

Energy Saving with UCS Compatible and “Zero” Mobile Phone Chargers

Viktor Rébay

Óbuda University

rebay.viktor@phd.uni-obuda.hu

***Abstract:** To reduce the energy needs of everyday mobile telecommunication, we have to use compatible and high efficiency mobile phones chargers. The environmental impact and the energy use of this kind of chargers have three major stages during its life cycle: manufacturing, transportation and the use phase. During the active phase the charging efficiency and the no-load consumption are the main aspects. The energy waste caused by external power supplies was significant in the first 10 years of the GSM era, but the trends have changed by now. The European Commission launched the IPP Pilot Project on Mobile Phones with the world’s top five mobile phone vendors, and they introduced a voluntary energy rating system to categorize mobile phone chargers by no-load energy consumption. A larger group of manufacturers started the Universal Charging Solution (UCS) project in 2009, to improve the efficiency of mobile phone chargers, and harmonise them based on the Micro-USB connector. In this article the reasons, the parts, the status and the possible future of this ongoing project have been analysed, concerning the newest charger techniques with zero no-load consumption as well.*

***Keywords:** mobile phone charger; universal charging solution; UCS; no-load consumption; energy efficiency; zero charger*

1 Introduction

Nowadays mobile phones and smartphones are more important in our daily life than ever. These devices are not simply communication proxies anymore, mobile phones are always with us, and they do not only make our life easier in more and more fields, they have become essential part of our life. All mobile phones are sold with some fixed and some optional accessories, where the most popular external device is the charger, which serves the same purpose from the beginning. Chargers are not widely compatible with each other, but many times we can use an old item with our new mobile phone. In these cases this compatibility results in at least one redundant charger, which generates extra and unnecessary expenses for the consumers and pointless environmental impact during manufacturing.

If we consider the Life Cycle Assessment of a mobile phone charger, we have to calculate with the environmental impacts, the energy use and greenhouse gas emissions from raw material manufacturing to the recycling of the product. Mobile phone charger’s energy use from cradle-to-grave have three major stages: manufacturing, transportation, and the use phase. To reduce the energy use, and of course the additional environmental impact, we have to cut down the number of unnecessarily produced and redundant chargers, and reduce the wastage during the active phase. The optimal way to reach the first goal is to sell mobile phones without charger in the box, but to achieve this, we need brand independent, widely compatible chargers. The use phase is also important, because two third of the used energy in this phase can be wasted with old and inefficient devices, if the charger remains plugged in after the charging process is finished. Naturally, the charging efficiency during the charging process can also results in an essential part of the total energy wastage.

To improve both fields, the top mobile phone vendors with the support of the European Commission, started a project together to harmonise mobile phone chargers based on the Micro-USB connector, with the implementation of EU Directive 2005/32/EC, which regulates the no-load electric power consumption and average active efficiency of external power supplies.

2 External Power Supplies

External Power Supplies (EPS) are sold in large amount worldwide and on the Community Market as well. In fact, the external charging devices of mobile phones, which we call chargers, are adapters, and they are only converting the line power into the required low voltage. Because mobile phone chargers do not contain charging circuit (which is the part of the electronics, inside the phone), these devices belong to the EPS category.

2.1 Energy Waste Caused by External Power Supplies

The common trait of these devices is that their energy consumption is one of the major environmental aspects during their life cycle. Their energy consumption is composed of losses of power conversion and no-load dissipation, which means 17 TWh energy wastage annually, corresponding to 6.8 Mt of CO₂ emissions only in the European Union [1]. To realize how much this wastage is, consider Table 1 (based on Eurostat data, where the original ktOE (kilo tonne of oil equivalent) energy unit is converted to TWh for the easier comparability), which contains the final energy consumption of electricity in 2009 of European Union countries, where this value is less then 17 TWh.

