Compare Results

Old File:		New File:
USB_PD_R3_1 V1.8 2023-04_Ch10.pdf	versus	**USB_PD_R3_2 V1.0 2023-10_Ch 10.pdf**
12 pages (898 KB)		**24 pages (820 KB)**
13/10/2023 19:37:41		31/10/2023 18:10:37

Total Changes

209

Text only comparison

Content

112 Replacements

62 Insertions

35 Deletions

Styling and Annotations

0 Styling

0 Annotations

Go to First Change (page 1)

10. Power Rules

10.1 Introduction

The flexibility of power provision on USB Type-C® is expected to lead to adapter re-use and the increasingly widespread provision of USB power outlets in domestic and public places and in transport of all kinds. Environmental considerations could result in unbundled adapters. Rules are needed to avoid incompatibility between the Sources and the Sinks they are used to power, in order to avoid user confusion and to meet user expectations. This section specifies a set of rules that Sources and Sinks ***Shall*** follow. These rules provide a simple and consistent user experience.

The PDP Rating is a manufacturer declared value placed on packaging to help the user understand the capabilities of a charger or the size of charger required to power their device. For PDP values of 10W and above the PDP ***Shall*** be declared as an integer number of Watts. For PDP values less than 10W, the PDP ***Shall*** be declared in increments of 0.5W.

The Source Power rules define a PDP to provide a simple way to tell the user about the capabilities of their power adapter or device. PDP Rating is akin to the wattage rating of a light bulb – bigger numbers mean more capability.

The Sink Power rules define a PDP to provide a simple way to tell the user which Sources will provide adequate power for their Sink.

10.2 Source Power Rules

In order to meet the expectations of the user, the Maximum Current/Power in the Source Capabilities PDO or APDO for Sources with a PDP Rating of x Watts ***Shall*** be as follows:

- Maximum current for Normative and ***Optional*** Fixed/Variable supply PDOs ***Shall*** be either RoundUp(x/Voltage) or RoundDown(x/Voltage) to the nearest 10mA.
- Maximum current for SPR Programmable Power Supply APDOs ***Shall*** be as defined in ***Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port*** Maximum PDP". Note that when the Constant Power bit is set in the APDO, the programmable power supply's output current is as defined in ***Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port*** Maximum PDP" however the programmable power supply will limit its output current so that the product of its actual output Voltage times the output current does not exceed the PDP.
- If a 9V Prog, 15V Prog or 20V Prog Programmable Power Supply APDO is advertised when not required by ***Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port*** Maximum PDP", then the maximum current ***Shall*** be RoundDown (x/Prog Voltage) to the nearest 50mA. When the PPS Power Limited bit is clear the Source ***Shall*** provide this current at Max Voltage.
- Maximum power for ***Optional*** Battery supply PDOs ***Shall*** be ≤ x.

10.2.1 Source Power Rule Considerations

The Source power rules are designed to:

- Ensure the PD Power (PDP) of an adapter specified in watts explicitly defines the Voltages and currents at each Voltage the adapter supports.
- Ensure that adapters with a large PDP Ratings are always capable of providing the power to devices designed for use with adapters with a smaller PDP Rating.
- Enable an ecosystem of adapters that are interoperable with the devices in the ecosystem.

The considerations that lead to the Source power rules are based are summarized in *Table 10.1 "Considerations for Sources"*.

Table 10.1 "Considerations for Sources"

Considerations	Rationale	Consequence
Simple to identify capability	A user going into an electronics retailer knows what they need	Cannot have a complex identification scheme
Higher power Sources are a superset of smaller ones	Bigger is always better in user's eyes – don't want a degradation in performance	Higher power Sources do everything smaller ones do
Unambiguous Source definitions	Sources with the same power rating but different VI combinations might not interoperate	To avoid user confusion, any given power rating has a single definition
A range of power ratings	Users and companies will want freedom to pick appropriate Source ratings	Fixed profiles at specific power levels don't provide adequate flexibility, e.g., profiles as defined in previous versions of PD.
5V@3A USB Type-C® Source is defined by *[USB Type-C 2.3]*	5V@3A USB Type-C® Source is considered	All > 15W adapters must support 5V@3A or superset consideration is violated
Maximize 3A cable utilization	3A cables will be ubiquitous	Increase to maximum Voltage (20V) before increasing current beyond 3A
Optimize Voltage rail count	More rails are a higher burden for Sources, particularly in terms of testing	5V is a basic USB requirement. 20V provides the maximum capability.
Some Sources are not able to provide significant power	Some small Battery-operated Sources e.g., mobile devices, are able to provide more power directly from their Battery than from a regulated 5V supply	In addition to the minimal 5V Advertisement are able to Advertise more power from their Battery
Some Sources share power between multiple Ports (Hubs)	Hubs have to be supported	See *Section 10.2.4 "Power sharing between ports"*

10.2.2 Normative Voltages and Currents

The Voltages and currents an SPR Source with a PDP Rating of x Watts ***Shall*** support are as defined in ***Table 10.2 "SPR Normative Voltages and Minimum Currents"***.

Table 10.2 "SPR Normative Voltages and Minimum Currents"

Port Maximum PDP Rating (W)	5V Fixed	9V Fixed	15V Fixed	20V Fixed	SPR AVS
0.5 ≤ x ≤ 15	(PDP/5)A[3]	-	-	-	-
15 < x ≤ 27	3A[2]	(PDP/9)A[3]	-	-	-
27 < x ≤ 45	3A[2]	3A[2]	(PDP/15)A[3]	-	(9V – 15V): (15V Fixed Max Current) A
45 < x ≤ 60	3A[2]	3A[2]	3A[2]	(PDP/20)A[3]	(9V – 15V): (15V Fixed Max Current) A[4] (15V – 20V): (20V Fixed Max Current) A
60 < x ≤ 100	3A[2]	3A[2]	3A[2]	(PDP/20)A[1, 3]	(9V – 15V): (15V Fixed Max Current) A[4, 5] (15V – 20V): (20V Fixed Max Current) A[1, 5]

1) Requires a 5A cable.

2) The Fixed PDOs Maximum Current field ***Shall*** advertise at least 3A, but ***May*** advertise up to RoundUp (PDP/Voltage) to the nearest 10mA. Requires a 5A cable if over 3A is advertised.

3) The Fixed PDOs Maximum Current field ***Shall*** advertise either RoundDown (PDP/Voltage) or RoundUp (PDP/Voltage) to the nearest 10mA.

4) SPR AVS current for this voltage range is the maximum current as advertised by the 15V Fixed Source PDO. This current can be higher than 3A (refer to Note 2). Requires a 5A cable if over 3A is advertised.

5) The Sink is allowed to request up to the 20V Fixed Max Current when the requested voltage is 15.0V.

SPR Managed Capability ports when power constrained are defined to offer higher voltages at lower Port Present PDP (as per ***Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"***) than the port's Port Maximum PDP (as per ***Table 10.2 "SPR Normative Voltages and Minimum Currents"***) because these voltages would otherwise be available if the Managed Capability port power hadn't been constrained. Managed Capability ports are required to be properly identified to the user based on the port's Port Maximum PDP.

Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"

Port Present PDP (W)	5V Fixed	9V Fixed	15V Fixed	20V Fixed	SPR AVS with Max Voltage of 15V or 20V per Table 10.2 "SPR Normative Voltages and Minimum Currents"[6]
0.5 ≤ x ≤ 15	(PDP/5)A[3]	(PDP/9)A[3, 7]	(PDP/15)A[3, 7]	(PDP/20)A[3, 7]	(9V – 15V): (15V Fixed Max Current) A[4] (15V – 20V): (20V Fixed Max Current) A
15 < x ≤ 27	3A[2]	(PDP/9)A[3]			
27 < x ≤ 45	3A[2]	3A[2]	(PDP/15)A[3]		
45 < x ≤ 60	3A[2]	3A[2]	3A[2]	(PDP/20)A[3]	
60 < x ≤ 100	3A[2]	3A[2]	3A[2]	(PDP/20)A[1, 3]	(9V – 15V): (15V Fixed Max Current) A[4, 5] (15V – 20V): (20V Fixed Max Current) A[1, 5]

1) Requires a 5A cable.

