BL 电调调参界面参数解释

目录

一． BLHeli_S 概述

BLHeli_S firmware is the next generation code, following the base BLHeli code. BLHeli_S固件是在遵循BLHeli代码的基础上，进行优化的新代码。

BLHeli_S is designed for superior performance in multirotors, and uses hardware generated motor pwm for smooth throttle response and silent operation. BLHeli_S为使用硬件生产马达PWM控制信号的多马达系统提供绝佳的性能。油门响应更顺滑，马达声音更安静。

All codes use damped light mode.代码使用于轻阻尼（刹车）模式。

Damped light does regenerative braking, causing very fast motor retardation, and inherently also does active freewheeling.

轻刹车模式利用反馈刹车，延时低，并且采用主动续流技术平衡刹车产生的损耗。

The code supports features to prevent sync loss. There are tuneable parameters that can make the code run well even in the most demanding situations, although default settings will work excellently in normal operating environments.

本代码支持同步保护功能。提供可调参接口，让马达在特定要求下也能胜任工作。同时，即使使用默认的参数，在大部分场合，也有出色的工作性能。

The code supports regular 1-2ms pulse width input, as well as Oneshot125 (125-250us), Oneshot42 (41.7-83.3us) and Multshot (5-25us).本代码支持常规1-2ms脉冲宽度输入信号，比如Oneshot125(125-250us), Oneshot42 (41.7-83.3us)和Multshot (5-25us).

Three Dshot signal rates are also supported (from rev16.5), Dshot150,Dshot300 and Dshot600.

从版本v16.5开始，支持3种信号频率的Dshot协议，分别是Dshot150，Dshot300，Dshot600

The input signal is automatically detected by the ESC upon power up.

The code also supports a beacon functionality, where the ESC will start beeping after a given time of zero throttle. This can be very useful for finding lost crafts.

在电调上电时，自动识别信号协议。本代码还支持定时警报功能（BB响）。零油门在持续时间超过给定时间后，电调将发出警报声。这个功能可用在炸机后，寻声找回飞机。

二． Code naming convention:固件命名规则

The BLHeli_S codes are named with a letter, another letter and two numbers, in addition to the revision. For example "A_L_10_REV16_0.HEX".

The first letter denotes the pinout of the MCU.

The second letter is either L or H. L is for 24MHz MCUs, and H is for 48MHz MCUs. The two numbers denote the FET switching deadtime. The unit is 20.4ns.

Some FET drivers have adaptive FET deadtime control, and for these 00 is usedto denote FET switching deadtime.

BLS版本号的命名规则是，由2位字母+2位数字。例如"A_L_10_REV16_0.HEX"。其中第一位字母代表MCU的引脚，第二位字母是L或者H。L代表24MHz的MCU频率，H是代表48MHz的MCU频率。2位数字代表场效应管FET的开关死区时间。基本单位是20.4纳秒。某些场效应管FET驱动本身具备死区自适应控制功能，对这些特殊管子，用数字00代表其开关死区参数。

三． Programming parameters:参数项解说

3．1 Startup power: 启动功率

Startup power can be set to relative values from 0.031 to 1.5. This is the maximum power

that is allowed during startup. Actual applied power depends on throttle input, and can be lower, but the minimum level is a quarter of the maximum level.

Startup power also affects bidirectional operation, as the parameter is used to limit the power applied during direction reversal.

For low rpms, the maximum power to the motor is limited, in order to facilitate detection of low BEMF voltages. The maximum power allowed can be set via the startup power parameter. A lower startup power parameter will give lower maximum power for low rpms (this is implemented from rev16.1).