Table 1
Final energy consumption of electricity 2009 [2]

Country	Value	
Malta	147 ktoe	1.70961 TWh
Cyprus	409 ktoe	4.75667 TWh
Latvia	525 ktoe	6.10575 TWh
Luxembourg	525 ktoe	6.10575 TWh
Estonia	572 ktoe	6.65236 TWh
Lithuania	720 ktoe	8.37360 TWh
Slovenia	971 ktoe	11.29273 TWh
Croatia	1334 ktoe	15.51442 TWh

It can be seen that the summarized energy consumption of electricity of the four smallest EU consumer countries is comparable to the energy wastage of the external power supplies used in the European Union, which is more than the total energy consumption of electricity in Croatia.

Mobile phone chargers have a dominant share (Fig. 1) in the total energy consumption in primary load products powered by EPS. Without any changes, the consumption of External Power Supplies is predicted to reach 30.6 TWh by 2020 [3][1].

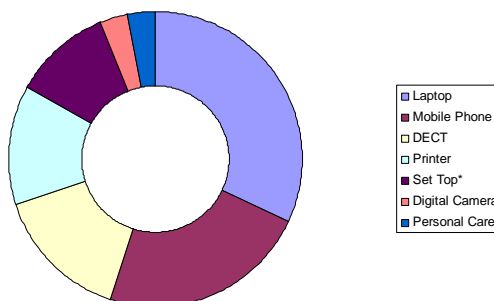


Figure 1

Share of total energy consumption in primary load product categories powered by EPS in 2009 (* "set top" means set top boxes and modems) [3]

3 Efficiency of Mobile Phone Chargers

The main subjects of this article are mobile phone chargers and efficiency of these devices. But it is important to note that the overall charging efficiency of a battery operated mobile phone is far behind the efficiency of chargers. It depends on the three parts of the charging system: the battery, the charging circuit, and the EPS. The overall charging efficiency equals to the multiplication of the individual

efficiency of these three parts. For example, if the EPS operates with 66.95% efficiency and both the charging circuit and the battery have outstanding capabilities (for example: 85% and 90%), the overall efficiency will be $66.95\% \cdot 85\% \cdot 90\% = 51.22\%$ only [4].

3.1 Stars and Chargers

The European Commission launched the Integrated Product Policy (IPP) Pilot Project on Mobile Phones with the world’s top five mobile phone vendors (Nokia, Sony Ericsson, Motorola, Samsung and LG) in 2005. The project is in the fifth stage now [5]. This group has introduced a voluntary energy rating system to categorize mobile phone chargers by no-load energy consumption, making the decision easier for customers. Five star rated chargers have the less no-load energy consumption, and the most wasteful group marked with no star, as you can see in Table 2. Important to note that this kind of energy rating system tells nothing about the average charging efficiency.

Table 2
No-load consumption score chart [6]

★★★★★	<0.03W
★★★★	0.03W – 0.15W
★★★	0.15W – 0.25W
★★	0.25W – 0.35W
★	0.35W – 0.5W
<i>no star</i>	>0.5W

3.2 No-Load Wastage Trends

Although in the last few years the global market share of Nokia reduced, it is unambiguous that this company dominated the cellular phone market globally from the beginning of the GSM era until now. To see the progress of no-load energy savings development on mobile phone chargers, the types of originally boxed chargers sold with new Nokia cellular phones announced from 1998, until the middle of 2011 have been collected and summarized in Table 3. Because the different regulations and market needs, selling the same model with various charges in different regions is an old-established practice. For the more precise comparability all the used data is based on the European, mostly on the Hungarian market, where Nokia sold only one, two, four and five star chargers with new mobile phones in the examined period.