2) The Fixed PDOs Maximum Current field ***Shall*** advertise at least 3A, but ***May*** advertise up to RoundUp (PDP/Voltage) to the nearest 10mA. Requires a 5A cable if over 3A is advertised.

3) The Fixed PDOs Maximum Current field ***Shall*** advertise either RoundDown (PDP/Voltage) or RoundUp (PDP/Voltage) to the nearest 10mA.

4) SPR AVS current for this voltage range is the maximum current as advertised by the 15V Fixed Source PDO. This current can be higher than 3A (refer to Note 2). Requires a 5A cable if over 3A is advertised.

5) The Sink is allowed to request up to the 20V Fixed Max Current when the requested voltage is 15.0V.

6) The Max Voltage for SPR AVS is what is allowed by *Table 10.2 "SPR Normative Voltages and Minimum Currents"* based on the port's Port Maximum PDP.

7) This SPR Fixed voltage is only available if allowed by *Table 10.2 "SPR Normative Voltages and Minimum Currents"* based on the port's Port Maximum PDP.

In reference to *Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"*, Table *Table 10.4 "SPR Source Port Present PDP less than Port Maximum PDP Examples"* gives examples of which SPR capabilities are Advertised based on Port Present PDP on a Managed Capability port and the port's Port Maximum PDP and cable's current rating.

Table 10.4 "SPR Source Port Present PDP less than Port Maximum PDP Examples"

Port Maximum PDP and Cable Rating	Port Present PDP	Offers				
		5V Fixed	9V Fixed	15V Fixed	20V Fixed	SPR AVS
80W / 5A	65W	3A[1]	3A[1]	3A[1]	3.25A	9V – 15V: 3A 15V – 20V: 3.25A
80W / 5A	40W	3A[1]	3A[1]	2.67A	2A	9V – 15V: 2.67A 15V – 20V: 2A
80W / 3A	40W	3A[1]	3A	2.67A	2A	9V – 15V: 2.67A 15V – 20V: 2A
40W / 5A	40W	3A[1]	3A[1]	2.67A	Not Offered	9V – 15V: 2.67A
40W / 3A	40W	3A[1]	3A	2.67A	Not Offered	9V – 15V: 2.67A
80W / 5A	20W	3A[1]	2.22A	1.33A	1A	9V – 15V: 1.33A 15V – 20V: 1A
80W / 3A	20W	3A[1]	2.22A	1.33A	1A	9V – 15V: 1.33A 15V – 20V: 1A
40W / 5A	20W	3A[1]	2.22A	1.33A	Not Offered	9V – 15V: 1.33A
40W / 3A	20W	3A[1]	2.22A	1.33A	Not Offered	9V – 15V: 1.33A

1) The Fixed PDO Maximum Current field will advertise at least 3A but ***May*** advertise up to RoundUp (PDP/voltage) to the nearest 10mA.

10.2.2.1 Fixed PDOs

Figure 10-1 "SPR Source Power Rule Illustration for Fixed PDOs" illustrates the minimum current that an SPR Source ***Shall*** support at each Voltage for a given PDP Rating for Fixed PDOs.

Note: Not illustrated are that currents higher than 3A are allowed to be offered up to a limit of 5A given that a 5A cable is detected by the Source and the Voltage times current remains within the Source PDP Rating.

Figure 10-1 "SPR Source Power Rule Illustration for Fixed PDOs"

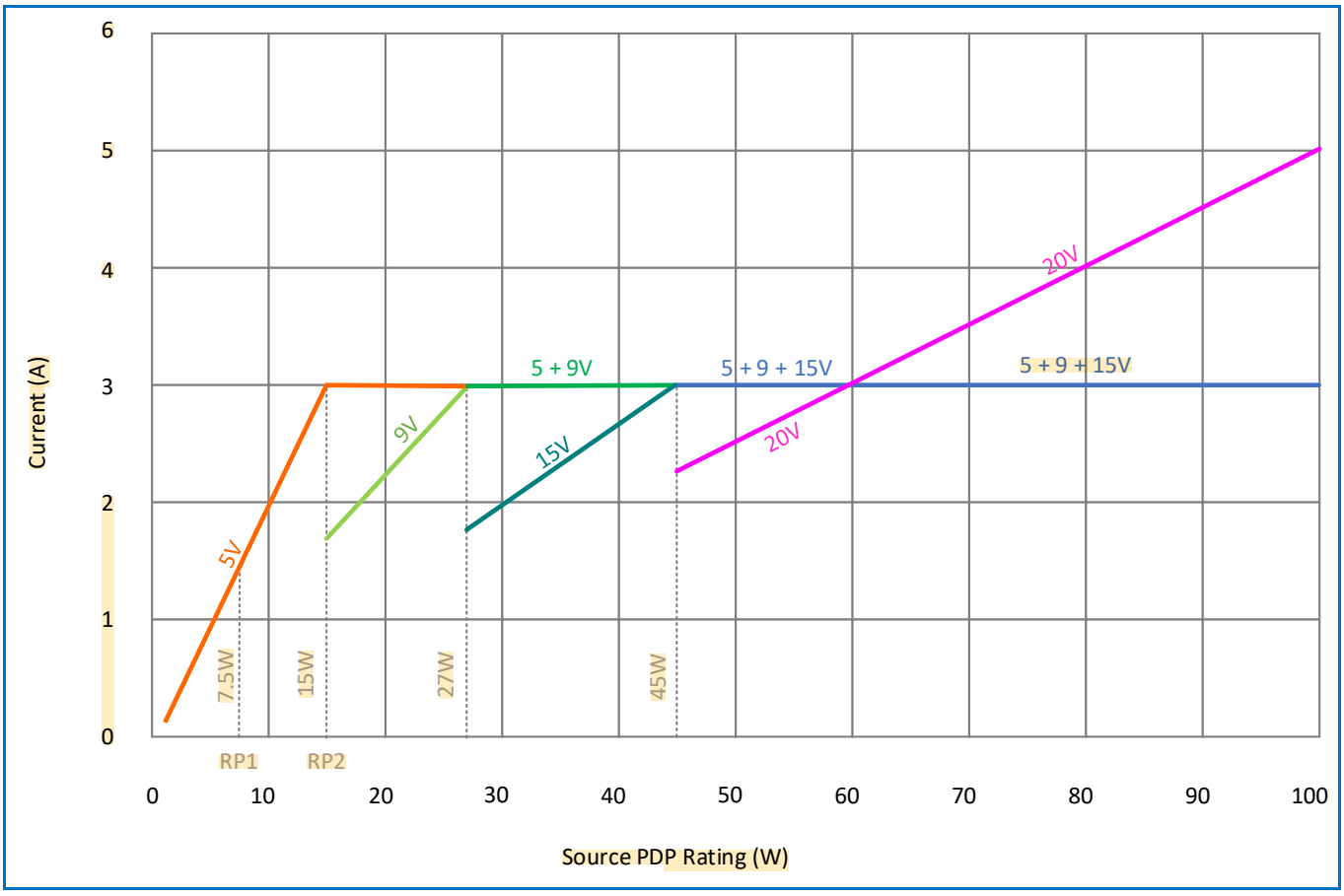


Figure 10-2 "SPR Source Power Rule Example For Fixed PDOs" shows an example of an adapter with a rating at 50W. The adapter is required to support 20V at 2.5A, 15V at 3A, 9V at 3A and 5V at 3A.

