



MDRIVE™-60A Sensorless Brushless DC Motor Controller User Manual

OVERVIEW

Unlike other brushless motor controllers, the newly designed MDRIVE™ Series controllers and ESC-View Software, released for the first time in January of 2006, provide you with a number of advanced new features making it more user friendly with a greater range of controls. You may now.....

1. Select preset User Modes for simple, quick and error proof programming at the field.
2. Program the controller with ease using ESC-View and a Windows computer.
3. Analyze, test and compare motors with the precision tools provided.
4. Save motor testing data in a text file for reporting or charting.
5. Read radio transmitter min/max pulse widths enabling precise control of the throttle.

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MDRIVE™ 60A CONTROLLER SPECIFICATIONS

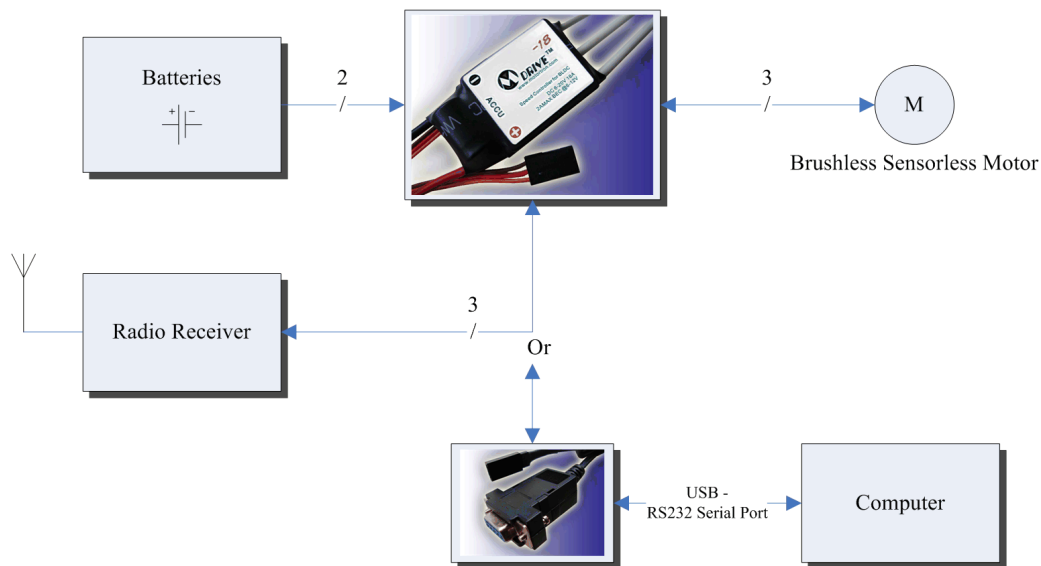
Cells (using BEC Connection)	6-10 NiCd/NiMH or 2-3 Li-Poly/Li-ion
Cells (BEC disabled)	6-16 NiCd/NiMH or 2-5 Li-Poly/Li-ion
Continuous Current	60 amps
PWM Frequency	8K and 16KHz PC Programmable Through ESC-View Software
BEC Max. Current	3A Max @ 5V
Minimum Working Voltage	6V DC
Maximum Working Voltage	20V DC
Connection Wires	14 Gauges, Silicon Rubber Insulation, 250C° Temperature Rating.
Size	60mm x 33mm x12mm (Including capacitors)
Weight (with 5 inches wires)	50 g

Programmable Features:

Battery Type	PC Programmable Through ESC-View Software
Cutoff type	PC Programmable Through ESC-View Software
Brake	PC Programmable Through ESC-View Software
Low Voltage Cut-off	PC Programmable Through ESC-View Software
Advance Motor Timing	PC Programmable Through ESC-View Software
Throttle Range and Endpoint Setting	PC Programmable Through ESC-View Software
Thermo Protection Cutoff	PC Programmable Through ESC-View Software
Acceleration Delay	PC Programmable Through ESC-View Software
Radio Throttle Pulse Width Reading and Programming	PC Programmable Through ESC-View Software
Reverse Motor Rotation	Change any two motor wires
Audible Indication	1200Hz Audible Tones
Radio Transmitter Programming	User Mode Selection Only
Signal Loss Auto Shut Off	Yes

SAFETY PRECAUTIONS: It is essential that the user exercise extreme caution when attaching the battery, but especially when the motor propeller is engaged. Spinning at such high RPMs, the propeller can strike, hurting a person very seriously. Eye protection is recommended. The controller and the motor can deliver explosive high power output in a blink of an eye. Children must be kept from playing with this type of controller.

Wire Connection and Installation



Connections:

1. The red wire connects to battery positive; the black wire connects to battery negative.

WARNING: Incorrect connection of battery polarity will totally destroy the controller and will not be covered by warranty.

2. The three white wires connect to the motor. The order of connection is not important. If the motor runs the wrong way, simply exchange any two of the three wires.

MDRIVE™ controllers are supplied without power connectors. The user has to solder their desired connectors to the wires. Motortron provides the best silicon insulated wires available for the controller.

We suggest using a 35W electronic soldering station with maximum temperature setting, applying no-clean flux (KESTER Brand #951) to wires and connectors. Connections need to be soldered properly in order to provide maximum power transfer from controller to motor.

Installation:

The controller should be mounted in a place with airflow to help dissipate the heat. The heat-sink side of controller must face toward the airflow. Keep good separation from other heat sources, like the motor or battery pack.

Always power on the radio transmitter first with throttle in the minimum position, and then connect battery connector to controller, before running a motor. However the controller will not arm if the throttle stick is above the currently set low throttle position.

MDrive™ controllers use a universal signal connector to the receiver. If you do not hear the arming tones (deedee, dodo, dada) from the motor after the transmitter and controller are powered up, please check to see that the signal connector is not plugged in backward.

Also check the throttle channel-reversing switch on the transmitter. Futaba transmitters should be set to “reverse”. Others should be set to “normal”.