Table 3
Nokia charger categories by no-load consumption (1998–2011)

	<i>no star</i>	★	★★	★★★★	★★★★★
1998		100%			
1999	20%	80%			
2000	25%	75%			
2001		100%			
2002		83.33%	16.67%		
2003		26.09%	73.91%		
2004		26.32%	73.68%		
2005		15.63%	65.63%	18.74%	
2006			50%	50%	
2007			55%	45%	
2008			25.58%	53.49%	20.93%
2009				30.77%	69.23%
2010				34.78%	65.22%
2011				53.85%	46.15%

3.3 European Commission Regulation

“Energy efficiency initiatives are influenced by international regulations and policies as a response to the climate change issue.” [7] In conjunction with Ecodesign Consultation Forum, the European Council has concluded that the life cycle energy consumption and the use-phase electricity consumption can be reduced significantly, and has adopted the commission regulation (EC) No 278/2009 of implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies [1]. In comparison with the “no action” scenario, with these regulations annual savings of 9 TWh of electricity consumption in the Community will be reached by 2020 (more than the annual energy consumption of electricity in Lithuania), which is equivalent to 3.6 Mt of CO₂ emissions [3].

4 Universal Charging Solution

Increasing energy efficiency is very important, but it is not enough itself to solve the incompatibility problems, described in [8]. To solve both issues, ten companies (Apple, LG, Motorola, NEC, Nokia, Qualcomm, Research in Motion (RIM), Samsung, Sony Ericsson and Texas Instruments) have signed a Memorandum of Understanding (MoU) about providing common charger for mobile phones and submitted this MoU to the European Commission on 29th June

2009. The European Commission has welcomed this proposal and commitment of harmonising mobile phone chargers based on the Micro-USB connector.

To choose the connector’s type (between the phone and the charger) was a point of great nicety, because it is almost inconceivable that the biggest brands switch to an existing, but vendor specific standard to use that as their common charging interface in the future. The brand, which has been using and maybe has invented the selected interface, would be in a great advantage, which is not acceptable for the competitors. To invent a brand new interface would also have been an opportunity, but a very risky one. Developers are usually maximizing the use of existing, tested and well-functioning components, instead of developing new subsystems, so the vendor independent USB port and standard was the evident choice. It is well tested and most of the brands already integrated it into certain mobiles.

Universal Charging Solution (UCS) covers all new data-enabled phones (excluding some special types, like wristwatch phones) [9], and contains three separate parts, which ensure its reusability. These subsystems, the Common Power Supply (charger), the Common Detachable Cable and the Charging and Local Data Connector on the phone, are specified in OMTP Common Charging and Local Data Connectivity recommendations [10].

4.1 Common Power Supply

The main part of the Universal Charging Solution is the Common Power Supply (CPS), which presents an USB Standard-A receptacle (Fig. 2) and fully compatible with USB Battery Charging Specifications 1.1 [11]. The CPS provides DC 5.0V \pm 5%, and delivers 850mA at least. Besides standard interface, energy saving is also a priority. With the improved active energy utilization, the average charging efficiency $[0.075 \cdot \ln(P)] + 0.561$ meets and exceeds EU directive 278/2009 energy efficiency targets [1], and with ≤ 0.15 W no-load power consumption the new chargers achieve the stricter requirement of the *Code of Conduct on Energy Efficiency of External Power Supplies version 3* (unchanged in the latest (version 4) CoC) [12] of the European Commission [13]. If we compare these efficiency targets with the IPP Pilot Project on Mobile Phones energy rating system (3.1), we can see, that UCS Common Power Supplies must be at least four star chargers.

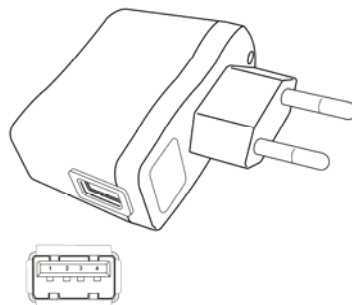


Figure 2

Common Power Supply with USB Standard-A receptacle

4.2 Common Detachable Cable

The connection between the Common Power Supply and the mobile phone is realised with a standard detachable USB cable, which has a USB Standard-A plug on its CPS end and a USB Micro-B plug on the phone side (Fig. 3) [13]. This is not the invention of the UCS. This part has stood the test of time in many fields, like MP3 players, digital cameras, GPS receivers. The modular design also allows to use the CPS with a non UCS compatible phone (or with any other devices with similar input voltage requirements) only by replacing the cable.