Figure 10-2 "SPR Source Power Rule Example For Fixed PDOs"

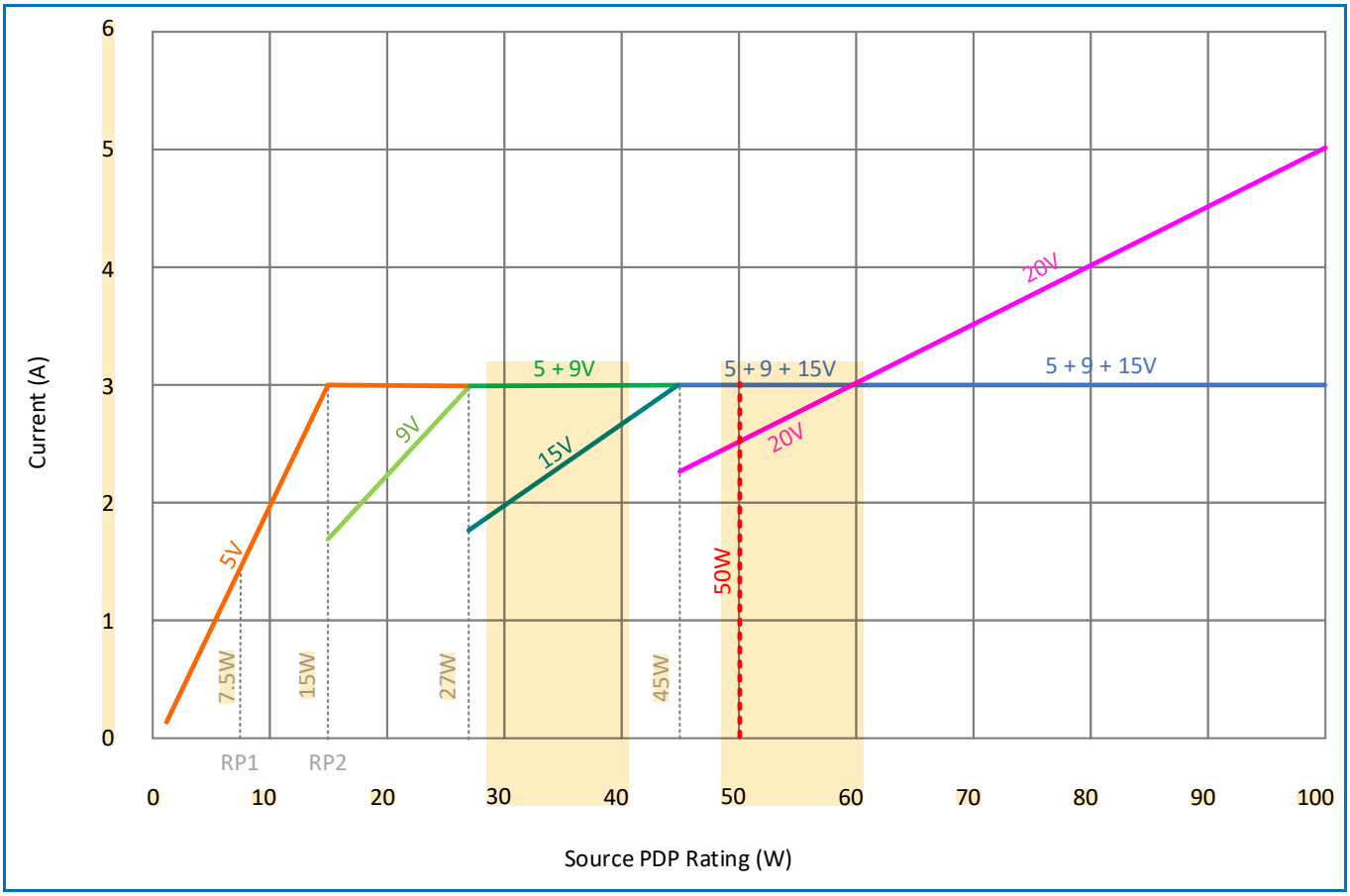


Table 10.5 "Fixed Supply PDO – Source 5V", ***Table 10.6 "Fixed Supply PDO – Source 9V"***, ***Table 10.7 "Fixed Supply PDO – Source 15V"*** and ***Table 10.8 "Fixed Supply PDO – Source 20V"*** show the Fixed Supply PDOs that ***Shall*** be supported for each of the ***Normative*** Voltages defined in ***Table 10.2 "SPR Normative Voltages and Minimum Currents".***

Table 10.5 "Fixed Supply PDO – Source 5V"

Bit(s)	Description
B31…30	Fixed supply
B29	Dual-Role Power
B28	USB Suspend Supported
B27	Unconstrained Power
B26	USB Communications Capable
B25	Dual-Role Data
B24…22	***Reserved*** **–** ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	5V
B9…0	Current based on PDP PDP Rating (x) / Current (A) 0.5 ≤ x ≤ 15 / x ÷ 5 15 < x ≤ 25 / 3 ≤ A ≤ x ÷ 5 25 < x ≤ 100 / 3 ≤ A ≤ 5

Table 10.6 "Fixed Supply PDO – Source 9V"

Bit(s)	Description
B31…30	Fixed Supply
B29…22	***Reserved*** **–** ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	9V
B9…0	Current based on PDP PDP Rating (x) / Current (A) 0.5 ≤ x ≤ 15 / PDO not required 15 < x ≤ 27 / x ÷ 9 27 < x ≤ 45 / 3 ≤ A ≤ x ÷ 9 45 < x ≤ 100 / 3 ≤ A ≤ 5

Table 10.7 "Fixed Supply PDO – Source 15V"

Bit(s)	Description
B31…30	Fixed Supply
B29…22	***Reserved*** **–** ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	15V
B9…0	Current based on PDP **PDP Rating (x) / Current (A)** 0.5 ≤ x ≤ 27 : PDO not required 27 < x ≤ 45 : x ÷ 15 45 < x ≤ 75 : 3 ≤ A ≤ x ÷ 15 75 < x ≤ 100 : 3 ≤ A ≤ 5

Table 10.8 "Fixed Supply PDO – Source 20V"

Bit(s)	Description
B31…30	Fixed Supply
B29…22	***Reserved*** **–** ***Shall*** be set to zero.
B21…20	Peak Current
B19…10	20V
B9…0	Current based on PDP **PDP Rating (x) / Current (A)** 0.5 ≤ x ≤ 45 : PDO not required 45 < x ≤100 : x ÷ 20

More current ***May*** be offered in the PDOs when ***Optional*** Voltages/currents are supported and a 5A cable is being used (see *Section 10.2.3 "Optional Voltages/Currents"*).

10.2.2.2 SPR Adjustable Voltage Supply (AVS)

For SPR AVS, *Figure 10-3 "Valid SPR AVS Operating Region for a Source advertising in the range of 27W < PDP ≤ 45W"*, *Figure 10-4 "Valid SPR AVS Operating Region for a Source advertising in the range of 45W < PDP ≤ 60W"* and *Figure 10-5 "Valid SPR AVS Operating Region for a Source advertising in the range of 60W < PDP ≤ 100W"* illustrate the valid operating region for SPR AVS RDO requests in the ranges of 27W < PDP ≤ 45W, 45W < PDP ≤ 60W and 60W < PDP ≤ 100W, respectively.

