ESC32 Current limiter calibration | AutoQuad

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Introduction

The purpose of ESC32 current limiter calibrations is to generate the Current Limiter (CL) terms for a particular motor/prop/powersource combination. This is done by a automated procedure in which the motor is asked to rapidly change speed and current is monitored.
The purpose of the current limiting calibration is to allow the motor a very fast response on smaller duty increases while still limiting the current if a large increase is demanded.
The biggest advantage of ESC32 (in open loop mode) is that there is no throttle shaping that traditional ESCs implement. That alone is enough to get good performance. However, without this traditional protection, current must be limited as you cannot give a motor 100% throttle changes in a single timestep. So the tradeoff for having quick throttle response is simply having to pick and implement an appropriate current limit.

How does the current limiter work

The job of the current limiter is to limit the maximum current allowed on ESC32. This limit is important to set correctly –overcurrent events can damage motors or make them loose sync leading to a rotor failure. The current limiter uses an onboard high-precision shunt to measure the current flow.
ESC32 has 2 options for current limiting: PI controller (default) or calibrated mode with CL terms. The intended behavior of the current limiter are the same whether you are using PI or CL terms – to reduce currents that could be harmful for motor and esc or make the motor loose sync.
The default setting is PI controller. In this mode, the current limiter is set to a maximum current allowed for RPM increase and overall current. The PI controller reads the current from the shunt and limits it according to the P and I terms of ESC32. But this is not ideal, and while this method works good for most motors and props, there is some motor and prop combinations that simply require individual calibration to make sure sync and commutation is not lost on rapid RPM increases.
If CL terms are generated and used, the current is limited by proactively reducing the throttle step change before it is seen instead of reacting to an over current situation as the PI controller does. This extra safety means that you can run closer to the limit without fear of going over current between timesteps
Current limiter calibration is always recommended to do for you specific motor/prop/power source combination.

Spikes and constant current

To understand current limiting, we have to differentiate between constant current and current spikes:
· Constant current is the current needed to maintain a given RPM.
· Current spikes are the short and large spikes that occur when the ESC is rapidly increasing RPM. It requires more energy to make a mass change speed than it takes to make that object maintain its speed. So even if your motor and prop only draws 10A at full speed, it may take 3-5 times that current to get from 10 to 100 percent duty in a single timestep (1/400 of a second) of the ESC and that may burn the ESC and motor if allowed. So we need to limit those spikes.
However, since we very rarely need to increase duty with more than 20-30 percent in a single timestep, we can allow the ESC such increases in speed very fast while still setting a limit for what is allowed if a larger increase is demanded.
This means we can have crisp response in the “normal range” and still be sure that if a large increase in speed is ever demanded, it then gets smoothed out over a few timesteps to avoid an overcurrent event that could cause the motor to loose sync or burn something out.

Setting the limit

There are 2 parameters you need to understand: Calibration current limit and overall current limit.
The calbration current limit defines how much current is allowed in one timestep during calibration. This is set during the CL calibration. If the motor looses sync during the calibration run, you should start over with a lower calibration current limit.
Overall limit is the maximum allowed current allowed. This is set in the ESC32 general settings. If the current limiter is not calibrated this limit should maximum be a few A more than what the motor draws constantly at 100 percent duty.
If the current limiter has been calibrated then set the overall limit at same or slightly above limit set in calibration.
The calibration procedure will output the result of the calibration expressed as 5 CL terms. It will also show the duty cycle increases and the currents resulting.
When the CL terms generated are loaded to the ESC32, they will be used instead of the PI controller to limit the maximum current increase in a single timestep. Maximum constant current is still limited by the overall current limiter setting.
So in rare cases, you could need a higher overall setting but in most cases the calibration and overall limits should be roughly the same or slightly higher for the overall limit
So even though a motor may be rated 25A from manufactorer, if you ramp throttle duty from 20 to 70 percent in a single timestep, the current needed by the ESC may very well exceed those 25A for a short while and that can be enough for the motor to loose sync or for the ESC and/or motor to burn out.

Example:

MT 3506-25 with 1150 Graupner Eprop – the 3506 is a known “trouble motor” that looses sync on rapid RPM increases with fast update ESC´s. But it works perfectly with ESC32, if correctly calibrated.

To get this motor to run properly the CL calibration was run on 4S 8000 25C, with a limit of 13A for the calibration. This still allows about 35 percent duty changes in 1 timestep without loosing sync. But calibration was run at higher current limit, the duty increases would exceed 35 percent and the motor would loose sync and stop.
The overall current limiter was set to 14A, to allow the motor to reach 100 percent duty with a little overhead, but the calibrated current limit will still limit the fast changes to 13A.

This is result is very much in line with specs for MT3506-25. A current of 14A on a 4S is 235W. As the motor is rated max 14.6A and 260W we are pretty close to that. This combination is flying a FCP-HL hexa at 1.8.-2.5 kg with no problems and the motors can reach 100 percent, but ramps exceeding 35 percent increase in a single timestep is smoothed out to keep things sane.