启动功率可设置为0.031至1.5（相对值）。 这就设定了启动时允许的最大功率。 而实际施加的功率取决于油门输入，并且可以更低，但最小值是最大值的四分之一。

启动功率也会影响双向操作（换向操作），因为该参数也用于限制方向反转时施加的功率。

对于低转速电机，对电机的最大功率进行限制，以便于检测低BEMF电压。 允许的最大功率可以通过启动功率参数设置。 低转速下，可以通过设置这个启动功率参数，来间接设定其最大功率。（这是从rev16.1实现）。

3．2 Commutation timing: 换向时序调节参数（即马达进角参数调节）（Motor Timming）

Commutation timing can be set to low/mediumlow/medium/mediumhigh/high, that correspond to 0^0/7.5^0/15^0/22.5^0/30^0 timing advance.

该参数可以设置为low/mediumlow/medium/mediumhigh/high五档 ,分别对应**提前**角度0°/7.5°/15°/22.5°/30°换向.

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 can result 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.

通常，设置为Medium就有不错的表现性能。但如果电机运行不顺畅有卡阻呆滞现象，就可以更改这个数值进行调整。

如果马达的磁感（磁性）比较高，那么就会有更长的换向退磁时间。 这可能会导致电机在油门快速增加时出现停止或阻涩现象，这种现象在低转速时候尤为明显！此时，调高这个参数，就能提供更长的换向退磁时间，匹配更换。

注：进角就是马达里提前换相的角度， 可以调整进角，小量改变马达的最大转速，进角越高，最大转速越高，同时消耗的功率也越大。但是，要仔细测试改了进角后的实际效果，再决定是不是真的需要更改。进角大，刹车困难，损耗和电流冲击也大，一般不用改。在特殊场合需要爆发，可以临时修改一下，但小心别烧了电调/马达！！！

我们知道，通电导体在磁场中运动，受到力的作用，90度方向力最大，偏离90度越多，力逐渐衰减。所以加大这个角度，让转子上的磁铁受到的推动转动的磁场力增大。进角并不是90度，不同绕线组和磁铁数，决定理论最大进角，太早换相，反而磁场推力就变成阻力，所以电调软件上调进角是有限制的。实际上要综合考虑发热、漆包线，电调能力，震动，刹车反冲电流的因素。

3．3 Demag compensation:消磁补偿参数

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 mentioned above, setting high commutation timing normally helps, but at the cost of efficiency.

Demag compensation is an alternative way of combating the issue. First of all, it detects whena demag situation occurs.

消磁补偿功能，可以防止由于电机换向后消磁时间过长而导致电机失速问题。典型现象是，当你快速推高油门时，马达有停止转动，或者马达走走停停有卡顿现象。特别是在转速越低，这种现象越明显。如上面“换向时序参数”中所提到，此时换向值设置高一些，可以改善卡顿现象，但会降低马达的效率，浪费电池电量。此时调节消磁补偿参数，是另外一种解决方法。首先，它检测马达在什么时间发生消磁，然后执行以下控制：

- In this situation, there is no info on motor timing, and commutation proceeds blindly with a predicted timing.如果没有检测到马达定时信息，则按照预设的进角参数进行换向

- In addition to this, motor power is cut off some time before the next commutation. 除此之外，在下次换向之前，马达功率会被切断一段时间。

A metric is calculated that indicates how severe the demag situation is. The more severe the situation, the more power is cut off. 采用数字对消磁情况进行测算和显示。消磁情况越严重，断电越多。

When demag compensation is set to off, power is never cut. 当停用消磁补偿功能时，则马达不会被断电。

When setting it to low or high, power is cut. For a high setting, power is cut more aggressively. 当启用消磁补偿功能时，则马达会被断电。设置参数值越大，马达断电越凶猛（靠提前停电让马达消磁）

Generally, a higher value of the compensation parameter gives better protection.通常，补偿参数值越大，对马达的保护效果越好。

If demag compensation is set too high, maximum power can be somewhat reduced.但如果

补偿参数值设置得太高，则马达的最大功率会被消减，马达无法工作在最大功率下。

3．4 Direction：马达转向

Rotation direction can be set to fwd/rev/bidirectional fwd/bidirectional rev. 马达旋转方向可设置为fwd（正转）/ rev（反转）/双向正转/双向反转。

In bidirectional mode, center throttle is zero and above is fwd rotation and below is reverse rotation. When bidirectional operation is selected, programming by TX is disabled.