Figure 10-3 "Valid SPR AVS Operating Region for a Source advertising in the range of 27W < PDP ≤ 45W"

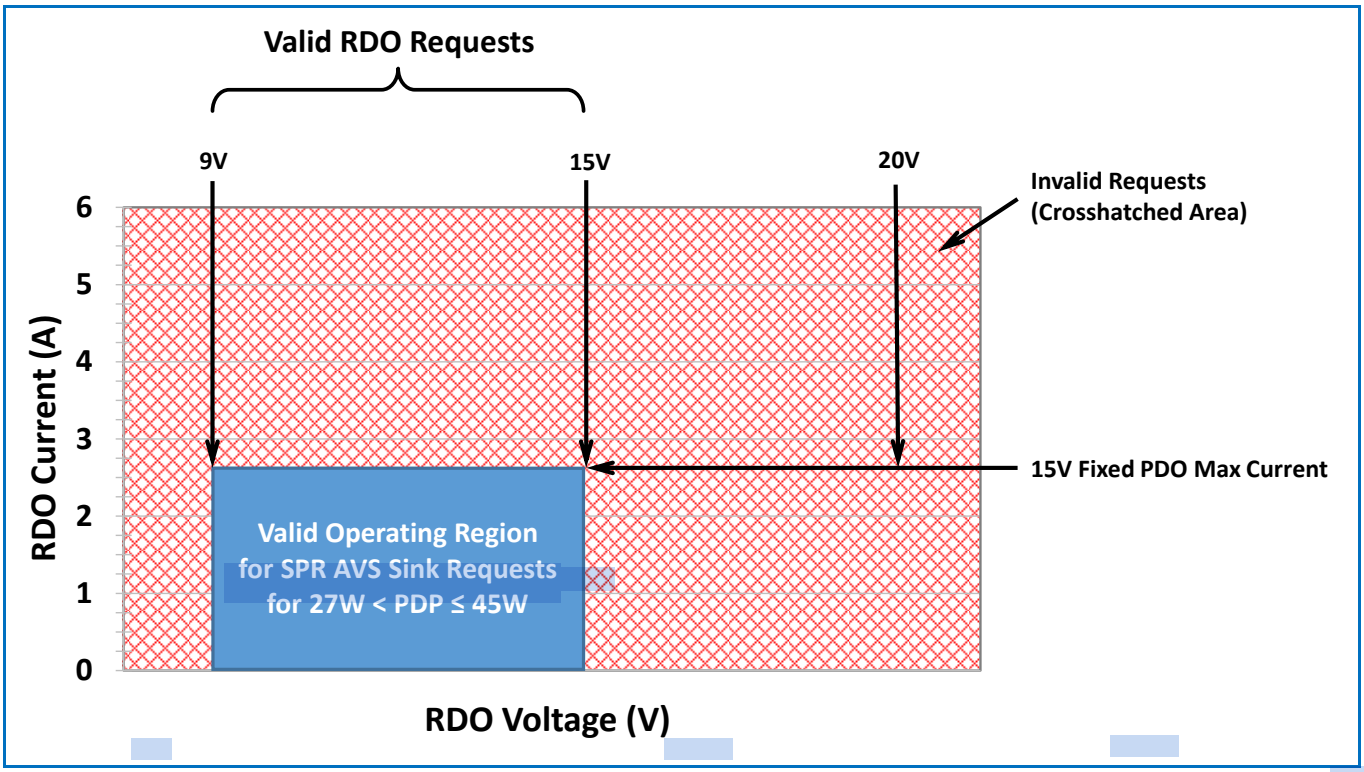


Figure 10-4 "Valid SPR AVS Operating Region for a Source advertising in the range of 45W < PDP ≤ 60W"

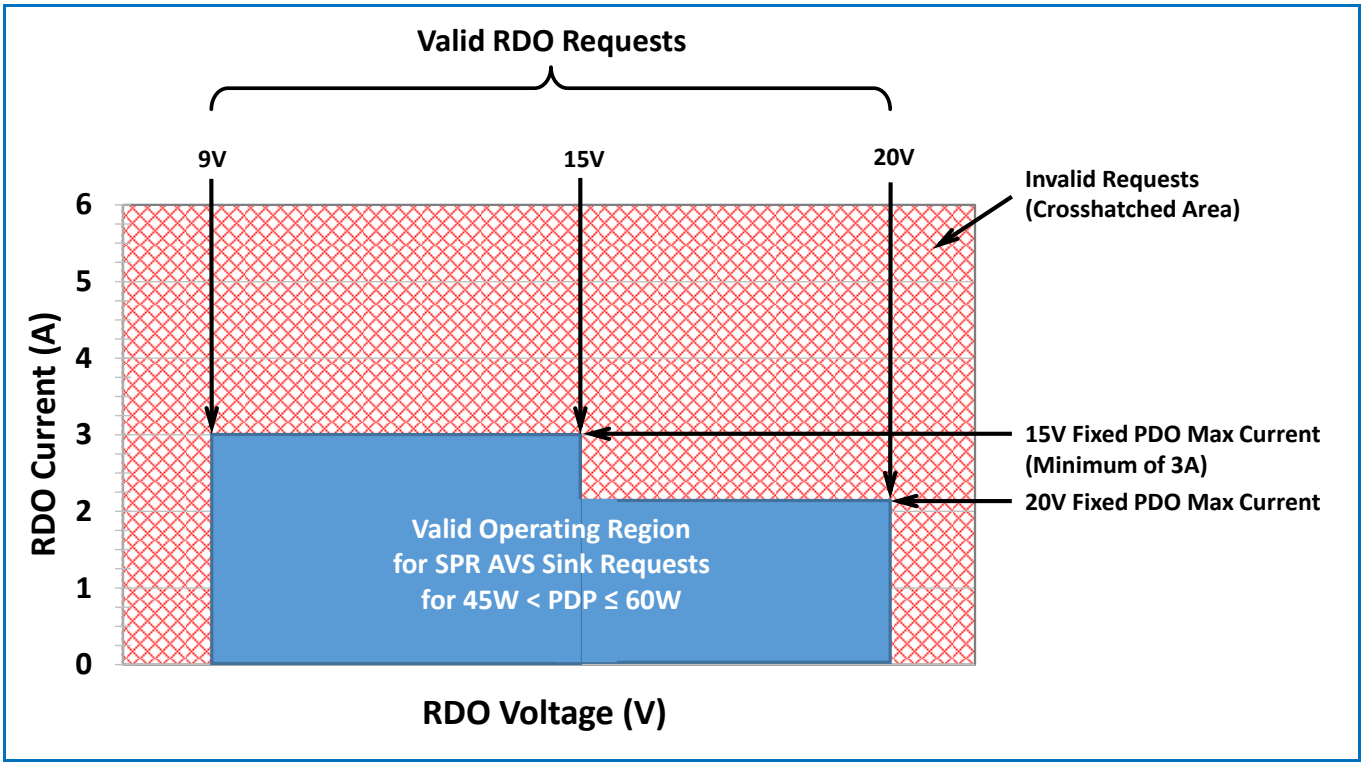
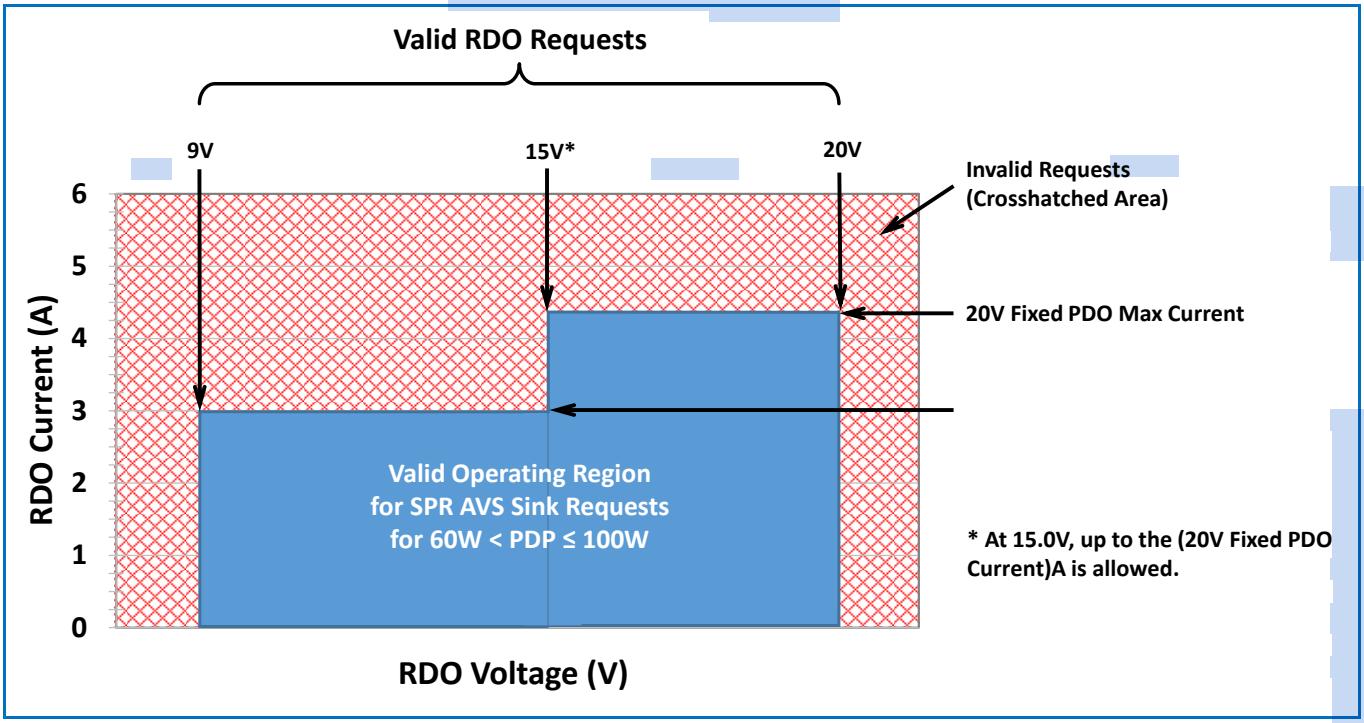


