Operation manual for BLHeli SiLabs Rev10.x

Normal operation:

This procedure is used for PWM input signal.

Power up:

Once

Throttle up detected (arming sequence start):

Once

The maximum throttle in this interval sets the ”arm” target for the governor.

Zero throttle detected (arming sequence end):

Once

After this, the motor will run.

Normal operation:

This procedure is used for PPM input signal.

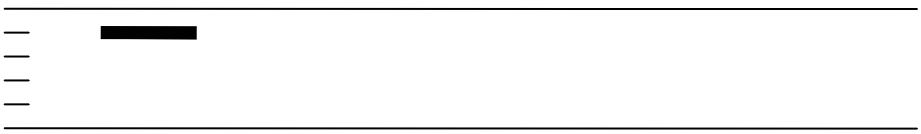
Power up:

Once

Throttle signal detected (arming sequence start):

Once

Zero throttle detected (arming sequence end):



Once

After this, the motor will run.

Entering programming mode:

This procedure is used for PWM input signal.

Power up:

Once

Throttle up detected (arming sequence start):

Once

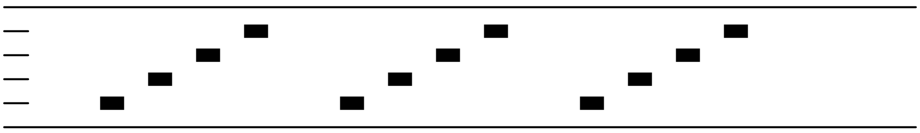
Full throttle detected (start of entering programming mode):

Infinite

Zero throttle detected (continue entering programming mode):

Infinite

Full throttle detected (programming mode entered):



Once

The above description is for main.
For the tail, follow the same sequence, but use right rudder as full throttle and left rudder as zero throttle.

Throttle range calibration and entering programming mode:

This procedure is used for PPM input signal.

Power up:

Once

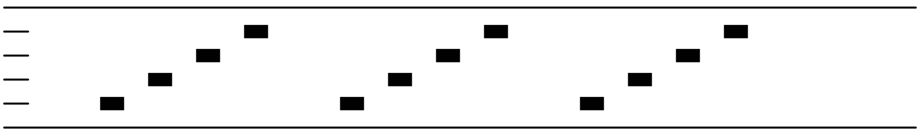
Throttle signal detected (arming sequence start):

Once

When throttle is above midstick (measuring max throttle):

While measuring

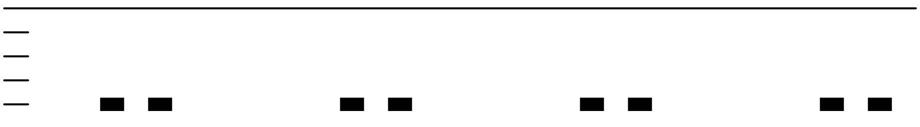
If throttle is above midstick for 3 seconds:



Once

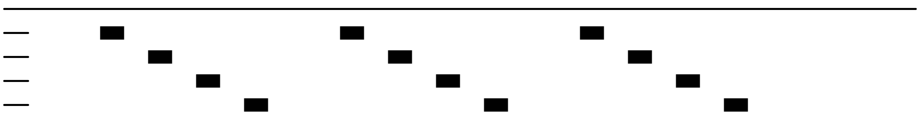
This beep sequence indicates that max throttle has been stored

When throttle is below midstick (measuring min throttle):



While measuring

If throttle is below midstick for 3 seconds:

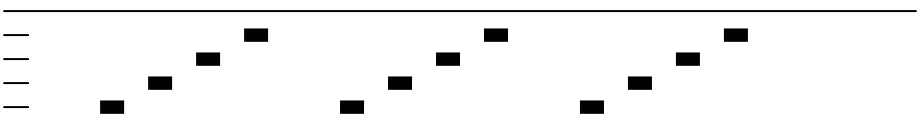


Once

This beep sequence indicates that min throttle has been stored

At this point throttle calibration values are stored. You may remove power from the ESC, if you just wanted to do a throttle calibration and not enter programming mode.

