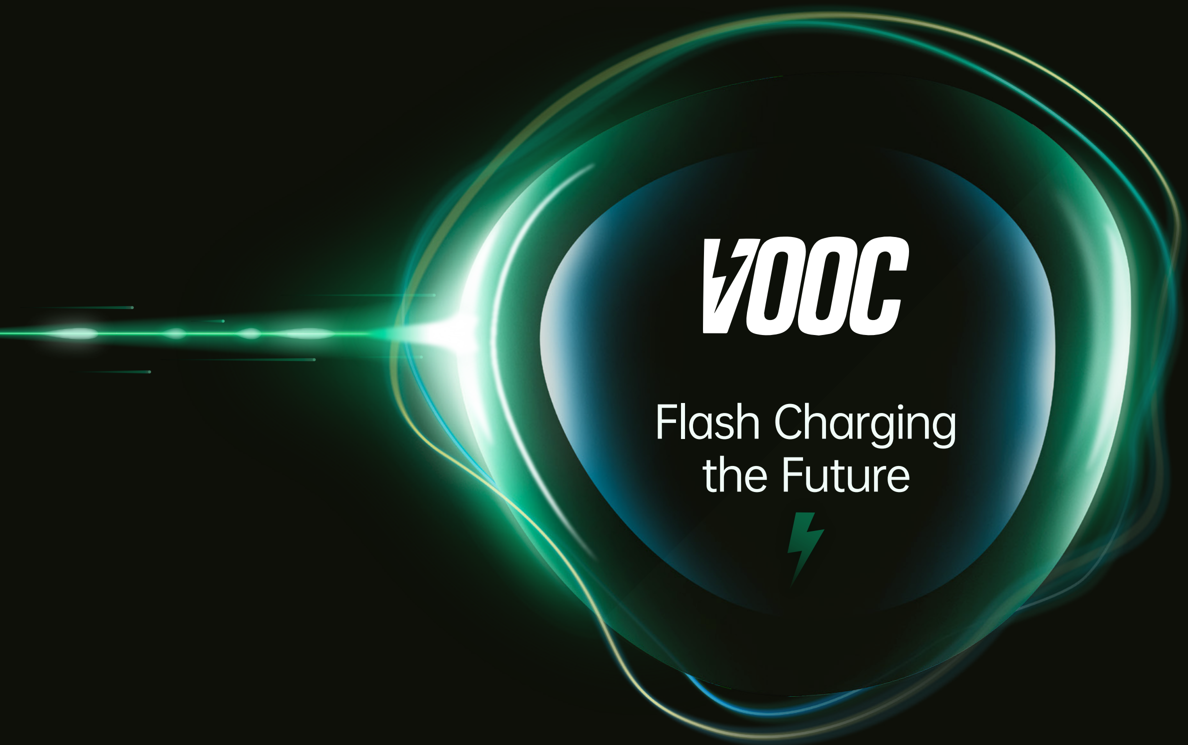

Flash Charging

TECHNICAL PAPER

CONTENTS

PREFACE

Our use of smartphones and other connected devices is constantly increasing. The number of smartphone users worldwide has reached nearly 4 billion - around half the global population[1] at the start of 2021.

As smartphone functions improve, they consume more electricity. This increased power demand comes from higher display resolutions, advanced processors, camera systems and more. But as users expect more from their devices, these raised expectations include better battery life - and higher battery capacities mean longer charging times. Fast charging technology was developed against this backdrop of slow smartphone recharge times.

Fast charging technology can improve charging efficiency, reducing the time to charge devices. Several fast charging solutions have already appeared, mainly falling into two categories: high-voltage, low-current and low-voltage, high current.

While both normal and fast charging are in use, companies have focused on device compatibility with each technology. Many have created new terminals and adaptors, while some have worked towards mutual compatibility, even across a variety of brands. But for the long-term development of fast charging technology, more standardization efforts are needed across several industries.

1 *www.statista.com/statistics/330695/number-of-smartphone-users-worldwide*

1 VOOC FLASH CHARGING TECHNOLOGY OVERVIEW

OPPO first offered a low voltage, fast charge solution in 2014, releasing the independently developed VOOC 22.5W (5V/4.5A) flash charger. This device delivered higher charging power, charging devices four times faster than normal charging technology, and 50% faster than other fast charging technologies.

In 2018, OPPO made further improvements to VOOC flash charging technology, releasing SuperVOOC. SuperVOOC has twice the charging power of VOOC, so the 50W SuperVOOC adapter could charge a 3,400mAh capacity battery to full in 35 minutes. In 2019, the 65W SuperVOOC 2.0 charger could charge a 4,000mAh battery to full in 30 minutes, breaking the previous record.

1.1 Definition of VOOC Flash Charging Technology

According to the definitions of the China Fast Charging Standard Technical Requirements and Test Methods for Fast Charging of Mobile Communication Terminals:

Fast charging is an electrical system which consists of an adaptor, cable and terminal. Charging takes 30 minutes from beginning to end, with an average input current greater or equal to 3A, and the total charge capacity should always be greater than or equal to 60% of the battery's rated capacity.

VOOC (Voltage Open Loop Multi-step Constant-Current Charging) is one of the systems that enables flash charging technology. It relies on dynamic interaction between the adapter and the terminal, as they communicate and work together to track voltage load. This communication underpins direct charging, as it allows the system to control the flow of power and maintain a constant voltage level. The open voltage loop allows for segmented current throughput in high current mode, while the slender design improves the terminal's charging power.

The defining characteristic of VOOC flash charging technology is that it improves the speed and efficiency of fast charging by increasing the current output, rather than the voltage. It also avoids the overheating issue that high-voltage fast charging solutions encounter, thanks to constant voltage increases, an enhanced structure, moving the charging control circuit to the charger, and using charge pump partial pressure technology - all of which also means that it does not need to conduct a secondary voltage conversion.

