Contents

General information

Pro-Master operating instructions

PC Software

General information

Introduction

Your Pro-Master is a professional motor testing device and a high-quality battery charging unit. The device is equipped with modern technology and so delivers utmost precision. This makes Pro-Master equally suited for hobby and industrial applications.

The features of the motor check function:

- Measurement of motor's characteristic curve according to flywheel principle
- Electronically regulated battery simulation for utmost precision of repetition
- Standalone operation with output of motor data on built-in display
- Output of motor data on protocol printer (optional) without a PC
- PC interface for data transfer to a PC
- PC software for MS-DOS, Windows 3.xx and Windows 95
- Evaluation on PC using graphics and tables

Features of the charging function:

- Battery pack charging function with temperature and delta-peak cut-off
- Linear and linear-flex charging methods
- Charging current range 0-10 amperes, set digitally
- Storage of five charging programs

Scope of delivery

Your Pro-Master includes the following components:

- ✓ Transport case
- ✓ Pro-Master main unit
- ✓ Motor support
- ✓ Flywheel
- ✓ Hex key
- ✓ Motor cable (red/black) with solder connectors
- ✓ Serial cable for PC
- ✓ Diskette with PC software (MS-DOS)
- ✓ Operating instructions

In addition, the following accessories are available:

RS409 Panasonic lead-acid battery Type LC-RC1217PG (12 Volt, 17 Ah)
RS114 Temperature sensor cable with clip
RS512 Charging cable (red/black) with battery clips
HP82240B Hewlett Packard Infrared printer

A T T E N T I O N P L E A S E R E A D T H I S

For best performance at the motor checking function use a small lead-acid battery with 12 Volt and a capacity of at least 17 Ah but not much more. We recommend a Panasonic lead-acid battery Type LC-RC1217PG.

Do not use a lead-acid battery with more than 40Ah !!!

Do not charge the lead-acid battery during a motor-check !!!

If you use a big automotive battery and check motor with 11 turns or less the power limit of the Pro-Master will be reached. (Pro-Master message: „High Power"). In this case you must use a battery with less capacity. **Don´t try a bigger one !!!!!**

Safety precautions

This device is not suited for use by children under the age of 14.

The motor support must be placed on a slip-proof surface out of the reach of small children.

The flywheel must be firmly attached to the motor armature by means of the hex (Allen) screws.

The safety guard for the flywheel must be attached to the safety mount on the motor support unit by means of the thumbscrew. See the assembly sketch on page 7.

During the measuring procedure maintain a safe distance of at least ½ meter from the motor support unit.

Always ensure that no cables or other moving parts are in the vicinity of the rotating flywheel.

Pro-Master operating instructions

Setup

Using the motor checking function requires a 12-volt lead-acid battery with a capacity of at least 17 Ah but not much more. We recommend a Panasonic lead-acid battery Type LC-RC1217PG.
Do not use a lead-acid battery with more than 40Ah !!!
Do not charge the lead-acid battery during a motor-check !!!
If you use a big automotive battery and check a motor with 11 turns or less the power limit of the Pro-Master will be reached. (Pro-Master message: „High Power“). In this case you must use a battery with less capacity. **Don´t try a bigger one !!!!!**
For the battery charging function you can instead use a stabilized power supply delivering 5-10 amperes. Connect the supply voltage with the battery clips of the Pro-Master main unit. See instructions on page 6 and the assembly sketch on page 7.
Pro-Master allows you to change the default parameters (see page 12) such as battery simulation voltage, and the default values can be reset by pressing the [START] key while connecting the supply voltage.

Pro-Master keys and operation

Description of keys:

[Mode]	selection key
[Start]	activation key
[+]	modification key (increase value)
[-]	modification key (decrease value)

Key functions on selection of a function (menu item)

The [Mode] key allows selection of a function from the menu.

Pressing the [Start] key activates the selected function.

Key functions for setting values

The [Mode] key allows selection of a value; a small bar under a value marks the selected parameter.

The [+] and [-] keys allow modification (increase or decrease, respectively) of the selected value.

Pressing the [Start] key saves the modified values and terminates setup.

Selecting a function

1. Motor check

```
-- Main Menu  --
1:Motor Check
```

This menu item allows you to carry out a motor check without a personal computer. The motor data are output to Pro-Master's own display. Pressing the [Start] key activates the motor check function, while the [Mode] key lets you move to another function.

2. Battery charging

```
-- Main Menu  --
2:Charge Battery
```

This menu item invokes Pro-Master's battery charging program and allows you to charge batteries with a current of up to 10 amperes. Pressing the [Start] key activates the charging function, while the [Mode] key lets you move to another function.

3. Pro-Master setup

```
-- Main Menu  --
3:Setup Master
```

This menu item allows you to set the contrast of Pro-Master's multifunction LCD display and the greeting message. Pressing the [Start] key activates the setup function, while the [Mode] key lets you move to another function.

Preparing for a motor check

Connect Pro-Master to a 12-volt lead-acid battery with a capacity of at least 17Ah. **Do not use a power supply**!

Place the test motor in the mount on the motor support unit. If, due to stickers, the motor is difficult to place in the mount, the O-rings in the motor mount can be removed. Then attach the flywheel to the motor armature with the hex key. The black/silver fields on the flywheel must be toward the motor.

Connect the sensor cable of the motor support unit with the 7-pole plug to the front side of Pro-Master.

Select Pro-Master's sensor check function to determine the correct position of the test motor in the motor mount. The distance between the reflex sensor on the motor mount and the flywheel should be 2-4 mm. The sensor check should display a value of at most 30% for a silver field and at least 70% for a black field.

Next solder the red/black motor cable to the test motor. We do not recommend a plug connection because the motor's high starting current (up to 120 amperes) combined with the resistance of a plug connector would cause a measurement error.

Connect the thin red/black measuring cable of the motor cable to the cable of the motor mount.

Next plug the motor cable into the socket marked "Output" on Pro-Master.

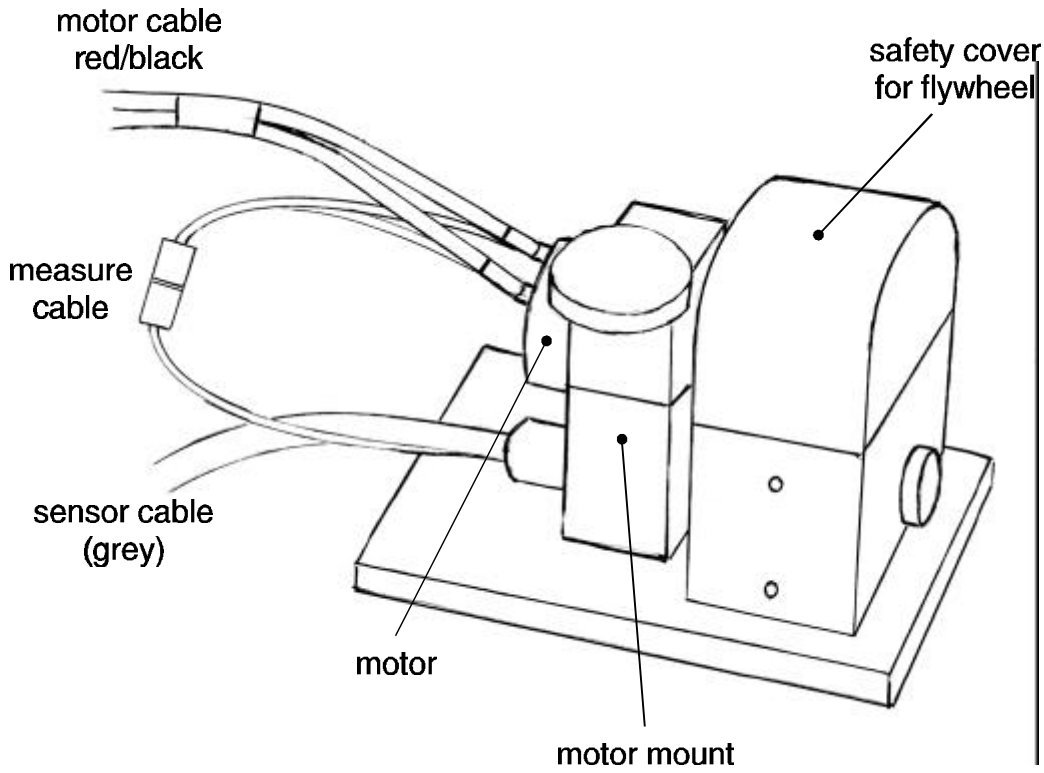
Check to assure that the flywheel has been firmly attached to the motor armature with the hex (Allen) screws.

Check the tightness of the thumbscrew to fasten the test motor.

Then mount the safety cover over the flywheel, attaching the cover to the mounting block with the thumbscrew.

To preclude the danger of injury by the rotating flywheel, the flywheel must be completely covered by the safety cover.

Assembly sketch



Checking the RPM sensor

--Motor Check -- 1:Sensor 12.5%OK	[Mode]	next function

The sensor check function in Pro-Master helps you to determine the correct position of the test motor in the motor mount. This function tests the distance between the flywheel and the RPM sensor; this distance should be 2-4 mm. For this test you need to turn the flywheel slowly by hand. When a silver (reflecting) field passes the RPM sensor, a value should be displayed of at most 30% and for a black field at least 70%.

Starting the measurement

--Motor Check --	[Start]	start measurement
2:Start Test	[Mode]	next function

Check whether the flywheel has been firmly mounted to the motor armature with the hex (Allen) screws.
Retighten the thumbscrews holding the test motor.
Maintain a safe distance of at least ½ meter from the rotating flywheel.
Press the [Start] key to begin measurement.

--Motor Check --	[Start]	terminate measurement
Running	[Mode]	terminate measurement

Measurement can be terminated at any time by pressing any key.

```
--Motor Check --
Calculate Pass15
```

Next comes the calculation of the motor's characteristic curve, followed by automatic display of maximum values (see next section, "Display of motor data").

Starting another measurement

--Motor Check --		
2:Please Wait30s	[Mode]	next function

After termination of a motor check, a further measurement is blocked for 30 seconds; i.e., a measurement can be started at most once every 30 seconds.

Error message

--Motor Check --	[Start]	return to sensor check
No RPM Signal	[Mode]	return to sensor check

On start of a motor check, no RPM sensor signal could be detected. Possibly the sensor cable was not plugged in properly or the motor cable not connected properly. Test proper operation of the RPM sensor (see section "Checking the RPM sensor" on page 7).

