPMENT FOR REPAIR AND / OR CALIBRATION

When returning equipment to MAGTROL INC. (United States) or MAGTROL S.A. (Switzerland) for repair and/or calibration, a completed **Return Material Authorization (RMA) form is required.**

Please visit the «Services/Return and Calibration» section on our web site www.magtrol.com.

Depending on where the equipment is located and which unit(s) will be returned, you will be directed to either ship your equipment back to MAGTROL, INC. in the United States or MAGTROL S.A. in Switzerland.

RETURNING EQUIPMENT TO MAGTROL INC. (UNITED STATES)

1. Visit the «Services/Return and Calibration» section of Magtrol's web site www.magtrol.com to initiate an RMA procedure. Complete the RMA form online and submit.
2. An RMA number will be issued to you via e-mail. Include this number on all return documentation.
3. Ship your equipment to: **MAGTROL, INC.**
70 Gardenville Parkway
Buffalo, NY 14224 | USA
Attn: Repair Department
4. After Magtrol's Repair Department receives and analyzes your equipment, a quotation listing all the necessary parts and labor costs, if any, will be e-mailed to you.
5. After receiving your repair estimate, provide Magtrol with a P.O. number as soon as possible. A purchase order confirming the cost quoted is required before your equipment can be returned.

CONTACT FOR AFTER SALES SERVICE AT MAGTROL INC.

After Sales, Repair & Calibration Services

phone +1 716 668 5555 ext. 115
fax +1 716 668 3162
e-mail service@magtrol.com

RETURNING EQUIPMENT TO MAGTROL S.A. (SWITZERLAND)

1. Visit the «Services/Return and Calibration» section of Magtrol's web site www.magtrol.com to initiate an RMA procedure; complete the RMA form online and submit.
2. After your request has been reviewed, you will receive an email containing an RMA number and dedicated return instructions including specifics about shipping details. The RMA number will be a Magtrol SA internal repair order (SR-xxxx) reference.

   Any **shipment sent without an RMA risks delays and possible rejection,** so please wait until you receive the email with the details you will need to properly return your equipment.

   Any **equipment returned for credit must be approved** prior to return and is subject to a re-stocking fee.

CONTACT FOR AFTER SALES SERVICE AT MAGTROL S.A.

After Sales, Repair & Calibration Services

phone +41 26 407 30 00
fax +41 26 407 30 01
e-mail repair@magtrol.ch

REVISIONS TO THIS MANUAL

The contents of this manual are subject to change without prior notice. The latest updated versions of our manuals are available and downloadable at any time on Magtrol's website www.magtrol.com in the « SUPPORT » section.

To ensure that you have the latest version, compare the issue date (on the back of this manual) with the last updated document available on our website.

The table of revisions below lists the significant updates that have been made.

REVISION DATES

DATE	EDITION	CHANGES	SECTION(S)
02/01/22	3rd Edition	New controller added to the Micro Dyne.	various
05/30/17	2nd Edition, rev. D	All instances of M-TEST 5.0 changed to M-TEST 7.	various
02/21/13	2nd Edition, rev. C	Chapter 7 Calibration - Watt Meter added.	Chapter 7
05/21/13	2nd Edition, rev. C	Calibration commands updated.	A.2.8
09/02/10	2nd Edition, rev. B	Step 3 has been removed. It is no longer neccessary to move the pendulum when installing the circular mass.	4.1 step 3
09/02/10	2nd Edition, rev. B	Speed Pick-up Connection has been removed from side of electronics box. It is now concealed in the dynamometer housing.	2.2.2
09/02/10	2nd Edition, rev. B	Earth ground has been removed from rear of base plate. It is now concealed in dynamometer housing.	2.2.1
09/30/09	2nd Edition, rev. A	The number of cycles performed changed from five to ten	6.3.2, step 4
07/11/08	2nd Edition	New calibration software and procedure	Chapter 6, A.2.8
10/21/07	1st Edition, rev. A	Added option to print calibration data results at end of calibration procedure.	6.3
06/13/07	1st Edition	Finalized version of preliminary manual	various

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