在双向转动模式下，油门杆居中为零位，油门杆高于中位为正转，油门杆低于中位，则反转。当启用双向转动模式后，遥控调参功能将被自动停用。

3．5 Beep strength：蜂鸣音量参数

Sets the strength of beeps under normal operation. 用于设置正常操作下的蜂鸣音量。

3．6 Beacon strength：定时待机警报声响音量

Sets the strength of beeps when beeping beacon beeps. The ESC will start beeping beacon beeps if the throttle signal has been zero for a given time. Note that setting a high beacon strength can cause hot motors or ESCs! 该参数用于设置马达警报鸣叫声音量。如果一直零油门(让马达在通电状态又没有对马达操作，也叫待机时间)在给定时间耗尽以后，电调控制马达发出警报声提醒用户。需要注意的是，如果此参数设置太高，则会让马达和电调发热。

3．7 Beacon delay：延时警报音设置

Beacon delay sets the delay before beacon beeping starts. 该参数用于设置延时多长后才开始发出警报音。

3．8 Programming by TX: 遥控器调参功能

If disabled, throttle calibration is disabled. 如果停用改功能，则油门校准功能也被停用

3．9 Min throttle, max throttle and center throttle:最大油门，最小油门，中位油门

These settings set the throttle range of the ESC. Center throttle is only used for bidirectional operation. The values given for these settings are for a normal 1000us to 2000us input signal, and for the other input signals, the values must be scaled.此项参数用于设置电调的油门行程量。中位油门只对双向转动模式有效。正常情况下，油门信号值落在1000us到2000us之间。如果对于其他数值输入信号，则需要做相应比例换算。

3．10 Thermal protection: 过热保护

Thermal protection can be enabled or disabled. And the temperature threshold can be programmed between 80ºC and 140ºC (programmable threshold implemented from rev16.3).可停用或启用过热保护功能。温度阀值可在80摄氏度到140摄氏度之间进行设置。（改功能从16.3版本开始）

The programmable threshold is primarily meant as a support for hardware manufacturers to use, as different hardwares can have different tolerances on the max temperatures of the various components used. 可编程设置温度阀值主要是供硬件厂商使用。因为不同硬件对最高温度的温度误差的容错率不同。

3．11 Low RPM power protect: 低转速功率保护设置

Power limiting for low RPMs can be enabled or disabled. Disabling it can be necessary in

order to achieve full power on some low kV motors running on a low supply voltage. However, disabling it increases the risk of sync loss, with the possibility of toasting motor or ESC. 可启用或停用低转速功率限制功能。 对于某些低KV值马达，工作在低电压时候，需要停用改工厂才能正常工作在最高功率状态下。不过要注意，停用该功能，可能会加剧马达不同步现象，导致烧坏马达。

3. 12 Brake on stop: 停车刹车设置

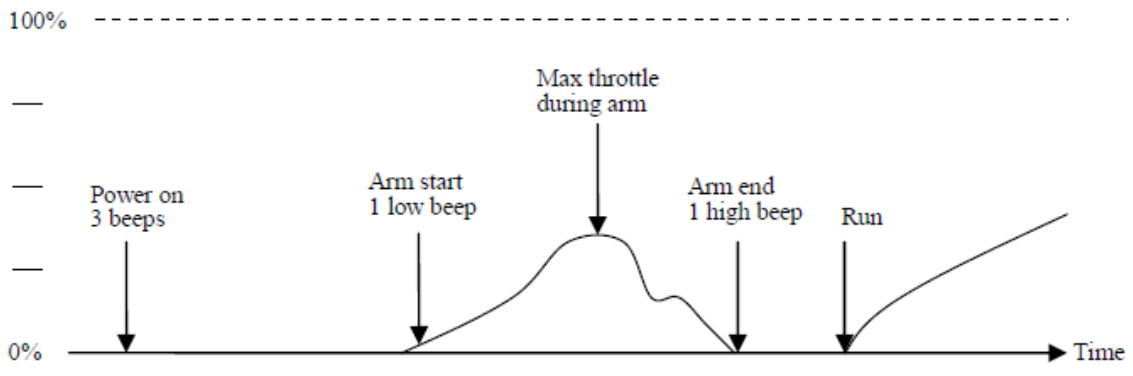
Brake on stop can be enabled or disabled. When enabled, brake will be applied when throttle is zero. For nonzero throttle, this setting has no effect. 可停用或请改功能。如果启用，则油门为0时，会有刹车功能（收油立刻停止转动）。非0油门值情况下，没有刹车功能。

