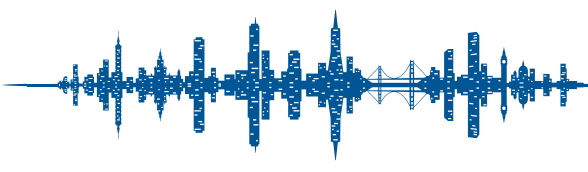
Battery life in wireless headsets



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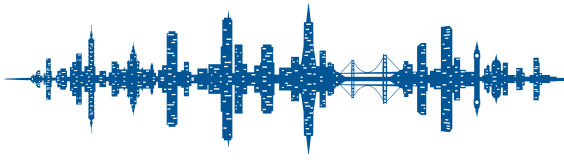
Introduction

We have all experienced the everyday challenge of juggling our portable devices and keeping them charged especially while travelling. Have we ever thought about the best way of charging these devices and when to charge, should we wait until the battery is almost flat or keep them on charge so they are always topped up? Does the way we charge our devices affect the battery life and longevity of the product? You may have heard of terms such as battery "memory effect" or "fast charging" what do these terms mean and should I be concerned about them.

This paper has been created from publicly available information primarily from Electropedia and recommendation's from Plantronics Marketing & Engineering.

Plantronics has a long history of designing wireless headset devices for the office and contact centre markets along with a division focused on providing solutions for the consumer and mobile professional. Plantronics invested early into wireless technology and were the 20th member of the Bluetooth consortium and associate member of the Bluetooth SIG (Special Interest Group) The first Bluetooth product the M1000 was launched in March 2001 and by 2003 Plantronics launched the M3000 the first Bluetooth headset with all day talk time.

Ten years on and the company is still working hard to deliver unparalleled audio experience that reflects the company's 50+ years of innovation. As the way we live and work continues to evolve along with the increasingly remote workforce, Plantronics remains dedicated to helping people work smarter by developing products that empower them to work effectively across all workspaces regardless of their location making wireless headsets more of an essential part the employee tool kit.



Battery technology

Lithium is the lightest of metals and it floats on water. It also has the greatest electrochemical potential which makes it one of the most reactive of metals. These properties give Lithium the potential to achieve very high energy and power densities.

Lithium batteries have now taken their place as the rechargeable battery of choice for portable consumer electronics equipment such as mobile phones, Bluetooth and DECT wireless headsets.

Lithium battery technology has many benefits over other battery types such as:

1. **Very low self discharge rate.**
2. **Less susceptible to memory effect. No reconditioning needed.**
3. **Tolerates microcycles.**
4. **Long cycle life.**

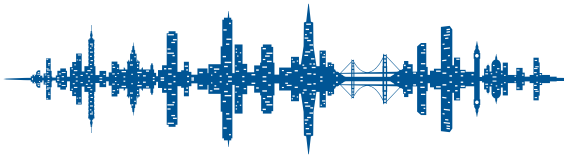
Lithium batteries and memory effects

Lithium batteries should be charged regularly and they are not overly susceptible to microcycles. This is where the battery is subject to rapid, shallow charge and discharge cycles and the battery lasts longer with partial charges rather than full charges. Lithium batteries are far less susceptible to memory effect than other battery technologies, memory effect is where the battery "remembers" how much discharge was required on previous discharges and would only accept that amount of charge in subsequent charges which obviously reduces the battery performance. Lithium batteries are therefore ideal for use in headsets where regular charging or partial charging is necessary either where the user is docking the headset between calls to top up the battery or for leaving on a long charge periods overnight or weekend.

Lithium-ion polymer batteries

Lithium-ion polymer batteries use liquid Lithium-ion electrochemistry in a matrix of ion conductive polymers that eliminate free electrolyte within the cell. The electrolyte thus plasticises the polymer, producing a solid electrolyte that is safe and leak resistant. Lithium polymer cells are often called Solid State cells. Because there's no liquid, the solid polymer cell does not require the heavy protective cases of conventional batteries. The cells can be formed into flat sheets or prismatic (rectangular) packages or they can be made in odd shapes to fit whatever space is available (ideal for headsets). As a result, manufacturing is simplified and batteries can be packaged in a foil. This provides added cost and weight benefits and design flexibility. Additionally, the absence of free liquid makes Lithium-ion polymer batteries more stable and less vulnerable to problems caused by overcharge, damage or abuse.