--Motor Check --	[Start]	return to sensor check
High Power	[Mode]	return to sensor check

If you use a big automotive battery and check a motor with 11 turns or less the power limit of the Pro-Master will be reached. (Pro-Master message: „High Power“). In this case you must use a battery with less capacity. **Don´t try a bigger one !!!!!**
We recommend a Panasonic lead-acid battery Type LC-RC1217PG 12 Volt 17 Ah.

--Motor Check --	[Start]	return to sensor check
High Amp Signal	[Mode]	return to sensor check

Check the motor or the Shottky diode.

--Motor Check --	[Start]	return to sensor check
Battery Fault	[Mode]	return to sensor check

Check the voltage of the lead-acid battery.

Displaying motor data

--Motor Check -- 3:Display Data	[Start] [Mode]	display measurement values next function

Display of maximum values

Max:143.9W 69.3% 38.541rpm 7.86s	[Start] [Mode]	return to function selection next display function

Displays maximum power, maximum efficiency, maximum RPM and time until maximum RPM is reached.

Display of average values

Average: 95.6W 56.3%	[Start] [Mode]	return to function selection next display function

Displays average power and efficiency.

Display of motor current table

20A 76.1W 60.3 29.879rpm 24.3N	[Start] [Mode] [+] [-]	return to function selection next display function display next value

Display motor data (power, efficiency, RPM and torque) in relation to motor current. The current steps for the display can be set in the parameter setup function (see page 13).

Display of torque table

20N 65.9W 57.4 31.474rpm 18.0A	[Start] [Mode] [+] [-]	return to function selection next display function display next values

Display motor data (power, efficiency, RPM and motor current) in relation to torque. The torque steps for the display can be set in the parameter setup function (see page 13).

Printing on the protocol printer

To print the data, you need a protocol printer (available as option) and a printer cable.

--Motor Check -- 4:Print Data	[Start] [Mode]	print data next function

Print data

Print Data Please Wait	[Start]	print additional data

If, in addition to the motor data, you also want to print the current table and the torque table, press the [Start] key again during printing.

Printing motor data:

==========
Robitronic
Pro Master
==========

Battery Simulation: 7.5 Voltage

Maximum Rpm	33.279 rpm
Maximum Power	175.6 W
Average Power	114.4 W
Maximum Efficiency	79.2 %
Average Efficiency	52.7 %

	Maximum Power	Maximum Efficiency	Maximum RPM
Power	175.6 W	112.1 W	
Eff	62.5 %	79.2 %	
RPM	16.983 rpm	26.187 rpm	33.279 rpm
Torqu	98.8 Nmm	41.0 Nmm	
Amp	51.8 A	21.4 A	5.6 A
Volt	5.5 V	6.7 V	7.3 V
Time	0.58 s	1.34 s	7.35 s

Printing additional data:

Amp Step	R P M U/min	Power Watt	Eff [%]	Torqu [Nmm]	Volt [V]	Time sec
20	26.587	106.4	78.9	38.2	6.7	1.4
30	23.040	145.3	76.5	60.2	6.3	1.0
40	19.914	167.3	70.5	80.2	5.9	0.8
50	17.327	175.6	63.5	96.9	5.5	0.6
60	14.834	172.9	56.3	111.5	5.1	0.5
70	12.612	163.2	49.1	124.1	4.8	0.4
80	10.379	146.8	42.3	135.6	4.3	0.3
90	8.284	125.5	35.5	146.1	3.9	0.2
100	6.178	101.2	28.6	156.0	3.6	0.1
110	4.066	66.9	19.3	168.2	3.2	0.1

Torq Nmm	R P M U/min	Power Watt	Eff [%]	Amps [A]	Volt [V]	Time sec
20	30.111	63.0	73.9	11.9	7.0	2.1
40	26.323	110.2	79.1	20.7	6.7	1.4
60	23.074	145.0	76.6	29.8	6.3	1.0
80	19.941	167.2	70.5	39.9	5.9	0.8
100	16.765	175.6	61.9	52.4	5.4	0.6
120	13.332	167.1	51.5	66.6	4.9	0.4
140	9.509	138.6	39.6	85.2	4.1	0.2
160	5.365	90.3	25.6	104.8	3.4	0.1

Setting parameters for a motor check

--Motor Check -- 5:Setup Motor	[Start] [Mode]	display parameters next function

Voltage for battery simulation

TestVoltage:7.5V Current Lim:120A	[Start] [Mode] [+] [-]	return to function selection next parameter change motor test voltage

Here the voltage can be set for the motor test; to simulate a 6-cell Ni-Cad battery pack requires a voltage of 7,5 volts. The set value is the no-load voltage, i.e., the voltage applied to the motor with no current flowing. Since even under no-load conditions some current flows in the motor, maximum motor voltage drops by a factor of the motor current multiplied times 0,04 (= 40 mΩ internal resistance of battery pack).

Current Limiter

TestVoltage:7.5V Current Lim:120A	[Start] [Mode] [+] [-]	return to function selection next parameter change sensitivity

Here the current limiter can be set between 50 and 150 Amps.

Maximum detection of RPM

TestVoltage:7.5V Rpm Detection: 1	[Start] [Mode] [+] [-]	return to function selection next parameter change sensitivity

There are two sensitivity levels for detecting final RPM. For modified motors, use level 1. For motors with worn commutators or stock motors, RPM detection with level 2 can be used.

Flywheel's moment of inertia

Flywheel: 45.00 Armature: 4.20	[Start]	return to function selection
	[Mode]	next parameter
	[+] [-]	change flywheel values

Using a different flywheel requires you to enter the moment of inertia here. This value is needed for the computation of torque, power and efficiency of the motors. Entering an incorrect moment of inertia results in falsified motor data. The moment of inertia for the included flywheel is 45,00 x $10e^{-6}$ kgm^2 .

Armature's moment of inertia

Flywheel: 45.00 Armature: 4.20	[Start]	return to function selection
	[Mode]	next parameter
	[+] [-]	change motor armature value

In addition to that of the flywheel, the moment of inertia of the motor armature must also be considered for a measurement. The value above is an average of various commonly available armatures. The value should not be changed initially, but can be adapted for special applications. The factory setting is 4.20 x $10e^{-6}$ kgm^2 .

Changing step values for current and torque table

The motor's characteristic curve is displayed in the form of a current table and a torque table with 10 entries each, where the 10 current and 10 torque values in the table are factory set and the corresponding motor data is computed. These 10 default values each for current and torque can be modified here.

Step Amp Torque 01: 20A 20Nmm	[Start]	return to function selection
	[Mode]	next parameter
	[+] [-]	change table index

Select the number of the table value; there are a total of 10 table values.

Step Amp Torque 01: 20A 20Nmm	[Start]	return to function selection
	[Mode]	next parameter
	[+] [-]	change current value

Change the current value for a table entry.

Step Amp Torque 01: 20A 20Nmm	[Start]	return to function selection
	[Mode]	next parameter
	[+] [-]	change torque value

Change the torque value for a table entry.

Overview of table with default values

No.	Default current	Default torque
1	20 A	20 Nmm
2	30 A	40 Nmm
3	40 A	60 Nmm
4	50 A	80 Nmm
5	60 A	100 Nmm
6	70 A	120 Nmm
7	80 A	140 Nmm
8	90 A	160 Nmm
9	100 A	180 Nmm
10	110 A	200 Nmm

Ending the motor check

--Motor Check -- 6:-> Main Menu	[Start]	return to main menu
	[Mode]	next function

This terminates the motor check function and returns to the main menu.

Charging battery packs

Preparing to charge a battery pack

To use the battery pack charging function, you need a 12-volt lead-acid battery or a stabilized power supply. Connect to the supply voltage to Pro-Master main unit using the battery clips.
The battery pack to be charged is connected to the socket labeled "Output" and the temperature probe (with clip attachment) to the "Sensor" socket on Pro-Master.

Selecting the charging function:

```
-- Main Menu  --
2:Charge Battery
```

The charging function is selected in the main menu by pressing the [Start] key.

Selecting a charging program

```
- Charge Menu  -
1:Start Progr: 1
```

This function invokes a battery pack charging program. The [+] and [-] keys allow you to select from among five charging programs. Pressing the [Start] key launches the charging program. With menu item 2 "Set up charge" you can modify the charging programs. This allows you to set different charging currents and cutoff methods to match your applications.

Start charging

After selecting a charging program, you can initiate charging by pressing the [Start] key again.

```
L 21.4/p15 00:00
 0.0A  0.0V 0000
```

Pressing the [Mode] key terminates charging.

Setting charging current

```
L 21.4/p15 00:00
Setup Amps: 5.0A
```

The charging current can be modified during charging with the [+] and [-] keys.
No general recommendations can be made for setting the charging current as it depends on both the battery packs and the intended application. A general rule is that higher charging current yields higher stored voltage (= power) and lower charging current yields more capacity (= operating time) when discharging the battery pack. For quick-charging battery packs, you should select a charging current between 3 and 6 amperes.

SANYO battery pack: charging current 4.5A - 5.5A (standard 5.0 A)

PANASONIC battery pack: charging current 4.0A - 5.0A (standard 4.5 A)

Settings for hobbyists:

Charging current:	3.5 amperes
Cutoff method:	peak 0.10V 10min

Settings for competition:

Charging current:	5.0 amperes
Cutoff method:	peak 0.10V 5min
or	temp 40°C 2800 mAh

Modifying a charging program

```
- Charge Menu  -
2:Setup Charge
```

Selecting the function "Setup Charge" allows you to modify the five charging programs. This enables you to store different charging options for different applications.

Setting the delta peak charging method

```
Progr:1 L   5.0A
Peak 0.15V  0min
```

Selecting the delta peak charging method *Peak* at the bottom left of the setup display allows you to set the value of the voltage peak (default value: 0,1V). Excessive peak voltage can overload and destroy a battery pack.
In addition, a delay time can be set. Here the battery pack voltage is tested for a voltage drop only after the set time. This enables charging even old battery packs with poor voltage characteristics using the delta peak method. CAUTION: the delay is not suited for recharging (repeaking) battery packs.