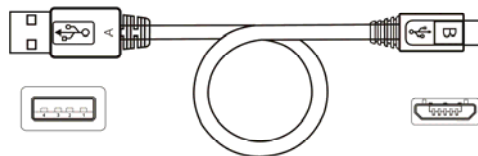


Figure 3

USB Standard-A to Micro-B Cable

4.3 Charging and Local Data Connector

The Charging and Local Data Connector is based on Open Mobile Terminal Platform (OMTP) Local Connectivity Recommendations v1.0 [10]. The receptacle on the phone (Fig. 4) must be USB Micro-AB or USB Micro-B compatible, which means it needs to meet in all parameters with Universal Serial Bus Micro-USB Cables and Connectors Specification Revision 1.01, as a part of Universal Serial Bus Revision 2.0 specification [14].

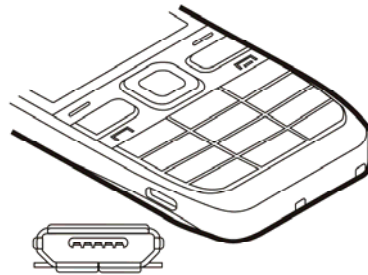


Figure 4

Mobile phone with Charging and Local Data Connector

4.4 State of the UCS in Late 2011

After the third quarter of 2011 it can be laid down as a fact that new, data ready mobile phones support the Charging and Local Data Connector only with very few exceptions. Some of the manufacturers use the micro USB receptacle exclusively, some others, like Nokia, use the brand specific charger connector and the UCS compatible micro USB interface as well.

The other important fact is, that all new mobile phones go to the end users with a charger in the box. The latter could be manufacturer specific, micro USB compatible with integrated charging cable, or full UCS compatible, modular implementation, but we can clearly see that the charger is still attached to all new mobile phones in the third quarter of 2011. The fully UCS compatible version is not so frequent yet, though all the biggest brands announced a UCS compatible charging device.

If we take no notice of modularity, it can be ascertained that the chargers of new mobile phones meet and exceed EU directive 278/2009 energy efficiency targets [1] as part of the UCS requirements. Among the products examined in details, Nokia announced the last cellular phone with worse than 4 star category in the third quarter of 2008, and supplied all new mobile phones with chargers less than 0.15W no-load consumption only in the last three years.

4.5 Future of UCS

Taking the advantage of modularity, any mechanical changes (without backward compatibility) could be easily overcome by only with a new cable, which means lower cost for the consumers and less e-waste and manufacturing pollution on the environmental side after any invention of the physical charging interface. However this modularity is unfortunately not the characteristic of chargers in late 2011, which reduces the benefits of the new technology. For this reason as a first

step it would be important to increase the proportion of the UCS compatible modular chargers, which could make the technology more flexible.

The first concerning change could be the appearance of the USB 3.0 interface on mobile phones, but due to the untouched power level and the compatible USB 3.0 Micro-B Connector (the USB 2.0 Micro-B plug works in a USB 3.0 Micro-B receptacle) [15] no problem would emerge with the chargers equipped the USB 2.0 Micro-B plug, whether it is UCS compatible modular charger, or a built together version.

Another important step will be when manufacturers start to sell new mobile phones without charger, which is also an essential goal of the UCS project and carries many benefits. This solution is an effective way to reduce the environmental impact, by saving energy and lowering pollution emissions during the manufacturing process, and decreasing the number of useless chargers, which cuts down the amount of hazardous waste. Without charger, the box of the mobile phones could also be lighter and smaller, reducing the emissions and energy required to transport and store. I think this modification will be very unusual for the consumers at first time, but it could reduce the price of new mobile phones, what is a tender spot in the markets.