Full throttle detected:

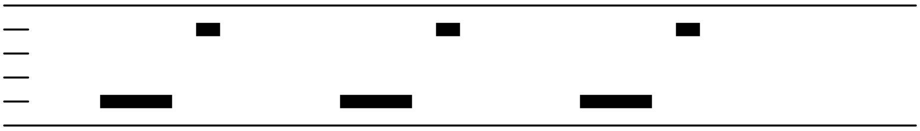


Once

This beep sequence indicates that programming mode is entered

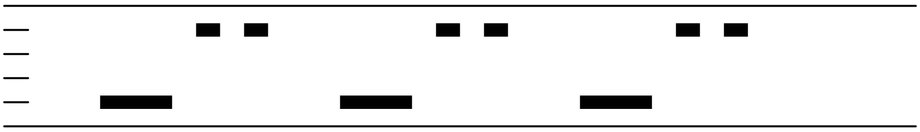
Programming mode:

Function 1, parameter value 1



Once

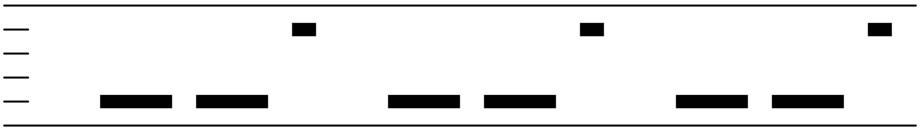
Function 1, parameter value 2



Once

…etc…

Function 2, parameter value 1

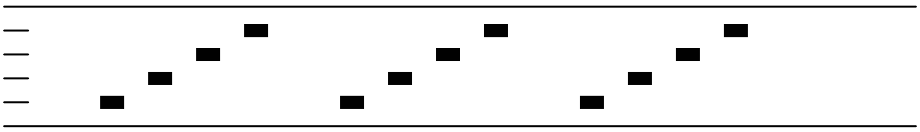


Once

…etc…

If the throttle stick is moved to zero during one of the above sequences, the parameter value of that function is selected and stored. And you will hear this sound:

Parameter value stored



Once

The ESC then resets itself.

If the throttle stick is moved below max (but not to zero), the current parameter will be skipped, and programming will proceed to the next parameter. This way it is possible to access the later parameters without going through all the beeps.
It is generally a good idea to go to full throttle again before selecting a parameter, to make sure you have selected the right parameter.
Throttle is read in the 1 second pause between the function/parameter beeps.

If the throttle stick is never moved to zero, the ESC will load the defaults and then reset itself after the last parameter value of the last function. This is a convenient way of setting all parameters to defaults.

If power is disconnected during the programming sequence, then no changes are done to the programmed values.

Programming functions and parameter values:

Programming parameter value table main:

Function	1	2	3	4	5	6	7	8	9	10	11	12	13
1 - Governor P gain	0.13	0.17	0.25	0.38	0.50	0.75	**1.00**	1.5	2.0	3.0	4.0	6.0	8.0
2 - Governor I gain	0.13	0.17	0.25	0.38	0.50	0.75	**1.00**	1.5	2.0	3.0	4.0	6.0	8.0
3 - Governor mode	**Tx**	Arm*	Setup	Off	-	-	-	-	-	-	-	-	-
4 - Governor range	**High**	Low	-	-	-	-	-	-	-	-	-	-	-
2 - Low voltage limit (/cell)	Off	3.0V	3.1V	**3.2V**	3.3V	3.4V	-	-	-	-	-	-	-
6 - Startup method**	Stepped	Direct	-	-	-	-	-	-	-	-	-	-	-
7 - Startup power**	0.031	0.047	0.063	0.094	0.125	0.188	0.25	0.38	0.50	0.75	1.00	1.25	1.50
8 - Startup rpm	0.67	0.80	**1.00**	1.25	1.50	-	-	-	-	-	-	-	-
9 - Startup acceleration	**0.4**	0.7	1.0	1.5	2.3	-	-	-	-	-	-	-	-
10 - Commutation timing	Low	MediumLow	**Medium**	MediumHigh	High	-	-	-	-	-	-	-	-
11 - Throttle change rate	2	3	4	6	8	12	16	24	32	48	64	128	**255**
12 - Damping force	**VeryLow**	Low	MediumLow	MediumHigh	High	Highest	-	-	-	-	-	-	-
13 - Pwm frequency	High	**Low**	DampedLight	-	-	-	-	-	-	-	-	-	-
14 - Demag compensation	**Off**	1	2	3	4	-	-	-	-	-	-	-	-
15 - Rotation direction	**Normal**	Reversed	-	-	-	-	-	-	-	-	-	-	-
16 - Input pwm polarity	**Positive**	Negative	-	-	-	-	-	-	-	-	-	-	-