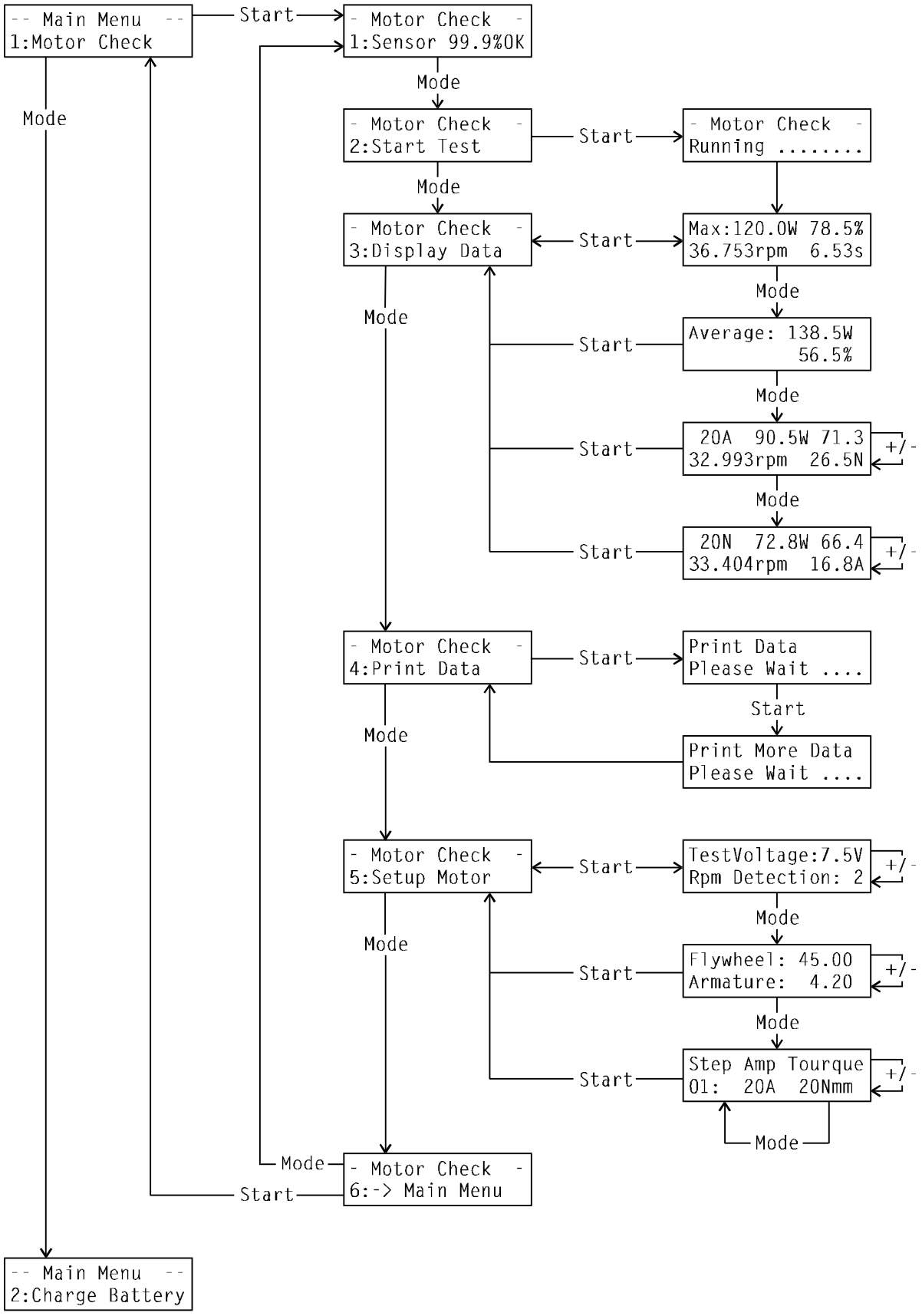
Setting the temperature charging method

```
Progr:1 L   5.0A
Temp 42C 3000mAh
```

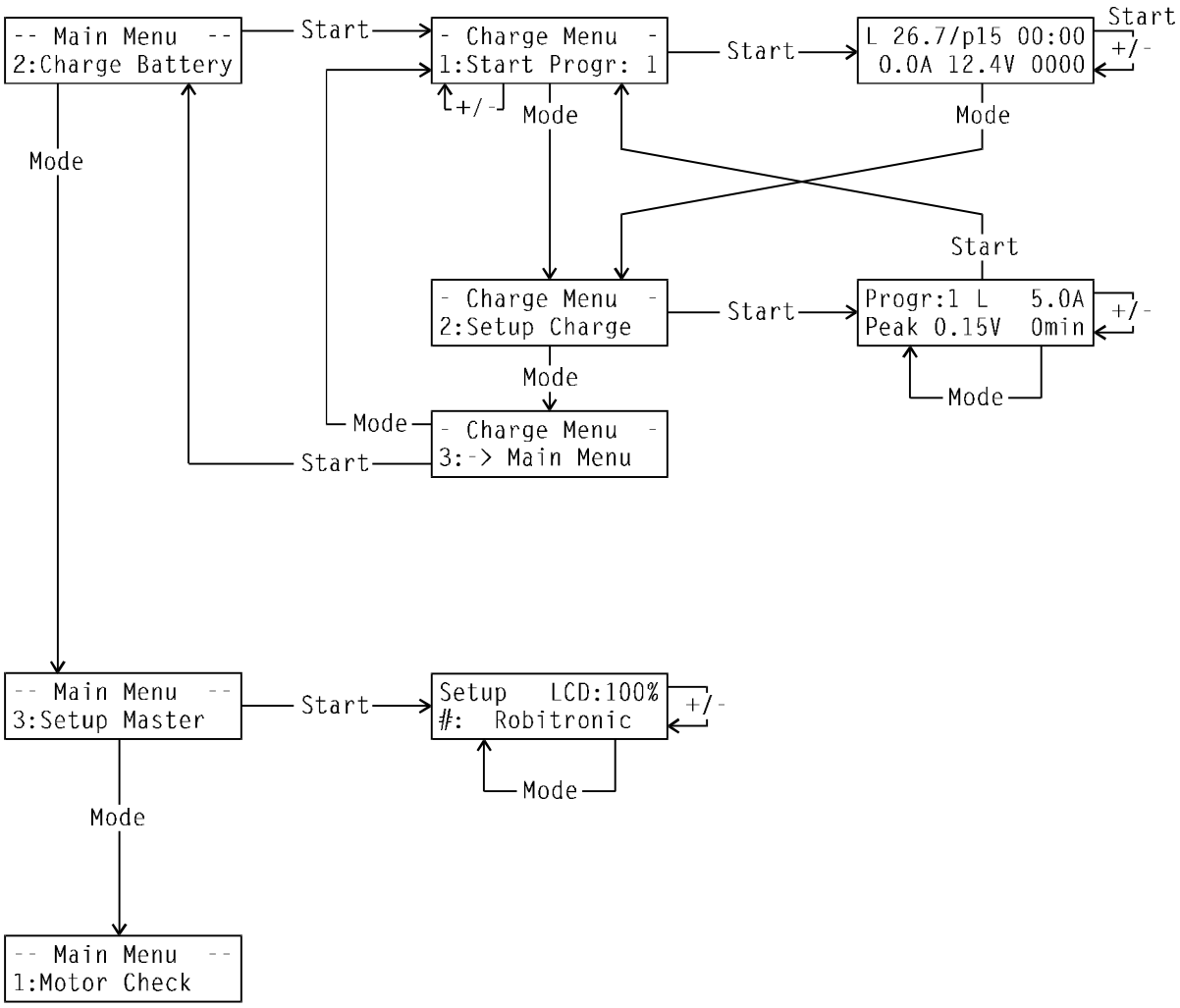
Selecting the temperature charging method *Temp* at the bottom left of the setup display allows you to set the cutoff temperature and the maximum charged capacity; i.e., charging is terminated when the preset battery pack temperature or the preset charged capacity is attained. If the temperature probe is not connected properly, the set maximum charged capacity still largely protects the battery pack against overloading. The setting for charged capacity must accommodate the respective battery pack type. This value can be determined via several test charges, where the highest possible capacity value is used. Experience puts the values for Sanyo battery packs at ca. 2500-2800 mAh and for Panasonic battery packs at ca. 2600-3000 mAh.

Function diagrams

Pro-Master function overview



Pro-Master function overview

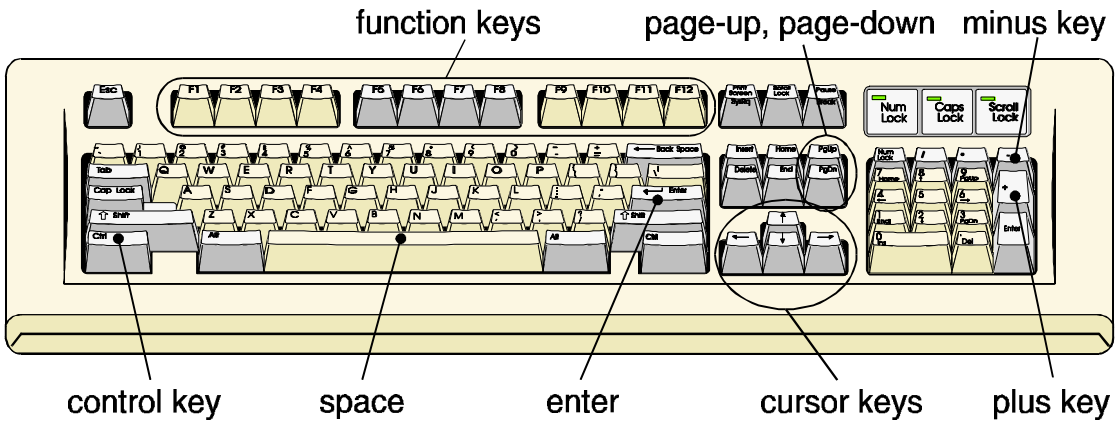


PC software

System requirements

The PC Software requires an IBM compatible computer with the MS-DOS operating system with a VGA board and at least one serial port.

Keyboard layout



Key to symbols

[key]	A word or letter in square brackets indicates a key on your PC keyboard, e.g., [Space], [F10] - function key, [J] - letter
[key1] + [key2]	Two keys must be pressed simultaneously; e.g., [Ctrl] + [D] means that you press and hold the control key [Ctrl] and then key [D].
<function>	These functions (in angled brackets) can be selected from the menu with the mouse pointer or cursor keys.
Function keys	[F1],[F2],[F3],[F4],[F5],[F6],[F7],[F8],[F9],[F10],[F11],[F12]
Enter key	[Enter]
Control key	[Ctrl]
Cursor keys	[Cursor up], [Cursor down], [Cursor left], [Cursor right]
Paging keys	[Page up], [Page down]
Plus & minus keys	[Plus], [Minus]
Functions	<Motor Check>, <File>, <Show Data>, <View Axis>, <Print Data>, <Setup>, <Export>, <Exit>; <Save>, <Cancel>; etc.