By the spread of the standard, universal mobile phone chargers will result in big improvements ranging from major environmental aspects to daily life as well. But the evolution process must be continuous, improvement of performance and quality is usually a continual process through the whole life cycle of any product [16]. In compliance with this, we can find the revision clause in the Commission Regulation (EC) No 278/2009, Article 7: *“No later than four years after the entry into force of this Regulation the Commission shall review it in the light of technological progress and present the result of this review to the consultation forum.”*[1]

4.6 Chargers with Zero No-Load Consumption

A four star UCS compatible charger generates €0.2913 annually wastage, which could be reduced close to half by decreasing the maximum amount of no-load consumption to the five star category. Only with this step, without improving the active mode efficiency, the annual wastage could be reduced from €0.2913 to €0.1753 per charger. If we calculate with 624 million chargers (in 2009 there were close to 624 million mobile phone subscriptions only in the European Union) the difference is more than 72 million Euro plus the additional environmental impact [8].

Reaching five star category with all new mobile phone chargers would be a great progress. The less than 0.03 W no-load power consumption is acceptable today, but of course not ideal. The newest and technically most advanced third party chargers offer zero standby consumption and high efficiency values during

charging. The zero no-load value does not necessarily mean a charger with absolute no standby power draw, because IEC 62301 Ed 1.0 (Household electrical appliances – Measurement of standby power) defines power usage lower than 5 mW as zero, which can help in the widespread of the new technology, because “zero” is much more saleable than a charger with less than 5 mW standby power consumption.

In a perfect green world every people would disconnect all electronic devices (TV, microwave oven, chargers...) from the mains when these equipments are not in use, achieving the real zero no-load consumption. Of course most people are more comfort-loving than this, so we have to handle this issue from the technical side. Achieving ultra-low standby or no-load consumption is a complex task, and require precise planning with considerable attention to details. “*Losses in EMI circuits, decisions related to startup time, transient response, and other design trade-offs mean that care must be taken in external component choices, not just the IC.*” [17]. In case of chargers, it would be optimal to turn of the charger completely and automatically after the charging process is finished to save energy, which is not a big technical challenge nowadays. The problem is how to turn it on again. There are different approaches to solve this problem.

The AT&T ZERO Charger auto-detects if a device is connected and turns the charger on or off as needed. This solution uses a rechargeable battery to operate a sensor all the time, which determines whether a chargeable device (e.g. mobile phone) is attached or not. This battery provides enough energy to operate a circuit which can turn on the adapter again when a compatible device is connected to charge [18].

The Volt-Star EcoCharger offers the same zero idle current within 15 second after reaching the no-load state, and automatically turns off when it senses that charging process is finished [19]. It is a very useful improvement, because mobile phones have been usually charged at night with a 1-2 hours long process only, when the owner sleeps, and does not get up to disconnect the charged device. This charger uses a switch to call the charger into action again, and start a new charging process. A “start button” is quite unusual on a mobile phone charger, but using this we do not need an extra battery to the proper operation.

Conclusion

Only the most “green” people care about the energy efficiency of a mobile phone charger, for an ordinary subscriber one charger is like the other. For this reason manufacturers and the European Union play important role to provide energy efficient adapters to end users, taking the lead in environmental protection. With the minimum efficiency and limited no-load consumption Universal Charging Solution helps us not only to reduce expenses and mitigate negative environmental impacts, but makes our daily life easier with modular, brand and type independent, interchangeable mobile phone chargers.

The UCS project is rising a bit slower than it was calculated in the original timeline, however all new, data ready mobile phones support the Charging and Local Data Connector in late 2011. This is the first step and necessary condition to reach chargerless mobile phone boxes in the market, which will be the next and very important step in the evolution process of mobile phone chargers, produces less unnecessary energy use and reduced greenhouse gas emission.

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