User Mode

Contents of each User Mode:

Each User Mode uses a single digit to represent and select a group of six operating options. These options are: low voltage cutoff (percentage of initial battery voltage or cell type and voltage per cell), cutoff type, brake type, motor timing advance, switching frequency and acceleration delay. Selection of which User Mode is used by the controller is easily programmable via the transmitter stick, or with the ESC-View software.

MDrive™ controllers have three User Modes. User Mode 1 is the factory default and its parameters cannot be edited. It is designed for “plug and play” use or when the user forgets the other User Mode settings. He can always select User Mode1 for safe operation. User Modes 2 and 3 are fully programmable through ESC-View.

Advantages of the User Mode Solution:

1. Any of the User Modes can be selected by the radio transmitter very simply:
Set throttle to maximum position during battery power up; then select the desired User Mode by just moving the throttle stick to the minimum position. Simple, quick and error proof! (For details see the next section, below.)
2. Selectable User Modes gives you the flexibility to easily change several options at the field For example:
 - i. **User has 1 plane, 1 motor, 1 prop, and 2 types of batteries:**
User Mode 2 can be set for the first type of battery.
User Mode 3 can be set for the second type of battery.
 - ii. **User has 2 planes, 2 motors, 2 props and 2 types of batteries:**
User Mode 2 contains all the parameters for the first power system.
User Mode 3 contains all the parameters for second power system.
And more!
3. User Modes are also a simple, quick method for RC vendors to configure the parameters of the MDrive™ controller to match a variety of types of DC brushless motors.

The factory default parameters of each User Mode in controller:

	(In-run motor)	(In-run motor)	(Out-run motor)
Parameter	User Mode1	User Mode 2	User Mode 3
Cutoff Voltage	70% of Power On voltage	70% of Power On voltage	70% of Power On voltage
Cutoff Type	Soft	Soft	Soft
Brake Type	Off	Medium	Off
Motor Timing Advance	5 Degree	5 Degree	15 Degree
PWM Frequency	8 KHz	8 KHz	16 KHz
Acceleration Delay	0.51 sec.	1 sec	0.17 sec.

Note 1: User mode 1 is factory-set and is not programmable with ESC-View software.
User Mode 2 is a suggested setting is for low pole-count motors (most in-runners).
(Programmable)
User Mode 3 is a suggested setting is for high pole-count motors (most out-runners)
(Programmable)

Note 2: Only one User Mode may be selected in a given power cycle. The battery connector must be disconnected and re-connected to enable selecting another User Mode.

Using Transmitter Throttle to Select User Mode and Audible Indications

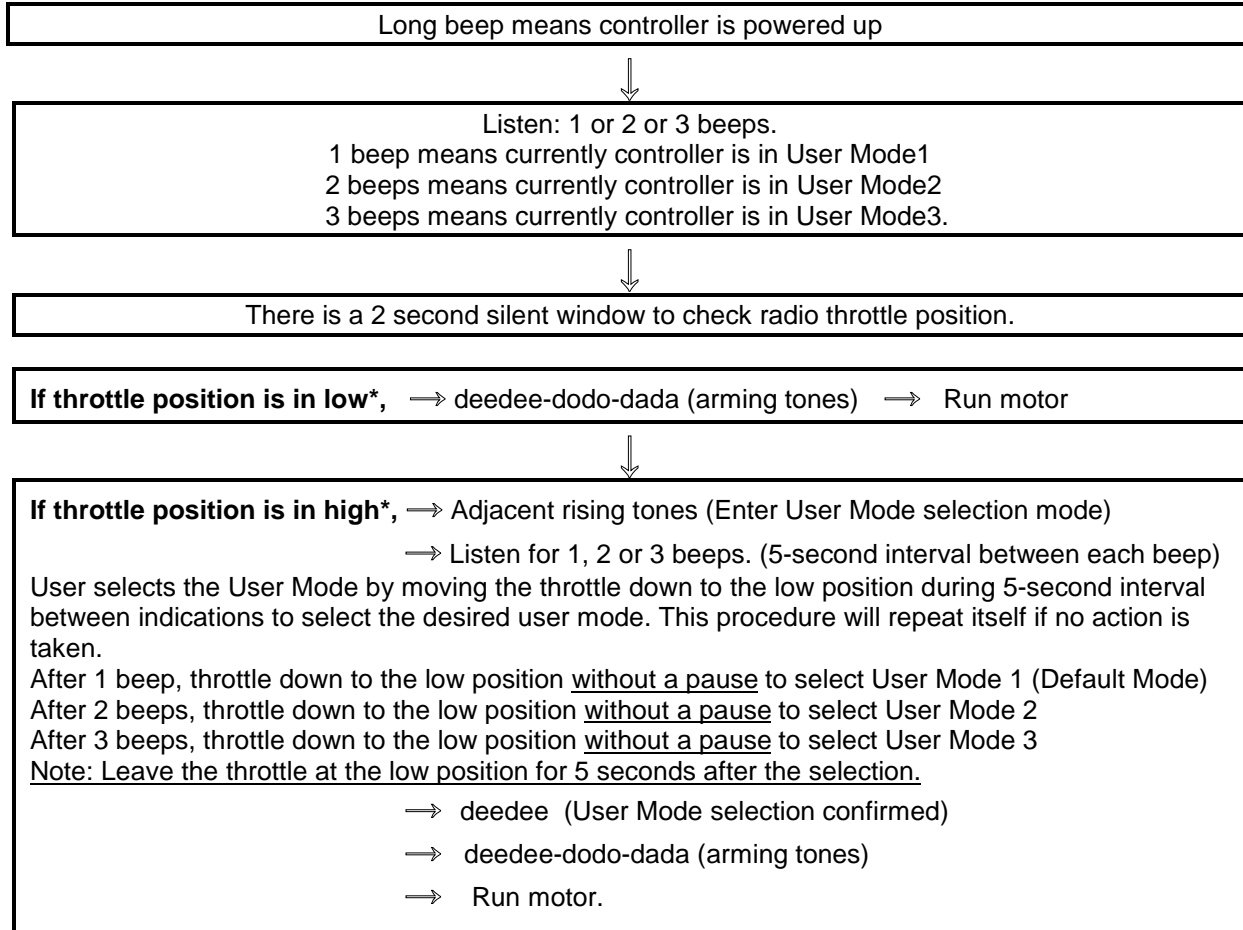
Where does the sound come from?