Installing the PC software

The program is installed under MS-DOS:

	Insert the installation diskette in drive A.
C:\> A:	Change to the installation diskette in drive A by entering [A] and [:] and then pressing the [Enter] key.
A:\> INSTALL C	Invoke the installation program by entering "INSTALL", pressing the [Space] bar and the letter [C], and pressing the [Enter] key.
	The program is copied to hard disk C: in directory C:\MASTER.
C:\MASTER> MOTOR	Invoke the program by entering "MOTOR" and pressing the [Enter] key.

Your first step should be to check program settings by pressing the key [F12] (see page 28). Check and correct the default parameters such as serial port and printer driver. The parameters can be selected with the cursor keys and modified with the space bar. Section "Program Settings" on page 28 provides a detailed description of the parameters.

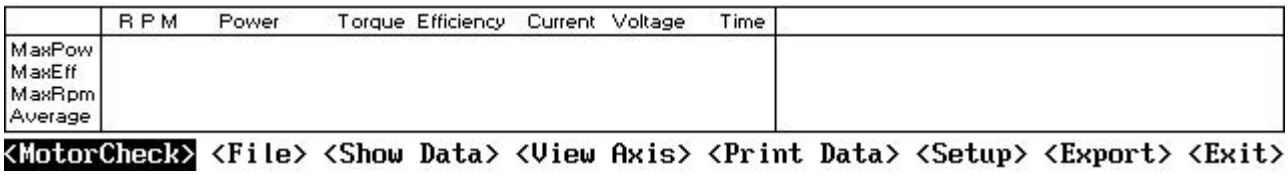
You can operate the program with the function keys [F1]-[F12], with a mouse, or with the cursor keys. The appendix provides a keyboard template that you can cut out and glue onto the keyboard over the function keys.

Connecting Pro-Master to a PC

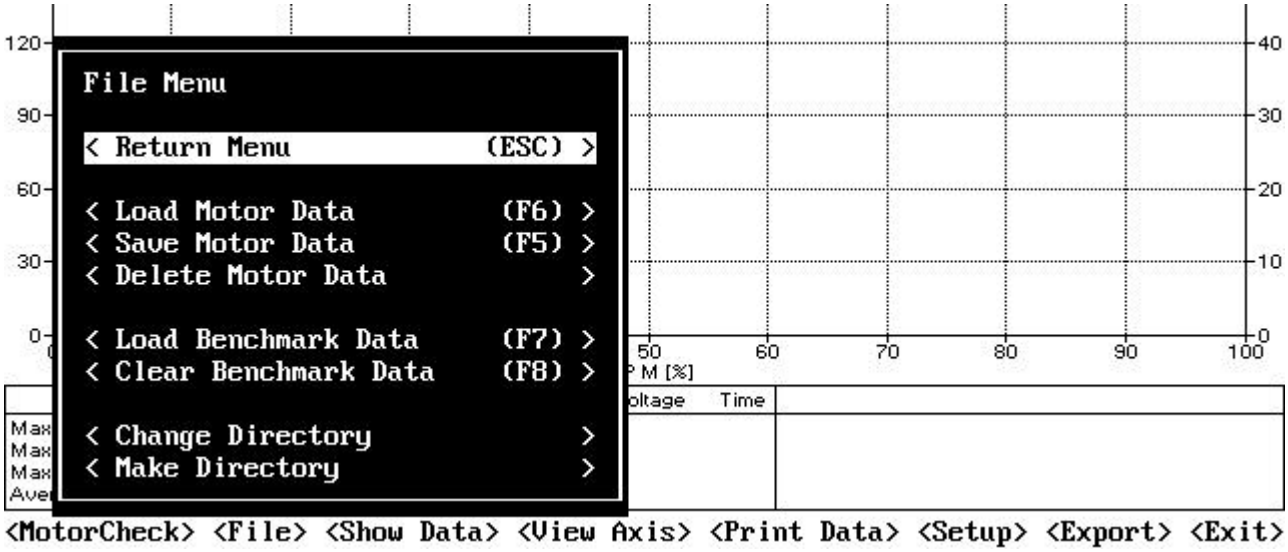
To operate the PC Software, you must connect the serial cable with the round 6-pole plug to the back of Pro-Master and the 9-pole socket to the serial port of your computer. If your computer has a 25-pole serial port, use a serial port adapter. If your computer has multiple serial ports, you must enter the port number that you use in the program settings (see page 28).

Selecting a function

The individual functions can be selected with either the mouse pointer or the cursor keys. Frequently used functions can be invoked with the function keys [F1]-[F12].



With the cursor keys [Cursor left] and [Cursor right] you can select a function from the menu at the bottom of the screen.
Please select the menu item <File> and confirm your selection with the enter key [Enter].

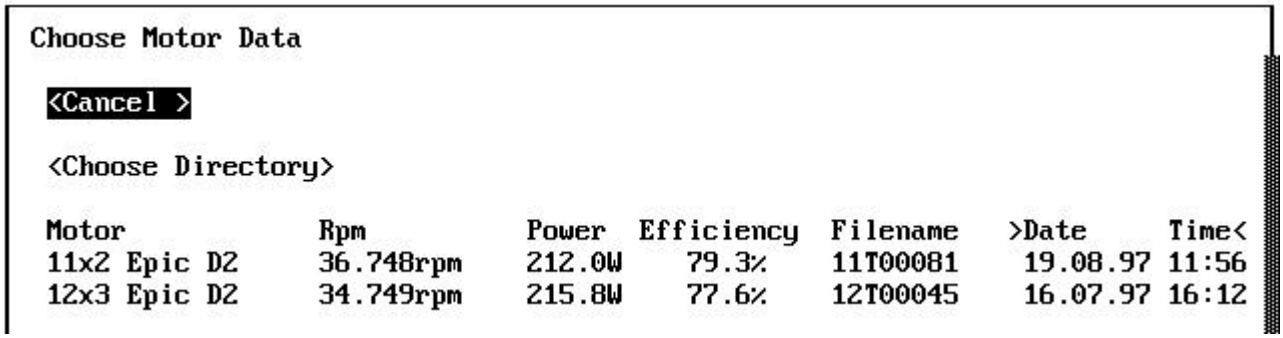


Another menu appears. The cursor keys [Cursor up] and [Cursor down] let you choose the desired function.

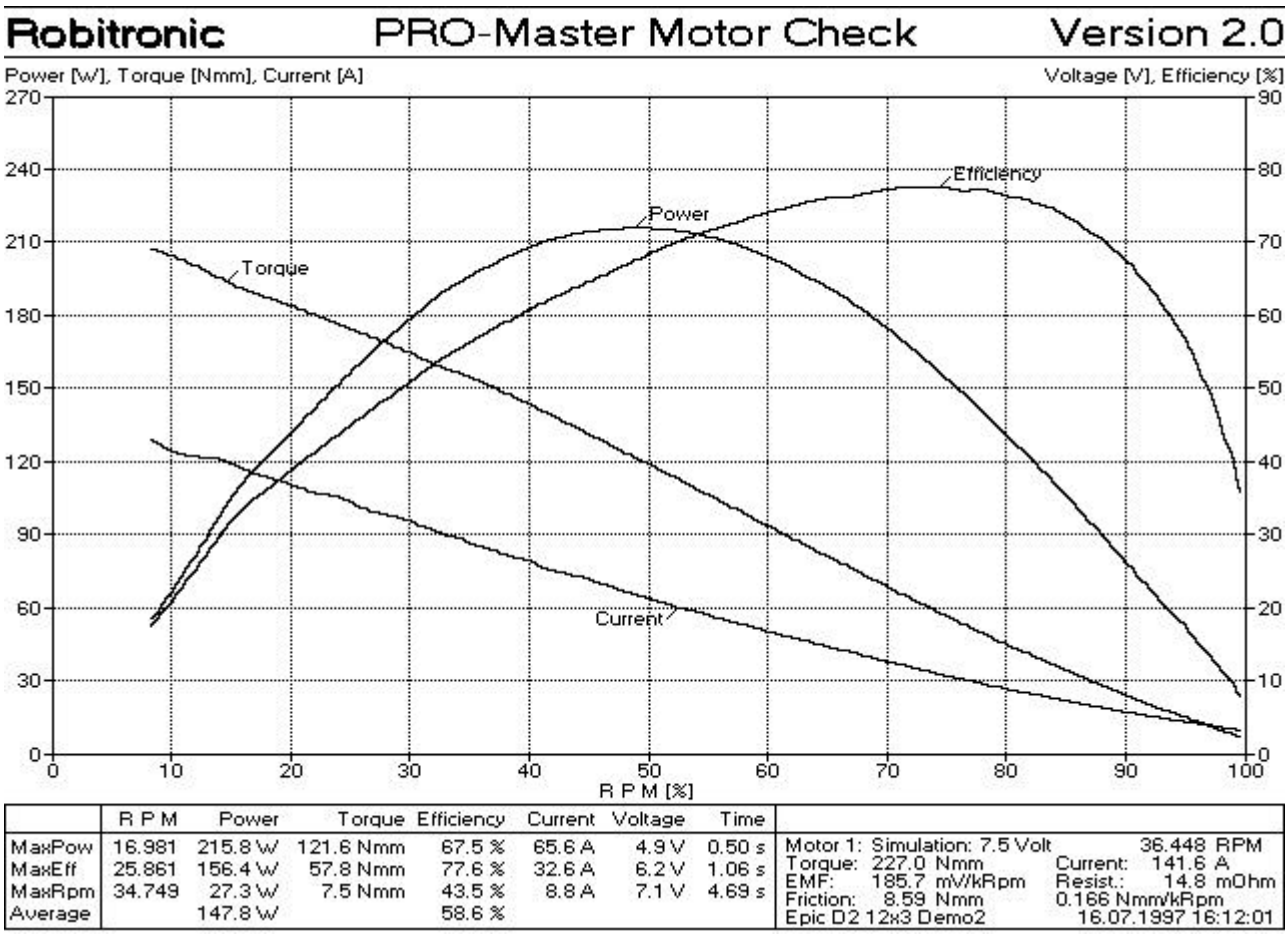
Load Motor Data:	Load motor data from hard disk
Save Motor Data:	Save motor data to hard disk
Delete Motor Data:	Delete saved motor data on hard disk
Load Benchmark Data.	Display stored motor data as benchmark (broken line curve)
Clear Benchmark Data:	No display of benchmark data
Change Directory:	Select a new data directory for loading or saving motor data
Make Directory:	Create new data directory for loading or saving motor data

Loading motor data

Select the menu item <Choose Motor Data> and confirm your selection with the [Enter] key.