A diagram of the VOOC flash charging system framework and functional principles is shown below:

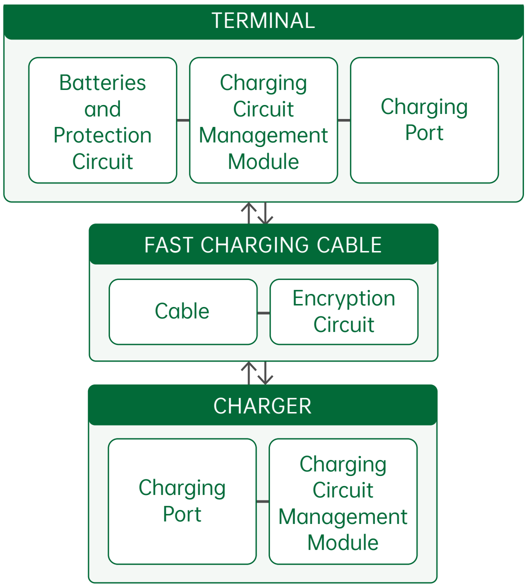

Figure 1.1 VOOC Flash Charging System Framework

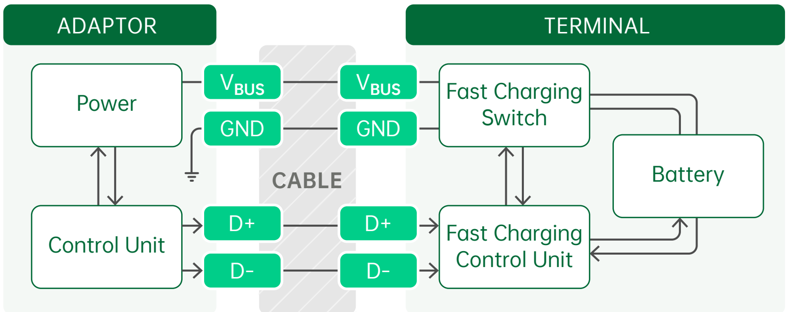

Figure 1.2 VOOC Flash Charging Functional Principle

1.2 Features of VOOC Technology

1 Direct Charging Structure

With direct charging, there is no depressurisation inside the phone. This reduces the amount of heat produced by voltage conversion and improves charging efficiency.

The latest version of VOOC technology - SuperVOOC 2.0 - has added a high precision adjustment function to control current and voltage even more accurately and efficiently, and reduce system losses. It adjusts voltage on a scale between 3V and 10V, and current between 0A and 6.5A, achieving a minimum of 100mA.

2 Two-way Communication

When the phone activates fast charging, the phone and the adapter will monitor and synchronize the status of the phone battery, adapter, interface, and mobile application scenarios in real time. Through this two-way communication between phone and adapter, the adapter can deliver smarter charging, by automatically reducing or increasing charging power as needed.

3 Smart Safety Protection

A safety scheme is in place from the adapter all the way through to the battery. Dedicated charging control units in both the device and the adapter monitor the status of components in real time, checking battery temperature, voltage, current, path impedance and numerous other parameters. The system can then respond quickly if any parameter strays outside the norm, to avoid abnormal charging.

In addition, fast charging only begins when an adapter is connected with the correct encrypted identity authentication. New hardware detection circuits on both the battery and the adapter sides also protect against over-discharge and excessive voltage, current or battery temperature during charging. These variables are also monitored inside the adapter in real time, by a combination of software and hardware, to ensure safe charging in every aspect of the system.

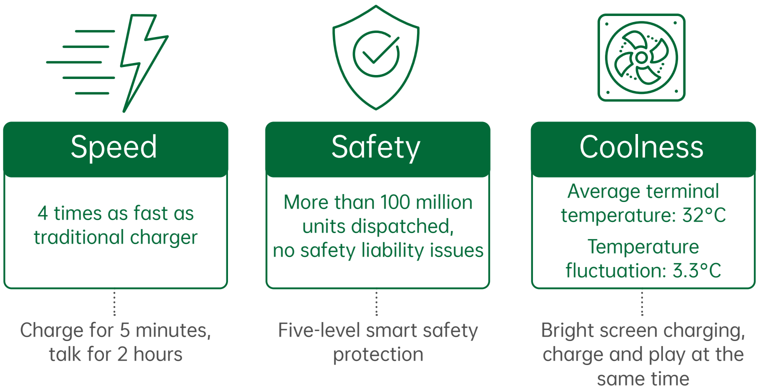

Figure 1.3 Characteristics of VOOC Flash Charging Technology: Speed, Safety, Coolness

2 VOOC STANDARDS & PERFORMANCE ASSESSMENT SCHEME

2.1 Overview of VOOC Standards

In June 2014, the China Telecommunication Technology Labs of the China Academy of Information and Communication Technology, together with OPPO, Huawei, Qualcomm, and MediaTek jointly formulated *YDB 195-2018: Technical requirements and test methods for fast charging of mobile communication terminals*. Five fast charging protocols were standardised, with OPPO's VOOC flash charging protocol named the *E Fast Charge Protocol*. Released on 20 March 2018, *YDB 195-2018* was the first international standard for fast charging technology, and it is now being upgraded to an industry standard.

The aim of this standard is to promote the use of flash charging technology in compatible mobile terminals, steer product R&D, and guide equipment manufacturers. The hope is that this will create a fast, safe and compatible charging environment for mobile phone users, and regulate the development of a flash charging industry.

2.2 E Fast Charge Protocol

The E protocol enables the two-way communication between the fast charging adaptor and mobile communication terminals (referred to below as a "terminal"), which supports VOOC flash charging. Transmission is carried out using serial communication technology, via a D+ D- signal USB data cable.

The E charging system framework diagram is shown in Figure 2.1.

The terminal is connected to an adaptor via a USB cable. D+ is used during transmission by a CLK clock signal, and D- is used during transmission by a DATA data transmission signal.

