USB Power Delivery ENGINEERING CHANGE NOTICE

Title: Update iPpsCLOperating
Applied to: USB Power Delivery Specification Revision 3.0
Version 1.2

Brief description of the functional changes proposed:

This ECR updates the definition of iPpsCLOperating to:

1. Clarify the measurements points (e.g. the beginning and end points)
2. Widen the negative allowance form 0 in the spec to -25mA (1/2 current step)
3. Clarify that the load has a positive allowance and sets the allowance to +25mA

Benefits as a result of the proposed changes:

Allowance of +/- ½ current step is sufficient to enable Fast Charging algorithms in a Sink.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:

Relaxation of the current testing. Some chargers that failed compliance will now be deemed to pass,

An analysis of the hardware implications:

Relaxes the design requirements.

An analysis of the software implications:

Has a potential impact on Fast Charge algorithms, although since it is less than one step, the impact is expected to be negligible.

An analysis of the compliance testing implications:

Short term to change one test parameter from -10mA to -25mA. Longer term will require testing of current increases as load resistance decreases.

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Actual Change Requested

(a). Section 7.1.4.4

From Text:

7.1.4.4 Programmable Power Supply Current Limit

The Programmable Power Supply ***Shall*** limit its output current to the Operating Current value in the Programmable RDO when the Sink attempts to draw more current than the Output Current level. The programming step size for the Output Current is ***iPpsCLStep***. All programming changes of the Operating Current ***Shall*** settle to the new Operating Current value within ***tPpsCLProgramSettle***. The PPS Operating Current regulation accuracy during Current Limit is defined as ***iPpsCLNew***. The minimum programmable Current Limit level is ***iPpsCLMin***. A Source that supports PPS ***Shall*** support Current Limit programmability between ***iPpsCLMin*** and the Maximum Current value in the PPS APDO.

The response of a PPS to a load change depends on the Operating mode of the PPS and the magnitude of the load change. These dependencies lead to one of four possible responses of a PPS to any load change. They are differentiated by the value of the PPS Status OMF Flag before and after the load change:

- If the PPS Status OMF Flag is cleared both before and after the load change, the PPS responds solely by maintaining the output voltage. The PPS output voltage shall remain within ***vPpsValid*** range. The PPS response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsTransient***. The Operating Mode Flag ***Shall*** remain cleared during the load change response of the PPS.
- If the PPS Status OMF Flag is cleared before the load change and set after the load change, the PPS responds by reducing its output voltage to limit the PPS output current. The PPS output current ***Shall*** stay within the ***iPpsCVCLTransient*** range once it reaches the ***iPpsCVCLTransient*** range. The PPS response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCVCLTransient***. The Operating Mode Flag ***Shall*** be set when the PPS load change response settles.
- If the PPS Status OMF Flag is set both before and after the load change, the PPS responds by adjusting its output voltage to maintain the output current. The PPS output current ***Shall*** stay within the ***iPpsCLTransient*** range. The PPS response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCLSettle***. The Operating Mode Flag ***Shall*** remain set during the load change response of the PPS.
- If the PPS Status OMF Flag is set before the load change and cleared after the load change, the PPS responds to the load change by increasing its output voltage to ***vPpsNew*** and then maintaining it. The PPS output voltage ***Shall*** stay within the ***tPpsCLCVTransient*** range. The PPS response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsCLCVTransient***. The Operating Mode Flag ***Shall*** be cleared when the PPS load change response settles.

The PPS Shall maintain its output voltage within the Minimum Voltage and Maximum Voltage values advertised in the PPS APDO for all static and dynamic load conditions during Current Limit operation. The PPS is not expected to deliver power if the load condition results in an output voltage that is lower than the Minimum Voltage value advertised in the PPS APDO. In this case, the Source May send ***Hard Reset*** Signaling and ***Shall*** discharge V_{BUS} to ***vSafe0V*** then resume default operation at ***vSafe5V***.