*: Governor arm mode is only supported with PWM input signal

**: Default startup method and power varies by ESC. Generally the stepped start is used for the original mCPX ESCs, and generally the default power is lower for larger ESCs.

Default values are marked in bold **green**.

If for some reason there is an error in the eeprom/flash write operation (e.g. due to loss of power or low voltage), defaults will be loaded.

Programming parameter value table tail:

Function	1	2	3	4	5	6	7	8	9	10	11	12	13
1 - Tail gain	0.75	0.88	**1.00**	1.12	1.25	-	-	-	-	-	-	-	-
2 - Tail idle speed	Low	MediumLow	Medium	**MediumHigh**	High	-	-	-	-	-	-	-	-
3 - Startup method**	Stepped	Direct	-	-	-	-	-	-	-	-	-	-	-
4 - Startup power**	0.031	0.047	0.063	0.094	0.125	0.188	0.25	0.38	0.50	0.75	1.00	1.25	1.50
5 - Startup rpm	0.67	0.80	**1.00**	1.25	1.50	-	-	-	-	-	-	-	-
6 - Startup acceleration	0.4	0.7	1.0	1.5	**2.3**	-	-	-	-	-	-	-	-
7 - Commutation timing	Low	MediumLow	**Medium**	MediumHigh	High	-	-	-	-	-	-	-	-
8 - Throttle change rate	2	3	4	6	8	12	16	24	32	48	64	128	**255**
9 - Damping force	VeryLow	Low	MediumLow	MediumHigh	**High**	Highest	-	-	-	-	-	-	-
10 - Pwm frequency	High	Low	**DampedLight**	**Damped***	-	-	-	-	-	-	-	-	-
11 - Demag compensation	**Off**	1	2	3	4	-	-	-	-	-	-	-	-
12 - Rotation direction	**Normal**	Reversed	-	-	-	-	-	-	-	-	-	-	-
13 - Input pwm polarity	**Positive**	Negative	-	-	-	-	-	-	-	-	-	-	-

*: Only enabled for some ESCs.
**: Default startup method and power varies by ESC. Generally the stepped start is used for the original mCPX ESCs, and generally the default power is lower for larger ESCs.

Default values are marked in bold **green**.

If for some reason there is an error in the eeprom/flash write operation (e.g. due to loss of power or low voltage), defaults will be loaded.

Programming parameter value table multi:

Function	1	2	3	4	5	6	7	8	9	10	11	12	13
1 - Closed loop P gain	0.13	0.17	0.25	0.38	0.50	0.75	1.00	1.5	**2.0**	3.0	4.0	6.0	8.0
2 - Closed loop I gain	0.13	0.17	0.25	0.38	0.50	0.75	1.00	1.5	**2.0**	3.0	4.0	6.0	8.0
3 - Closed loop mode	HiRange	MidRange	LoRange	**Off**	-	-	-	-	-	-	-	-	-
4 - Multi gain	0.75	0.88	**1.00**	1.12	1.25	-	-	-	-	-	-	-	-
5 - Low voltage limit (/cell)	**Off**	3.0V	3.1V	3.2V	3.3V	3.4V	-	-	-	-	-	-	-
6 - Startup method**	Stepped	Direct	-	-	-	-	-	-	-	-	-	-	-
7 - Startup power**	0.031	0.047	0.063	0.094	0.125	0.188	0.25	0.38	0.50	0.75	1.00	1.25	1.50
8 - Startup rpm	**0.67**	0.80	1.00	1.25	1.50	-	-	-	-	-	-	-	-
9 - Startup acceleration	0.4	0.7	1.0	1.5	**2.3**	-	-	-	-	-	-	-	-
10 - Commutation timing	Low	MediumLow	**Medium**	MediumHigh	High	-	-	-	-	-	-	-	-
11 - Throttle change rate	2	3	4	6	8	12	16	24	32	48	64	128	**255**
12 - Damping force	VeryLow	Low	MediumLow	MediumHigh	High	**Highest**	-	-	-	-	-	-	-
13 - Pwm frequency	**High**	Low	DampedLight	Damped*	-	-	-	-	-	-	-	-	-
14 - Demag compensation	Off	**1**	2	3	4	-	-	-	-	-	-	-	-
15 - Rotation direction	**Normal**	Reversed	-	-	-	-	-	-	-	-	-	-	-
16 - Input pwm polarity	**Positive**	Negative	-	-	-	-	-	-	-	-	-	-	-

