F O R U M   N O K I A

Nokia 2-mm DC Charging Interface Specification

Version 1.2; August 22, 2006

Charging Interface

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Contents

Change history

June 16, 2005	Version 1.0	Initial document release
October 26, 2005	Version 1.1	Sections 2.4 and 4.1 updated
August 22, 2006	Version 1.2	Figure 13 updated

1 Introduction

This document specifies the electrical and mechanical charging interface between Nokia mobile devices and power-supply accessories, specifically chargers. It also defines the charger-identification process of these mobile devices. The specification is valid only for devices with a 2-mm charging interface.

2 General electrical specifications

2.1 General

The interface supports the following two types of two-wire chargers:

1. Constant current chargers (standard charger)

A constant current type charger may have a wide output current range and the current may change with other parameters. The specifications for a constant current charger appear in Chapter 3, “Electrical specification for constant current type chargers.”

2. Special chargers

Special chargers take charging energy from a solar cell or hand-operated generator, for example. External charging conditions have a great impact on the charging current — the waveform of the charging current is unknown and charging can even be stopped. Battery charging time may vary considerably. Specifications for special chargers are described in Chapter 4, “Electrical specification for special chargers.”

2.2 Charger output capacitance

The capacitance in charger output causes charging current spikes when the charger's load changes. Low-capacitance values are recommended if possible. Maximum charger output filter capacitor size is 1000 µF if the charger $V_{MAX-OUTPUT}$ is less than 7 V. For output voltages of 7 V – 9.3 V, the maximum capacitance value decreases linearly so that for a 9.3 V charger, maximum output capacitance is 700 µF.

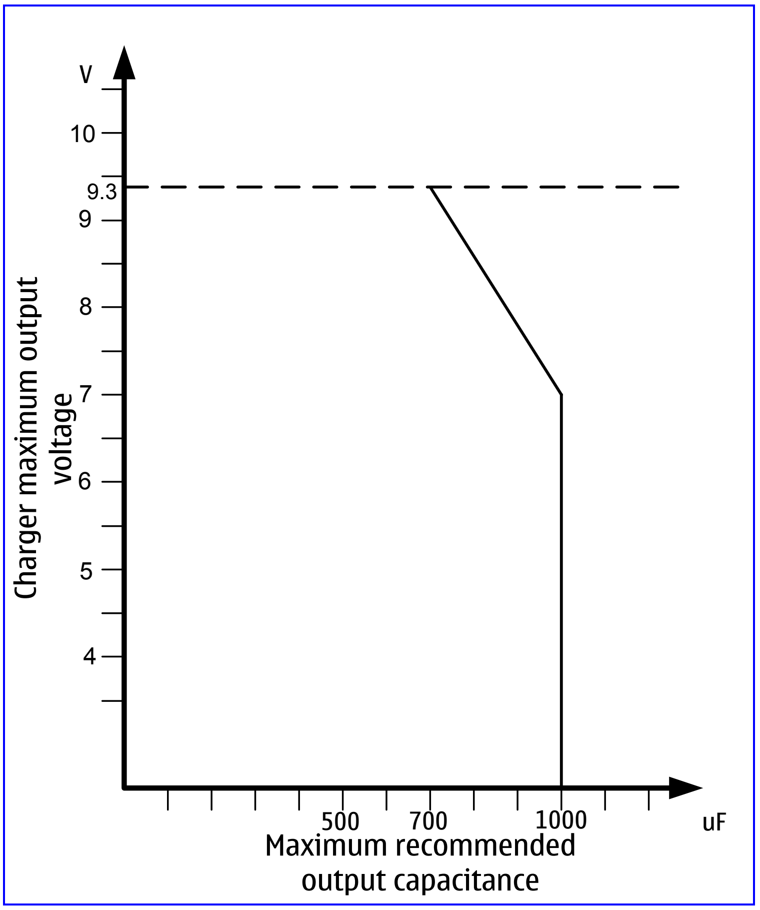


Figure 1: Maximum charger output capacitance

2.3 Maximum voltage and current values

Maximum charger output overshoot	16 V
Maximum reverse voltage at charger output	1 V
Maximum time for **constant current type charger** to achieve steady state value (U and I) after load change	10 ms
Maximum duration of charging current overshoot peak value greater than 1.1 A	5 ms

Table 1: Limits for maximum voltage and settling time

* Limits are also valid for a damaged charger.
* These voltage and current limits must be doubly insured; in other words, if the general charging voltage control system fails, there must be a backup limiter inside the charger.