3. 13 LED control: LED 控制设置

LEDs can be controlled on ESCs that support it. Up to 4 LEDs can be turned on or off.最高可控制开或关4个LED灯。要求电调支持LED灯控制功能。

3. 14 Arming sequence: 解锁信号序列

The figure below shows an example of throttle value versus time.下图是油门值与时间关系图



At power on, the ESC beeps 3 beeps. 上电时，电调发出3声鸣叫。

When throttle signal is detected, it beeps one low tone beep. This signals the start of the arming sequence. 当侦测到油门信号时，发出一声低沉响声。表示解锁信号序列开始

Then, when or if throttle is zero, it beeps one high tone beep. This signals the end of the arming sequence. 然后，当油门值为0，发出一声明亮响声，代表解锁信号序列结束。

Also, if 100% throttle is detected during the arming sequence, the ESC starts throttle calibration. 另外，当在解锁信号序列中，检测到100%油门信号，则电调开始校准油门行程。

If the esc is armed and sees zero throttle for a given time, it beeps beacon beeps, which are about a beep per three seconds. 当电调已经被解锁，但油门在给定时间内保持0油门，每3秒钟发出警报声。

3. 15 Input signal: 输入信号

Available throttle calibration range is from 1000us to 2000us, and the difference between minimum and maximum throttle must be more than 140us (70us in bidirectional mode). If a calibration is done where the difference is less than 140us (70us), the maximum will be shifted so that the difference is 140us (70us).油门校准可用范围是1000us到2000us，并且最值和最小值之间差别要在140us以上(双向模式下需大于70us)。如果在差别小于140us(70us) 情况下校准，则会引起最大值漂移，以确保差别在140us以上。

Oneshot125 mode works just the same as regular 1-2ms mode, the only difference is that all timing is divided by 8. And the same for Oneshot42, where all timing is further divided by 3. Multishot also works similarly, except the input signal range is 5-25us.

Oneshot125模式工作方式与常规1-2ms模式相同，唯一的区别在于Oneshot125的时序是常规时序的1/8（8倍速度）。Oneshot42工作方式也类似Oneshot125。只是时序是常规时序的

1/3(3倍速)。Multishot也类似，但Multishot的输入信号范围是5-25us。

The input signal is always sampled with the MCU clock, at 24MHz or 48MHz.

For MCUs running at 24MHz, input signal pulse rates above 8kHz are not recommended.

For MCUs running at 48MHz, input signal pulse rates up to 32kHz are supported.

But please remember that signal rates faster than the gyro or PID loop of the FC does not make sense, it only results in unnecessary loading of the MCU.

输入信号通常从MCU时钟频率采样，同样是24MHz或者48MHz。

对于工作在24MHz的MCU而言，输入信号不推荐使用超过8KHz的脉冲频率。

对于工作在48MHz的MCU而言，输入信号的脉冲频率最高可支持32KHz。

不过大家要清楚，信号频率过高，超过陀螺仪的采样频率，或者超过飞控PID控制器的循环采样计算频率，就没什么意义了（太监急，皇帝不急，太监急了也没用：））

Dshot150 theoretically supports up to 8kHz input rates, Dshot300 supports 16kHz and Dshot600 32kHz. MCUs running at 24MHz do not support Dshot600. Generally it is recommended to run 48MHz MCUs at Dshot300, as the benefit from a higher signalling speed at Dshot600 is outweighed by the increased margins and robustness of Dshot300. Similarly Dshot150 is the recommended max for 24MHz MCUs.