*: Only enabled for some ESCs.
**: Default startup method and power varies by ESC. Generally the stepped start is used for the original mCPX ESCs, and generally the default power is lower for larger ESCs.

Default values are marked in bold **green**.

If for some reason there is an error in the eeprom/flash write operation (e.g. due to loss of power or low voltage), defaults will be loaded.

Programming parameters for main:

In the governor “tx” mode, the throttle value while running sets the speed target for the governor.
In this mode, the throttle curve when flying should be flat.

In the governor “arm” mode the maximum throttle seen during the arming sequence will set the speed target for the governor.
Note that governor “arm” mode is not supported for PPM input signal.

In the governor “setup” mode the governor target is stored in the ESC. It’s default value is 70% (about 4800rpm on mCPX with a 6pole motor and an 8T pinion). The value can be changed with configuration software.

In governor “arm” and “setup” modes, the throttle curve when flying does not influence headspeed.
Throttle curve can be set to a V-curve for the desired main to tail mix (this mix is in the mCPX 3in1).
Throttle must be above 20% in these modes. Values below 20% will cause spooldown.

Governor P gain sets the proportional gain for the governor.
This setting controls the gain from speed error to motor power.

Governor I gain sets the integral gain for the governor.
This setting controls the gain from integrated speed error (summed over time) to motor power.

Governor range sets the available range of speeds that the governor can operate on.
- For the high range, throttle values from 25% to 100% will lead to governor targets from 70000 to 208000 electrical rpm
- For the low range, throttle values from 25% to 100% will lead to governor targets from 20000 to 89000 electrical rpm

The low range is primarily intended for low pole count motors (e.g. 2-pole inrunners).

The low voltage limit sets the voltage at which motor power is reduced.
Motor power is reduced while at this voltage, but only temporarily, and full power is resumed if the voltage rises again.
Low voltage limiting can also be disabled.

Programming parameters for multi:

In the closed loop mode, the throttle value while running sets the rpm target of the motor.

Closed loop P gain sets the proportional gain for the rpm control loop.
This setting controls the gain from speed error to motor power.

Closed loop I gain sets the integral gain for the rpm control loop.
This setting controls the gain from integrated speed error (summed over time) to motor power.

Closed loop mode sets the range of speeds that the control loop can operate on.
- For the high range, throttle values from 0% to 100% linearly correspond to rpm targets from 0 to 200000 electrical rpm
- For the middle range, throttle values from 0% to 100% linearly correspond to rpm targets from 0 to 100000 electrical rpm
- For the low range, throttle values from 0% to 100% linearly correspond to rpm targets from 0 to 50000 electrical rpm

When closed loop mode is set to off, the control loop is disabled.

Programming parameters for tail/multi:

Tail/multi gain scales the power applied to the motor for a given input.
Beware that a low tail/multi gain will also limit the maximum power to the motor.

Tail idle speed is the speed of the motor during the delayed stop.

Programming parameters for main/tail/multi:

The startup method selects which method is used to start the motor.
Stepped method first runs the motor as a stepper motor at a given power, rpm and acceleration. This is done for an rpm range selected by the rpm parameter. Normal running begins after this.
Direct startup method runs the motor using back emf detection from the very start. In this mode power is given by the throttle used, but limited to a maximum level. This maximum level can be controlled with the startup power parameter.