You will see a list with motor data, which can be sorted by criteria such as motor winding, RPM, power, efficiency and date. In this example the motor data are sorted by >Date Time<, as indicated by the angular brackets. To sort the motor list by power, use the keys [Cursor down] and [Cursor right] to select the word "Power" in the heading. Press the [Enter] key to sort the motor list by power.
Select the motor 12x3 from the list and press the [Enter] key.

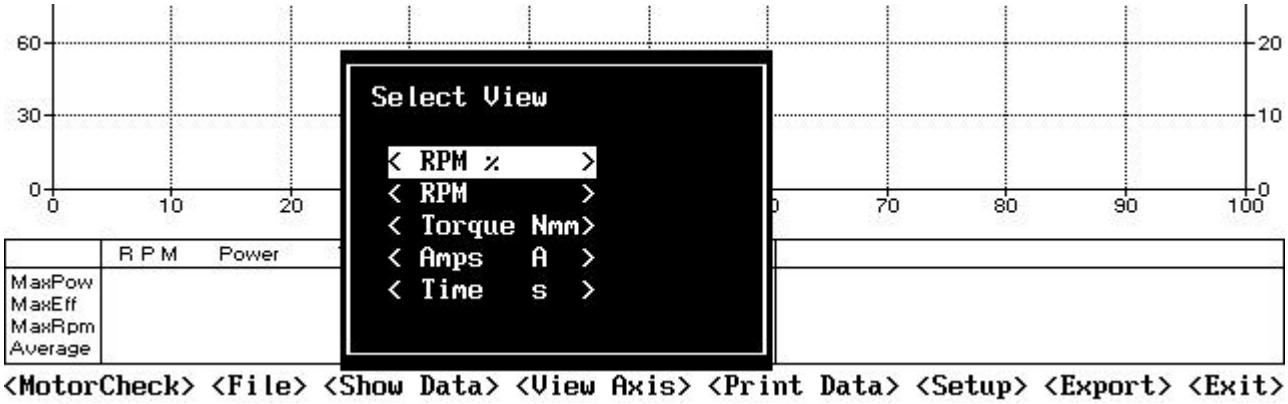


	R P M	Power	Torque	Efficiency	Current	Voltage	Time
MaxPow	16.981	215.8 W	121.6 Nmm	67.5 %	65.6 A	4.9 V	0.50 s
MaxEff	25.861	156.4 W	57.8 Nmm	77.6 %	32.6 A	6.2 V	1.06 s
MaxRpm	34.749	27.3 W	7.5 Nmm	43.5 %	8.8 A	7.1 V	4.69 s
Average		147.8 W		58.6 %			

Motor 1: Simulation: 7.5 Volt 36.448 RPM
Torque: 227.0 Nmm Current: 141.6 A
EMF: 185.7 mV/kRpm Resist.: 14.8 mOhm
Friction: 8.59 Nmm 0.166 Nmm/kRpm
Epic D2 12x3 Demo2 16.07.1997 16:12:01

Display modes for motor data

The motor data are loaded from the hard disk and displayed on the screen. You can choose from among five different display modes (views) for the motor's characteristic curve. The usual view depicts the relationship of the values of RPM; i.e., horizontally (on the X-axis) we have either RPM or nondimensional RPM. Switch between RPM and nondimensional RPM with function key [F11]. The view with nondimensional RPM assumes the maximum RPM to be 100%. This simplifies the comparison of motors with different RPMs. Select another mode using the menu item <View>.



RPM %	Default setting uses nondimensional RPM on the X-axis; ideal for graphical comparison of several groups of motor data.
RPM	View motor data via RPM.
Torque Nmm	View motor data in relation to torque:
Amps A	View motor data in relation to motor current. This view enables, e.g., a simple comparison for a given current value (current limitation).
Time s	View motor data in relation to time.

Meaning of computed motor data

In the table under the graphical display, the first row depicts the individual values at maximum power (MaxPow). In our example the maximum power (Power) is 215.8 watts, the RPM at maximum power is 16.981, the torque is 121.6 Nmm, the efficiency is 67.5%, the motor current is 65.6 amperes, the motor voltage is 4.9 volts, and the time to reach maximum power is 0.50 seconds. The next row shows the maximum efficiency with its corresponding values; in our example the maximum efficiency is 77.6%. The row "MaxRPM" displays the maximum RPM with its corresponding values. The last row in the table, "Average", shows the average values for power and efficiency; the average power in our example is 147.8 watts and the average efficiency is 58.6%.
Maximum power is achieved at a certain RPM, while average power is a specification of the motor that covers its complete RPM range.

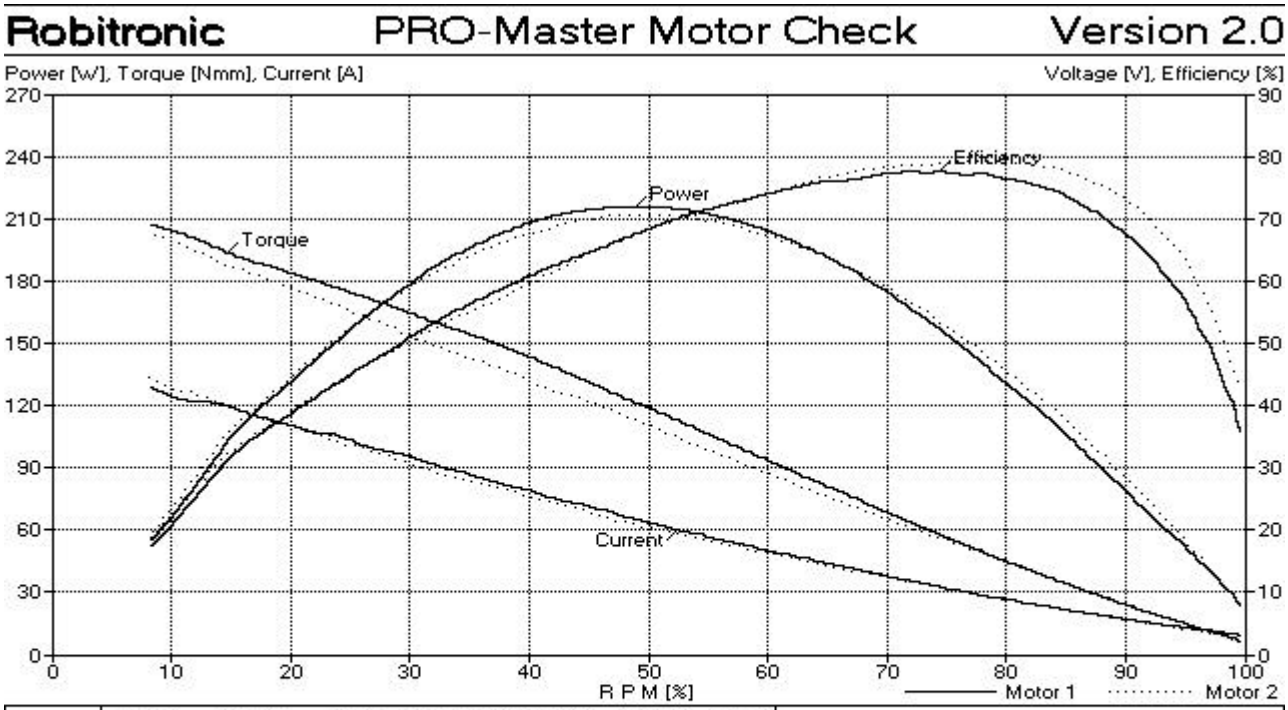
	R P M	Power	Torque	Efficiency	Current	Voltage	Time	
MaxPow	16.981	215.8 W	121.6 Nmm	67.5 %	65.6 A	4.9 V	0.50 s	Motor 1: Simulation: 7.5 Volt 36.448 RPM
MaxEff	25.861	156.4 W	57.8 Nmm	77.6 %	32.6 A	6.2 V	1.06 s	Torque: 227.0 Nmm Current: 141.6 A
MaxRpm	34.749	27.3 W	7.5 Nmm	43.5 %	8.8 A	7.1 V	4.69 s	EMF: 185.7 mV/kRpm Resist.: 14.8 mOhm
Average		147.8 W		58.6 %				Friction: 8.59 Nmm 0.166 Nmm/kRpm
								Epic D2 12x3 Demo2 16.07.1997 16:12:01

To the right of the table with the maximum values there are some auxiliary data. The first row indicates the battery simulation voltage of the test run. (Note that comparing different sets of motor data only makes sense at the same simulation voltage.) The RPM value of 36.448 RPM is the computed idle RPM of the motor without the load of the flywheel. "Torque" and "Current" reflect the starting torque and the starting current or short-circuit current of the motor. "EMF" is a motor constant with the unit millivolts per thousand revolutions. "Resist" is the internal resistance of the motor (resistance of the windings and brushes); this allows identification of a motor winding. "Friction" reflects the static friction in Nmm and the dynamic friction in Newton millimeter per thousand revolutions; this friction results from the motor's bearing friction and the friction of the brushes. The final row specifies the motor name, the winding, the date and the time of the motor check. The values for EMF, Resistance and Friction are computed only if the program settings item "Measure Auxiliary Data" was set to "Yes" (see page 28).
Pressing the control key [Ctrl] simultaneously with the key [D] allows you to toggle the display of this auxiliary information. This also toggles the display of entered data such as brushes, springs, timing or a remark.

	R P M	Power	Torque	Efficiency	Current	Voltage	Time	
MaxPow	16.981	215.8 W	121.6 Nmm	67.5 %	65.6 A	4.9 V	0.50 s	Motor 1: Demo2 Epic D2 12x3
MaxEff	25.861	156.4 W	57.8 Nmm	77.6 %	32.6 A	6.2 V	1.06 s	Brushes: Original Simulation: 7.5 Volt
MaxRpm	34.749	27.3 W	7.5 Nmm	43.5 %	8.8 A	7.1 V	4.69 s	Timing: 3 Springs: Silver
Average		147.8 W		58.6 %				New Motor, First Check
								File: 12T00045.MOT 16.07.1997 16:12:01

Loading benchmark data

You can load an additional set of motor data from the hard disk and display this for comparison (as a benchmark). Press function key [F7] to display a list of motors. Select motor 11x3 and press the [Enter] key.