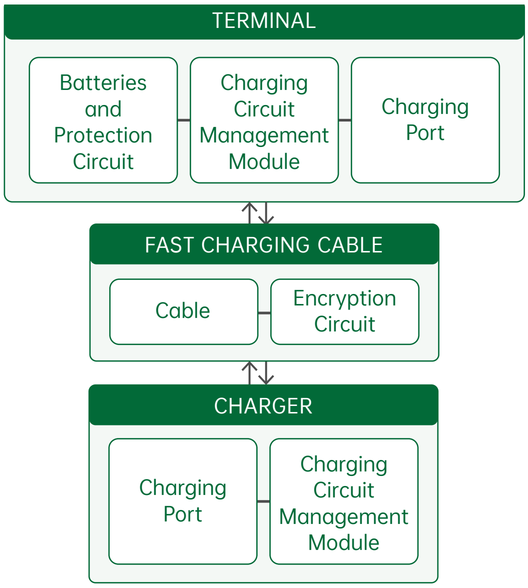

Figure 2.1 The E Charging System Framework

Before switching on fast charging, the terminal and the adaptor must have a complete communication circuit established, to begin the transmission of information. The terminal and the adaptor must have the fast charging function switched on, otherwise only normal charging will occur.

The fast charging adaptor serves as the host, providing a CLK clock signal in the communication process. The signal between the terminal and the adaptor always comes from the adaptor.

2.2.1 Fast Charge Protocol Process

2.2.1.1 The Fast Charge Initiation Process

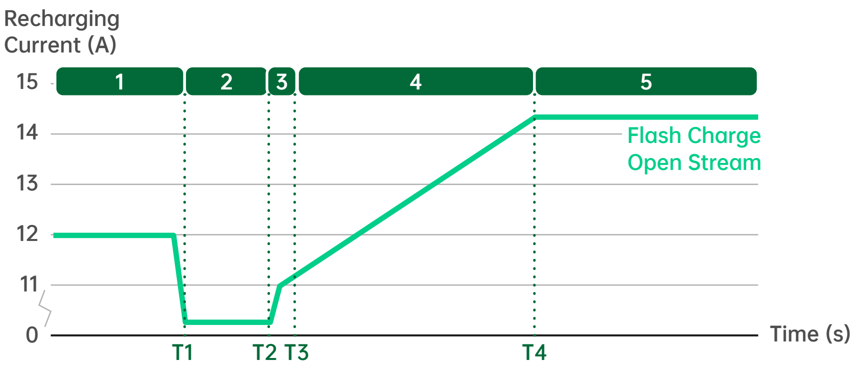

Figure 2.2 The Fast Charge Open Stream

As Figure 2.2 shows, the fast charge starting process contains five stages:

Stage 1

» After the terminal and the fast charging adaptor complete handshake, the terminal will initiate fast charging.

Stage 2

» The adaptor assesses and adjusts the output voltage to a suitable value for the terminal.

Stage 3

» The adaptor receives the maximum charging current supported by the terminal for that state.

Stage 4 & 5

» The adaptor sets its output current at the specified value, and the constant current stage begins.

» When this stage begins, the adaptor initiates a security check and switches on the protection mechanism. During this period, the terminal and the fast charging adaptor are in constant battery contact, ensuring the stability of the charging process.

2.2.1.2 The Fast Charge Communication Process

The fast charge communication process is shown in Figure 2.3.

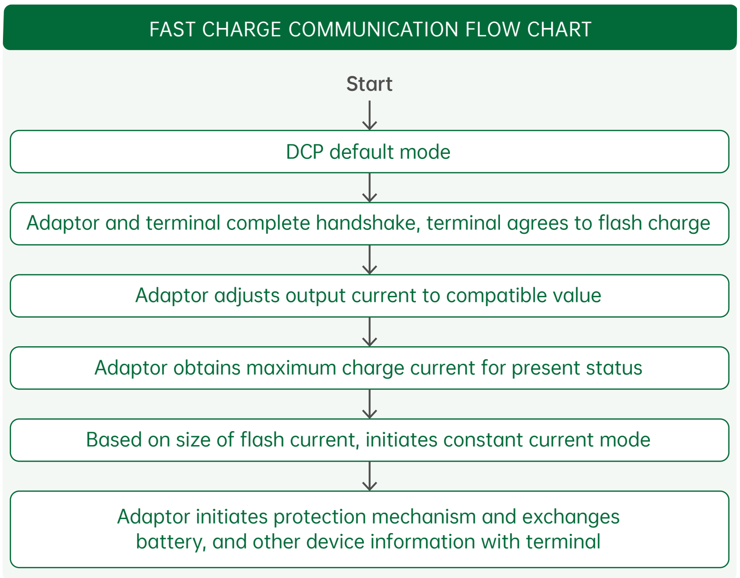

Figure 2.3 Fast Charge Communication Flow Chart

2.2.2 Implementation of the Fast Charge Physical Layer

2.2.2.1 Fast Charge Functions Flow Chart and Principles

The fast charge functions flow chart is shown in Figure 2.4.

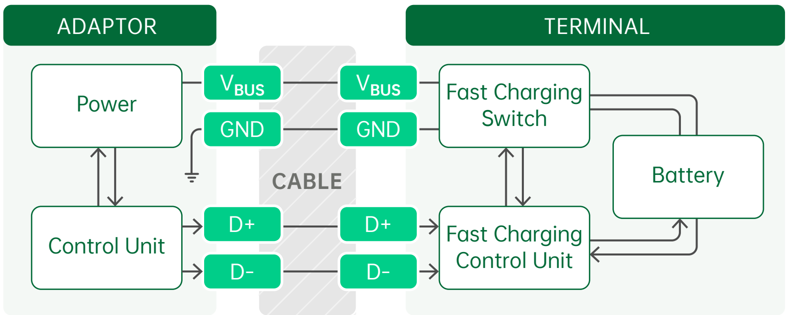

Figure 2.4 Fast Charging Function Principles Block Diagram

The entire fast charging circuit core is comprised of two control units, allocated to the adaptor and terminal. At the fast charging initiation stage, a handshake occurs through a reading of D+ and D- signals from these two units, which control several functions, including adjustment of the power unit's output, the fast charging on/off switch, monitoring the charging process, and handling unexpected errors.

D+ uses a CLK data transmission handshake signal, D- uses a DATA data transmission handshake signal.

2.2.2.2 USB Data Line Structure

The data line at one end should be a USB A-type connector, and its mechanical structure must comply with the requirements of USB 2.0 specifications. The other end of the data line can be a 7Pin Micro-USB B-type connector: its mechanical structure is shown in Figure 2.5.

The data line can also be a USB C-type connector and its mechanical structure design should meet the requirements of the USB 3.1 specification.