Startup power, rpm and acceleration are parameters that control the startup of the motor for the first initial rotations only (about a second or less).
Startup power sets the power applied to the motor in this phase.
Beware that setting startup power too high can cause excessive loading on ESC or motor!
Startup rpm is used for stepped method only, and sets the rotational speed with which the motor is started.
Startup acceleration is used for stepped method only, and sets the rate at which the motor is accelerated.
If required, these parameters can be used to optimize motor startup for different motors and loads.

Commutation timing can be adjusted in three steps. Low is about 0^0, mediumlow 8^0, medium 15^0, mediumhigh 23^0 and high 30^0.
Typically a medium setting will work fine, but if the motor stutters it can be beneficial to change timing.
Some motors with high inductance can have a very long commutation demagnetization time. This results in motor stop or stutter upon quick throttle increase, particularly when running at a low rpm. Setting timing to high will allow more time for demagnetization, and often helps.

The throttle change rate parameter is an additional mechanism to avoid demagnetization problems. Setting this parameter to a low value will result in slow changes in motor power. Which of course is not desirable in order to have a responsive motor, but in some cases it can be required. This parameter determines how many steps motor power is allowed to increase for each new received input pulse. Full motor power is 255 steps. So, e.g. for a 400Hz input rate and a throttle change rate setting of 2, motor power can change 2 steps every 2.5ms. Which means that zero to full power will take (255/2)*2.5ms=319ms, which is really slow. On the other hand, the default setting of 255 means that motor power can change from zero to full power instantly.

High pwm frequency is around 20-25kHz, and low pwm frequency is around 8-12kHz.
One benefit of using a low pwm frequency is that the step from almost full power to full power becomes smaller. On the other hand, 8kHz is in the audible frequency range, and also there is a step in power when the motor rotation frequency is equal to the pwm frequency.

Pwm damped mode adds loss to the motor for faster retardation. Damped mode always uses high pwm frequency.

In full damped mode, all three motor terminals are shorted when pwm is off, while in damped light mode, two motor terminals are shorted. The full damped mode is only supported on some ESCs (where fet switching is sufficiently fast).

If one of the damped modes is selected, then the damping strength can be varied.
If damping is highest, loss is added in all pwm cycles.
If damping is high, loss is added in 7 out of 9 pwm cycles.
If damping is medium high, loss is added in 3 out of 5 pwm cycles.
If damping is medium low, loss is added in 2 out of 5 pwm cycles.
If damping is low, loss is added in 1 out of 5 pwm cycles.
If damping is very low , loss is added in 1 out of 9 pwm cycles.

Damped mode may result in uneven running at low speeds on some motor/ESC/voltage combinations.
This can be seen on high electrical rpm systems, with high damping force and an ESC with slow switching fets.
If this is a problem, reduce the damping force or use an ESC with faster switching fets.

The rotation direction setting can be used to reverse motor rotation.

The input pwm polarity setting can be used to inverse the throttle behaviour. This is intended to be used with receivers that provide negative pwm (at least some Walkeras do). When using PPM input it must be set to positive.

Demag compensation is a feature to protect from motor stalls caused by long winding demagnetization time after commutation. The typical symptom is motor stop or stutter upon quick throttle increase, particularly when running at a low rpm. As described earlier, setting high commutation timing normally helps, but at the cost of efficiency. Throttle change rate can also be reduced, but at the cost of slower throttle response.

The demag compensation is an alternative way of combating the issue. First of all, it detects when a demag situation occurs.
- Then there is no info on motor timing, and commutation proceeds blindly with a variable advance.
- In addition to this, motor power is cut off some time before the next commutation.
- As a third countermeasure, commutation timing is set to high during the demag event.