	R P M	Power	Torque	Efficiency	Current	Voltage	Time
MaxPow	16.981	215.8 W	121.6 Nmm	67.5 %	65.6 A	4.9 V	0.50 s
MaxEff	25.861	156.4 W	57.8 Nmm	77.6 %	32.6 A	6.2 V	1.06 s
MaxRpm	34.749	27.3 W	7.5 Nmm	43.5 %	8.8 A	7.1 V	4.69 s
Average		147.8 W		58.6 %			

Motor 1: Simulation: 7.5 Volt 36.448 RPM
Torque: 227.0 Nmm Current: 141.6 A
EMF: 185.7 mV/kRpm Resist.: 14.8 mOhm
Friction: 8.59 Nmm 0.166 Nmm/kRpm
Epic D2 12x3 Demo2 16.07.1997 16:12:01

MaxPow	18.180	212.0 W	111.5 Nmm	67.9 %	61.4 A	5.1 V	0.57 s
MaxEff	28.512	147.4 W	49.4 Nmm	79.3 %	29.2 A	6.4 V	1.30 s
MaxRpm	36.748	22.0 W	5.9 Nmm	37.2 %	8.0 A	7.2 V	5.35 s
Average		143.6 W		57.7 %			

Motor 2: Simulation: 7.5 Volt 38.742 RPM
Torque: 220.7 Nmm Current: 145.1 A
EMF: 185.0 mV/kRpm Resist.: 15.0 mOhm
Friction: 6.11 Nmm 0.098 Nmm/kRpm
Epic D2 11x2 Demo1 19.08.1997 11:56:10

The benchmark data are displayed as dotted lines. In the table the benchmark data are displayed in the lower table (Motor 2).

Motor data in table view

Pressing function key [F10] or selecting the function <Table> from the menu displays the motor data in table form.

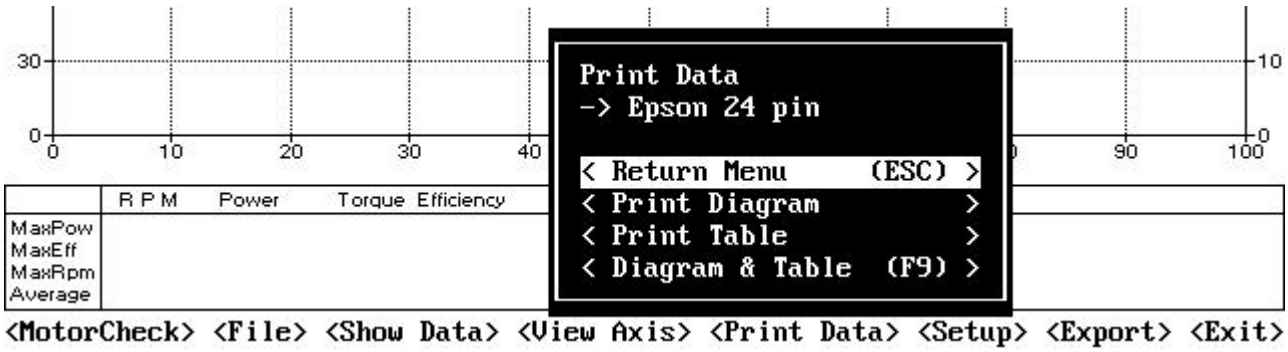
Torq Step	R P M M1	R P M M2	Power[W] M1	Power[W] M2	Efficiency M1	Efficiency M2	Current[A] M1	Current[A] M2	Voltage M1	Voltage M2	Time[s] M1	Time[s] M2
20.0	31993	33933	67.0	71.0	63.7	69.1	15.3	14.8	6.9	6.9	2.1	2.3
40.0	28588	30200	119.8	126.5	75.5	78.9	24.4	24.4	6.5	6.5	1.4	1.5
60.0	25536	26677	160.5	167.6	77.4	78.7	33.8	34.6	6.1	6.2	1.0	1.1
80.0	22732	23266	190.3	194.9	76.0	75.9	43.3	44.8	5.8	5.7	0.8	0.9
100.0	19962	20026	208.8	209.5	72.7	71.0	53.7	55.6	5.3	5.3	0.6	0.7
120.0	17207	16796	215.8	210.7	68.0	65.0	64.3	67.1	4.9	4.8	0.5	0.5
140.0	14407	13380	210.4	195.4	62.0	56.3	76.0	81.3	4.4	4.3	0.4	0.4
160.0	11143	10070	187.0	167.6	53.4	47.5	91.6	96.7	3.8	3.7	0.3	0.3
180.0	7700	6803	142.7	126.2	41.5	37.2	106.6	112.5	3.2	3.0	0.2	0.2
200.0	4219	3535	82.6	67.5	25.5	21.8	121.8	129.3	2.6	2.3	0.1	0.1

Amp Step	R P M M1	R P M M2	Power[W] M1	Power[W] M2	Efficiency M1	Efficiency M2	Torque[Nmm] M1	Torque[Nmm] M2	Voltage M1	Voltage M2	Time[s] M1	Time[s] M2
20.0	30167	31930	95.9	102.4	71.6	76.2	30.4	30.6	6.7	6.7	1.6	1.8
30.0	26730	28263	145.3	150.3	77.1	79.2	51.9	50.8	6.3	6.3	1.1	1.3
40.0	23682	24852	181.4	184.0	76.7	77.7	73.1	70.7	5.9	5.9	0.9	1.0
50.0	20836	21730	204.1	203.2	74.0	73.5	93.6	89.4	5.5	5.5	0.7	0.8
60.0	18195	18779	214.8	211.7	70.1	69.0	112.9	107.8	5.1	5.1	0.6	0.6
70.0	15977	16187	214.9	209.0	65.3	63.4	128.7	123.5	4.7	4.7	0.5	0.5
80.0	13655	13800	206.5	197.9	60.2	57.3	145.1	137.5	4.3	4.3	0.4	0.4
90.0	11438	11297	189.8	180.2	54.3	51.3	158.4	152.1	3.9	3.9	0.3	0.3
100.0	9184	9550	163.5	161.9	46.7	46.0	171.8	163.3	3.5	3.5	0.2	0.2
110.0	7049	7381	133.2	134.2	39.1	39.2	183.4	176.7	3.1	3.1	0.2	0.2

A table with ten torque steps (Torq Step) and a table with ten current steps (Amp Step) are displayed. For each current value, the table shows the corresponding values for RPM, power, efficiency, torque, voltage and time, where the values under "M1" are for motor 1 and "M2" for the benchmark motor. The default values for the torque steps and current steps can be changed in the program settings (see page 28).

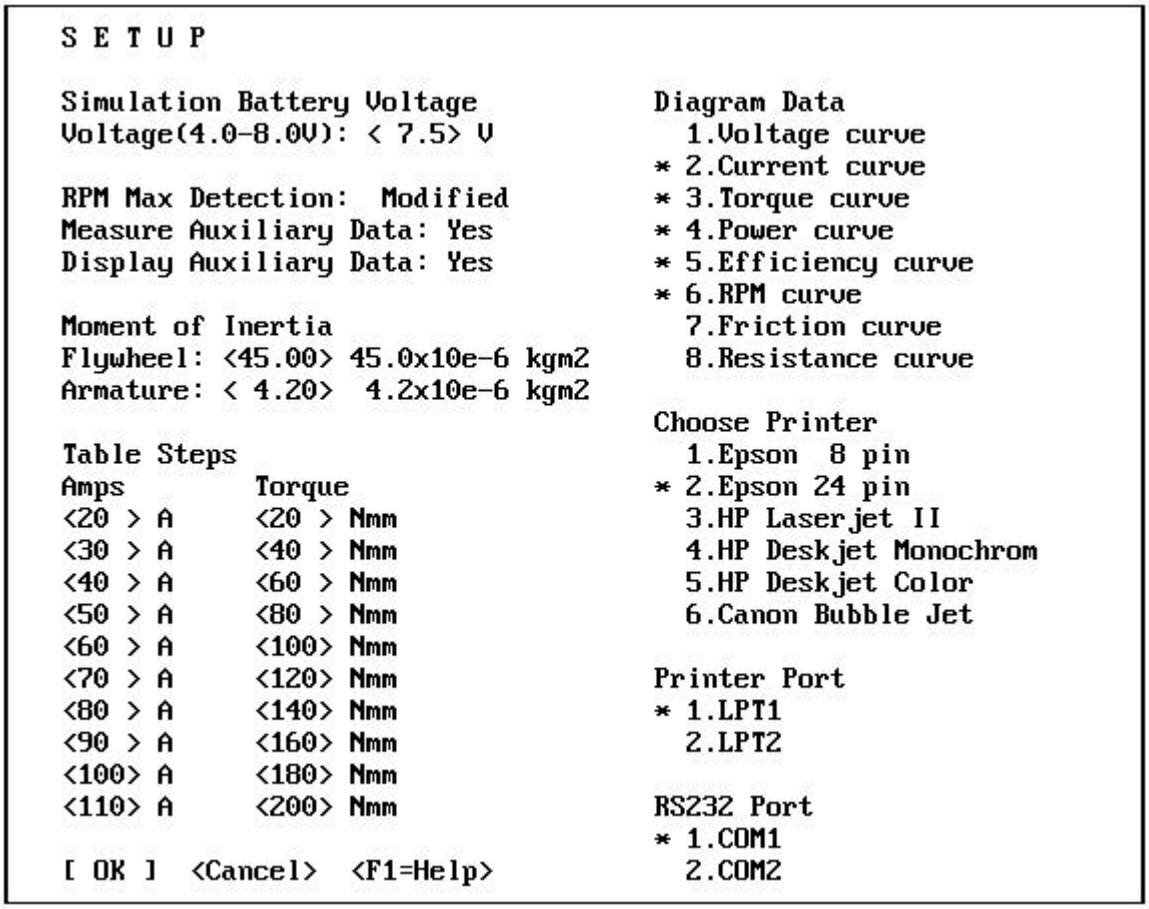
Printing motor data

The motor data can be printed as a diagram, as a table, or as diagram and table. Press function key [F9] to print the diagram and the table. The printer must already have been selected in the program settings (see below).