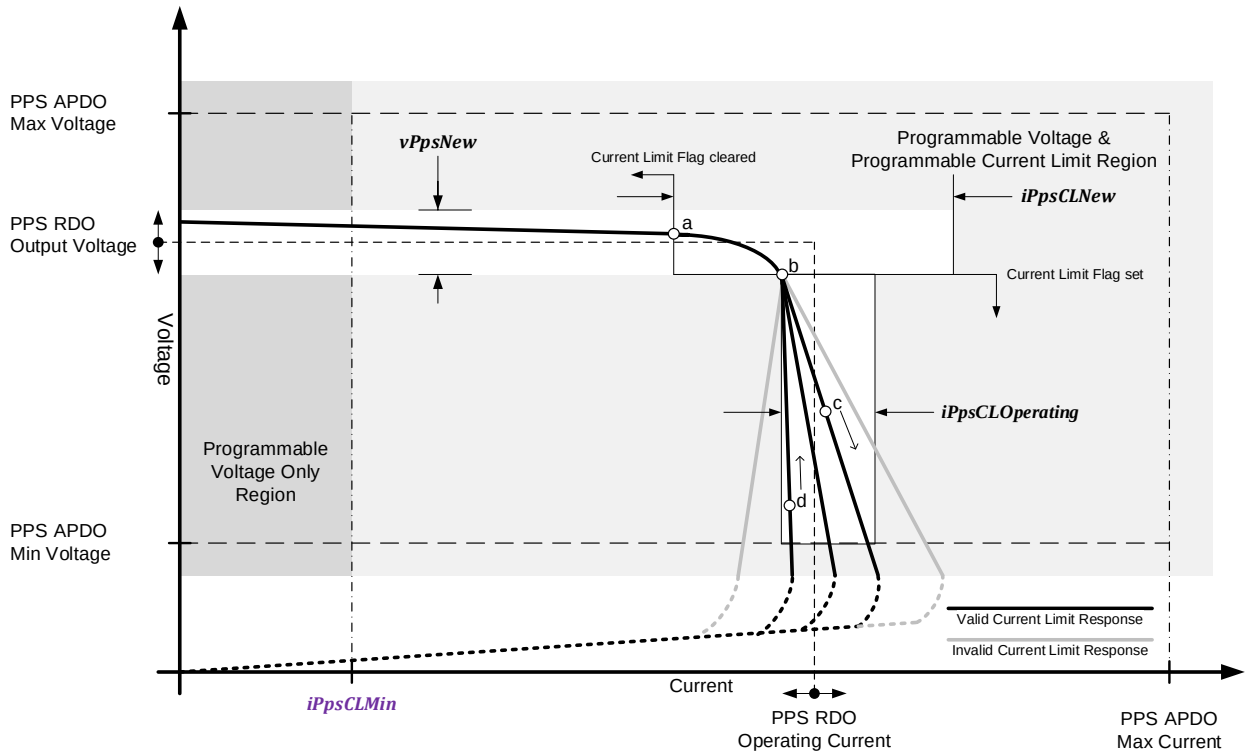
When the Sink attempts to draw more current than the Operating Current in the RDO, the Source ***Shall*** limit its output current. The current available from the Source during Current Limit mode shall meet ***iPpsCLNew*** plus ***iPpsCLOperating***. The Sink ***May Not*** reduce its Operating Current request in the RDO when the PPS Status OM Flag is set.

Current limiting ***Shall*** be performed by the PPS Source. Sinks ***May Not*** limit their input current with respect to the RDO but ***Shall*** meet the requirements of Section 7.2.9. The Source ***Shall Not*** shutdown or otherwise disrupt the available output power while in Current Limit mode unless another protection mechanism as outlined in Section 7.1.7 is engaged to protect the Source from damage.

The relationship between PPS programmable output voltage and PPS programmable Current Limit ***Shall*** be as shown in Figure 7-7. The transition between the Constant Voltage mode and the Current Limit mode occurs between points *a* and *b*. The PPS Status OM Flag shall be set or cleared within this region. In Current Limit mode

when the load resistance decreases the output current of the Source shall never decrease nor increase more than iPpsCLOperating. The proper behavior is represented by point *c*. Likewise, as the load resistance increases, the output current of the Source ***Shall Not*** increase. The proper behavior is represented by point *d*.

Figure 7-1 PPS Programmable Voltage and Current Limit



Notes:

- Point *a* represents entry into the transition region between Constant Voltage mode and Current Limit mode.
- Point *b* represents exit from the transition region between Constant Voltage mode and Current Limit mode.
- Point *b* is where the allowable increase in current up to ***iPpsCLOperating*** begins.
- Point *c* represents the behavior as the load resistance decreases during Current Limit mode. See Table 7-22 for the allowed change in Operating Current (***iPpsCLOperating***) during this behavior.
- Point *d* represents the behavior as the load resistance increases during Current Limit mode. See Table 7-22 for the allowed change in Operating Current (***iPpsCLOperating***) during this behavior.