Figure 10-5 "Valid SPR AVS Operating Region for a Source advertising in the range of 60W < PDP ≤ 100W"



10.2.2.2.1 SPR Adjustable Voltage Supply (AVS) Voltage Ranges

Table 10.12 "EPR Source Capabilities based on the Port Maximim PDP and using an EPR Capable Cable" shows the Minimum and Maximum Voltage for the SPR AVS ranges.

Table 10.9 "SPR Adjustable Voltage Supply (AVS) Voltage Ranges"

	AVS Voltage Range	
	15V AVS	20V AVS
Maximum Voltage	15V	20V
Minimum Voltage	9V	9V

The Voltage output at the Source's connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.2.3 Optional Voltages/Currents

10.2.3.1 Optional Normative Fixed, Variable and Battery Supply

In addition to the Voltages and currents specified in *Section 10.2.2 "Normative Voltages and Currents"*, an SPR Source that is optimized for use with a specific Sink or a specific class of Sinks ***May Optionally*** supply additional Voltages and increased currents. However, the ***Optional*** Voltages ***Shall Not*** exceed 9V.

Optional Voltages ***Shall Not*** be implemented on EPR Sources including for both SPR and EPR modes of operation. Additionally, while operating in EPR mode, Variable and Battery supplies are not allowed.

While allowed, the use of ***Optional*** voltages and currents is not recommended as two Sources with the same PDP rating but not supporting the same ***Optional*** voltages and currents may behave differently thus confusing the user.

See *Section 10.2 "Source Power Rules"* for the rules that ***Shall*** apply to ***Optional*** PDOs in order to be consistent with the declared PDP Rating and the ***Normative*** Voltages and currents.

10.2.3.2 Optional Normative SPR Programmable Power Supply

The Voltages and currents a Programmable Power Supply with a PDP Rating of x Watts ***Shall*** support are as defined *Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port* Maximum PDP".

When ***Optional*** Programmable Power Supply APDOs are offered, the following requirements ***Shall*** apply:

- A Source that Advertises ***Optional*** Programmable Power Supply APDOs ***Shall*** Advertise the PDOs and APDOs shown in *Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port* Maximum PDP".
- A Source ***Shall*** Advertise ***Optional*** Programmable Power Supply APDOs with Maximum Voltage and Minimum Voltages for nominal Voltage as defined in *Table 10.11 SPR "Programmable Power Supply Voltage Ranges"*.
- A Source ***Shall Not*** advertise a Programmable Power Supply APDO that does not follow the Minimum Voltage and Maximum Voltage defined in *Table 10.11 SPR "Programmable Power Supply Voltage Ranges"*.
- In no case ***Shall*** a Source Advertise a current that exceeds the attached cable's current rating.
- The Max Voltage ***Shall Not*** exceed 21V while in SPR mode.

Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port Maximum PDP"

PDP Maximum PDP (W)	SPR Fixed and AVS	9V Prog[3]	15V Prog[3]	20V Prog[3]
x < 15W	Required per *Table 10.2 "SPR Normative Voltages and Minimum Currents"* (or *Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* when applicable)	-	-	-
15W		-	-	-
15 < x < 27W		(PDP/9)A[1]	-	-
27W		3A	-	-
27 < x < 45W		3A[2]	(PDP/15)A[1]	-
45W		-	3A	-
45 < x < 60W		-	3A[2]	(PDP/20)A[1]
60W		-	-	3A
60 < x < 100W		-	-	(PDP/20)A[1]
100W		-	-	5A

1) The SPR PPS APDOs Maximum Current field ***Shall*** advertise RoundDown (PDP/Prog Voltage) to the nearest 50mA.

2) The SPR PPS APDOs Maximum Current field ***Shall*** advertise at least 3A, but ***May*** advertise up to RoundDown(PDP/Prog Voltage) to the nearest 50mA.

3) Applies to APDOs regardless of value of the PPS Power Limited bit.

10.2.3.2.1 SPR Programmable Power Supply Voltage Ranges

The SPR Programmable Power Supply Voltage ranges map to the Fixed Supply Voltages. For each Fixed Voltage there is a defined Voltage range for the matching Programmable Power Supply APDO. *Table 10.11 SPR "Programmable Power Supply Voltage Ranges"* shows the Minimum and Maximum Voltage for the Programmable Power Supply that corresponds to the Fixed nominal Voltage.

Table 10.11 SPR "Programmable Power Supply Voltage Ranges"

	Fixed Nominal Voltage		
	9V Prog	15V Prog	20V Prog
Maximum Voltage	11V	16V	21V
Minimum Voltage	5V	5V	5V

The Voltage output at the Source's connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.2.3.2.2 Examples of the use of SPR Programmable Power Supplies

The following examples illustrate what a power adapter that Advertises a particular PDP Rating ***May*** offer:

1) PDP 27W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A, and
   - 9V Prog @ 3A.

2) PDP 36W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 2.4A,
   - SPR AVS with 9V – 15V @ 2.4A,
   - 9V Prog @ 3 A, and
   - 15V Prog @ 2.4A.

3) PDP 36W implementation that optionally includes higher current in the 9V Prog PPS:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 2.4A,
   - SPR AVS with 9V – 15V @ 2.4A,
   - 9V Prog @ >3A up to 4A (with a 5A cable) and 15V
   - Prog @ 2.4A.

4) PDP 50W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 3A,
   - 20V @ 2.5A,
   - SPR AVS with 9V – 15V @ 3A & 15V – 20V @ 2.5A,
   - 15V Prog @ 3A, and
   - 20V Prog @ 2.5A.