These two mechanisms are used to a varying degree as shown below, selected by the demag compensation parameter:

Demag compensation	1	2	3	4
Blind commutation advance	15	15	7.5	7.5
Power off time	0	7.5	7.5	15

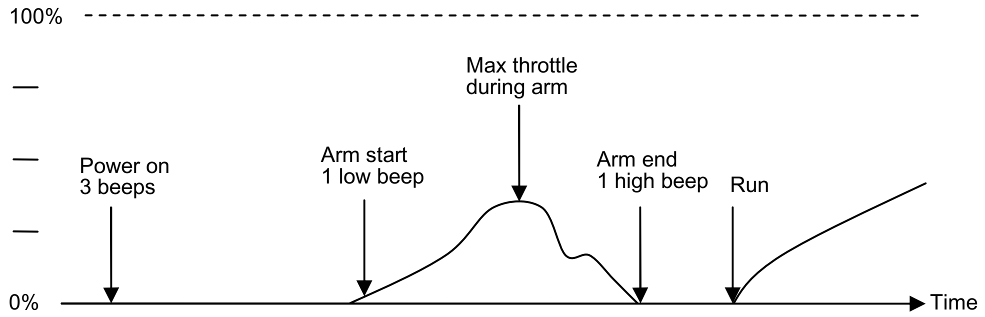
The values are in degrees. A motor electrical revolution is 360degrees, and a commutation cycle is 60degrees.

As shown in the above table, power off time will depend upon the selected commutation timing.
Generally, a higher value of the demag compensation parameter gives better protection.
If demag compensation is set too high, maximum power can be somewhat reduced.

Programming parameters that can only be accessed from configuration software (BLHeliSetup, BLHeliTool):
- Throttle minimum and maximum values for PPM input (will also be changed by doing a throttle calibration).
- Governor setup mode rpm target.
- Beep strength, beacon strength and beacon delay.
- Programming by TX. If disabled, the TX can not be used to change parameter values (default is enabled).
- Re-arming every start. If enabled, a new arming sequence will be required for every startup, not just the first after poweron (default is disabled).
- High/low BEC voltage for ESCs that support it.

Arming sequence:

The figure below shows an example of throttle value versus time.



At power on, the ESC beeps 3 beeps.

For PWM input, the following applies:
When throttle is raised above zero, it beeps one low tone beep. This signals the start of the arming sequence.
When throttle is reduced to zero again, it beeps one high tone beep. This signals the end of the arming sequence.

For PPM input, the following applies:
When throttle signal is detected, it beeps one low tone beep. This signals the start of the arming sequence.
Then, when or if throttle is zero, it beeps one high tone beep. This signals the end of the arming sequence.

For a main motor esc running with PWM input, throttle is monitored during the arming sequence. The maximum value of throttle is recorded.
If governor arm mode is selected, this value will be used as the governor speed target when the motor starts running.
When running, the throttle input has no effect, as long as it is not below 20%.

Also, if 100% throttle is detected during the arming sequence, the ESC starts entering programming mode.

Restarting the main motor after a stop behaves differently, depending upon the chosen startup method.
For the stepped startup method, there is a 3 second delay from motor stop (zero throttle) has been initiated until a new start can commence.
For the direct startup method, a new start can commence any time after a stop.

The main motor has a soft spoolup of about 5 seconds for full power (longer for code before rev9.2). The spoolup is done in three phases, in order to be soft enough for the heli not to move, particularly before tail rpm is high enough to give some tail authority. In the first phase power is limited to the startup power for about one second. Then the power limit is slowly increased over the next three seconds. And in the final phase the power limit is increased more rapidly, until full power is available.

If the esc is armed and sees zero throttle for a given time, it beeps beacon beeps, which are about 1 beep per second

Input signal:

The ESC accepts both positive and negative PWM, as well as PPM as input signal.
The type of input signal is auto detected during the arming sequence.
The only input signal that requires changing the default parameters, is negative PWM.

PWM is accepted as 8kHz (mCPX v1), 4kHz, 2kHz (several Walkeras) and 1kHz (mCPX v2).
PPM has a default throttle range of 1150us-1830us, and accepts rates from the normal 50Hz up to several hundred Hz.

Available throttle calibration range for PPM is from 1000us to 2000us, and the difference between minimum and maximum throttle must be more than 520us. If a calibration is done where the difference is less than 520us, the maximum will be shifted so that the difference is 520us.

Thermal protection:

The ESC measures temperature within the MCU and limits motor power if the temperature is too high.
Motor power is limited in four steps:
- If the temperature is above 140^0C, motor power is limited to 75%.
- If the temperature is above 145^0C, motor power is limited to 50%.
- If the temperature is above 150^0C, motor power is limited to 25%.
- If the temperature is above 155^0C, motor power is limited to 0%.