理论上，Dsot150协议支持高达8kHz输入频率；Dshot300协议支持高达16kHz输入频率；Dshot600协议支持高达32kHz输入频率。工作在24kHz的MCU无法支持Dshot600协议。

一般情况，推荐工作在48kHz的MCU使用Dshot300协议，因为Dshot600协议的信号速度虽然快，但与Dshot300协议的容错率和系统健壮性相比，Dshot300综合表现更佳。同样道理，对于工作在24MHz的MCU而言，推荐使用Dshot150协议。

When the input signal is Dshot, throttle calibration is disabled, and the throttle calibration values are ignored.当输入信号采用Dshot协议，将自动停用油门校准功能，并且忽略油门校

准值。

3．16 Thermal protection: 过热保护

The ESC measures temperature within the MCU and limits motor power if the temperature is too high. 电调会检查MCU的温度，如果温度过高，则会限制马达的功率。

Motor power is limited in four steps:限制马达功率遵循以下4步：

- If the temperature is above threshold, motor power is limited to 75%.

- If the temperature is above threshold plus 5^{0}C, motor power is limited to 50%.

- If the temperature is above threshold plus 10^{0}C, motor power is limited to 25%.

- If the temperature is above threshold plus 15^{0}C, motor power is limited to 0%.

1． 若MCU温度超过设定值，则马达功率限定在75%；

2． 若MCU温度比设定值高出5°C，则马达功率限定在50%；

3． 若MCU温度比设定值高出10°C，则马达功率限定在25%；

4． 若MCU温度比设定值高出15°C，则马达功率限定在0%；

3．17 Stall protection: 失速保护

If the motor has attempted to start but not succeeded for a few seconds, it will stop attempting and wait for throttle to be zeroed before attempting again. 若马达在启动前几秒期间，马达尝试启动不成功，那么油门值回归零位之前，马达将放弃启动，等待油门值回归零位后，再进行下一次启动尝试。

3．18 Regenerative braking / active freewheeling:反馈制动与主动续流设置（同步整流）

Damped light mode is implemented by doing regenerative braking, and inherently active freewheeling is also implemented.

Then losses due to braking are counteracted by the reduced losses of active freewheeling.

轻阻尼模式（轻刹车模式）是通过执行反馈制动和主动续流（同步整流）实现的。目的是利用减少主动续流的损耗来平衡刹车损耗。

注：主动续流（AFW，active freewheeling）正式名称应该叫同步整流，英文synchronous rectification或者active rectification. 核心是采用一个主动电路元件（比如FET）替代低效二极管。Active Free-wheeling 主要是电调软件方面的功能，硬件上基本不需要改变电路。不过前提是mos管的开关速度必须够快才能实现active free-wheeling

3．19 Motor PWM: 马达 PWM 频率设置

The motor PWM frequency is always 24kHz. The resolution is 2048 steps for MCUs running at 48MHz on ESCs that have automatic deadtime control. On ESCs that have fixed deadtime, the PWM resolution is 1024 steps. For MCUs running at 24MHz, the PWM resolutions are half. 马达的PWM频率恒定为24kHz。对于工作在48kHz的具有自动开关死区时间控制的电调而言，其分别率是2048（即分为2048格）。对于固定开关死区时间的电调而言，其PWM分辨率是1024（即1024格）。对于工作在24MHz的MCU，其PWM信号分辨率减半。

3．20 Maximum speeds: 最大速度

For ESCs with a 24MHz MCU, maximum speed is limited to 350k eRPM, at which point

power to the motor is limited.

For ESCs with an MCU running at 48MHz, this number is 500k eRPM.

For Dshot input signal, the supported max eRPMs are somewhat reduced.