To Text:

7.1.4.4 Programmable Power Supply Current Limit

The Programmable Power Supply ***Shall*** limit its output current to the Operating Current value in the Programmable RDO when the Sink attempts to draw more current than the Output Current level. The programming step size for the Output Current is ***iPpsCLStep***. All programming changes of the Operating Current ***Shall*** settle to the new Operating Current value within ***tPpsCLProgramSettle***. The PPS Operating Current regulation accuracy during Current Limit is defined as ***iPpsCLNew***. The minimum programmable Current Limit level is ***iPpsCLMin***. A Source that supports PPS ***Shall*** support Current Limit programmability between ***iPpsCLMin*** and the Maximum Current value in the PPS APDO.

The response of a PPS to a load change depends on the Operating mode of the PPS and the magnitude of the load change. These dependencies lead to one of four possible responses of a PPS to any load change. They are differentiated by the value of the PPS Status OMF Flag before and after the load change:

- If the PPS Status OMF Flag is cleared both before and after the load change, the PPS responds solely by maintaining the output voltage. The PPS output voltage shall remain within ***vPpsValid*** range. The PPS response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsTransient***. The Operating Mode Flag ***Shall*** remain cleared during the load change response of the PPS.
- If the PPS Status OMF Flag is cleared before the load change and set after the load change, the PPS responds by reducing its output voltage to limit the PPS output current. The PPS output current ***Shall*** stay within the ***iPpsCVCLTransient*** range once it reaches the ***iPpsCVCLTransient*** range. The PPS response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCVCLTransient***. The Operating Mode Flag ***Shall*** be set when the PPS load change response settles.
- If the PPS Status OMF Flag is set both before and after the load change, the PPS responds by adjusting its output voltage to maintain the output current. The PPS output current ***Shall*** stay within the ***iPpsCLTransient*** range. The PPS response to the load change ***Shall*** settle within the ***iPpsCLNew*** tolerance band by the time ***tPpsCLSettle***. The Operating Mode Flag ***Shall*** remain set during the load change response of the PPS.
- If the PPS Status OMF Flag is set before the load change and cleared after the load change, the PPS responds to the load change by increasing its output voltage to ***vPpsNew*** and then maintaining it. The PPS output voltage ***Shall*** stay within the ***tPpsCLCVTransient*** range. The PPS response to the load change ***Shall*** settle within the ***vPpsNew*** tolerance band by the time ***tPpsCLCVTransient***. The Operating Mode Flag ***Shall*** be cleared when the PPS load change response settles.

The PPS Shall maintain its output voltage within the Minimum Voltage and Maximum Voltage values advertised in the PPS APDO for all static and dynamic load conditions during Current Limit operation. The PPS is not expected to deliver power if the load condition results in an output voltage that is lower than the Minimum Voltage value advertised in the PPS APDO. In this case, the Source May send ***Hard Reset*** Signaling and ***Shall*** discharge V_{BUS} to ***vSafe0V*** then resume default operation at ***vSafe5V***.