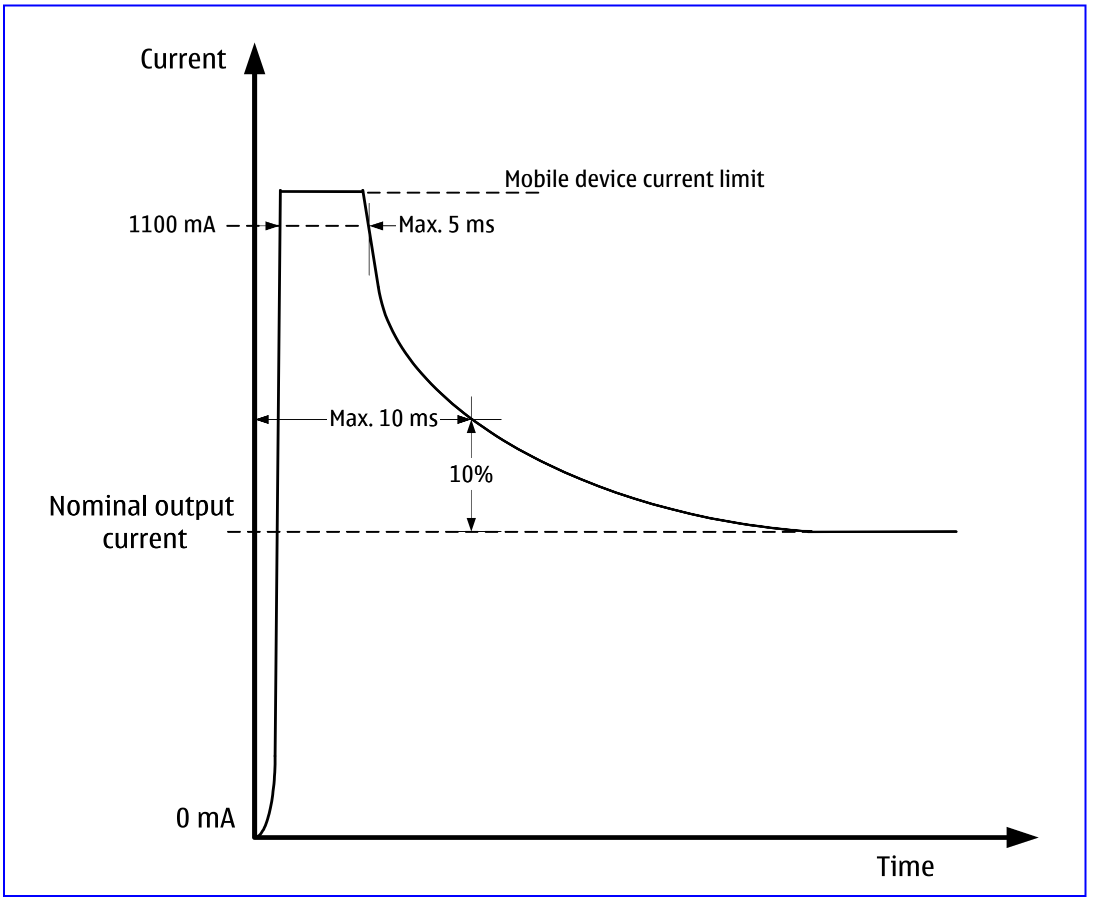


Figure 2: Maximum duration of charging current overshoot

2.4 Maximum output ripple voltage

The maximum acceptable **output ripple voltage** with maximum output current (constant current mode, 2.5 V < U_{out} < 5.5 V) is **300 mV (root mean square, RMS).**

The maximum acceptable **output peak-to-peak ripple voltage** is separated to four frequency areas. A summary of ripple voltages with different frequencies over the full frequency area (0 – 1 MHz) is **800 mV_{P-P}.** Ripple voltage shall be measured using **0 – 6 kΩ** resistive load.

Note: Charging voltage, **including ripple,** may never have peak values outside the U/I window for charger output.

Frequency	Maximum voltage
0 - 20 Hz	200 mV_{p-p}
20 Hz - 200 Hz	200 mV_{p-p}
200 Hz - 20 kHz	200 mV_{p-p}
20 kHz – 1 MHz	400 mV_{p-p}

Table 2: Maximum ripple voltage by frequency

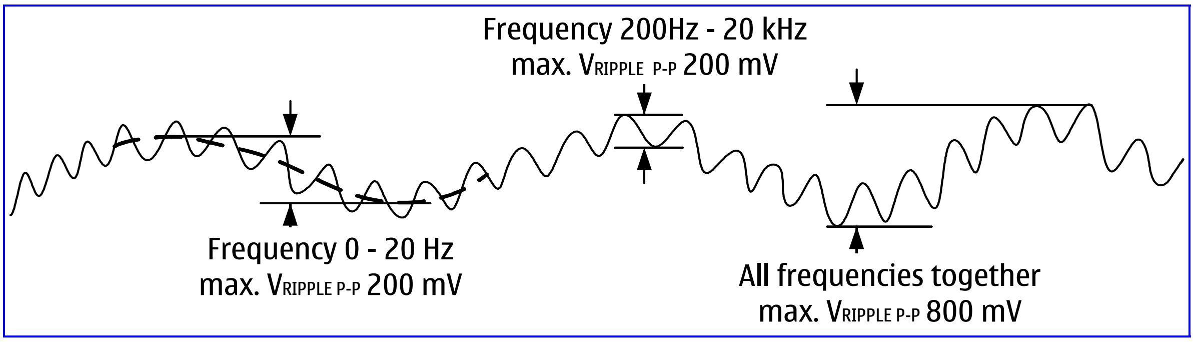


Figure 3: Maximum peak-to-peak ripple voltage

2.5 Charger output conducted emissions

Frequency range	Maximum EMI disturbances
1 MHz – 80 MHz	-40 dBm to -65 dBm linearly
80 MHz – 150 MHz	-65 dBm

Table 3: Maximum conducted disturbances

The limits for conducted emissions from charger output are presented in Table 3 and Figure 4. The charger shall be connected to artificial load (Appendix A: Artificial load) during measurement.

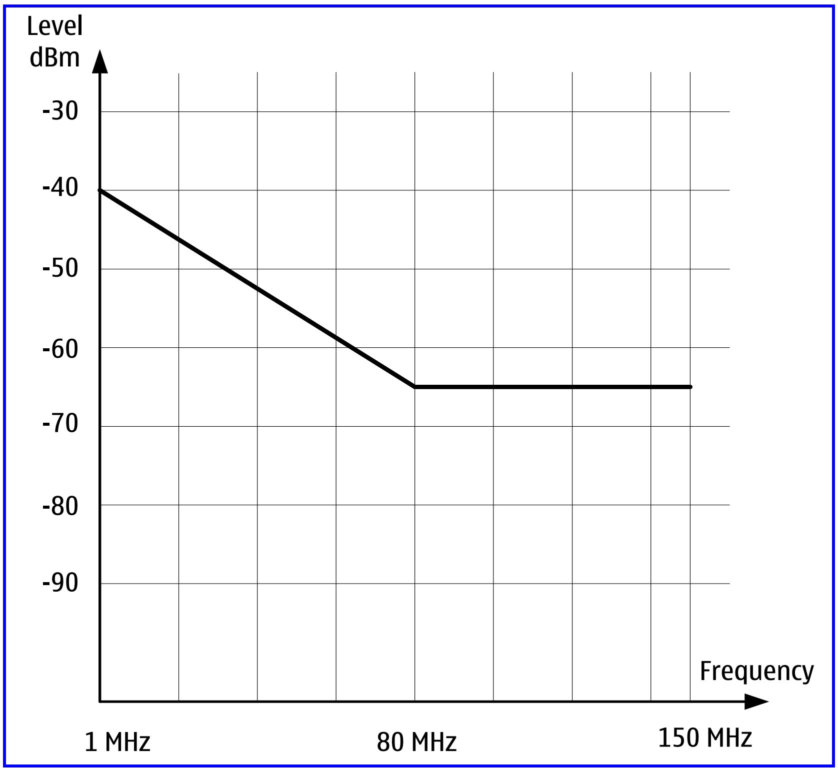


Figure 4: Maximum conducted emissions

2.6 Leakage current of AC chargers

Maximum leakage current from AC mains to the mobile device through the charger is 5 μA.