对于24MHzMCU的电调，最大速度限制在35万eRPM，在该转速处，马达功率也被限定。

对于48MHzMCU的电调，最大速度限制在50万eRPM。

对Dshot输入信号，最高速度会有所降低。

四． Beeps - Normal operation: 蜂鸣声 – 正常操作提示音

Power up: 上电时123（do re mi）连续短响叫一次

Throttle signal detected (arming sequence start):侦测到油门信号（解锁脉冲开始），一声低音长响

Zero throttle detected (arming sequence end):侦测到0油门信号（解锁脉冲结束），一声高音长响

After this, the motor will run.至此，解锁成功，马达可转动。

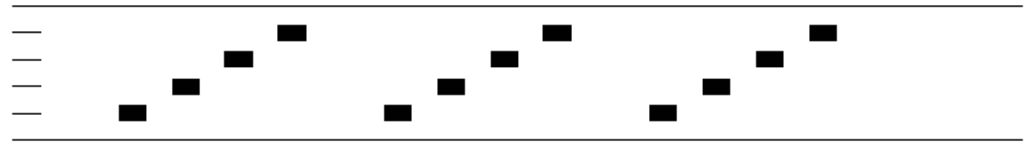
五． Beeps - Throttle calibration: 蜂鸣声 – 油门校准操作提示音

Power up: 上电时123（do re mi）连续短响叫一次

Throttle signal detected (arming sequence start):侦测到油门信号（解锁脉冲开始），一声低音长响

When throttle is above midstick (measuring max throttle):当侦测到油门高于中位（开始测量最大油门），间断4声高音短响，代表此阶段正在检测中

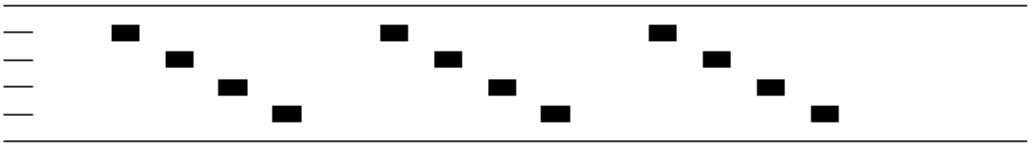
If throttle is above midstick for 3 seconds:如果油门在中位以上保持3秒，发出1234连续由低音到高音的4声短响，并间断重复这4声三次。代表最大油门值已存储完成。



This beep sequence indicates that max throttle has been stored

When throttle is below midstick (measuring min throttle): 当侦测到油门低于中位（开始测量最小油门），间断2声低音短响，并回重复这两声，代表此阶段正在检测中

If throttle is below midstick for 3 seconds: 如果油门在中位以下保持3秒，发出4321连续由高音到低音的4声短响，并间断重复这4声三次。代表最小油门值已存储完成。



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, or just continue running your ESC. 至此，油门校准数值已保存成功。你可以拔掉电源或继续使用电调做其他事。

六. Revision history: 版本变更记录

- Rev16.0 Started. Built upon rev 14.5 of base code

Using hardware pwm for very smooth throttle response, silent running and support of very high rpms

Implemented reverse bidirectional mode

Implemented separate throttle gains fwd and rev in bidirectional mode

Implemented support for Oneshot42 and Multishot

- Rev16.1 Made low rpm power limiting programmable through the startup power parameter

- Rev16.2 Fixed bug that prevented temperature protection

Improved robustness to very high input signal rates

Beeps can be turned off by programming beep strength to 1

Throttle cal difference is checked to be above required minimum before storing. Throttle cal max is not stored until successful min throttle cal

- Rev16.3 Implemented programmable temperature protection

Improved protection of bootloader and generally reduced risk of flash corruption

Some small changes for improved sync hold

- Rev16.4 Fixed bug where bootloader operation could be blocked by a defective

"eeprom" signature

- Rev16.5 Added support for DShot150, DShot300 and DShot600

- Rev16.6 Fixed signal detection issue of multishot at 32kHz

Improved bidirectional mode for high input signal rates

忠达模型增加附录：AFW 技术 Active Free Wheeling（同步整流技术）

核心：PWM 信号关闭期间，电感中有残余电流，会通过电感体二极管发热浪费。此时增加一个 MOS 管，控制该 MOS 管在 PWM 信号关闭期间打开，把电感中的残余电流导回供下次利用，减少残余电流通过体二极管发热。因为 MOS 管发热量远远小于二极管。

What is active free-wheeling?? And what are the benefits???