Program settings

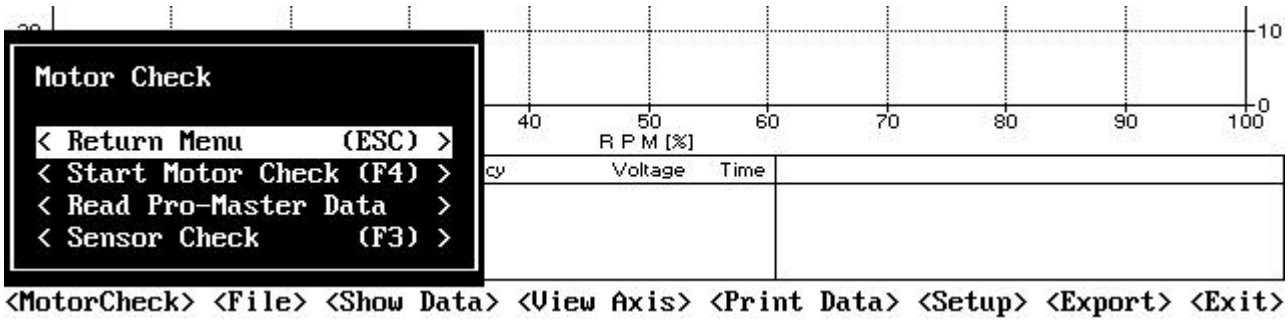
Selecting the function <Settings> from the menu or pressing function key [F12] allows you to change the program's default settings or your previous settings.



Simulation Battery Voltage:	Voltage specification for the motor check. The voltage can be set between 4 and 8 volts, covering motors for 4 to 7 cell battery packs.
RPM Detection:	Detection of final RPM can be set for modified or stock motors. If you select "Stock", the final RPM detection is not as sensitive; the measurement takes a bit longer. You can toggle between the two with the [Space] bar.
Measure Auxiliary Data:	If you want to measure auxiliary data such as friction, internal resistance and EMF, enter "Yes" here. Toggle back and forth with the [Space] bar or with the keys [Y] and [N].
Display Auxiliary Data:	Entering "Yes" here displays the auxiliary data; "No" displays the entered data for brushes, springs, etc. Toggle the display directly from the program with the keys [Ctrl] + [D].
Moment of Inertia:	The moment of inertia of the flywheel should be changed only if you use a different flywheel. The moment of inertia is used for the computation of the motor's characteristic curve. An erroneous value would produce falsified motor data. The value for the supplied flywheel is 45.0×10^{-6} kgm^2. The value for the armature, 4.2×10^{-6} kgm^2, corresponds to a model car. If you measure a test motor with a larger or smaller armature, the moment of inertia must be recomputed.
Table Step:	For viewing the motor data in table form, the values for the torque and current steps can be set.
Diagram Data:	A total of eight different characteristic curves of a motor can be displayed diagramatically. Select the curves with the [Space] bar; selected curves are marked with an asterisk "*".
Choose Printer:	Move to a printer with the cursor keys and select with the [Space] bar.
Printer Port:	Select one of two printer ports.
RS232 Port:	Select a serial port (RS232) for data transfer from Pro-Master to your computer.

Motor check

Choose the function <Motor Check> from the menu or press function key [F4] to launch the motor check directly from the computer.



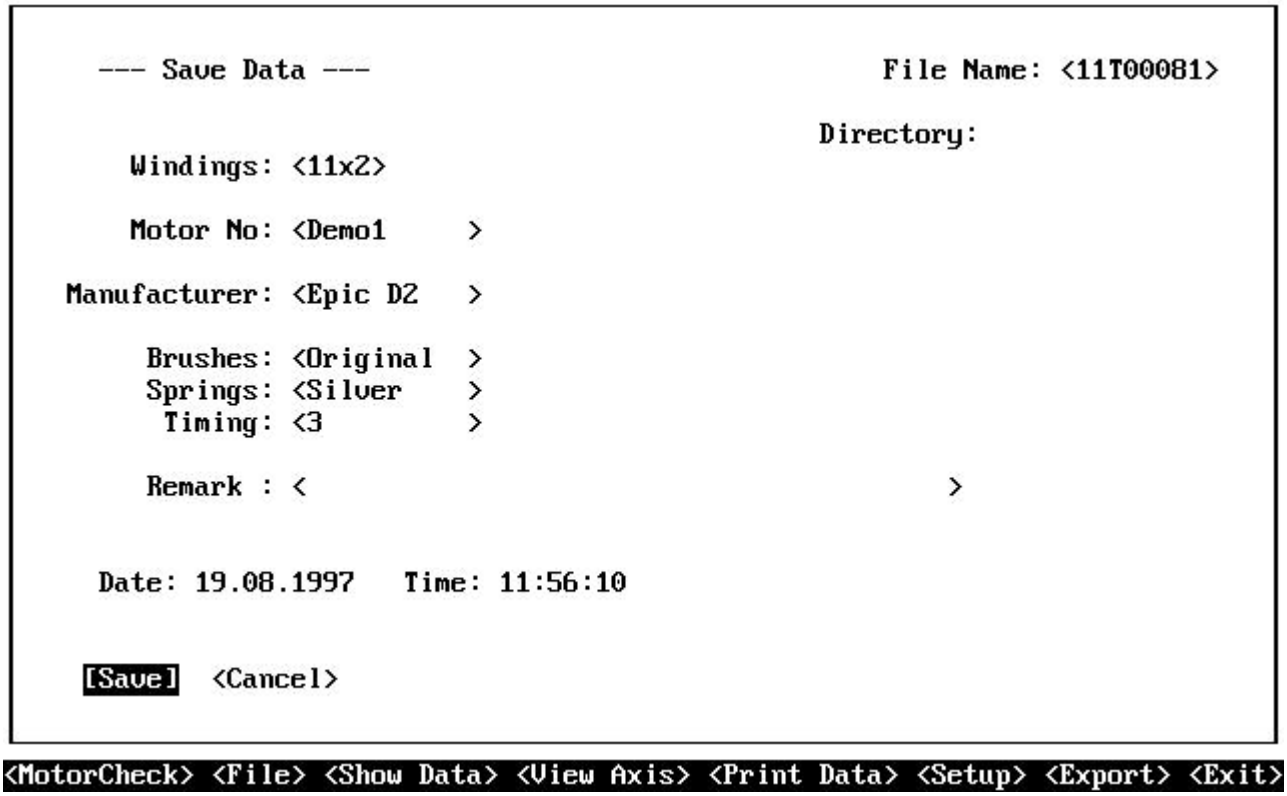
<Start Motor Check> Starts the motor check and automatically transfers the data.

<Read Pro-Master Data> The motor data are read from Pro-Master. If you carry out a motor check on the racetrack without a computer, you can read and store the data with the computer at home. Pro-Master always stores the latest motor check.

<Sensor Check> This allows you to check the proper functioning of the RPM sensor.

Saving motor data

Selecting the function <File> from the menu or pressing function key [F5] allows you to save the displayed motor data on the hard disk.



In addition to the computed motor data, data such as windings, manufacturer, brushes, etc. can be saved.

Windings:	Enter the motor's windings
Motor No:	Enter a number or identifier for the motor
Manufacturer:	Motor manufacturer or name of motor
Brushes:	Type of brushes
Springs:	Type of motor springs
Timing:	Present motor timing
Remark:	Additional comment, e.g., about the condition of the motor
Date, time:	Date and time of motor check are automatically saved
File name:	The program automatically assigns a file name, which you can change.
Data Directory:	The motor data can be saved in various data directories. Choose a directory with the cursor keys and the [Space] bar. You can also create a data directory yourself by selecting the menu item <Data>, followed by <Create Data Directory>.

Example of setting motor timing

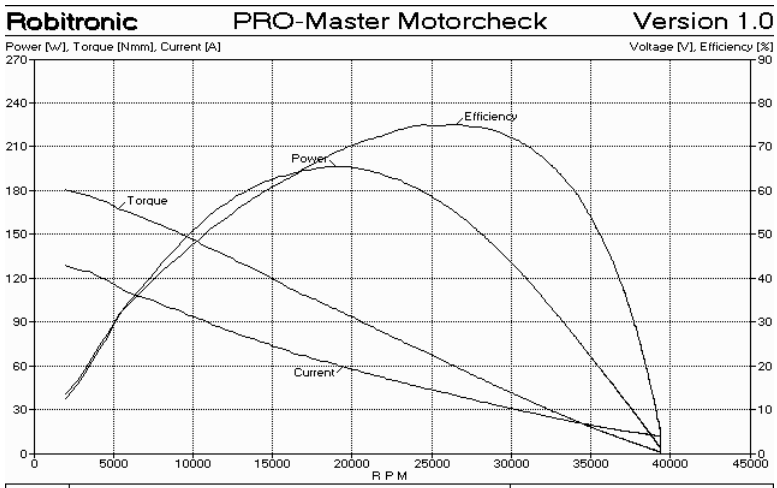
To find a motor's optimal timing point, you need to run motor checks with different timing settings and compare these. The timing should be modified from the default setting in at most four steps. If you check more than four settings, there is the danger that the motor data will change too much due to heating of the motor or changes in the brushes and the collectors. This encumbers assessment of the measurement results.
If you check the motor with different timing settings with the PC, we recommend using the best test result as the benchmark curve (depicted as a dotted line). Pressing function key [F2] displays the present motor curve additionally for comparison. On the next test run, the new measurement results will be compared with the previous one.

The motor is checked with the standard settings.

Press function key [F4].
The motor check begins.

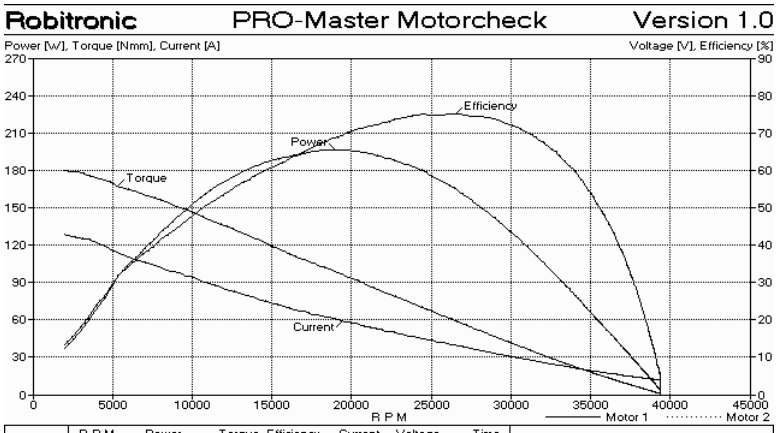
Measurement results are displayed on the screen.