3 Electrical specification for constant current type chargers

3.1 Charging voltage — current window

The minimum charging current is 300 mA. During charging, the current and voltage must fit within the charging window shown in Figure 5.

The only time that the charging voltage is allowed to go out of the charging current/voltage window is in a load change situation (see Section 2.3, “Maximum voltage and current values").

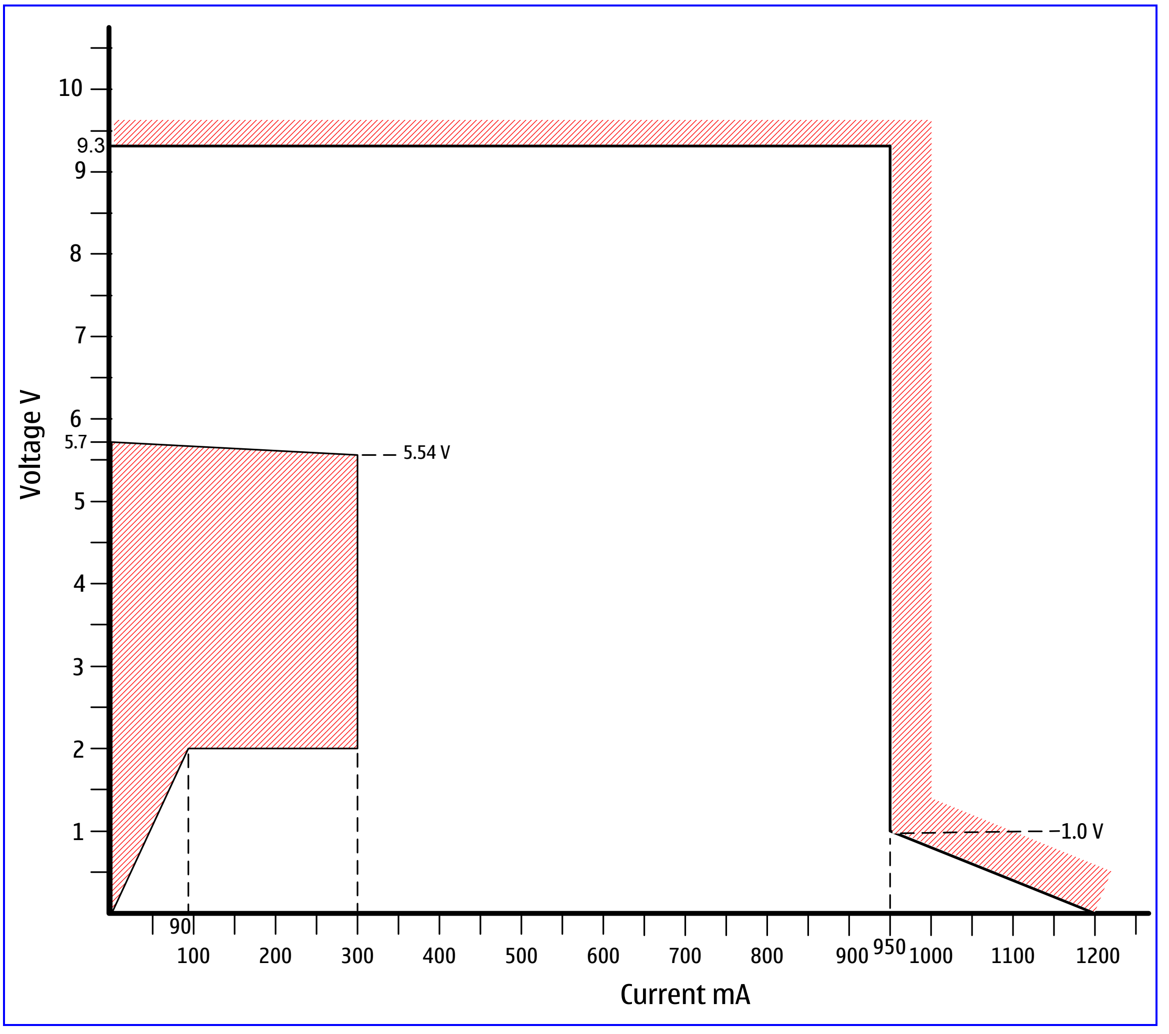


Figure 5: Charging current/voltage window for constant current type chargers

3.2 U/I corner point

The U/I curve corner point when the constant voltage mode changes to the constant current mode is **greater than 5.54 V** if the current is more than 300 mA.

3.3 Current linearity

Maximum current fluctuation under stable temperature condition is 30 percent when the charger output voltage changes from 3.5 V to 5.0 V (for example, 500 mA - 30% = 350 mA) when input voltage and ambient temperature stay constant.