5) PDP 80W implementation includes:
   - 5V @ 3A,
   - 9V @ 3A,
   - 15 @ 3A,
   - 20V @ 4A,
   - SPR AVS with 9V – 15V @ 3A & 15V – 20V @ 4A,
   - 15V Prog @ 3A, and
   - 20V Prog @ 4A.

The first example illustrates a basic example of a supply that can only support 5V and 9V.

The second and third examples illustrates as the PDP Rating goes higher there are more possible combinations that meet the power rules. These examples also add SPR AVS. Although there are multiple ways to meet the power rules, while operating in SPR Mode no more than a combination of seven SPR PDOs and APDOs can be offered.

The fourth and fifth example show that the 15V Prog @ 3A fully covers the 9V Prog @3A range so it is not necessary to advertise both. These examples also illustrate SPR AVS being extended up to 20V with separate current limits for the 9V – 15V and 15V – 20V ranges – a single SPR AVS APDO covers advertising both ranges.

10.2.3.3 Optional Normative Extended Power Range (EPR)

Support of EPR Mode is ***Optional***. An EPR-capable port has a PDP Rating that is >100W and ≤240W. An EPR-capable Source port ***May*** operate in either SPR mode or EPR mode when operating at 100W or less.

An EPR- capable Source port operating in SPR Mode ***May*** offer less than 100W to avoid violating safety regulations. When operating in EPR Mode, an EPR-capable Source port ***Shall*** offer 100W in Fixed 20V when not constrained by multi- port sharing limits.

An EPR-capable Source ***May*** include multiple ports and these ports can be functionally implemented as Shared or Assured ports as defined in ***[USB Type-C 2.3]***.

Any port on an EPR Source that has a Port Present PDP of 100W or less ***Shall*** follow the ***Normative*** requirements for SPR Source Ports and ***Shall*** operate only in SPR mode. Any port on an EPR Source that is operating with a cable that is not EPR-capable ***Shall*** operate only in SPR mode. An EPR Source, when operating in SPR Mode with a 5A cable, ***May*** offer less than 5A due to design tolerances in order to meet applicable safety standards. For best user experience it ***Should*** be as close to 100W as possible.

Table 10.12 "EPR Source Capabilities based on the Port Maximim PDP and using an EPR Capable Cable" and ***Table 10.13 "EPR Source Capabilities when Port Present PDP is less than*** Port Maximum PDP and using an EPR-capable cable" define the ***Normative*** requirements for ports on EPR Source Ports. While not included in these tables, any EPR-capable Source port that also supports SPR PPS Shall offer the SPR Fixed 20V PDO and PPS 20V Prog APDO at 100W (or the maximum available PDP when the port is operating at an Equivalent PDP <100W) when in EPR mode:

- When an EPR Source port is capable of supplying its PDP Rating, it ***Shall*** adhere to the requirements defined in ***Table 10.12 "EPR Source Capabilities based on the Port Maximim*** PDP and using an EPR Capable Cable" based on its PDP Rating of x Watts.
- When a Source Port on an EPR charger is unable to provide its Port Maximum PDP, it ***Shall*** adhere to the requirements defined in ***Table 10.13 "EPR Source Capabilities when Port Present PDP is less than*** Port Maximum PDP and using an EPR-capable cable" based on a Port Present PDP of x Watts. Some examples:
  - An EPR Source port ***May*** be unable to provide its rated PDP because it is thermally constrained at the time of power negotiation.
  - A Shared port on a multi-port EPR Charger that is limited by the remaining available power.
- When an EPR charger is in an Adjustable Voltage Source (AVS) contract:
  - It ***Shall*** Reject all Requests outside of the defined Voltage range (see ***Table 10.15 "EPR Adjustable Voltage Supply (AVS) Voltage Ranges"***) or for a requested Voltage and Current that results in a power level that is more than the Port's Advertised PDP.
  - In no case ***Shall*** a Source Advertise a Current or accept a Current requested by a Sink that exceeds the attached cable's current rating.
- The Max Voltage offered by an EPR Source ***Shall Not*** exceed 48V.

Table 10.12 "EPR Source Capabilities based on the Port Maximim PDP and using an EPR Capable Cable"

Port Maximum PDP (W)	SPR Fixed and AVS	28V Fixed	36V Fixed[3]	48V Fixed	EPR AVS[3, 4]
100 < x ≤ 140	Required per *Table 10.2 "SPR Normative Voltages and Minimum Currents"* (or *Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* when applicable)	(PDP/28) A[2]	***N/A***[1]	***N/A***[1]	(15V – PDP/5A): 5A (>PDP/5A – 28V): (PDP/AVS Voltage) A
140 x ≤ 180		5A	(PDP/36) A[2]	***N/A***[1]	(15V – PDP/5A): 5A (>PDP/5A – 36V): (PDP/AVS Voltage) A
180 < x ≤ 240		5A	5A	(PDP/48) A[2]	(15V – PDP/5A): 5A (>PDP/5A – 48V): (PDP/AVS Voltage) A

1) EPR Sources are disallowed from offering Fixed Voltages that are above the defined Voltages for a given PDP, e.g., 36V is disallowed for any PDP of 140W or lower.

2) The Fixed PDOs Maximum Current field ***Shall*** advertise either RoundDown (PDP/Voltage) or RoundUp (PDP/Voltage) to the nearest 10mA.

3) EPR Sources ***Shall*** reject any request for more than the Advertised PDP, i.e., when output voltage and operating current requested in the Sink RDO is outside of the defined AVS voltage and current range represented by the advertised PDP, the RDO will be rejected.

4) The current available for a given AVS Voltage is as indicated in this column. The current defined here is describing the top edge of the Valid Operating Region as illustrated in *Figure 10-6 "Valid EPR AVS Operating Region"*. The AVS APDO does not have a Maximum Current field, so the maximum current has to be calculated from the PDP.

Table 10.13 "EPR Source Capabilities when Port Present PDP is less than Port Maximum PDP and using an EPR-capable cable"

Port Present PDP (W)	SPR Fixed and AVS	28V Fixed	36V Fixed[4]	48V Fixed[4]	EPR AVS with Max Voltage of 28V, 36V or 48V per Table 10.12[2, 5, 6]
7.5 ≤ x ≤ 15	Required per *Table 10.2 "SPR Normative Voltages and Minimum Currents"* (or *Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* when applicable)	(PDP/28) A[1]	(PDP/36) A[1]	(PDP/48) A	(15V – PDP/5A): 5A (>PDP/5A – Max Voltage): (PDP/AVS Voltage) A
15 < x ≤ 27					
27 < x ≤ 45					
45 < x ≤ 60					
60 < x ≤ 100					
100 < x ≤ 140	*Table 10.3 "SPR Source Capabilities When Port Present PDP is less than Port Maximum PDP"* with a Port Present PDP of 100W.				
140 < x ≤ 180		5A			
180 < x ≤ 240		5A	5A		

1) The Fixed PDOs Maximum Current field ***Shall*** Advertise either RoundDown (PDP/Voltage) or RoundUp (PDP/Voltage) to the nearest 10mA.

2) EPR Sources ***Shall*** reject any Request for more than the Advertised PDP, i.e., when output voltage and operating current requested in the Sink RDO is outside of the defined AVS voltage and current range represented by the advertised PDP, the RDO will be rejected.

3) EPR Sources ***Shall Not*** offer an AVS APDO at this Port Present PDP.

4) This EPR Fixed voltage is only available if allowed by *Table 10.12 "EPR Source Capabilities based on the Port Maximim PDP and using an EPR Capable Cable"* based on the port's PDP Rating.

