TEKNOLOGISK INSTITUT

Lithium ion battery in drone

The Danish Technological Institute

Title:
Lithium ion battery in drone

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1. Project description

The drone battery protection features were tested to find the level of protection in terms of overcurrent and overvoltage. The test also examines the possibility that charging from a PC or from an external USB charger can cause damage to the drone battery.

The drone is labelled "Hawk Drone M15" and is described in the instruction manual as a ''6-axis gyro aircraft".

2. Background

The battery is labelled:

-SPY 802035
+3.7V 400mAh 1.4Wh
20160704

According to the accompanying manual, the battery must be charged through a PC USB connector or socket. USB versions 1 and 2 provide 5V and 500mA, while the USB version
3 delivers 5V and 900mA. If the battery is charged using an independent charger, it can be charged with higher currents, typically 1A, but a 2A charger is also available.

It has not been possible to find a specification of the above battery, but similar batteries labelled "802035 / 3.7V / 400mAh" have the following specifications.

Max. Charge voltage	4.2V	
Min. Discharge voltage	3.0V	
Max. charge current	1C = 400mA	
Max. continuous discharge current	20C = 8A	
Max. burst discharge current	40C = 16A	(Single peak current)

Other similar batteries typically have a discharge rate of 2 C = 800mA or less.

The battery is assumed to be of the lithium polymer cobalt cathode type, and it is emphasised that the aforementioned specifications do not necessarily apply to the tested battery.

The battery is equipped with a protection print, which among other things is equipped with an integrated circuit, DW01A-G, which is designed to provide protection against power surges, undervoltage and overcurrent.

3. Test results

To find the limits for overvoltage, undervoltage and overcurrent, the battery was tested via the mounted protection print. The results are shown in the table below.

Examination of:	Effect	Performance Battery 1	Performance Battery 2
Undervoltage	Discharging: 400mA	No reaction above 2V	No reaction above 2V
Undervoltage	Discharging: 1200mA	No reaction above 1V	
Overvoltage	Charging: 500mA at 4.4V	Power interrupted at 2.7V	
Overvoltage	Charging: 900mA at 4.3V		Power interrupted at 2.8V
Overcurrent	Discharging: 2.5A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Discharging: 4 A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Discharging: 8 A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Discharging: 12A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Discharging: 15A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Charging: 2.5A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Charging: 3.4A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Charging: 4.0A in approx. 3 sec.	No reaction	No reaction
Overcurrent	Charging: 5.0A in approx. 3 sec.	No reaction - power fades out	

There was an overvoltage limit of about 4.275V, which slightly exceeds the limit as cobalt cathode batteries typically should not be charged to more than 4.20V.

It was not possible to find a undervoltage limit, which means the battery can be discharged far below the limit specified for this type of battery, typically between 2.5V and 3.0V. Over-discharge will usually result in increased battery degradation, and can at worst cause a battery fire on subsequent charging.

Nor was it possible to find an overcurrent limit within reasonable limits. At 8A the battery was warm while it quickly became heated at 12A. At 15A the battery was very hot in just the 3 seconds that the current was turned on, and overheating usually results in a battery fire. The heat dissolved the glue on the piece of tape protecting the components of the protection print against short circuiting, and it deposited dark spots on the tape near the MOSFET transistors.

Whether the lack of undervoltage and overcurrent limits is due to errors in the protective print, where a component is mounted to handle these functions, or whether there is a deliberate disruption of these, are beyond the scope of this test.

No thermal sensor was found which means that temperature protection is also lacking.

4. Conclusion

The test found no undervoltage limit, current limit or thermal protection of the battery, and as this is handled outside of the drone, for example during recharging, the protection level was found to be unacceptable, even if these protective functions are eventually implemented in the drone.

During recommended charging via the USB port of a PC, the battery exceeded normal charging current by 2.25 times. If charged through a USB-3 port, and if net adapters are used, this overrun could be more than doubled, without the customer having been warned. This would normally lead to unnecessary increased degradation (loss of battery capacity), but in the worst case it could lead to the development of lithium-plating, which in turn can cause a battery fire. This will especially be the case when charging beyond the usual recommended surge limit.

It was not possible to find an exact specification of the battery, but if one is sourced at a later date, it can be compared with the report's findings. However, the battery is used outside of the safety limits, which either reduces battery lifetime significantly or at worst involves the risk of the battery catching fire.

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