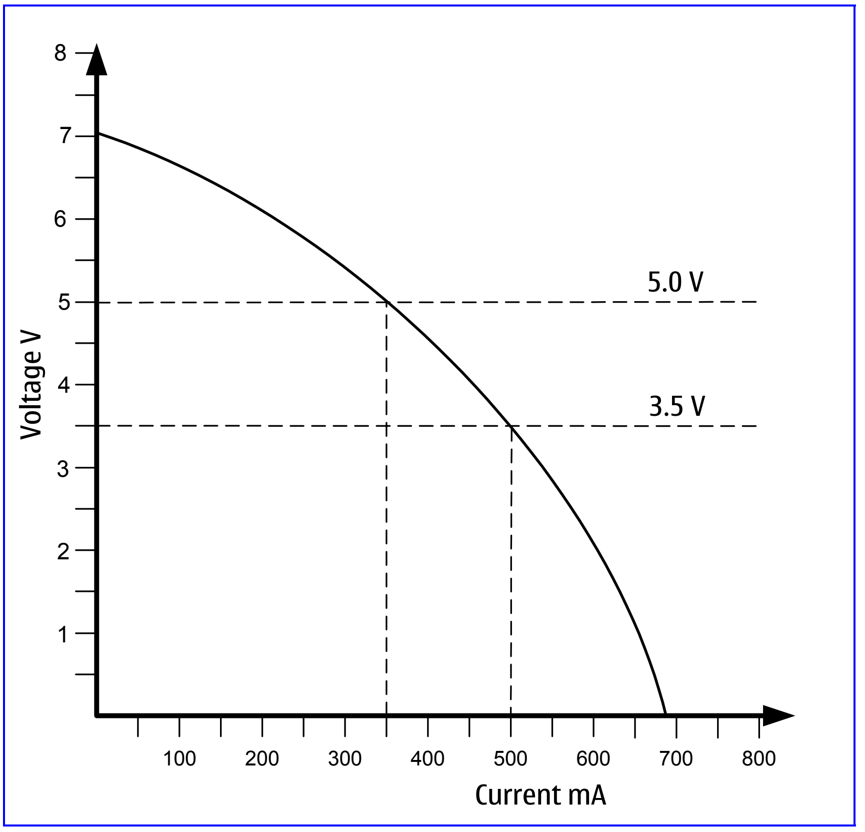


Figure 6: Current linearity specification

4 Electrical specification for special chargers

4.1 Charging voltage — current window

The minimum charging current is 90 mA. During charging, the current and the voltage must fit within the charging window shown in Figure 7. The only time that the charging voltage is allowed to go out of the charging current/voltage window is in a load change situation (see Section 2.3, "Maximum voltage and current values").

Products having high boot-up current consumption may be unable to boot-up with empty battery even if special charger, which provides only small current, is connected.

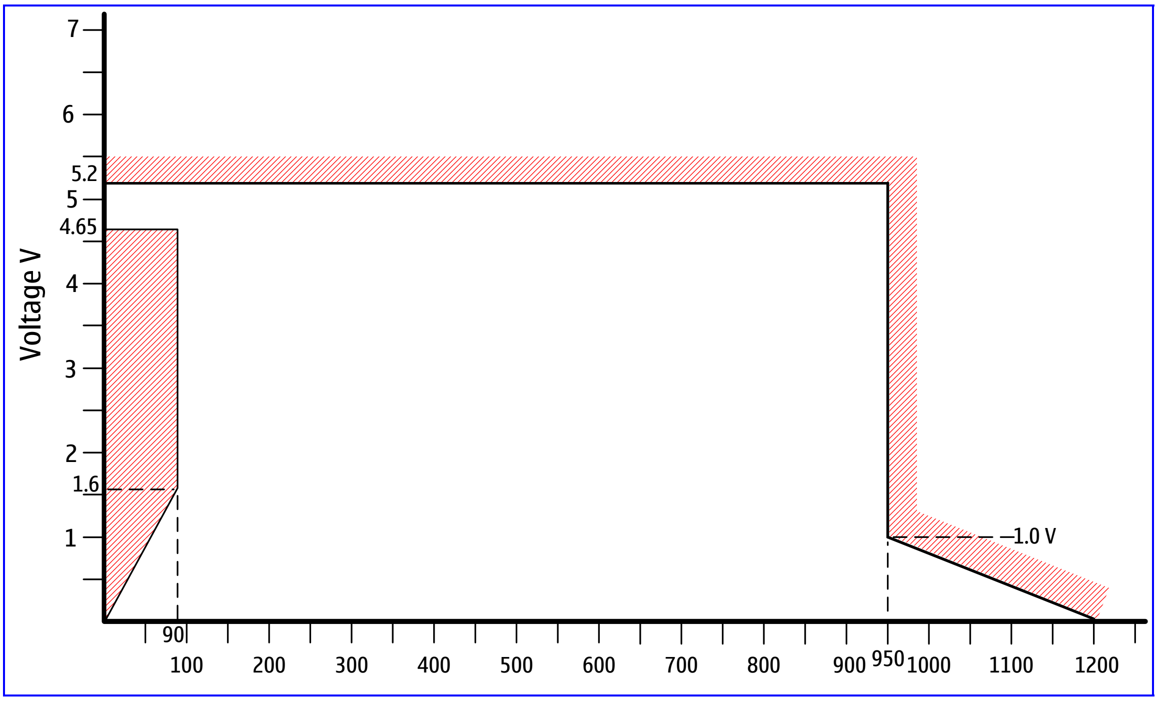


Figure 7: Charging current/voltage window for special chargers

4.2 Charging voltage rise time

Special chargers don't have a time limit on how fast the charger must archive the steady state value (U and I) after load change. Charging will not start until the charger output voltage reaches 4.65 V. The charger must provide a minimum charging current according to Figure 8, even if the voltage is rising slowly.

4.3 Current linearity recommendation

Following current linearity recommendations yields the best results between chargers and Nokia mobile devices, thus good current linearity should be the goal when designing new chargers. However, adhering to the specification is not mandatory if doing so is impossible due to the structure of a specific charger.

Charging current linearity is divided into two parts, based on the charging current change frequency. For f_{ICHAR} < ½ Hz, the maximum allowed current slew rate is 0.28*I_{CHAR} A/sec. For f_{ICHAR} > ½ Hz, the maximum charge current crest factor is < 1.14.

Crest factor = I_{PEAK} / I_{RMS}.