Some electrical basics first..

1) Every motor is an inductor.

2) The current in an inductor can never change instantly.

3) The voltage across an inductor can change instantly.

4) A FET is a like switch, and turns on/off with a given gate signal

5) A diode is like a valve, only allows current to flow in one direction.

Some BLDC Basics:

1) BLDC motors have three phases, which consist of coils (or inductors).

2) Commutation is achieved by energizing each phase in order, causing a rotating magnetic field, which

causes the magnets to follow.

3) Motor power is controller by adjusting average motor voltage. Average voltage is varied by chopping the commutation signal with a PWM signal. 50% ON and 50% OFF means the phase is only seeing half the applied voltage.

Some ESC Basics:

1) Every ESC uses FETs to switch the voltages going to our motor phases.

2) The FETs used all have inbuilt diodes, called Body Diodes.

3) Every ESC requires some form of Free-wheeling. There are two types: Passive (Diode) Free-wheeling, or Active (FET Based) Free-wheeling.

But what is Free-wheeling??

Ok.. Its not what you think it is. Many of you think free-wheeling means: When you release the throttle, free-wheeling allows the motor to keep rotating freely.. I can understand why someone would think that.. Yes the name is a little deceptive. Freewheeling is actually much more complex than that, and to truly understand how it works, you need to understand the basics mentioned above, and have some general understanding with electronics circuits.

Passive FW

Ok, now the hard part.. Look at the picture below: You will see two arrows. A RED arrow showing us how current flows when the PWM is ON, and the Blue arrow showing us how the current flows when the PWM is OFF. When a Phase is energized, the current begins to flow from the Supply (U), through FET Q1, through the motor phases, then back out of FET Q6. Then FET Q1 Turns off (PWM-OFF at Partial

load). Now as we learnt from the above basics, the current cannot cease flowing instantly. And it can no longer flow via FET Q1 because its turned OFF. So the residual current (stored in the winding inductance) finds a new path via D2 (the Body Diode in FET 2). Then FET Q1 begins to conduct again during our PWM-ON, and the cycle repeats with the ON-OFF-ON-OFF nature of PWM. The lower the PWM duty cycle, the longer the Body Diode D2 conducts, thus more heat. I hope this makes sense.

This is the in-efficient method of free-wheeling, or Passive FW. Why is it in-efficient?? Because diodes burn voltage off as heat. Yep, even FET Body Diodes burn voltage too.

The above free-wheeling method (Passive FW) is the type seen in Scorpion and Castle ESC's. These ESCs require heat-sinks to dissipate the free-wheeling losses.

So how do we make it efficient?? and not burn off voltage??

Well, we use Active Free-Wheeling.

Active FW

Ok, refer to this diagram.. As you can see our loop currents are the same. When the phase is energised, the current flows via FET M1, through the motor, and then out of FET M6. When the Phase is de-energized, the residual current flows via FET M2, instead of diode D2. . All we are doing is turning FET M2 ON when FET M1 turns OFF (to provide a current loop).

FETs dont burn voltage like diodes, thus providing us with a more effecint means of controlling phase voltage.

AFW is seen in Kontronik, YGE and now.. YEP.

Active free-wheeling is pretty complex, and difficult to understand. It also has other names like Synchronous rectification, or Active rectification. Whenever you hear these names, you can safely assume there is a power circuit somewhere, where an active component (like a FET) has replaced a in-efficient diode.

Video Explanations:

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