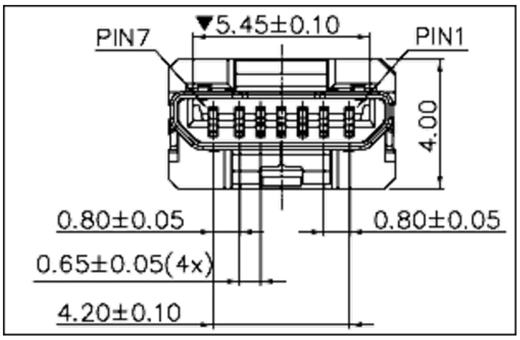

Figure 2.5 7Pin Micro-USB B-type Connector Interface Structure and Dimensions

2.2.2.3 Pin Definitions

USB A-type connector pin definitions must comply with the specifications in Table 2.1.

Pin number	Pin definition
1	V_{BUS}
2	D-
3	D+
4	GND
5	ID

Table 2.1 Definitions of Cable A End Connector Pins

7Pin Micro-USB B-type connector pin definitions must comply with the specifications in Table 2.2.

Pin number	Pin definition
1	V_{BUS}
2	V_{BUS}
3	D-
4	D+
5	ID
6	GND
7	GND

Table 2.2 Definitions of 7Pin Micro-USB B-type Connector Pins

2.2.2.4 Electrical Specifications for Adaptor End Signal Wire

Type of Signal	Min. Value	Std. Value	Max. Value	Conditions	Unit
High input level*	V_{DD}-0.7	-	-	3.2< V_{DD}<4.5	V
Low input level*	-	-	0.8	3.2< V_{DD}<4.5	V
High output level*	0.25V_{DD}+0.8	-	4.5	3.2< V_{DD}<4.5	V
Low output level*	-	-	0.15 V_{DD}	3.2< V_{DD}<4.5	V

Input and output data in Table 2.3 is represented by CLK and DATA adaptor pins.

Table 2.3 Electrical Specifications for Adaptor End Signal Wire

2.2.3 Safety Guarantee Mechanism

2.2.3.1 Adaptor End Safety Measures

During the fast charging process, the adaptor end safety measures are as follows:

1. Charging path impedance is monitored in real time, and the fast charging function is shut down if any abnormality is detected.
2. If communication is lost between the adaptor and terminal, the fast charging function is shut down.
3. In accordance with differences between terminal specifications and the charging current, the guaranteed current cannot exceed the terminal design specifications.
4. The adaptor monitors the voltage of the battery in real time and adjusts the current to ensure battery safety.

2.2.3.2 Terminal End Safety Measures

During the fast charging process, the terminal end safety measures are as follows:

1. Real-time monitoring of battery status: if a failure to comply with battery status requirements is detected, the fast charging function is shut down.
2. Real-time monitoring of each high-current interface: if the interface temperature exceeds the standard, the fast charging function is shut down.
3. Real-time monitoring of charging current: if the charging current exceeds the design specifications, the fast charging function is shut down.
4. If communication is lost between the adaptor and terminal, the fast charging function is shut down.

2.3 VOOC Performance & Five-Star Safety Assessment Scheme

2.3.1 SuperVOOC Five-Star Assessment and Testing Scheme

In 2018, China Telecommunication Technology Labs (CTTL) released a five-star rating scheme to assess fast charging performance - a full assessment of the quality, speed and safety of fast charging applications. It drew on CTTL's in-depth experience with fast-charging technologies and was based on existing standards, whilst also recognising increased performance requirements.

The scheme assesses four dimensions of mobile and charging systems: charging speed, system safety, charging temperature, and efficiency.

Each assessment metric is scored out of five, based on the *CTTL Fast Charging Performance Rating Scheme*, with the total score deciding the final grade. The product is then given an overall star rating between one and five.

No. & assessment item	Assessment content
1 Charging speed	Time to charge the battery to 100% from automatic shut-down
2 Safety	Evaluates the safety of the entire charging system, including charger, cable, battery and end device
3 Charging temperature	Assesses maximum temperature and charging speed of the end device under different conditions
4 Energy efficiency	Energy conversion efficiency of the charger and charging system

Table 2.4 Fast Charging Performance Five-Star Rating Scheme

Figure 2.6 Fast Charging Capability Certificate

2.3.2 SuperVOOC 2.0 Testing Scheme

Building on its *Fast Charging Performance Rating Scheme*, CTTL has added a battery life cycle test, so the testing scheme now looks at five areas. This update was based on certification standards for consumer electronics and informed by current developments and applications of fast charge technologies.

This document covers the assessment of the Reno4 Pro, equipped with SuperVOOC 2.0.

No. & Dimension	Test
1 Charging temperature (temperature under different fast charging conditions and different product operating conditions)	Video call mode: Simulation of an online video call
	Gaming mode: Simulation of a consumer playing an online game
	Video mode: Simulation of a user watching videos online
	Recording mode: Simulation of a user recording high definition videos
	Car mode: Simulation of a user using GPS when driving
	Heaviest load mode: Simulation of CPU and GPU at full load
2 Charging safety	Basic test: Fast charging recognition, overvoltage and high/low temperature protection
	Single fault: Fault testing of the aforementioned 5-step protection
3 Charging performance	Charging speed: Verification of the charging speed in different use environments and after data cable degradation, using battery charge measurements
	Trickle current duration: Verification of trickle current duration by monitoring voltage, current and battery charge during charging
4 Charging performance	Adapter input - battery input energy conversion efficiency
	Adapter output - battery input energy conversion efficiency
5 Battery life	Battery life: After carrying out battery charge and discharge cycling at the nominal charging rate of the battery, the life of the battery is verified by measuring the battery capacity.
	Battery cell life: After carrying out battery charge and discharge cycling at the nominal charging rate of the battery, the life of the battery is verified by measuring the battery capacity.

Table 2.5 SuperVOOC 2.0 Testing Scheme

The significant increase in the charging power of SuperVOOC 2.0 - added to the wide range of end devices and scenarios where multiple functions are used - makes temperature control a huge challenge during charing. Temperature control capability is one of the characteristics of VOOC charging technology.