Curve1: Timing 1.5



	R P M	Power	Torque	Efficiency	Current	Voltage	Time	
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s	Motor 1: Testmotor 12x2
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s	Kohlen: Original Simulation: 7.2 Volt
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s	Timing: 1.5 Federn: Original
Average		132.6 W		55.0 %				File: 12T00109.MOT 07.02.1997 13:55:29

Display measurement results additionally as benchmark data by pressing function key [F2].



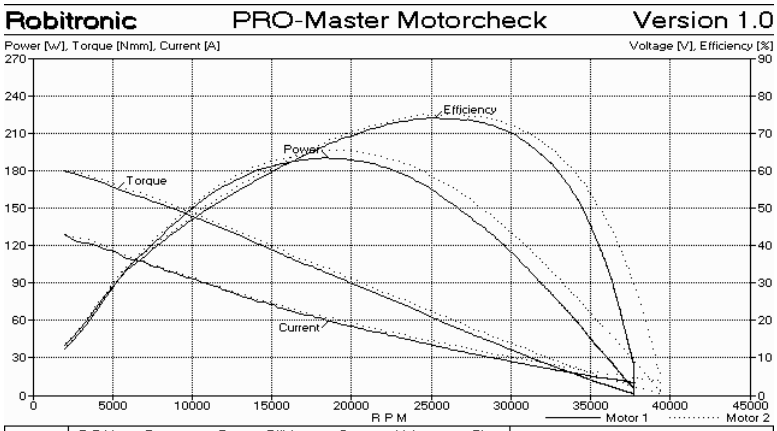
	R P M	Power	Torque	Efficiency	Current	Voltage	Time	
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s	Motor 1: Testmotor 12x2
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s	Kohlen: Original Simulation: 7.2 Volt
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s	Timing: 1.5 Federn: Original
Average		132.6 W		55.0 %				File: 12T00109.MOT 07.02.1997 13:55:29
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s	Motor 2: Testmotor 12x2
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s	Kohlen: Original Simulation: 7.2 Volt
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s	Timing: 1.5 Federn: Original
Average		132.6 W		55.0 %				File: 12T00109.MOT 07.02.1997 13:55:29

Next the motor timing is retarded by a half step.

Press function key [F4].
The motor check begins.

Curve1: Timing 1.0 (solid line)
Curve2: Timing 1.5 (dotted line)

The result is a reduction in RPM, power and efficiency.
The new timing is not optimal.



	R P M	Power	Torque	Efficiency	Current	Voltage	Time
MaxPow	18556	190.0 W	97.9 Nmm	67.0 %	59.6 A	4.7 V	0.65 s
MaxEff	25231	163.0 W	61.7 Nmm	74.1 %	39.6 A	5.5 V	1.09 s
MaxRpm	37752	0.0 W	0.0 Nmm	0.0 %	10.2 A	6.7 V	5.82 s
Average		128.9 W		54.2 %			
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s
Average		132.6 W		55.0 %			

Motor 1: Testmotor 12x2 Kohlen: Original Timing: 1.0 Simulation: 7,2 Volt Federn: Original
File: 12T00108.MOT 07.02.1997 13:54:45

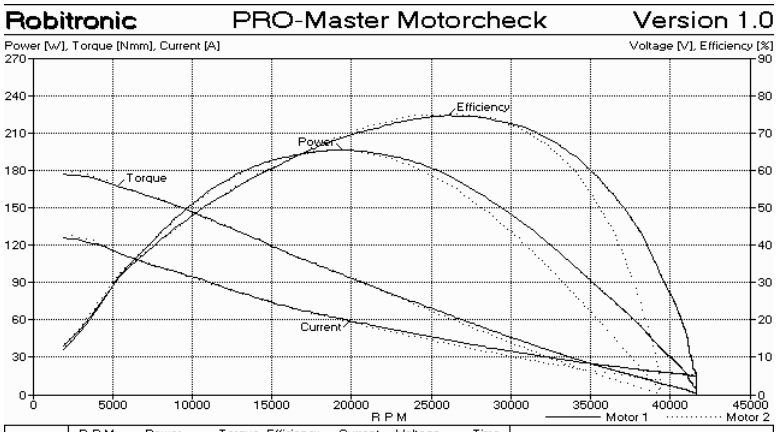
Motor 2: Testmotor 12x2 Kohlen: Original Timing: 1.5 Simulation: 7,2 Volt Federn: Original
File: 12T00109.MOT 07.02.1997 13:55:29

The motor timing is now advanced by one step.

Press function key [F4].
The motor check begins.

Curve1: Timing 2.0 (solid line)
Curve2: Timing 1.5 (dotted line)

The result is an increase in RPM, power and efficiency.
The optimal timing is between settings 1.5 and 2.0.



	R P M	Power	Torque	Efficiency	Current	Voltage	Time
MaxPow	19428	196.1 W	96.5 Nmm	68.7 %	60.8 A	4.7 V	0.68 s
MaxEff	26073	175.9 W	64.5 Nmm	74.6 %	44.0 A	5.4 V	1.12 s
MaxRpm	41662	0.0 W	0.0 Nmm	0.0 %	15.2 A	6.5 V	6.69 s
Average		133.6 W		54.7 %			
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s
Average		132.6 W		55.0 %			

Motor 1: Testmotor 12x2 Kohlen: Original Timing: 2.0 Simulation: 7,2 Volt Federn: Original
File: 12T00110.MOT 07.02.1997 13:56:07

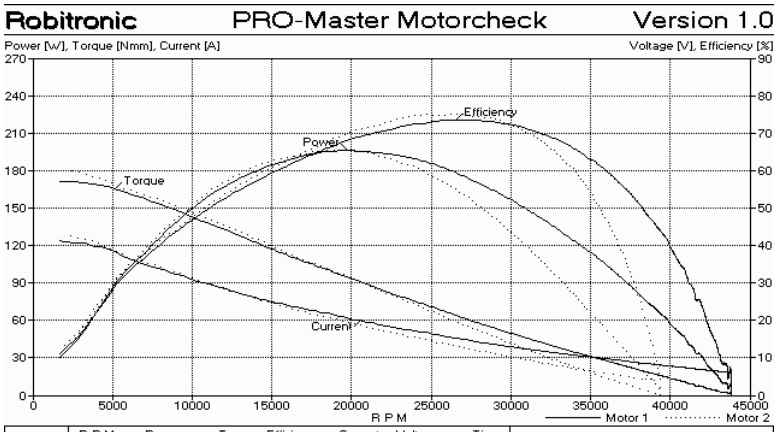
Motor 2: Testmotor 12x2 Kohlen: Original Timing: 1.5 Simulation: 7,2 Volt Federn: Original
File: 12T00109.MOT 07.02.1997 13:55:29

The motor timing is advanced by one step.

Press function key [F4].
The motor check begins.

Curve1: Timing 2.0 (solid line)
Curve2: Timing 1.5 (dotted line)

The power and the efficiency are reduced.
The timing is not optimal.



	R P M	Power	Torque	Efficiency	Current	Voltage	Time
MaxPow	19761	196.0 W	94.8 Nmm	67.9 %	62.2 A	4.7 V	0.72 s
MaxEff	26503	178.6 W	64.4 Nmm	73.5 %	46.0 A	5.3 V	1.17 s
MaxRpm	43834	0.0 W	0.0 Nmm	0.0 %	17.8 A	6.4 V	7.65 s
Average		133.3 W		53.3 %			
MaxPow	18963	196.4 W	99.1 Nmm	68.6 %	61.2 A	4.7 V	0.66 s
MaxEff	26518	165.1 W	59.4 Nmm	75.1 %	39.6 A	5.5 V	1.16 s
MaxRpm	39385	0.0 W	0.0 Nmm	0.0 %	11.6 A	6.6 V	6.56 s
Average		132.6 W		55.0 %			

Motor 1: Testmotor 12x2 Kohlen: Original Timing: 2.5 Simulation: 7,2 Volt Federn: Originak
File: 12T00111.MOT 07.02.1997 13:56:46

Motor 2: Testmotor 12x2 Kohlen: Original Timing: 1.5 Simulation: 7,2 Volt Federn: Original
File: 12T00109.MOT 07.02.1997 13:55:29

Overview of function keys

Key	Function
ESC	Escape, cancel
F1	
F2	Display measurement data as benchmark data
F3	Sensor check
F4	Start motor check
F5	Save measurement data
F6	Load measurement data file
F7	Load benchmark data from file
F8	Clear benchmark data
F9	Print diagram and table
F10	View data table
F11	Change the diagram view (X-axis)
F12	Change settings
Plus	Change the range of the X-axis
Minus	Change the range of the X-axis
Page up	Change diagram view of X-axis
Page down	Change diagram view of X-axis
Ctrl + D	Toggle the display of auxiliary data

Displaying measurement data as benchmark data

Pressing function key [F2] allows you to display the current measurement data additionally as benchmark data. This function is particularly helpful in setting a motor's timing.

Changing the range of the X-axis

The [Plus] and [Minus] keys on the numeric keyboard allow you to increase or decrease, respectively, the range of the diagrammatic display.

Resetting the current parameters

Pro-Master stores the current parameters. Reset these values to the default values by pressing the [START] key while connecting to the power supply.

Test results

Evaluating the results

Many different opinions exist on this subject, and after gaining some experience with Pro-Master, you will also develop your own strategy for assessing results.
The data that are of primary importance are the maximum power, the maximum efficiency, the maximum RPM, the average power and the average efficiency. The maximum RPM can be used to compute the proper transmission ratio. From the maximum efficiency we derive the RPM range for most efficient operation. The average efficiency provides information about the efficiency of the motor over its complete RPM range; i.e., the higher the average efficiency of the motor, the less current it consumes. The average power provides information about the motor's acceleration.

Comparing results

To enable comparison of results, the voltage set for the motor check must be identical for the two sets of data. A simulation voltage of 7.5 volts is preset, corresponding approximately to a racing battery pack with 6 cells.

Technical note on motor checking

Pro-Master simulates a battery pack with adjustable voltage and constant internal resistance (40 mOhm = 0.04 Ohm). The resulting voltage curve on starting the motor corresponds to the battery pack in a model car. The voltage for the battery simulation can be changed in the program settings. The default value is 7.5 volts, corresponding to a battery pack with 6 cells. The maximum voltage on the motor during a test run is certainly under the set value. The maximum voltage on the motor depends on the current consumption of the motor at maximum RPM and can be computed as follows: motor voltage = 7.5 V - (motor current (in amps) x 0.04 ohms).

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