Note: The above is valid for rev4.1 and up. For rev4.0, these limits were 85^0C to 130^0C

Regenerative braking / active freewheeling:

The various damped modes are implemented by doing regenerative braking.

It is implemented differently for ESCs that support full damped mode and those that do not.
The table below shows which phases are being used for braking. In this context, the three motor terminals are named DrivenH, DrivenL and Comparator. X'es in the table below indicate phases that are shorted.

	Fully damped enabled		Not fully damped enabled	
	Damped Light	Damped	Damped Light	Damped
DrivenH	X	X	X	Not supported
DrivenL	X	X		Not supported
Comparator		X	X	Not supported

When the DrivenL terminal is used for braking, active freewheeling is also implemented.
Then losses due to braking are counteracted by the reduced losses of active freewheeling.

When the Comparator terminal is used for braking, damping force should be reduced, in order to allow for comparator information to be read in some of the pwm of cycles. Otherwise the motor will run jerky, particularly at low throttle.

Maximum speeds:

Approximate maximum speeds for the various settings are:

	Maximum speed
Non damped, open loop	200 000 eRPM
Non damped, closed loop	160 000 eRPM
Damped light, open loop	180 000 eRPM
Damped light, closed loop	125 000 eRPM

The maximum speed is reduced with damping and closed loop, since timing margins and MCU processing load is then higher.
These numbers will vary somewhat between ESCs.

Revision history:

- Rev1.0: Initial revision based upon BLHeli for AVR controllers
- Rev2.0: Changed "Eeprom" initialization, layout and defaults
    Various changes and improvements to comparator reading. Now using timer1 for time from pwm on/off
    Beeps are made louder
    Added programmable low voltage limit
    Added programmable damped tail mode (only for 1S ESCs)
    Added programmable motor rotation direction
- Rev2.1: (minor changes by 4712)
    Added Disable TX Programming by PC Setup Application
    therfore changed EEPROM_LAYOUT_REVISION = 8
    Added Vdd Monitor as reset source when writing to "EEProm"
    Changed for use of batch file to assemble, link and make hex files
- Rev2.2: (minor changes by 4712)
    Added Disable Throttle Re-Arming every motor start by PC Setup Application
- Rev2.3: (minor changes by 4712)
    Added bugfixed (2x CLR C before j(n)c operations)thx Steffen!
- Rev2.4: Revisions 2.1 to 2.3 integrated
- Rev3.0: Added PPM (1050us-1866us) as accepted input signal
    Added startup rpm as a programming parameter
    Added startup acceleration as a programming parameter
    Added option for using voltage measurements to compensate motor power
    Added governor target by setup as a governor mode option
    Governor is kept active regardless of rpm
    Smooth governor spoolup/down in arm and setup modes
    Increased governor P and I gain programming ranges
    Increased and changed low voltage limit programming range
    Disabled tx programming entry for all but the first arming sequence after power on
    Made it possible to skip parameters in tx programming by setting throttle midstick
    Made it default not to rearm for every restart
- Rev3.1: Fixed bug that prevented chosen parameter to be set in tx programming
- Rev3.2: ...also updated the EEPROM revision parameter
- Rev3.3: Fixed negative number bug in voltage compensation