The SuperVOOC 2.0 Testing Scheme includes multiple complex testing scenarios that simulate the real situations where consumers use fast charging technologies. This allows the charging temperature of SuperVOOC 2.0 to be assessed under various load environments. The results show that while power is increased, the charging temperature of the product - Reno4 Pro - is far lower than the temperature defined in international electrical safety standard *IEC 62368-1*, or Chinese national standard *GB 4943.1-2011*. This reflects the strength of OPPO's fast charging technology.

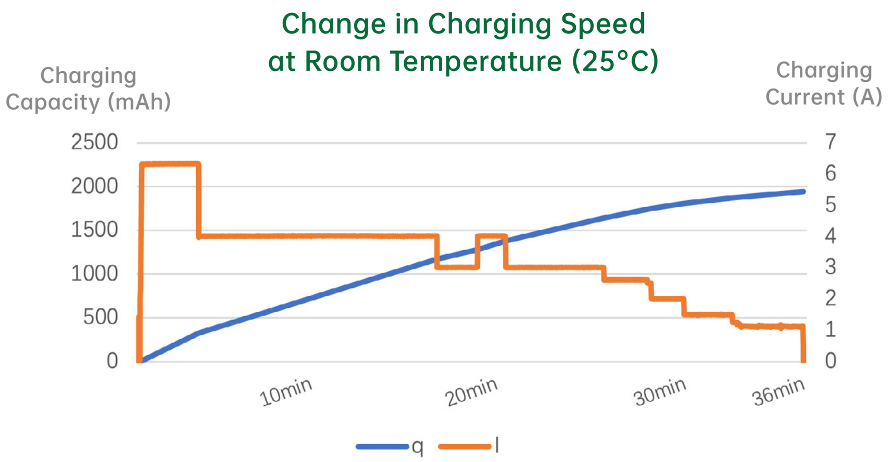

Figure 2.7 Reno4 Pro Change in Charging Speed
at Room Temperature (25°C)

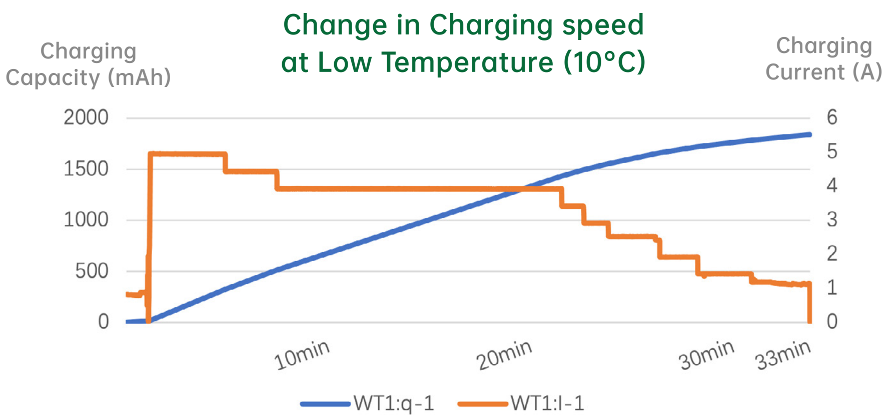

Figure 2.8 Reno4 Pro Change in Charging Speed
at Low Temperature (10°C)

The charging performance test mainly covers charging speed and trickle current duration. The charging speed is the time it takes to charge the battery to 100% from automatic shut-down: this is the most tangible part of the consumer experience.

The demand for fast charging research and development comes from the excessively long charging time of most charging methods. As end device functions increase, so does power consumption - but battery capacity is not growing at the same rate. Fast charging technologies can therefore save consumers a significant amount of time.

This testing scheme verifies charging speed by monitoring charging current, charging capacity and several other technical metrics during charging. In the case of the Reno4 Pro, the device can be fully charged in 35 minutes in a variety of temperatures, including 10°C and 25°C.

For devices that use non-removable batteries, the battery life may represent the usable life of the end device itself. And in fast charging systems, high speed charge and discharge cycles inevitably impact battery life. Following the Chinese national standard *GB/T 18287-2013: General Specification for Lithium Ion Batteries and Battery Packs for Mobile Phones*, CTTL verifies the battery's long life cycle by simulating repeated fast charge and discharge cycles. By comparing the battery's capacity before and after, we see that even if the battery and battery cell go through this process hundreds of times, capacity remains at 97.4% and 94.6% of rated capacity, respectively. Thus we can see that the battery life of the Reno4 Pro has not been affected.

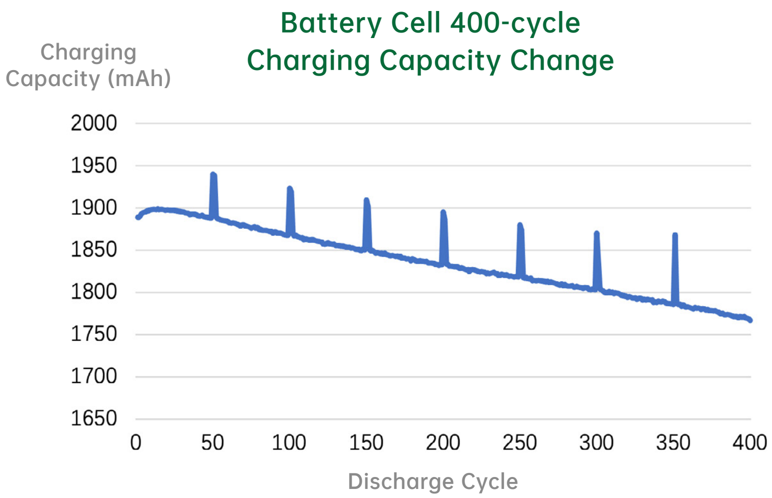

Figure 2.9 Change in the Battery Cell Charge and Discharge Cycle Capacity of the Reno4 Pro