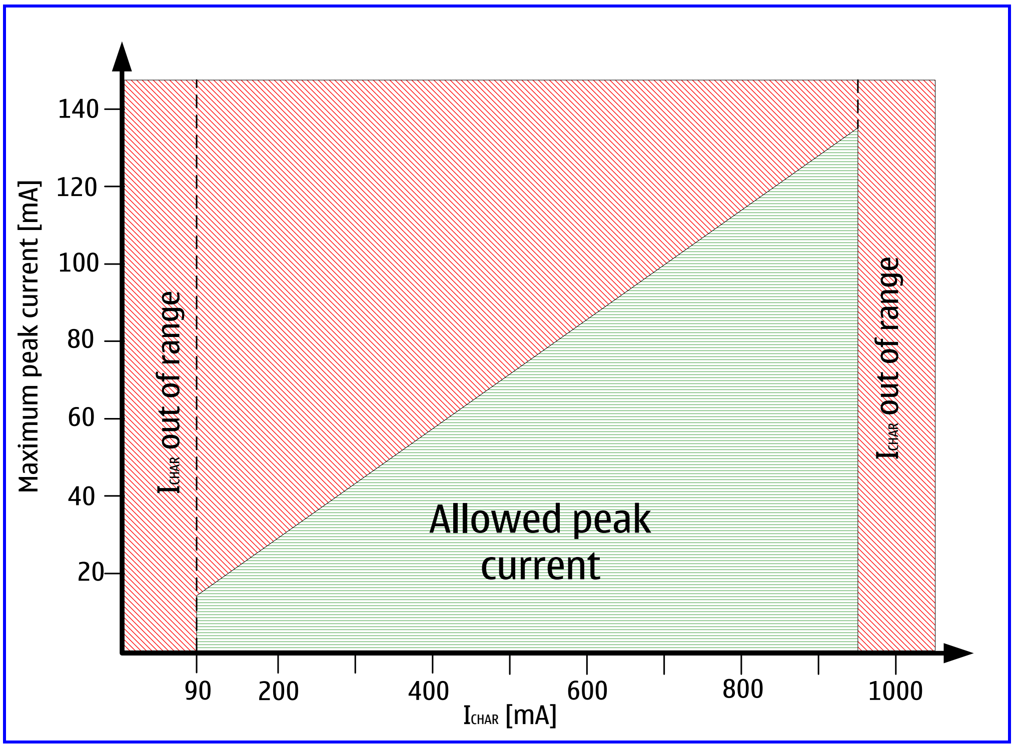


Figure 8: Maximum allowed charging current peaks (crest factor) f_{ICHAR} > ½ Hz

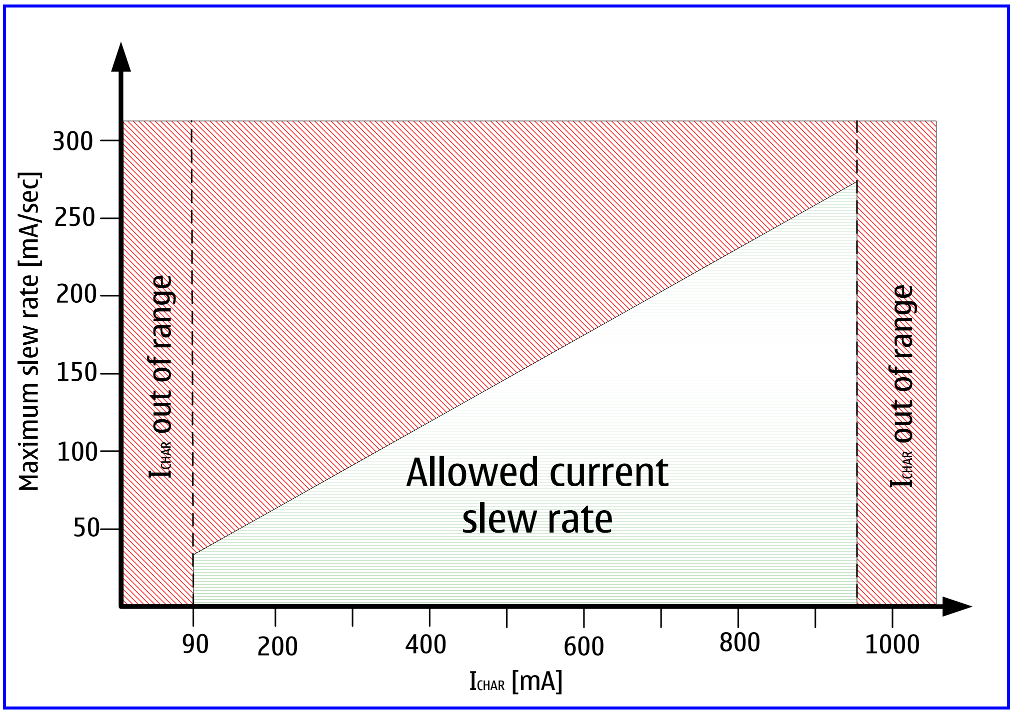


Figure 9: Maximum allowed charging current slew rate f_{ICHAR} < ½ Hz

5 Accessories connected between the charger and the mobile device

5.1 Accessory interfaces

An accessory connected between the charger and the mobile device shares energy with that mobile device while taking energy for its own needs. The sharing policy varies based on the type of accessory and the operating conditions. The accessory must always provide an interface to the mobile device that meets this *Nokia 2-mm DC Charging Interface Specification*. The interface is indicated with dashed lines in Figure 10.