The controller provides a 1200Hz audible tone signal to the motor's windings during power on. The motor then acts as a loudspeaker.

To Enter User Mode Selection:

Power on the radio transmitter first with throttle stick at the maximum position, then power on controller. Listen to the beeps carefully. Move throttle to minimum low position to select user mode as follows:

Power on sequence of audible indications



Note: Throttle position is in low* --- throttle is below 1.3 ms pulse width.
Throttle position is in high* -- throttle is above 1.7 ms pulse width

The controller will record your particular radio transmitter's pulse width data every time you use the radio throttle to select User mode. The recorded values (minimum and maximum pulse width) may vary if your throttle position and/or throttle trim position are not exactly the same each time you select a User mode.

Power-on safety start feature: The controller will not arm the motor unless the throttle stick position is below pre-selected throttle start point. Details in the FAQ section below.

ESC-View Software

PC Hardware and Software:

- The ESC-View program requires a desktop or notebook PC with a serial port. If your PC does not have a serial port, a USB to serial converter cable can be used.
- ESC-View will operate with most Microsoft™ operating systems, including Windows95™, Windows 98™, Windows 2000™, and Windows XP™. It may also be run on one of these versions of Windows installed in Microsoft™Virtual PC on a Macintosh™ in conjunction with a compatible USB to serial converter.
- Install the software from the supplied CD or download the latest version of ESC-View from the downloads area of www.motortron.com.

Connections:

1. ESC-View requires use of the ESC-link cable supplied by Motortron System Inc. One end of ESC-link cable connects to the speed controller's receiver connector. The other end connects to PC's serial port or the USB-to-serial converter.

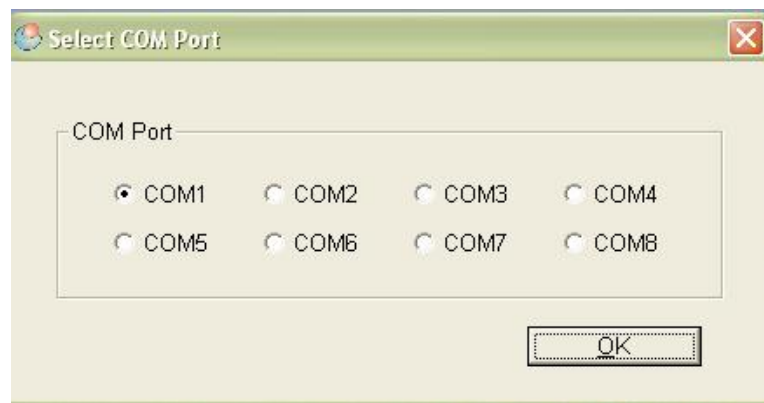
Note: Reversing the receiver lead connection will not damage MDRIVE™-link cable or the controller, but will not provide communication between the controller and the PC.

2. Connect the controller to the motor. If you desire to simply program the setup parameters, a motor connection is not required.
3. Connect a drive battery to the controller.

WARNING: Incorrect connection of battery polarity will totally destroy the controller and will not be covered by warranty.

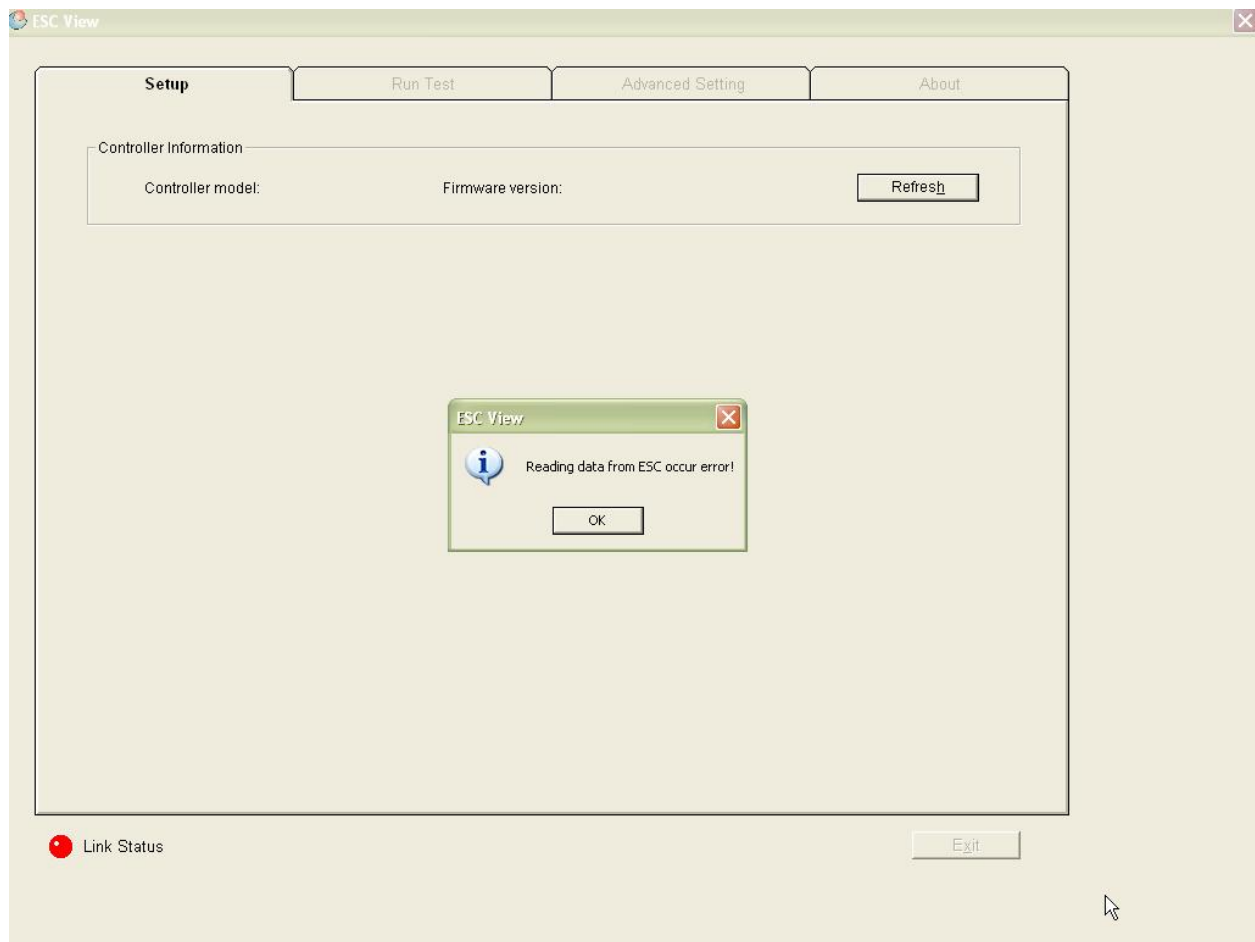
COM port selection:

When ESC-View starts, there are up to 8 COM ports to choose from.



If you are not sure which COM port to choose, please check the Windows Device Manager to find an available COM port. Procedure: select Start—Control Panel—System—Hardware—Device manager—Ports.

For more detail, see "COM port" in the Troubleshooting section below.



NOTE: ESC-View will not start up if there is no communication established between controller and the PC. Common causes are:

- **Incorrect COM port selected**
- **Power not supplied to the controller**
- **Receiver plug reversed in ESC-link cable.**

Set Up Tab User Mode Settings:

As discussed above, MDrive™ controllers offer three unique User Mode settings. These User Modes work like flight plans. To edit the settings, highlight a User Mode by clicking on the User Mode 2 or User Mode 3 button, then select the desired parameters for the flight. Clicking on the Update ESC button saves these parameters into the controller's memory.

Currently, the user can store User Mode 2 and User Mode 3 data in the controller's memory. All three User Mode settings can be selected through the radio transmitter in the field. The radio transmitter throttle is used to select one of the three User Modes as described above in the Using Radio Throttle Select User Mode and Audible Indications section.

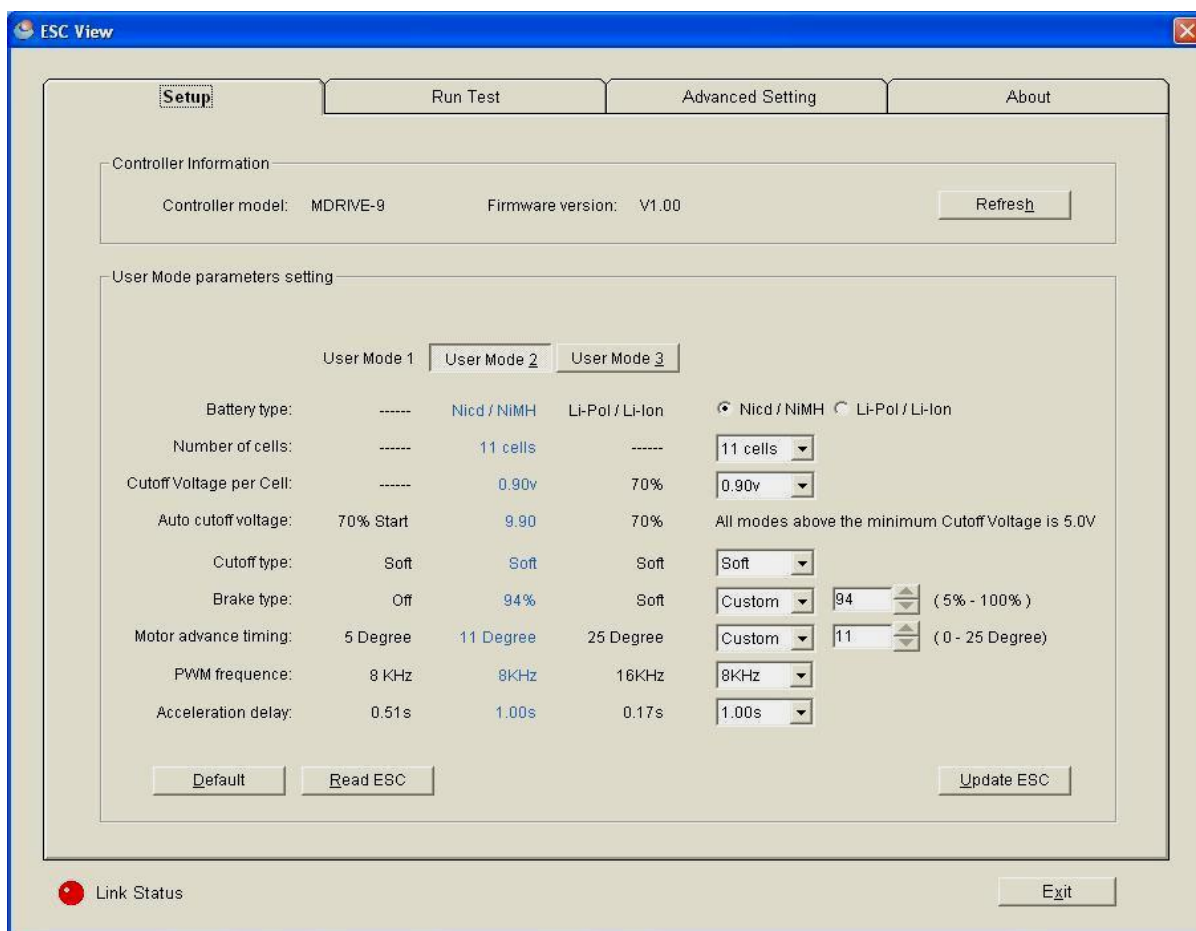
NOTE: Only one User Mode may be selected in a given power cycle. The battery connector must be disconnected and re-connected to enable selecting another User Mode.