5) The Max Voltage for AVS is what is allowed by *Table 10.12 "EPR Source Capabilities based on the Port Maximim PDP and using an EPR Capable Cable"* based on the port's Port Maximum PDP.

6) The current available based on AVS voltage is as indicated in this column. The current defined here is describing the top edge of the Valid Operating Region as illustrated in *Figure 10-6 "Valid EPR AVS Operating Region"*. AVS APDO does not have a Maximum Current field so the maximum current has to be calculated from the PDP.

Note: EPR Managed Capability ports when power constrained are defined to offer higher voltages at lower Port Present PDP (as per *Table 10.13 "EPR Source Capabilities when Port Present PDP is less than* Port Maximum PDP and using an EPR-capable cable") than the port's Port Maximum PDP (as per *Table 10.12 "EPR Source Capabilities based on the Port Maximim* PDP and using an EPR Capable Cable"*)* because these voltages would otherwise be available if the Managed Capability port power hadn't been constrained. Managed Capability ports are required to be properly identified to the user based on the port's Port Maximum PDP.

In reference to *Table 10.13 "EPR Source Capabilities when Port Present PDP is less than* Port Maximum PDP and using an EPR-capable cable", *Table 10.14 "EPR Source Examples when Port* Present PDP is less than Port Maximum PDP" gives examples of which EPR capabilities, in addition to the required SPR Fixed PDOs and SPR AVS APDO, are Advertised based on Port Present PDP and the port's Port Maximum PDP.

Table 10.14 "EPR Source Examples when Port Present PDP is less than Port Maximum PDP"

Port Maximum PDP	Port Present PDP	Offers			
		28V Fixed	36V Fixed	48V Fixed	AVS
200W	108W	3.86A	3A	2.25A	48V@108W
160W	108W	3.86A	3A	Not offered	36V@108W
120W	108W	3.86A	Not offered	Not offered	28V@108W
200W	72W	2.57A	2A	1.5A	48V@72W
160W	72W	2.57A	2A	Not offered	36V@72W
120W	72W	2.57A	Not offered	Not offered	28V@72W
200W	36W	1.29A	1A	0.75A	48V@36W
160W	36W	1.29A	1A	Not offered	36V@36W
120W	36W	1.29A	Not offered	Not offered	28V@36W

EPR Sources when operating in an AVS contract are required to stay within their PDP as such they ***Shall*** respond to any request (VA) for more than the PDP with a ***Reject*** Message. *Figure 10-6 "Valid EPR AVS Operating Region"* illustrates the definition of the ***Valid*** operating range for an EPR Source operating in an AVS contract based on its Advertised PDP.

Figure 10-6 "Valid EPR AVS Operating Region"

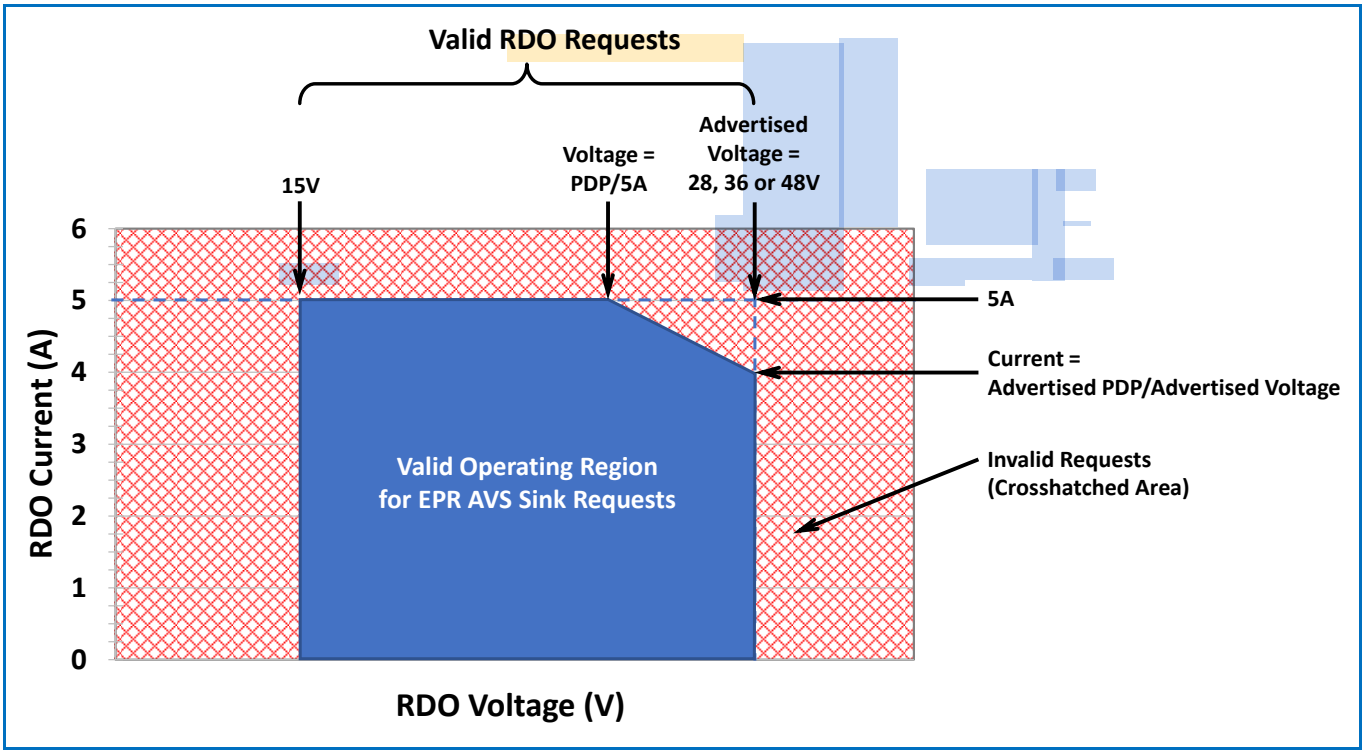
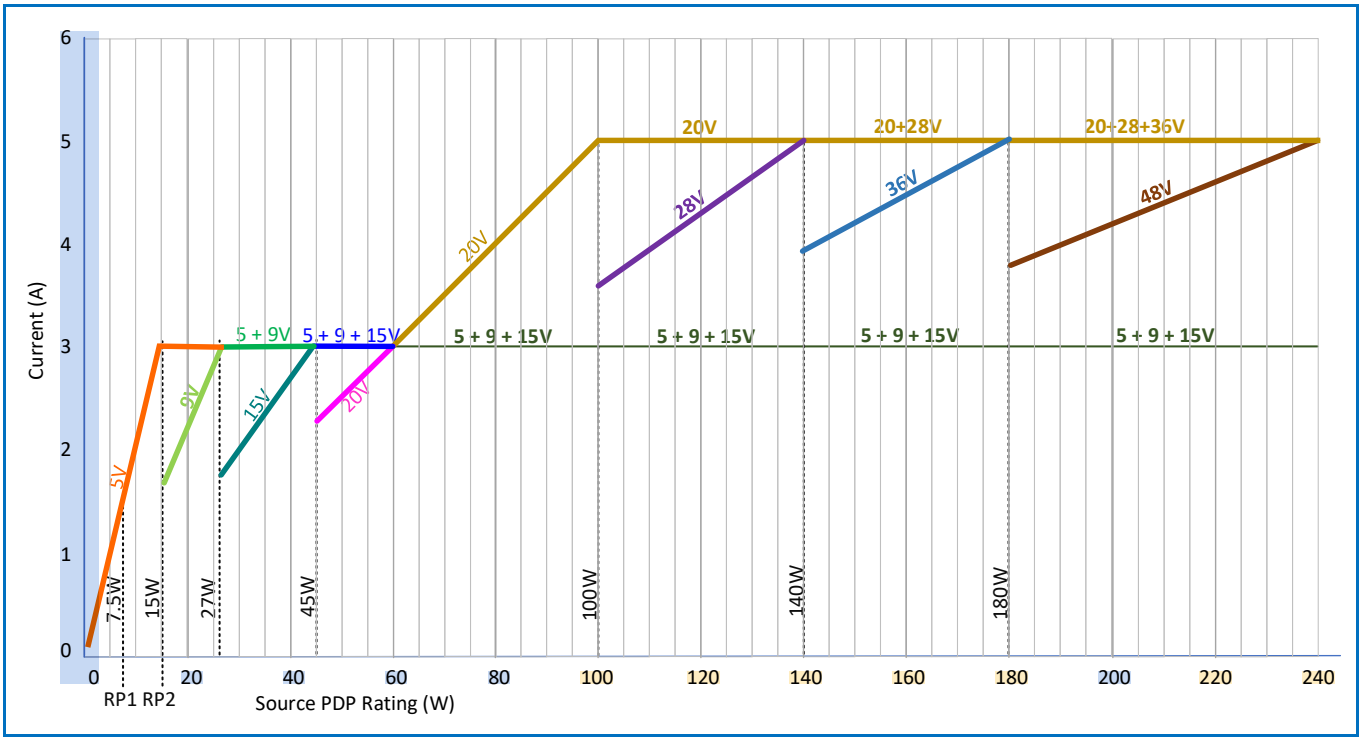