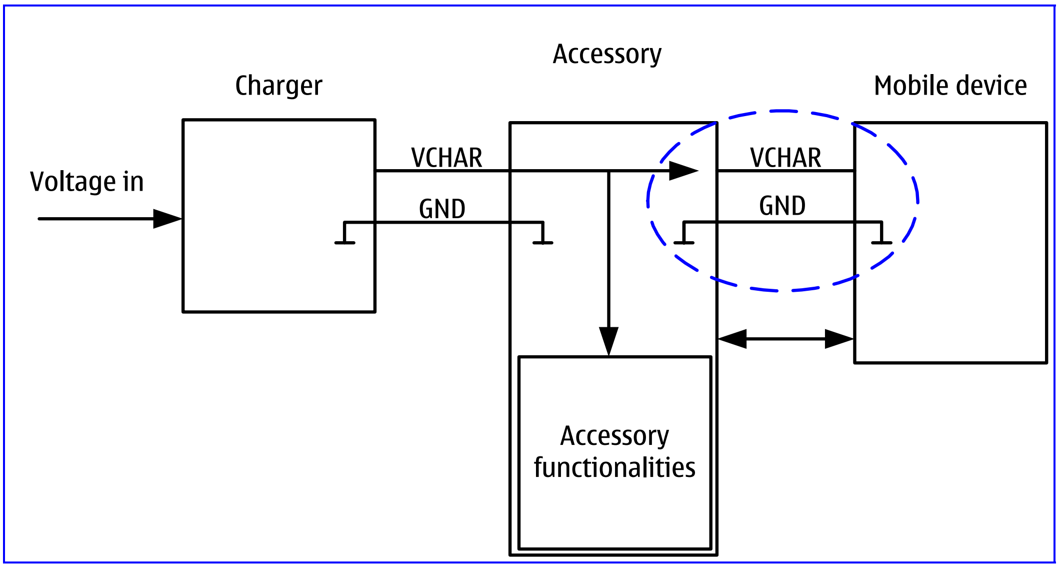


Figure 10: Accessory/mobile device interface

5.2 Electrical specifications for accessories

Accessories connected between the charger and the mobile device and having direct contact with charging lines (for example, a desk stand), must not disturb the charging or charger identification.

Description	Min.	Typ.	Max.	Unit
Ground lead resistance with contacts	0		0.05	Ω
Positive lead resistance	0	0.2	0.40	Ω
Capacitance between charging lines	0		4.0	μF

Table 4: Electrical specification for accessory contacts

Figure 11 shows the U/I window that the accessory must provide to the mobile device.

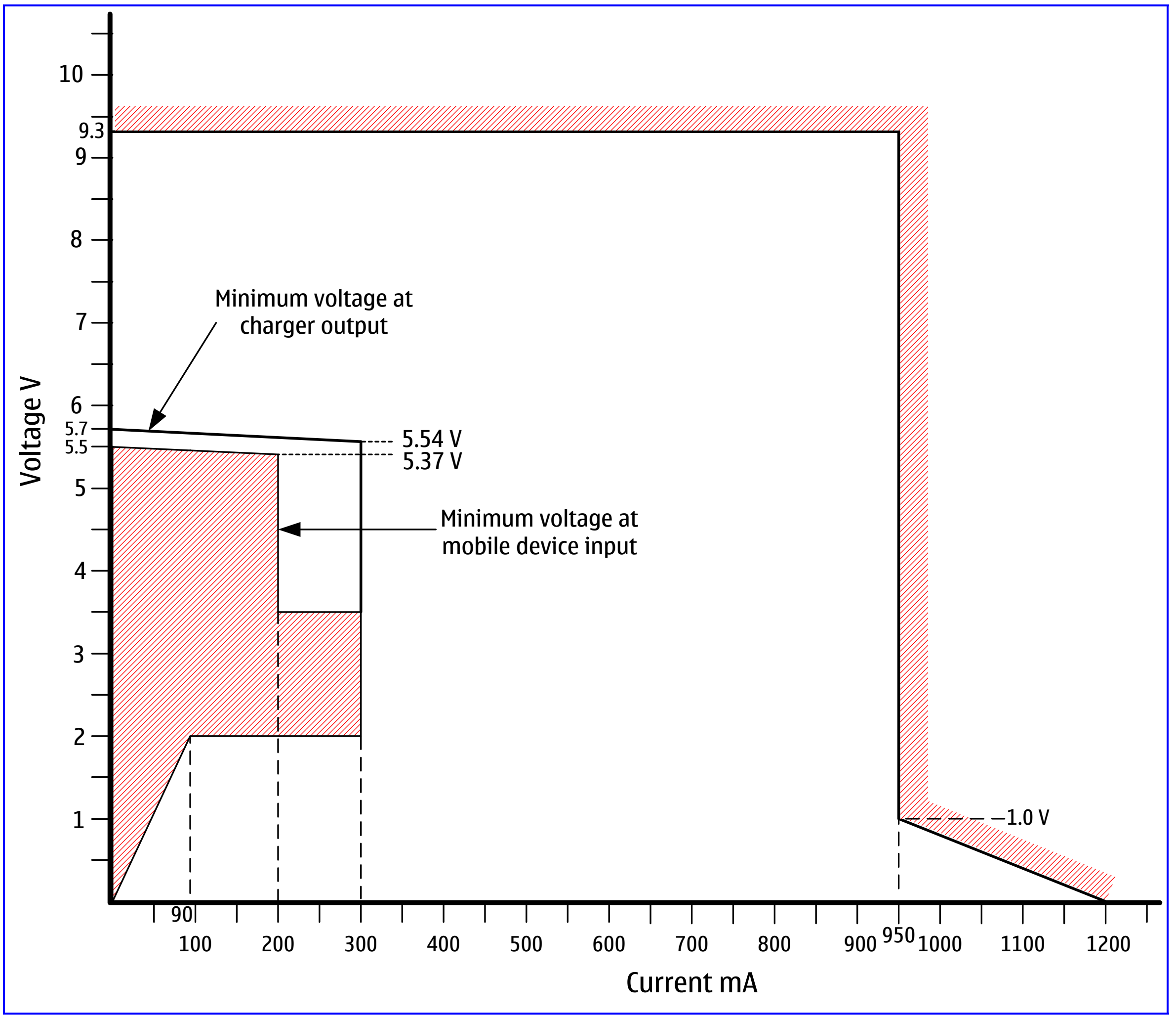


Figure 11: Charging current/voltage window for a mobile device

Even if the accessory is powered by a standard, constant current charger, it doesn't need to fulfill the current linearity specification for constant current type chargers (see Section 3.3, "Current linearity")

5.3 Booting up the mobile device when connected to an accessory

While the mobile device is booting up, the accessory connected between the charger and the device must not limit the charging current between the two. Also, it must be possible to boot up the mobile device when there is an accessory connected between the charger and the device and the device's battery is totally empty.