User Mode 1: (Factory default setting- Cannot be reprogrammed)

To change parameters for either User Mode 2 or User Mode 3, click on the desired User Mode, then select desired values with the radio buttons and drop down menus. At any time you can click **Update** to write the parameter set to the controller. The current settings for the selected User Mode are displayed in the appropriate column. The ones currently being edited are shown in a different color.

To check or confirm the data been written into memory, click **Read ESC**.

More explanations on Setup and Advance Settings can be found in the FAQ or Technical Information on the Web at: <http://www.motortron.com>



1. Battery type:

Select the type of battery and then the **number of cells**. Then, select **Cutoff per cell**.
 NOTE: Please refer to the battery manufacture's specifications for appropriate cutoff per cell values. In general, the lower the cutoff per cell voltage, the longer the flying time. However, discharging the battery too deeply can seriously shorten its overall life. This is especially true of lithium batteries. The program automatically shows the total Auto cutoff voltage. If you wish to use a cutoff of 70% of initial voltage (as in User Mode 1) set the number of cells to "blank".

2. Cutoff type:

Soft cutoff --- The controllers detects the value of the Auto cutoff voltage, the controller will then reduce the power to the motor for two seconds. During this time the battery voltage will rebound since less current is being used. If the battery voltage rises above Auto cutoff voltage, full throttle power can be reapplied. When the voltage is below the Auto cutoff voltage again, the protocol above repeats itself. This pulses the motor and tells you it is time to land immediately.

Hard cutoff --- The program will shut off the power to motor completely. Full throttle power can be applied only after the battery voltage re-bounds above the Auto cutoff voltage.

The BEC circuit will maintain the power to the radio receiver and the servos during the cutoff.

3. Brake type:
Brake type is designed for aerobatic flying. By selecting the Hard brake setting, you can stop the motor instantly by quickly pulling the throttle stick all the way off. Other choices are “off”, “soft”, “medium” and “custom”. The custom setting allows you to set the brake from 5% to 100% in 1% increments.
4. Motor timing:
Since the motor windings provide an inductive load to the controller, the controller needs to advance the time it energizes the motor windings to maximize motor turning torque as well as to improve the motor efficiency. In general, a motor with fewer poles (like most inrunners) requires less advanced timing (5-12 degrees). Outrunner type or other motors with more poles can use more timing advance (15-25 degrees). There are discrete selections for 0, 5, 10, 15, 20 and 25 degrees of advance or you may set a Custom value anywhere between 0 and 25 degrees in one degree increments.
5. PWM frequency:
There are two frequencies to select from: 8 KHz or 16 KHz. The controller uses PWM (pulse width modulation) to drive the motor. The best selection depends on the motor's specifications, including the windings, stator core's lamination etc. The higher frequency results in a quieter running motor, but may cause higher core losses. The lower frequency will likely provide better starting torque at the low speeds.
6. Acceleration delay:
This is a function that it is designed for some types of aerobatic maneuvers that require a delay time for motor acceleration after the throttle is moved up. There are six values to choose from, ranging from 0.17s to 1.00s.

Run Test Tab

The ESC-View program Run Test feature helps you learn more detail about the controller, motor, RPM etc. Run Test is a powerful motor analyzing tool. (See illustration next page) User can take advantage of this function to experiment and optimize the combination of battery, motor, gearing and propellers.

1. Poles

Definition: number of poles equals number of magnets on brushless DC motor's rotor. One magnet means 1 pole. A BLDC motor requires a minimum of 2 magnets. Selecting the correct number of poles will correctly show the Mechanical RPM.

2. Electromagnetic RPM

Definition: A complete 360° degree rotation on the controller charges the BLDC motor stator's 3 (X.Y.Z) windings, producing 1 Electromagnetic turn.

Electromagnetic RPM = how many turns / minute

The screen's tachometer displays the speed of Electromagnetic RPM that the controller provides to the motor.

3. Mechanical RPM

Definition: A 360° degree turn of motor's rotor shaft = 1 mechanical turn

If rotor has 2 magnets (1 is N, another is S), the Mechanical RPM is the same as Electromagnetic RPM.

If rotor has 4 magnets, Mechanical RPM = Electromagnetic RPM divided by 2.

If rotor has 6 magnets, Mechanical RPM = Electromagnetic RPM divided by 3.

Mechanical RPM is the real RPM to the load (propeller or gearbox).

4. Temperature

Temperature refers to the controller's printed circuit board temperature, not motor temperature.

The Controller has a built in temperature sensor to protect from damage due to over heating.

Temperature protection parameter can be programmed in Advance Settings

5. Voltage

Real time battery voltage sampled by the controller.

6. Throttle bar

The throttle here is not quite the same as a throttle on the radio but performs the same function. Press computer keyboard ">" key for accelerating, "<" key for decelerating.