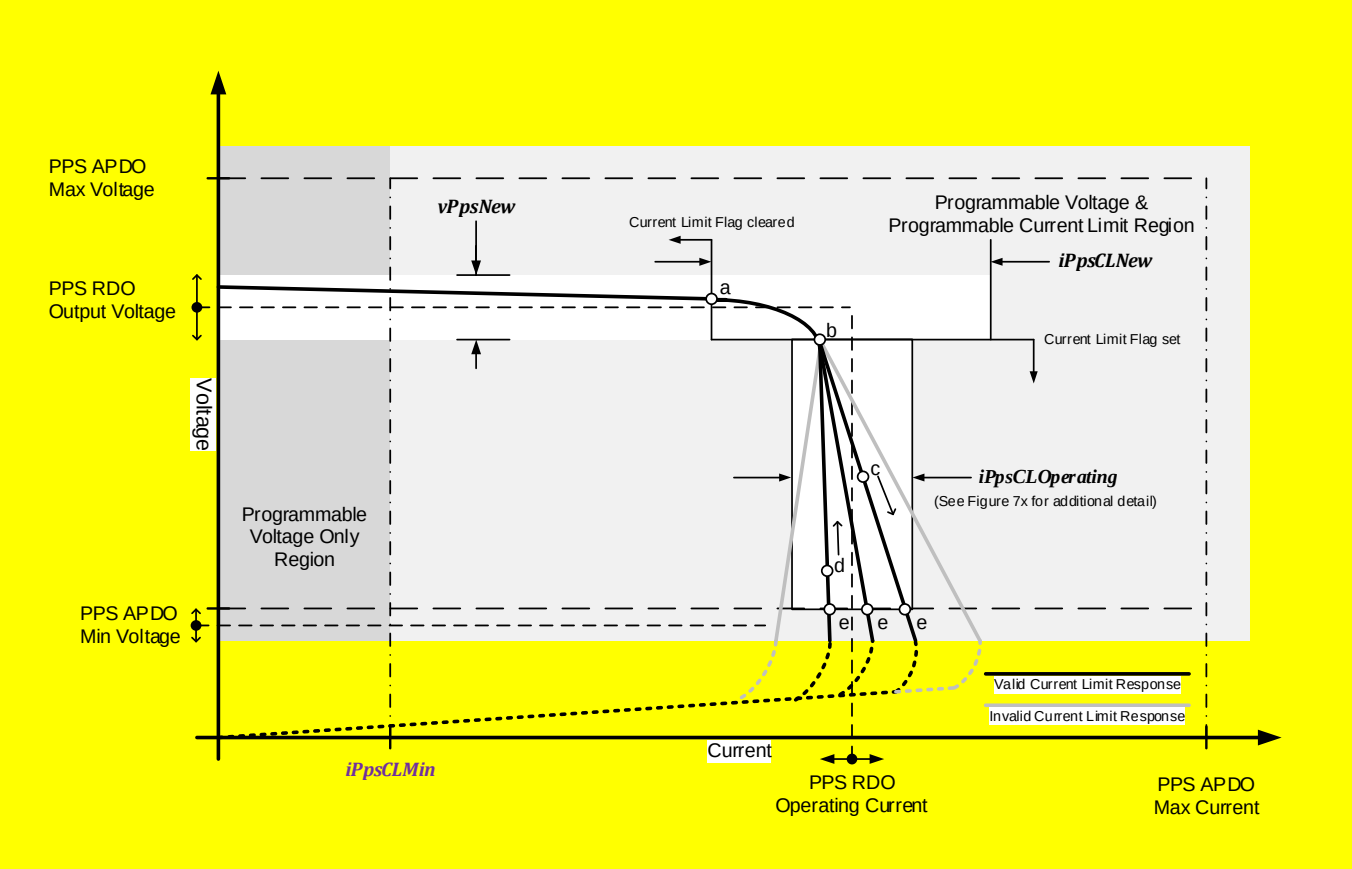
When the Sink attempts to draw more current than the Operating Current in the RDO, the Source ***Shall*** limit its output current. The current available from the Source during Current Limit mode shall meet ***iPpsCLNew*** plus ***iPpsCLOperating***. The Sink ***May Not*** reduce its Operating Current request in the RDO when the PPS Status OM Flag is set.

Current limiting ***Shall*** be performed by the PPS Source. Sinks ~~***May Not*** limit their input current with respect to the RDO but~~that rely on PPS Current Limiting ***Shall*** meet the requirements of Section 7.2.9. The Source ***Shall Not*** shutdown or otherwise disrupt the available output power while in Current Limit mode unless another protection mechanism as outlined in Section 7.1.7 is engaged to protect the Source from damage.

The relationship between PPS programmable output voltage and PPS programmable Current Limit ***Shall*** be as shown in Figure 7-7 and Figure 7-x. The transition between the Constant Voltage mode and the Current Limit mode occurs between points *a* and *b*. The PPS Status OM Flag ***Shall*** be set or cleared within this region. In Current Limit mode when the load resistance changes the output current of the Source ***Shall*** stay within ***iPpsCLOperating***, which is determined by point *b* (a measured value). As the load resistance decreases the output current should stay the same or increase slightly and as the load resistance increases the output current should stay the same or decrease slightly. The amount of allowable increase and decrease ***Shall Not*** ~~not~~ exceed iPpsCLTolerance relative to a straight line drawn between points *b* and *e* as illustrated in Figure 7-x.

The proper behavior is represented by point *c*. Likewise, as the load resistance increases, the output current of the Source ***Shall Not*** increase. The proper behavior is represented by point *d*.