An accessory may have current consumption **I_{MAX} = 10mA** as long as the charging voltage (V_{CHAR}) is below 3.5 V.

5.4 Charger identification

An accessory connected between the charger and the mobile device must not prevent the device from identifying the charger type correctly. For example, if the accessory is connected to the charger, and the mobile device, which is powered on, is later connected to the accessory, the power consumption of the accessory may result in the wrong charger identification.

The accessory must limit its power consumption (or use some other method) so that there is a minimum 5.5 V charging voltage available in the charging interface for the mobile device during the first 300 ms after the mobile device is connected to the accessory.

Some old charger types are detected with a 100/120 Hz output ripple voltage. The accessory must not prevent that detection. If the accessory input voltage is a rectified AC voltage, there must be a minimum 5.5 V average charging voltage available for the mobile device during 300 ms after the mobile device is connected to the accessory. The peak-to-peak value of the charging voltage must be more than 2000 mV.

6 Charger identification method

6.1 Charger voltage measurement

When a charger is connected to the mobile device, the device's system will start the charger-recognition procedure by checking the charger voltage with 1 – 2 mA current. Identification is based on measured average voltage and waveform: 4.65 V – 5.20 V is identified as a special charger and 5.5 V – 9.3 V is identified as a standard charger.

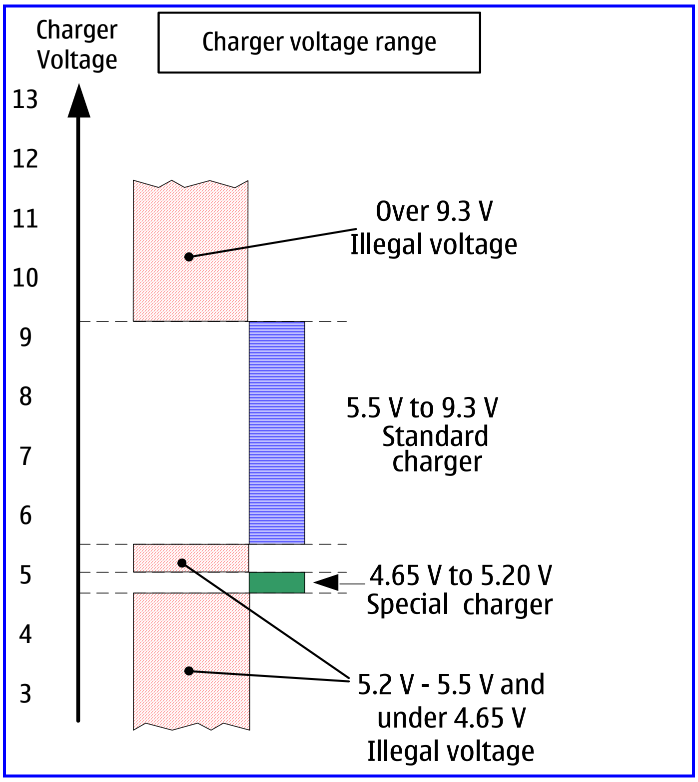


Figure 12: Charger identification voltages

7 Mechanical specification

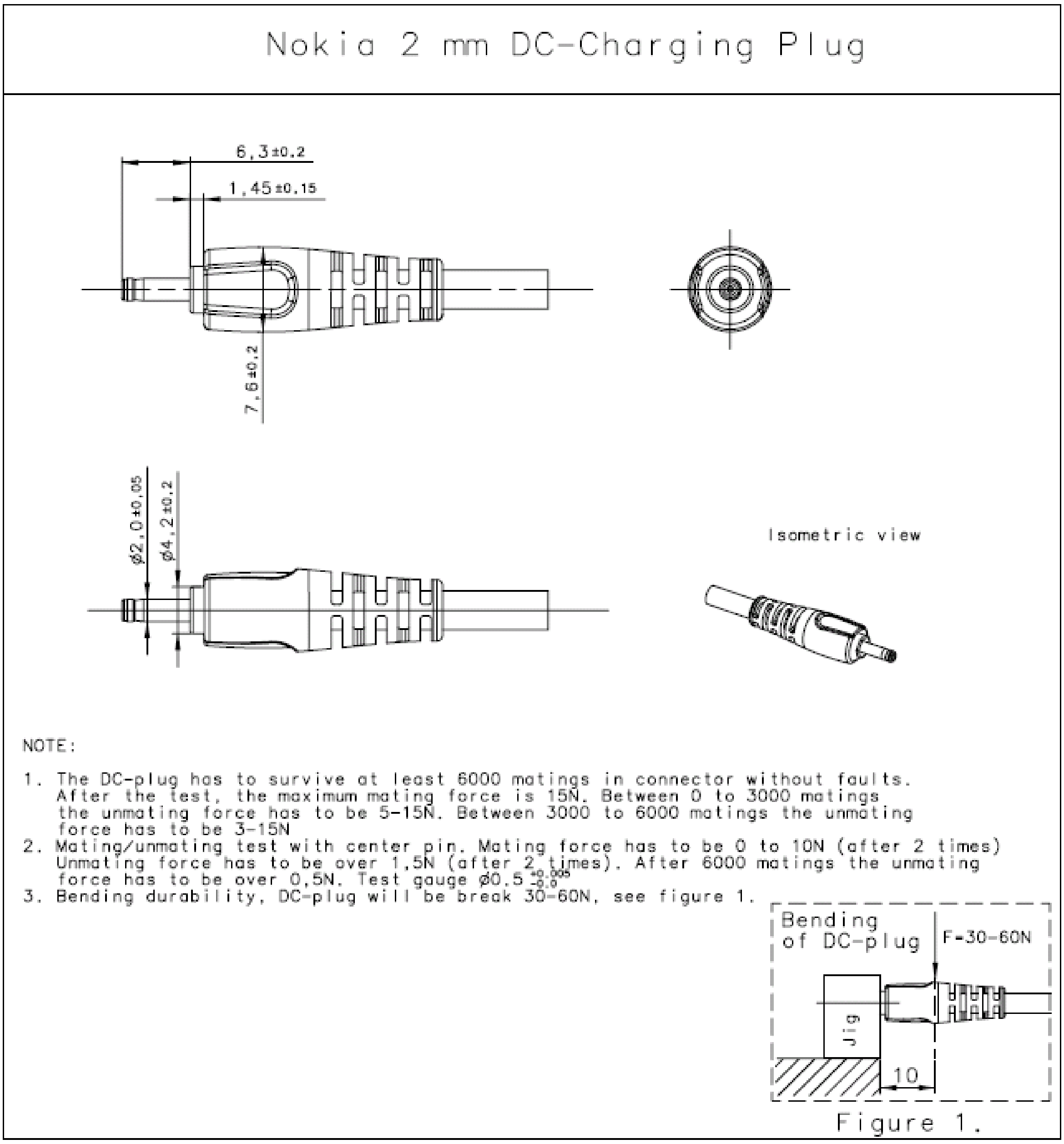
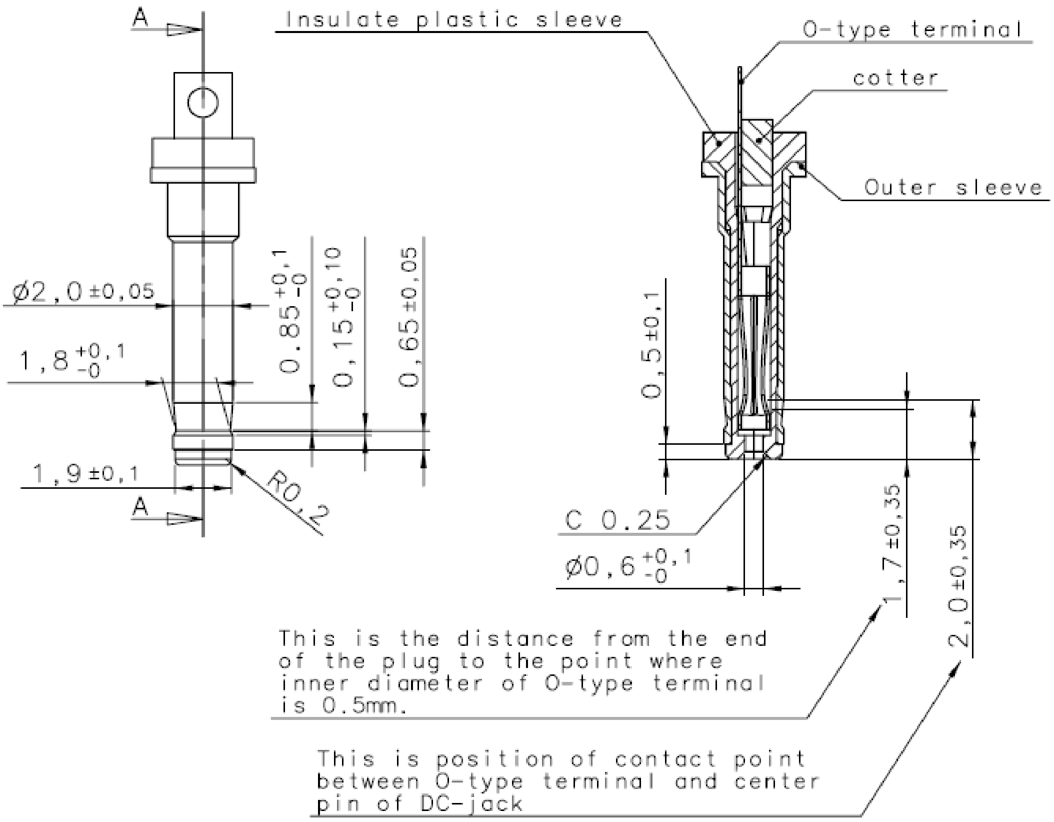


Figure 13: Mechanical specification for Nokia 2-mm charging plug (outmolding)

The charging voltage is connected to the center pin and the ground is connected to the outer surface of the plug.

Nokia 2 mm DC-Charging Plug



NOTES:

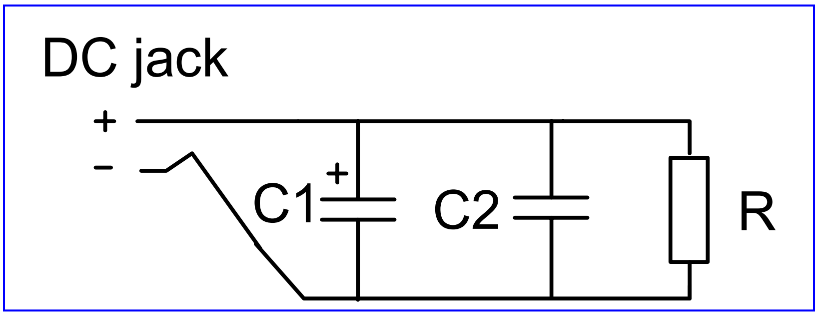
1. Dielectric strength: 400 VAC between adjacent contact/ 1 minute. No Voltage breakdown.
2. Insulation resistance: DC 500V/100 Mohm.

Figure 14: Mechanical specification for Nokia 2-mm charging plug

8 Terms and abbreviations

Term or abbreviation	Meaning
AC	Alternating current
CDN	Coupling and decoupling network
Crest factor	Current peak value/current RMS value
DC	Direct current
EMI	Electromagnetic interference
ESR	Equivalent series resistance
Pop-Port	System connector in Nokia mobile devices
PWM	Pulse width modulation
RMS	Root mean square
Slew rate	(U or I) value change/changing time
U/I	Voltage/Current
VCHAR	Charging voltage

Appendix A: Artificial load



In an artificial load circuit:

R value is selected so that charger output is 5.0 V.

C1 value is 4,400 µF – 6,000 µF, low ESR.

C2 value is 1 nF, low ESR.

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