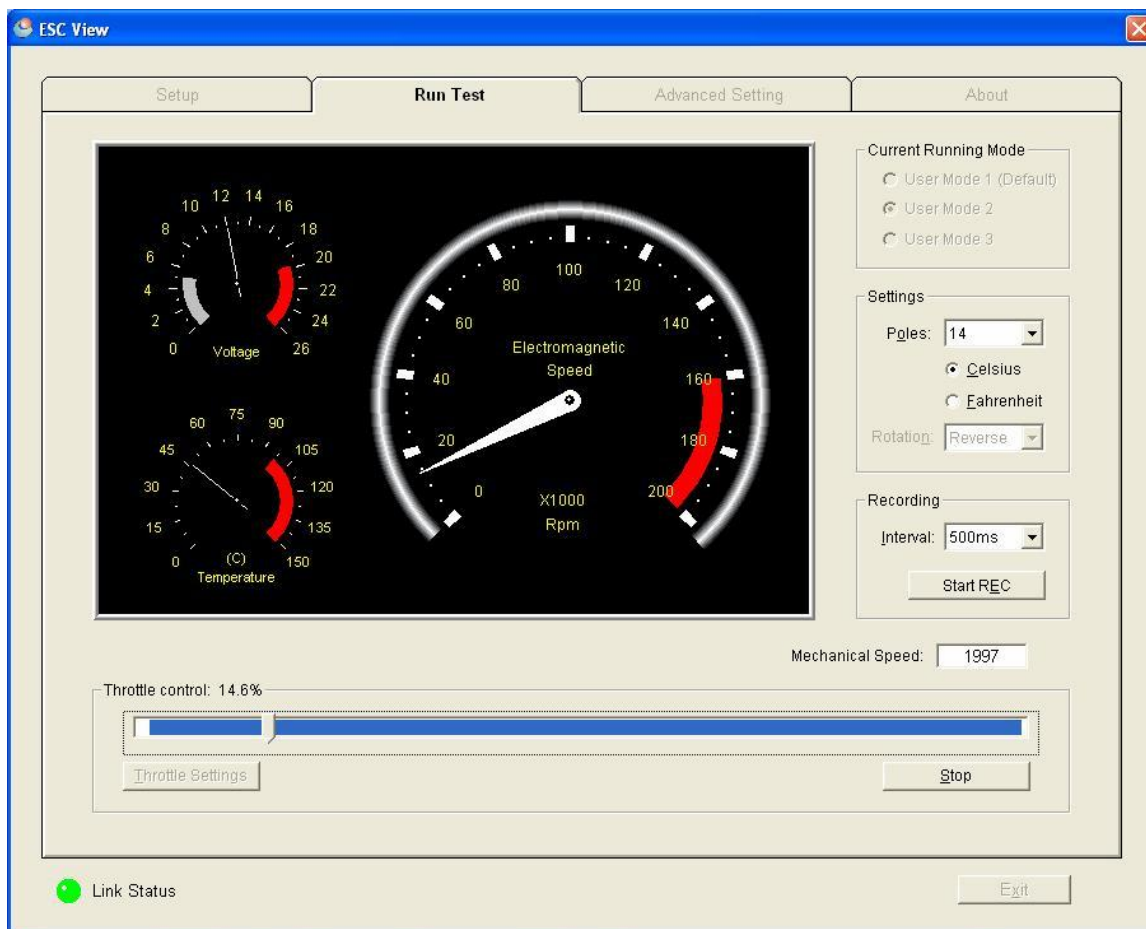
On Throttle settings, the percent scale accelerating steps are selectable. More explanations on Run Test are offered through FAQs or Technical Information.

7. Recording

You are able to record all the data during the testing. Recorded data is saved as a txt file and can be viewed by popular programs. The recording interval is user selectable. Recorded data will be stored to: C:\program\motortron\esc-view\ automatically. When you use "Save as", recorded data will be stored using name and directory you assigned. Microsoft Excel™ is the preferred program to view data and to make a chart.

8. Current Running Mode

To select the desired User Mode, click on the User Mode 1, 2 or 3 radio button in the upper right-hand corner of the Run Test screen. This will reset which User Mode is active just as if you had selected it using the transmitter stick procedure above. The power-up sequence also tells you which mode is active after the initial power-up tone: one beep for mode 1, two for mode 2 and so forth.



Advanced settings Tab

First, click “Read ESC” to show the current data in the controller memory.

1. Throttle Setting

Throttle starts at: (0.7ms—1.3ms; Default setting is 1.10ms) Read the detail on FAQ

Select proper value to state low stick position of radio throttle. Once user starts to use the radio throttle to select a User Mode, controller will record accurate radio receiver’s pulse width. Both low and high stick position pulse width data will show on this screen. This on screen data is used to set up throttle control range. The throttle start point must be above the throttle minimum position reading in order to arm the motor.

Throttle Range: (0.4ms- 1.2ms; Default setting is 0.8ms) Read the detail on FAQ

Select proper value to state the radio throttle travel range from the throttle low position. The throttle end position value will be: Throttle start value + Throttle Range

Example: User’s radio receiver throttle low value is 1ms, the high value is 2ms. User sets the throttle start setting to 1.10ms, the throttle range to 0.7ms. The throttle endpoint value will then be 1.80ms. User’s radio throttle functioning travel range is now set to operate between 1.10ms to 1.80ms, and the range 1.80ms to 2ms is non-functioning.

This is a very helpful feature for some types of radio transmitters. ESC-VIEW provides detailed radio transmitter pulse width data so the user is able to set up a very precise throttle range.

Another useful application is to control the motor's threshold saturation point. In many cases, the motor will go into saturation before user's throttle reaches the maximum high position. Now the user can use "RUN TEST" feature to learn motor's maximum running capacity before it reaches saturation and use the resulting data to set up the radio throttle. This will protect the motor and controller from accidental damage.