Lithium Ion Polymer (LiPo) batteries are used in the majority of Plantronics wireless headsets including: Savi™ 700 Series, Savi™ 400 Series, CS500™ Series, Voyager™ Pro UC, Voyager™ Pro HD, BackBeat® GO, Marque™ M155™



Talk time and fast charging

Talk time is a key parameter that is commonly quoted by wireless headset manufacturers. Talk time is the maximum amount of time you can expect a product to perform on an active call before the battery requires a further charge. Manufacturers typically state an "Up to" X hours of talk time as a number of factors can influence this specification such as distance between the headset and mobile or base unit, also wideband audio can have a significant reduction in the talk time versus narrowband due to the radio transmitting more or longer data packets.

Partial charging between calls is recommended to top up the battery charge level, if the battery charge level is low, Plantronics headsets will rapid charge initially usually for the first 30% of the charge time then trickle charge for the remaining 60% of the charge cycle carefully controlling the battery temperature. In CS540 for example the headset takes 3 hours to fully charge from empty but will charge to 50% of battery capacity in the first hour. Fast charging is sometimes referenced by manufacturers as a product 'feature' however if you fast charge a battery too quickly you can overheat and damage the battery also reducing its life expectancy as described below in temperature effects.

Battery cycle life

This is defined as the number of complete charge – discharge cycles a battery can perform before its nominal capacity falls below 80% of its initial rated capacity. Lifetimes of 300 to 500 full charge-discharge cycles are typical in batteries Plantronics uses. The actual ageing process results in a gradual reduction in capacity over time. What happens is the discharge current remains the same, while the capacity reduces over time. As a result, the battery needs to be recharged more often.

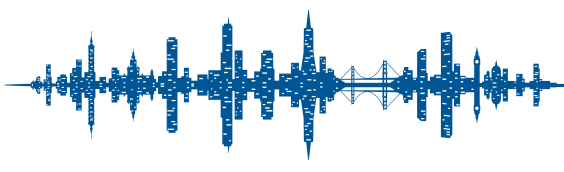
When a cell reaches its specified lifetime it does not stop working suddenly. The ageing process continues at the same rate as before so that a cell whose capacity had fallen to 80% after 1000 cycles will probably continue working to perhaps 2000 cycles when its effective capacity will have fallen to 60% of its original capacity. There is therefore no need to fear a sudden death when a cell reaches the end of its specified life.

Battery longevity – what impacts the lifespan of the battery?

All batteries have a finite life is due to occurrence of the unwanted chemical or physical changes to, or the loss of active materials of which they are made. Otherwise they would last indefinitely.