Fixed bug in startup power calculation for non-default power
Prevented possibility for voltage compensation fighting low voltage limiting
Applied overall spoolup control to ensure soft spoolup in any mode
Added a delay of 3 seconds from initiation of main motor stop until new startup is allowed
Reduced beep power to reduce power consumption for very strong motors/ESCs
- Rev3.4: Fixed bug that prevented full power in governor arm and setup modes
Increased NFETON_DELAY for XP_7A and XP_12A to allow for more powerful fets
Increased initial spoolup power, and linked to startup power
- Rev4.0: Fixed bug that made tail tx program beeps very weak
Added thermal protection feature
Governor P and I gain ranges are extended up to 8.0x gain
Startup sequence is aborted upon zero throttle
Avoided voltage compensation function induced latency for tail when voltage compensation is not enabled
Improved input signal frequency detection robustness
- Rev4.1: Increased thermal protection temperature limits
- Rev5.0: Added multi(copter) operating mode. TAIL define changed to MODE with three modes: MAIN, TAIL and MULTI
Added programmable commutation timing
Added a damped light mode that has less damping, but that can be used with all escs
Added programmable damping force
Added thermal protection for startup too
Added wait beeps when waiting more than 10 sec for throttle above zero (after having been armed)
Modified tail idling to provide option for very low speeds
Changed PPM range to 1150-1830us
Arming sequence is dropped for PPM input, unless it is governor arm mode
Loss of input signal will immediately stop the motor for PPM input
Bug corrected in Turnigy Plush 6A voltage measurement setup
FET switching delays are set for original fets. Stronger/doubled/tripled etc fets may require faster pfet off switching
Miscellaneous other changes
- Rev6.0: Reverted comparator reading routine to rev5.0 equivalent, in order to avoid tail motor stops
Added governor range programmability
Implemented startup retry sequence with varying startup power for multi mode
In damped light mode, damping is now applied to the active nfet phase for fully damped capable ESCs
- Rev6.1: Added input signal qualification criteria for PPM, to avoid triggering on noise spikes (fix for plush hardware)
Changed main and multi mode stop criteria. Will now be in run mode, even if RC pulse input is zero

Fixed bug in commutation that caused rough running in damped light mode
Miscellaneous other changes
- Rev7.0 Added direct startup mode programmability
Added throttle calibration. Min>=1000us and Max<=2000us. Difference must be >520us, otherwise max is shifted so that difference=520us
Added programmable throttle change rate
Added programmable beep strength, beacon strength and beacon delay
Reduced power step to full power significantly
Miscellaneous other changes
- Rev8.0 Added a 2 second delay after power up, to wait for receiver initialization
Added a programming option for disabling low voltage limit, and made it default for MULTI
Added programable demag compensation, using the concept of SimonK
Improved robustness against noisy input signal
Refined direct startup
Removed voltage compensation
Miscellaneous other changes
- Rev9.0 Increased programming range for startup power, and made it's default ESC dependent
Made default startup method ESC dependent
Even more smooth and gentle spoolup for MAIN, to suit larger helis
Improved transition from stepped startup to run
Refined direct startup
- Rev9.1 Fixed bug that changed FW revision after throttle calibration or TX programming
- Rev9.2 Altered timing of throttle calibration in order to work with MultiWii calibration firmware
Reduced main spoolup time to around 5 seconds
Changed default beacon delay to 3 minutes
- Rev9.3 Fixed bug in Plush 60/80A temperature reading, that caused failure in operation above 4S
Corrected temperature limit for HiModel cool 22/33/41A, RCTimer 6A, Skywalker 20/40A, Turnigy AE45A, Plush 40/60/80A. Limit was previously set too high
- Rev9.4 Improved timing for increased maximum rpm limit

- Rev10.0 Added closed loop mode for multi
  Added high/low BEC voltage option (for the ESCs where HW supports it)
  Added method of resetting all programmed parameter values to defaults by TX programming
  Added Turnigy K-force 40A and Turnigy K-force 120A HV ESCs
  Enabled fully damped mode for several ESCs
  Extended startup power range downwards to enable very smooth start for large heli main motors
  Extended damping force with a highest setting
  Corrected temperature limits for F310 chips (Plush 40A and AE 45A)
  Implemented temperature reading average in order to avoid problems with ADC noise on Skywalkers
  Increased switching delays for XP 7A fast, in order to avoid cross conduction of N and P fets
  Miscellaneous other changes
- Rev10.1 Relaxed RC signal jitter requirement during frequency measurement
  Corrected bug that prevented using governor low
  Enabled vdd monitor always, in order to reduce likelihood of accidental overwriting of adjustments
  Fixed bug that caused stop for PPM input above 2048us, and moved upper accepted limit to 2160us
- Rev10.2 Corrected temperature limit for AE20-30/XP7-25, where limit was too high
  Corrected temperature limit for 120HV, where limit was too low
  Fixed bug that caused AE20/25/30A not to run in reverse
- Rev10.3 Removed vdd monitor for 1S capable ESCs, in order to avoid brownouts/resets
  Made auto bailout spoolup for main more smooth