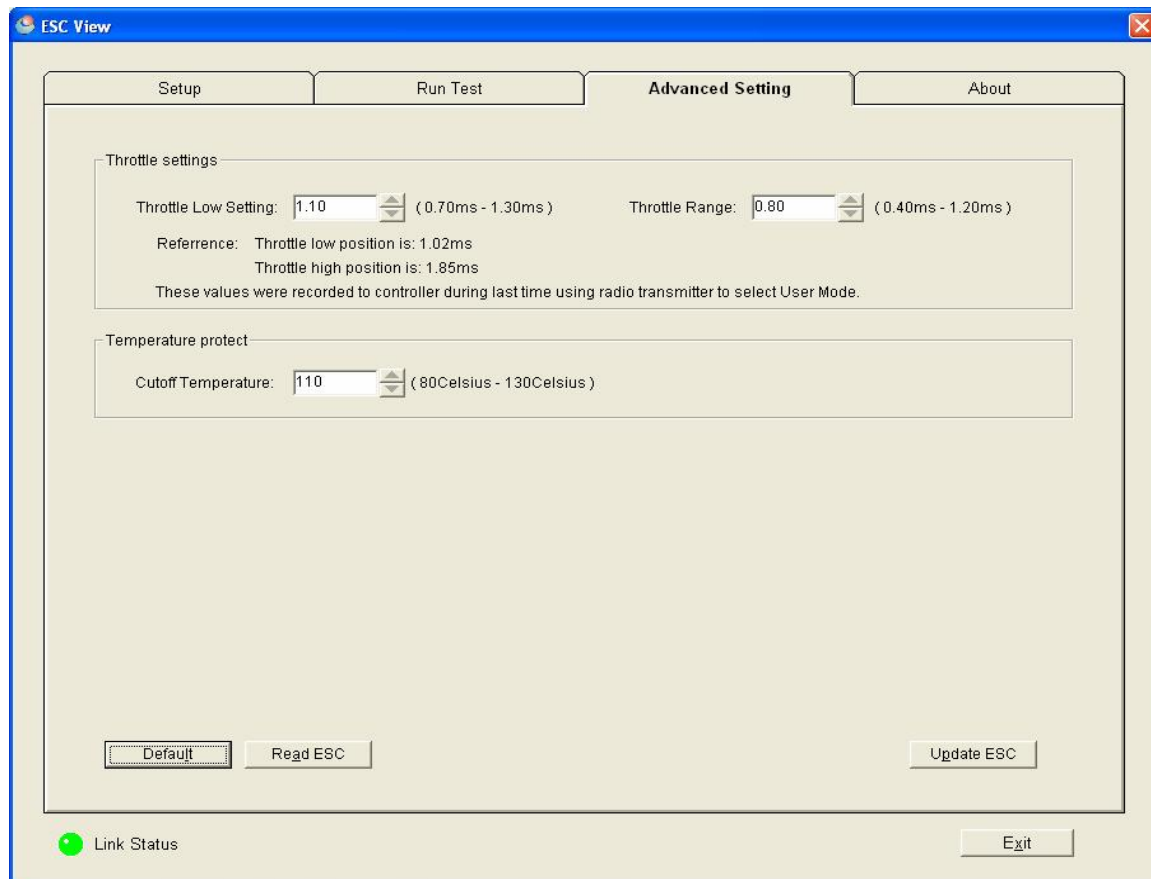
2. Thermal protection (Default setting is 110 Celsius)

The controller will reduce the power to the motor when the temperature of the printed circuit board reaches a pre-selected setting. The controller will stop the power to the motor within 5-10 seconds if the temperature is still above the cutoff setting. If the temperature cools down and below the cutoff setting during the 5-10 seconds period, the full throttle power to the motor can be applied. The protocol repeat itself if the temperature is above the cutoff setting again.

The flyer will notice the irregular behavior of the plane. The flyer is advised to take the action to reduce the throttle power to the motor or land the plane.

Note1: The user may have a shorter flying time if the temperature setting is too low.

Note2: The controller may sustain damage by overheating if the temperature setting is too high (above 120 Celsius).



Note: Both the advanced throttle settings and the thermal protection setting apply equally to all three User Modes.

Warranty Policy

Motortron System Inc. provides one year limited manufacturer's warranty to MDrive™ series sensorless brushless motor controllers. This includes MDrive™-9A, MDrive™-18A ,MDrive™-36A, MDrive™-60A, MDrive™-90A and MDrive™-120A.

Warranty covers:

Controller malfunctions due to faulty components, poor workmanship and improper performance from software.

Warranty does not cover the following due to user mishandling:

1. Controller damaged due to application of improper voltages or current exceeding product rating.
2. Controller damaged due to wrong connection on battery polarity.
3. Controller damaged due to abuse that includes dropping into water, improper installation and physical damage.
4. Controller damaged due to motor windings short circuit.
5. Controller damaged due to self service or if modified by user.

The 1 year warranty starts the date of purchase. Please contact your local dealer for details.

FAQ:

Questions about the serial port connections:

Q: Does ESC-View program and ESC-Link Cable run with other brand controllers?

A: No. ESC-View program and ESC-link only work with Motortron System's MDRIVE™ controller.

Q: My new notebook PC does not have serial port. I bought a USB to Serial cable and installed driver. How do I know my Com port number?

A: Go to Start-Control panel- System- Hardware- Device manager-Port. Check the properties of the newly installed driver and find out COM port number.

Please note: Once a USB to Serial cable works in a particular USB port, you need to use this same port for the next connection, other USB ports may not work.

Q: I selected COM port 1 which is shown to be available through the Device manager, but I still could not make the program work.

A: Please check your dial up modem's Com port number in Device Manager. If modem occupies Com1, you may have to release modem from Com 1 by disabling the modem. Be sure to refresh it.

The information about programming the MDrive™ controllers to match a radio transmitter throttle control:

How does it work?

The controller will records user particular radio receiver output pulse width during the User Mode selection procedure. Power on transmitter with the throttle on maximum position, then move the stick down the low position without a pause to select a User Mode. This procedure allows the controller to record the receiver output pulse width and both high and low throttle stick positions into controller memory. You can then read out the low and high throttle position data through the ESC-View software. Base on above data, you can setup the precise throttle stick position for the motor start point as well as the end point.

The controller will enter User Mode selection Mode if the transmitter throttle's position above the middle or 1.70ms during power on cycle.

Without a pause: During the time of the stick traveling down, the controller software is measuring the pulse width. If the pulse width maintains a position for two seconds, and below 1.30ms, the software assumes the stick has reached the low point and provides the User Mode selection confirmation tones (deedee). In the mean time, the controller records the low throttle position pulse width.