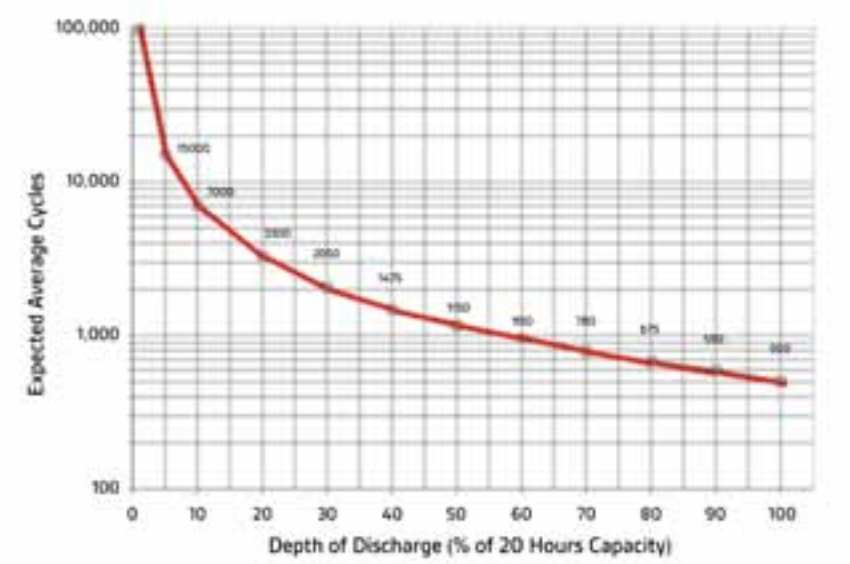
Temperature effects

Chemical reactions internal to the battery are driven either by voltage or temperature. The hotter the battery, the faster chemical reactions will occur. High temperatures can thus provide increased performance, but at the same time the rate of the unwanted chemical reactions will increase resulting in a corresponding loss of battery life. The shelf life and charge retention depend on the self discharge rate and self discharge is the result of an unwanted chemical reaction in the cell. Temperature therefore affects both the shelf life and the cycle life as well as charge retention since they are all due to chemical reactions.



Depth of discharge

The relation between the cycle life and the depth of discharge (DOD) is also logarithmic as shown in the graph below. In other words, the number of cycles yielded by a battery goes up exponentially the lower the DOD. This holds for most cell chemistries. There are important lessons here both for designers and users. By restricting the possible DOD in the application, the designer can dramatically improve the cycle life of the product. Similarly the user can get a much longer life out of the battery by using cells with a capacity slightly more than required or by topping the battery up before it becomes completely discharged.



For the user, the time the product can be used before recharging is important. In addition to the battery capacity, the discharge current is important. The discharge current depends on technology, but also on smart operation of the electronics. Low power modes, behaviour in idle-wearing mode, etc. are also important when it comes to the operation time of a product.

Mobile phone users typically recharge their batteries when the DOD is only about 25 to 30 percent. At this low DOD a lithium-ion battery can be expected to achieve between 5 and 6 times the specified cycle life of the battery which assumes complete discharge every cycle. Thus the cycle life improves dramatically if the DOD is reduced. The same behaviour applies to headset batteries. Regular charging by docking your headset between calls or when on a break will top up the battery charge and will increase the longevity of the battery.

Charging accessories

Plantronics manufactures various charging accessories to make charging easy wherever you are, some examples are shown below:

IN-THE-OFFICE: Savi™ W440

The Savi W440 headset includes several accessories. This first one is a convenient desk charging stand, the LED on the stand shows when the headset is charging and when it is fully charged. Plantronics free software also includes a battery meter which resides on your PC system tray showing the battery level, you also get a warning pop up on your PC screen when it is time to charge at 25% capacity.

ON-THE-MOVE: Savi™ W440

When travelling with the The Savi W440 the headset includes a hard carry case and a USB charging accessory, but if you buy the optional Deluxe USB charger as shown allowing you to charge one battery when you are using the other. The headset supports a hot swappable feature so you can change the battery even while on a live call and you will not lose the call. This essentially gives you unlimited talk time.

ON-THE-MOVE: Voyager™ Pro UC

The Voyager Pro UC headset comes with convenient carry case to hold your headset and the mini USB adapter. The headset itself includes enhanced voice alerts and with a tap of the power button tells you the battery talk time remaining. Plantronics free software also includes a battery meter which resides on your PC system tray showing the battery level and you also get a warning pop up on your PC screen when it is time to charge at 25% capacity.

IN-THE-OFFICE: Marque™

The Marque headset includes an innovative 2in1 USB charging solution so you can charge both your smartphone and headset together from one USB socket.

The headset includes a free iPhone battery meter app for your smartphone. This shows you the headset charge level displayed on your phone alongside the phone charge level indicator

ON-THE-MOVE: BackBeat® GO

The BackBeat GO stereo Bluetooth headset also comes with an innovative 2in1 USB charging solution so you can charge both your smartphone and headset together from one USB socket.

The headset can deliver upto 4.5 hours of listening and talk time. Battery meter shows automatically on your iPhone or iPad indicating the charge level left on your earbuds.