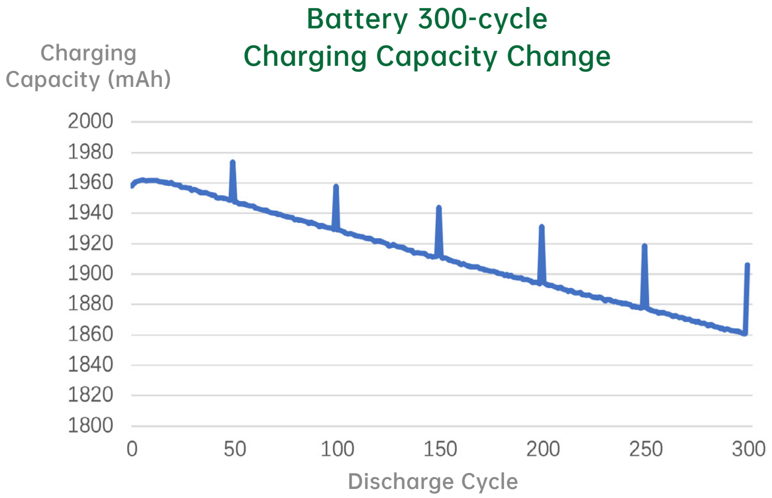

Figure 2.10 Change in the Battery Cell Charge and Discharge Cycle Capacity of the Reno4 Pro

	Rated Capacity	Capacity after Cycle	Percentage of Rated Capacity Retained
Cell (400 cycles)	1,955 mAh	1,851 mAh	94.6%
Battery (300 cycles)	1,955 mAh	1,906 mAh	97.4%

Table 2.6 Capacity Change of Battery Cell and Battery through Charge and Discharge Cycles

Fast charging speeds must not come at the expense of safety, so fast charging technologies must take safety into consideration as much as speed. Based on its accumulated know-how in fast charging technologies - and its safety testing experience - CTTL has established a complete assessment and testing system covering the charger, data cable, mobile device and mobile battery.

Charging efficiency consists of two parts: the efficiency of the entire charging system (from adapter input to battery input) and the efficiency of the end device (from end device input to the energy that enters the battery). Fast charging technologies must not only meet the demand for faster charging, but also comply with national environmental and energy-saving policy objectives, by making each drop of energy genuinely available to the user.

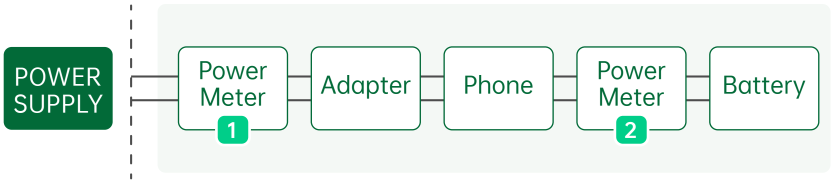

Figure 2.11 Energy Conversion from Adapter Input to Battery Input

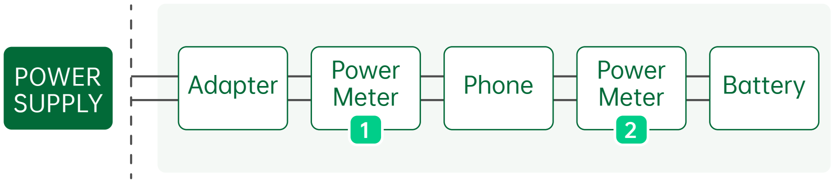

Figure 2.12 Energy Conversion from Adapter Output to Battery Input

The results of the tests described above show that this mobile device can fully charge within 35 minutes, while also ensuring that the heat emitted by the adapter and end device is lower than the values required by international and Chinese national standards. In addition, the five-step safety protections of SuperVOOC 2.0 ensure the safety of the consumer using the fast charging technology.

After carrying out battery charge and discharge cycling at the nominal charging current of the battery, the battery's capacity remained at more than 94% of its rated capacity.

Each test metric reflects the advanced status of SuperVOOC 2.0 technology and demonstrates the strong overall capabilities of OPPO.

3 VOOC APPLICATIONS & ECOSYSTEM CERTIFICATION

3.1 VOOC Ecology Prospects

As OPPO's proprietary technology, VOOC Flash Charge technology was the first rapid charging technology to receive a five-star rating from CTTL, proving its effectiveness, safety and reliability. In addition, by the end of 2020, OPPO had applied for more than 2,950 patents relating to VOOC Flash Charge technology, and nearly 1,400 of these had been granted. This wide-reaching patent coverage provides the comprehensive legal protection needed for the continued global development of these products.

OPPO has also worked with CTTL to establish the VOOC Flash Charge industry standard. This standard will ensure the compatibility of rapid charging technology in smart devices across the industry. It will also guide the development and creation of devices by multiple manufacturers, ensuring fast and safe charging for mobile phone users, and a healthy, standardised rapid charging industry.

By continuing to concentrate on users' core needs, OPPO is bringing VOOC Flash Charge innovations to this wider field of applications and user devices, through these partners. Some of the possible applications include in-car charging, office charging and charging in public spaces. The hope is that one charger could be used for a variety of devices, from smartphones to tablet computers, laptops or wearables. And the overall aim is to provide users with the benefits of rapid charging at any time and any place, addressing the power needs of consumers in the mobile 5G era.

Guided by FRAND principles, OPPO has openly licensed its flash charging technology to over 40 outstanding partners so far. These include chip businesses like Rockchip, Injoinic Technology, Ismartware, Southchip, Silan, Anker Innovations, Bull, Romoss, Mophie and Aukey, as well as charging services providers, such as Dian Baobao. OPPO is also active in the field of vehicle electronics and in-car charging, partnering with NXP Semiconductors and vehicle module producers like ADAYO and Desay SV, as well as car makers FAW-Volkswagen. By using VOOC Flash Charge technology, these 40-plus partners will bring rapid charging to a broad range of settings.

To ensure products with licensed VOOC technology are both cutting edge and safe, OPPO provides partners with technical guidance and support during the patent licensing process. In addition, the company uses closed loop licensing monitoring to ensure product quality is verified before go-to-market - as well as dynamic quality tracing and management after release.

OPPO partners' VOOC products undergo enhanced safety testing and certification, thanks to ongoing work with China Telecommunication Technology Labs (CTTL) of the China Academy of Information and Communications Technology. These rigorous checks ensure standardised safety and quality certification to the strictest standards.

3.2 VOOC Ecosystem Accessories Certificate

TL Certification Centre (TLC) is a certification body, owned and operated by the China Academy of Information and Communication Technology. TLC provides certification for products, services, and management bodies in the information and communications sector. It also delivers evaluation services for information management systems and green factory operations.