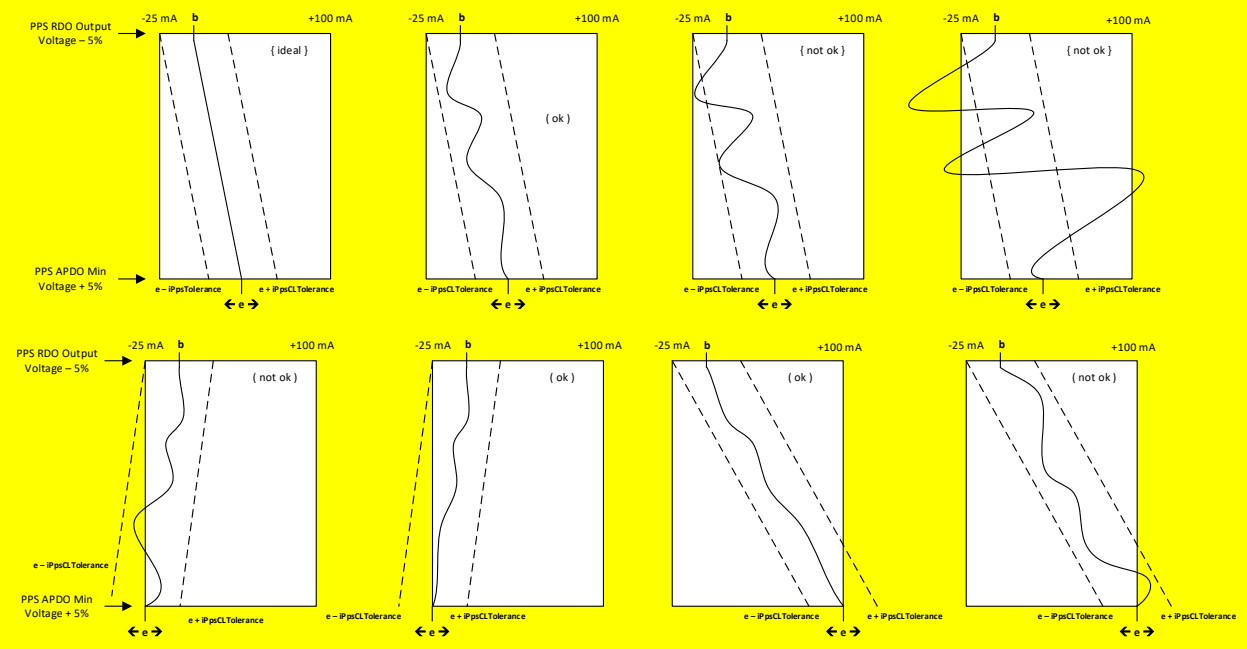
Figure 7-2 PPS Programmable Voltage and Current Limit



Notes:

- Point *a* represents entry into the transition region between Constant Voltage mode and Current Limit mode.
- Point *b* represents exit from the transition region between Constant Voltage mode and Current Limit mode.
- Point *b* is where the allowable increase in current up to ***iPpsCLOperating*** begins.
- Point *c* represents the behavior as the load resistance decreases during Current Limit mode. See Table 7-22 for the allowed change in Operating Current (***iPpsCLOperating***) during this behavior.
- Point *d* represents the behavior as the load resistance increases during Current Limit mode. See Table 7-22 for the allowed change in Operating Current (***iPpsCLOperating***) during this behavior.
- Point *e* represents the exit from the ***iPpsCLOperating*** region.

Figure 7-x iPpsCLOperating Detail



(b). Table 7-22 (note only relevant portion of table shown)

From Text:

Table 7-1 Source Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSrcBulk[1]	Source bulk capacitance when a Port is powered from a dedicated supply.	10			µF	Section 7.1.2
cSrcBulkShared[1]	Source bulk capacitance when a Port is powered from a shared supply.	120			µF	Section 7.1.2
iPpsCLMin	Minimum Current Limit setting.	1			A	Section 7.1.4.4
iPpsCLNew	Current Limit accuracy					Section 7.1.4.4
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCLOperating	Total allowed change in Operating Current from point b in Figure 7-7 as the load resistance decreases during Current Limit mode.	0		100	mA	Figure 7-7

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
iPpsCLStep	PPS Current Limit programming step size.		50		mA	Section 7.1.4.4

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To Text:

Table 7-2 Source Electrical Parameters

Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSrcBulk[1]	Source bulk capacitance when a Port is powered from a dedicated supply.	10			µF	Section 7.1.2
cSrcBulkShared[1]	Source bulk capacitance when a Port is powered from a shared supply.	120			µF	Section 7.1.2
iPpsCLMin	Minimum Current Limit setting.	1			A	Section 7.1.4.4
iPpsCLNew	Current Limit accuracy					Section 7.1.4.4
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCLOperating	Total allowed change in Operating Current from point b in Figure 7-7 as the load resistance changes in Current Limit mode.	-25		100	mA	Figure 7-7
iPpsCLTolerance	Allowable deviation of the operating current along the load line between the point *b* and *e* as shown in Figure 7-x.	-25		25	mA	Figure 7-x
iPpsCLStep	PPS Current Limit programming step size.		50		mA	Section 7.1.4.4

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