It may not produce the arming tones unless the stop position pulse width is below the pre-selected setting.

The safety start feature:

The controller will not arm the motor unless the throttle stick position is below pre-selected throttle start point for two seconds during the power on cycle for running a motor or for the User Mode selection. This feature will allow the user always start the motor smoothly and SAFE.

The "standard radio":

There is none regulatory body in the RC industry that asking the standardization of the radio receiver signal output format. MDrive™ controller adapts the most widely applied signal format which is a PWM: the T=20ms or the frequency=50Hz; the minimum throttle pulse width =1.0ms; the maximum throttle pulse width=2.0ms; the signal lever is 1.0V ppv; as the factory default throttle setting in the memory.

Each mode or brand of radio transmitter and receiver specifications has the minor, sometimes significant differences on the minimum and maximum throttle position pulse width. The user is able to customize the controller to match a particular radio through the ESC-View software. The

user can modify the throttle start point position ranges from 0.70ms --- 1.30ms. The throttle function ranges is 0.4ms—1.2ms. The end point will be: the start point+ the range.

The controller software protocol will check the signal integrity from the receiver during the power on cycle. This protocol will prevent the motor running in an accident situation since the radio receiver may pick up interference signal from the airwave. If the arming tones (dee-doo-daa) has not been heard. It likely causes by the following scenarios:

1. The universal signal wire connector connects in reverse.
2. The throttle stick position is not low enough.(below pre-selected throttle start point setting)
3. The signal comes from receiver is not an authentic, either the frequency or pulse lever is not correct.

What I am going to do on the scenario 2? (The throttle stick position is not low enough)

The first step, the user is advised to proceeding the User Mode selection, then switch the signal connector to ESC-link and run the ESC-View program. On Advanced Setting screen, click Read ESC. If the throttle stick low readout data is: For an example 1.20ms, the user is suggested to change the start point to 1.25ms and click Update ESC . The user should always add up 0.05ms to 0.10ms to the minimum throttle stick pulse width to smooth start up a motor.

Another reason, the safety start feature requires that the minimum throttle stick position pulse width must be below the throttle start point pulse width to arming the motor. The suggested value is: 0.05ms—0.10ms.

The preferred transmitters throttle setup for airplane:

1. The motor will completely stop when the transmitter throttle is on the minimum low position. The throttle travels a little distance to smooth start the motor.
2. The throttle range setting is the further and the better, so user can have more detail control through the throttle stick. However, the range setting must be referred by the combination setup among the batteries—the controller and the motor. Using the RUN TEST feature to test the best possible combination, and then setup the range. The user is not encouraged to drive the motor into saturation that cause the motor, controller overheat and waste the electric power from the batteries.

How to test a motor:

Q: ESC-View program is able to run the motor from the PC. How do I know that the motor is in the saturation state? How do I set the radio throttle to avoid the saturation?

A: This is one of the important features that the ESC-View program offers to the user. First we should know that the DC brushless motor will go into saturation when there is excessive current, voltage and load applied on the motor. You must learn when the motor goes into saturation. On the PC, moving the throttle bar to the right will accelerate the motor and you will read mechanical RPM from the screen (You have to put in the right poles number). The further the bar goes to the right, the higher mechanical RPM. The two data should be in linear relationship. However, when the bar reaches to a certain percent of the throttle, the RPM will stop going higher. Depending on each individual setting case (the motor, voltage, props, PWM frequency), RPM either maintains certain speed, or can jump up and down irregularly. That will show you the motor is in saturation state. Any extra current that goes into the motor will become the heat, iron loss. The temperature of the motor will increase very quickly even under the very high velocity airflow from props.

Q: What is the specification on PC simulated throttle bar?

A: The total control length of the simulated throttle bar on screen is 1.00ms. The software divides it into 1024 steps. The percentage of the throttle bar indicates the percentage radio transmitter stick position.

Q: How to setup the radio throttles low end range and how do I set the radio throttle to avoid the saturation?

A: Once you learned your motor's limit from RUN TEST, you are able to program the radio throttle position precisely. Here is an example: Your radio throttle's lowest reading is 1.00ms, the highest reading

is 2.00ms, and when you do the RUN TEST, motor goes to saturation state at 70% of PC throttle. The suggested setting for your radio throttle is: The throttle low setting: 1.05ms, The Range: 0.70ms
Note: Above descriptions is based on battery voltage does not drop. In real play, battery voltage drops, user must move the throttle beyond the high throttle setting to get the motor into peak performance. So, user may setup the range 15 percent higher than 0.70ms to offset the battery voltage drop. It is up to user to find out the balance to apply this feature.

Q: What does motor saturation mean?

A: Applying excessive current/voltage to the motor's stator winding, the stator's electromagnetic property curve changes from linear to non linear. That causes the stators over heating and the motor becomes saturated. Current, voltage, PWM frequency, the load and the motor speed can all contribute to motor saturation. Motor manufacturer's spec. sheet shows maximum applicable voltage, current, KV, propeller size. It is not necessary that the motor can work well in these areas. The controller makes a big difference in running the motors.

Q: What does this mean **2A MAX BEC @ 6-12V ?**

A: BEC means battery elimination circuit. The BEC circuit provides +5V to radio receiver as well as the power to the servos. The BEC circuit is designed by linear voltage regulator. Here is the math: Input voltage is +12V, BEC drains 2amps at +5V, then:

Power input to the BEC: $12V \times 2A = 24 \text{ Watt}$

Power output from BEC: $5V \times 2A = 10\text{Watt}$

Power converted into heat: $24W - 10W = 14 \text{ Watt}$.

The efficiency: $10W \div 24W = 0.416$ or 41.6%

The efficiency will get worse if the input voltage is too high or drains too much current from the BEC. The switching power regulator is the best alternative solution for planes with many servos.

Questions about this manual, please email to: mail@motortron.com

Motortron System Inc. Web: <http://www.motortron.com> US Patents Pending

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