Between its 15 contract laboratories, TLC has certified over 300 different products, which are now in use across broadcast, rail transport, banking, government ministries and more. The company also provides electronic authentication services, as well as digital certification security solutions for clients in communications, transport, finance, IoT and other sectors.

In 2018, TLC became the certifying body for OPPO's VOOC ecosystem products, ensuring that any accessory product equipped with VOOC flash charging is safe and effective.

3.2.1 Product Classification & Technical Standard Systems

VOOC accessory products are organised into the following categories, according to licence agreements and product attributes:

- Flash charge protocol chips
- AC adaptors (chargers)
- Car DC chargers
- Mobile power sources
- Flash charging cables
- Other devices with VOOC protocols (mobile charging stations, USB plug socket chargers)

Based on the standards of *YDB 195-2018: Technical Requirements and Test Methods for Fast Charging of Mobile Communication Terminals*, and considering the requirements for different products, four sets of technical specifications have been drafted:

- ***TLC 016-2019*** *Technical Certification Specifications for Fast Charging VOOC Protocols for Mobile Communication Terminals and Adaptors*
- ***TLC 017-2019*** *Technical Certification Specifications for Fast Charging Adaptors for Mobile Communication Terminals*
- ***TLC 018-2019*** *Technical Certification Specifications for car DC power adaptors*
- ***TLC 019-2019*** *Technical Certification Specifications for VOOC flash charging cables*

Technical standard	Main technical requirement categories
TLC 016-2019	VOOC protocol test requirements
TLC 017-2019	Requirements for interface structures and mechanical functions, electrical performance, security functions, electromagnetic functions, environmental adaptability
TLC 018-2019	Requirements for interface structures and mechanical functions, electrical performance, security functions, environmental adaptability
TLC 019-2019	Interface and cable structure, loop impedance, security functions, VOOC protocol identification functions

Table 3.1 Technical Certification Specification Requirements System

The following state standards have also become part of the technical standards for product certification:

- ***GB 4943.1-2011*** *Information Technology Equipment-Safety-Part 1: General Requirements*
- ***GB/T 35590-2017*** *Information Technology General Specifications for Portable Digital Equipment Using Power Bank)*

Secondary testing and test indicators have been defined (in addition to the main requirements in Table 3.1), with detailed procedures to clarify the scope and process of testing. The aim is to simulate real consumer use - in the most demanding conditions - to fully check product safety and certify all types of VOOC accessory.

3.2.2 Matching Authorisation Mechanism & Standardised Certification Process

TLC has drafted certification documentation based on VOOC product accessory types, complying with the rules and regulations of the China National Certification and Accreditation Administration Commission.

The certification documentation, product accessory types and technical specifications (certification basis) are shown in figure 3.1.

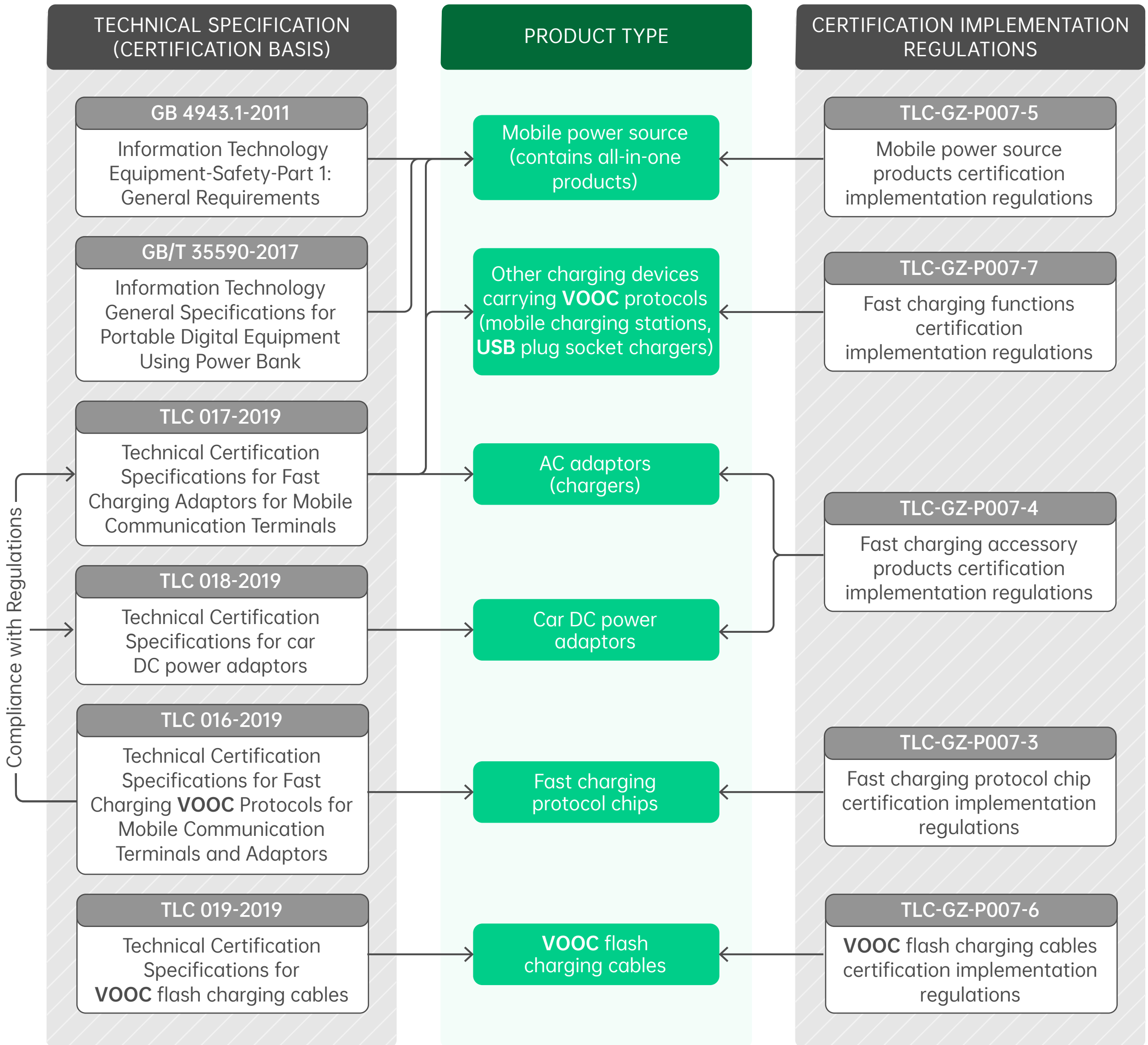

Figure 3.1 The Applicable Certification Documentation, Product Accessory Types and Technical Specifications (Certification Basis)

Application Conditions Must Strictly Match the Authorisation Requirements.