Figure 10-7 "EPR Source Power Rule Illustration for Fixed PDOs" illustrates the minimum current that an EPR Source ***Shall*** support at each voltage for a given PDP Rating.

Note: Not illustrated are that currents higher than 3A are allowed to be offered up to a limit of 5A given that a 5A cable is detected by the Source and the Voltage times current remains within the Source PDP Rating.

Figure 10-7 "EPR Source Power Rule Illustration for Fixed PDOs"



10.2.3.3.1 EPR Adjustable Voltage Supply (AVS) Voltage Ranges

Table 10.15 "EPR Adjustable Voltage Supply (AVS) Voltage Ranges" shows the Minimum and Maximum Voltage for the EPR AVS ranges.

Table 10.15 "EPR Adjustable Voltage Supply (AVS) Voltage Ranges"

	AVS Voltage Ranges		
	28V AVS	36V AVS	48V AVS
Maximum Voltage	28V	36V	48V
Minimum Voltage	15V	15V	15V

The Voltage output at the Source's connector ***Shall*** be +/-5% for both the Maximum Voltage and the Minimum Voltage.

10.2.4 Power sharing between ports

The Source power rules defined in *Section 10.2.2 "Normative Voltages and Currents"* and S*ection 10.2.3 "Optional Voltages/Currents"* ***Shall*** apply independently to each port on a system with multiple ports.

When applying the power rules to a given port, only the power rules appropriate for the remaining available PDP (i.e., the remaining available port power) at the time of the Advertisement ***Shall*** be applied.

EPR Examples of power sharing

For an EPR-capable Fixed Voltage charger (per the power rules of *Table 10.12 "EPR Source Capabilities based on the Port Maximim* PDP and using an EPR Capable Cable") with EPR-capable Sinks in EPR mode with two Managed Capability ports with a PDP rating of 140W with an overall charger capacity of 220W, the following is an example of power sharing between ports.

1. Sharing when >100W capacity is not available for both ports simultaneously after the first port contract is established.
    a. The first shared port negotiates a Fixed Voltage contract for 28V @ 5A.
    b. The Advertisement for the second port will be based on a PDP of 80W, therefore the highest offer that can be made is a Fixed Voltage contract for 20V @ 4A. No offers higher than 20V can be made at this remaining available power level.
2. Sharing when >100W capacity is available for both ports simultaneously after the first port contract is established.
    a. The first shared port negotiates a Fixed Voltage contract of 28V @ 4A.
    b. The Advertisement for the second port will be based on a PDP of 108W, therefore the highest offer that can be made is a Fixed Voltage contract for 28V @ 3.85A.

10.3 Sink Power Rules

10.3.1 Sink Power Rule Considerations

The Sink power rules are designed to ensure the best possible user experience when a given Sink used with a compliant Source of arbitrary Output Power Rating that only supplies the ***Normative*** Voltages and currents.

The Sink Power Rules are based on the following considerations:

- Low power Sources (e.g., 5V) are expected to be very common and will be used with Sinks designed for a higher PDP.
- Optimizing the user experience when Sources with a higher PDP Rating are used with low power Sinks.
- Preventing Sinks that only function well (or at all) when using ***Optional*** Voltages and currents.

10.3.2 Normative Sink Rules

Sinks designed to use Sources with a PDP Rating of x W ***Shall***:

- Either operate or charge from Sources that have a PDP Rating ≥ x W.
- Either operate, charge or indicate a capability mismatch (see *Section 6.4.2.3 "Capability Mismatch"*) from Sources that have a PDP Rating < x W and ≥ 0.5W.

A Sink optimized for a Source with ***Optional*** Voltages and currents or power as described in *Section 10.2.3 "Optional Voltages/Currents"* with a PDP Rating of x W ***Shall*** provide a similar user experience when powered from a Source with a PDP Rating of ≥ x W that supplies only the ***Normative*** Voltages and currents as specified in *Section 10.2.2 "Normative Voltages and Currents"*. For example, a 60W source might not offer 9V Prog or 15V Prog since 20V Prog is a suitable substitute for both (as shown in *Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port* Maximum PDP").

The Operational Current/Power in the Sink Capabilities PDO for Sinks with an Operational PDP of x Watts ***Shall*** be as follows:

- Operational current for Fixed/Variable supply PDOs: RoundDown(x/Voltage) to the nearest 10mA.
- Operational power for Battery supply PDOs: ≤ x.
- Operational current for Programmable Power Supply APDOs as defined in *Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port* Maximum PDP": RoundDown (x/Prog Voltage) to the nearest 50mA.

The Maximum Current/Power in the Sink RDO for Sinks with an Operational PDP of x Watts and Maximum PDP of y Watts ***Shall*** be as follows:

- Maximum current for Fixed/Variable Supply RDOs from Sinks without a Battery: RoundDown(x/Voltage) to the nearest 10mA.
- Maximum current for Fixed/Variable Supply RDOs from Sinks with a Battery: RoundDown(y/Voltage) to the nearest 10mA.
- Maximum power for Battery Supply RDOs from Sinks without a Battery: ≤ x.
- Maximum power for Battery Supply RDOs from Sinks with a Battery: ≤ y.
- Maximum current for PPS Supply RDOs from Source PDOs as defined in *Table 10.10 "SPR Programmable Power Supply PDOs and APDOs based on the Port* Maximum PDP" or *Table 10.14 "EPR Source Examples when Port* Present PDP is less than Port Maximum PDP": RoundDown (y/Prog Voltage) to the nearest 50mA.

The following requirements ***Shall*** apply to the Advertised Sink Capabilities:

- A Sink ***Shall Not*** Advertise Fixed Supply PDO maximum Voltages and currents that exceed the PDP Rating they were designed to use.
- A Sink ***Shall Not*** Advertise Variable Supply PDO maximum Voltages and currents that exceed the PDP Rating they were designed to use.
- A Sink ***Shall Not*** Advertise a Battery Supply PDO maximum allowable power that exceeds the PDP Rating they were designed to use.
- A Sink ***Shall Not*** Advertise a PPS APDO maximum allowable power that exceeds the PDP Rating they were designed to use.
- A Sink ***Shall Not*** Advertise an AVS APDO maximum allowable power that exceeds the PDP Rating they were designed to use.