The certification applicant must be a legally authorised manufacturer and the product named in the application must not be outside the authorised range.

The product and its brand label must clearly show the VOOC protocol output port and the output specifications. The brand label or trademark must show it is from an authorised manufacturer and must not show the label or trademark of an unauthorised manufacturer.

All power adaptors must use a chip manufactured by an authorised chip manufacturer.

Key Elements of Certification Revolve Around Key Product Features.

VOOC accessory certification uses recommended certification mode No.5 from the International Organisation for Standardisation (ISO): Type test + initial factory inspection + post-certification supervision (production factory quality inspection review + factory or market sampling).

The party organising the type test must separate the units for certification based on chip model number or circuit structure, and differences between multiple model numbers in the same certification unit must also be identified. To refine certification, different units - or the same certification unit with different model numbers - are tested separately.

The initial factory inspection - undertaken during a quality check of the functions, for products with chips - focuses on design and development resources (and their management), testing of packaging sealed with tape, verification of VOOC protocol functions and inventory conditions.

For AC adaptors (chargers) and other whole products, the initial factory inspection focuses on control of purchase of components, manufacture and testing equipment configuration (and its management), control of the manufacturing process, quality control of the finished product, and batch product consistency control.

During the initial factory inspection, samples taken on-site are given a product consistency check and a visual inspection. The manufacturer's actual production facility location is also checked, as well as the authorisation and quality system documentation (when appropriate).

The post-certification supervision (during the annual review of the production facility quality system) focuses on the same areas as the initial factory inspection, as well as checking the consistency of products.

Using either market purchase samples or samples taken directly from the manufacturing facility, a re-test checks the key indicators of verified products, to increase the effectiveness of the inspection.

Certification Process Strictly Follows Established Regulations.

The certification process is conducted stage by stage, based on certification regulations (including certification fees), and in the form of documents that are fully accessible to the public. The stages include certification application, sample inspection, production facility inspection, and review and issue of certification.

The product sample inspection stage includes closed-loop control of the processes of laboratory testing and product rectification (where appropriate), and follows the uniform specifications of test reports. The on-site inspection stage follows clear regulations for the roles of on-site inspection personnel, the schedules and content for inspections, and inspection reports.

Finally, before the certification is issued, personnel not involved in the testing - and without conflicts of interest - re-check the output data from each of the stages outlined above, ensuring the impartiality and accuracy of the results of the certification process.

3.2.3 Post-certification Monitoring and Authoritative Issue of Certification Results

Improved Mechanism for Managing Post-certification Amendments.

A mechanism for managing any post-certification changes for VOOC product accessories has been developed. This involves checking documentation and materials, inspecting products and premises (if necessary), and ensuring that the results of the certification remain valid. This mechanism could be required for changes to the manufacturer's name or address, the key components used, the production process, the external appearance of the products or their composition.

Authoritative Issue of Certification Results Platform.

Certified VOOC product accessories and certification information can be found at the National Certification and Accreditation Information Public Service Platform of the State Administration for Market Regulation of the People's Republic of China and TL Certification Centre Limited Company's website.

National Certification and Accreditation Information Public Service Platform
http://cx.cnca.cn

TL Certification Centre Limited Company's website
http://www.tlc.com.cn

VOOC product accessories certification documents can be accessed and read on TL Certification Centre Limited Company's website.

4 THE FUTURE OF VOOC

4.1 Development Trend of VOOC Technology

The arrival of 5G is accelerating the development of the Internet of Things (including vehicles), VR, AR and numerous other areas, thanks to low latency, broad connections and greater bandwidth.

But more and more devices are facing mounting friction between impressive (but power-hungry) features and limited battery capacities. VOOC Flash Charging can help to address this imbalance - and not just in smartphones.

Fast charging technology is soon expected to broaden out from phones to other hardware, such as tablets, watches, laptops, Bluetooth headsets and more. But it could also support smart home appliances - even industrial equipment, like automated guided vehicles in warehouses.

And in the future, the standardization of this technology could help to improve compatibility, meaning one charger is capable of charging numerous devices.

As users' charging needs become more abundant, we will see more diverse modes of charging emerge, with wireless charging expected to become very popular. But flexibility will be crucial, as the charging methods at any given moment will be chosen based on what is most suitable for that scenario - and gives the best charging experience. Charging adapters will also become more compact and lightweight, with higher power density. 'High power, small size' chargers are one area of focus for R&D in the near future.

As charging power has continued to increase, heating and safety issues have become more prominent. At the same time, higher standards are being put forward for the reliability and power loss of charging systems too - a key area for ongoing research.

4.2 Summary

The ability to *'speak for two hours after charging for five minutes'* makes OPPO's unique IP remarkable. VOOC Flash Charge technology enables charge speeds four times faster than normal charging, while using universal intelligent device protection, making it one of the fastest and safest charging technologies available.

Focusing on the core needs of users, VOOC Flash Charging technology will expand to a wide range of application scenarios and devices. The aim will be to meet the different charging needs of users in all weathers, across multiple devices, in any number of situations, and to alleviate the 'charge anxiety' of users in the 5G era.

OPPO will continue to promote the development and use of VOOC Flash Charging technology, using standardization to guide more companies towards product compatibility. Working with outstanding partners across industries, OPPO will license and authorize its patents to expand the applications and product family of Flash Charging technology. And it will do so while keeping safety and reliability front of mind, building a healthy Flash Charging technology ecosystem for years to come.

Flash Charging the Future

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