USB Power Delivery ENGINEERING CHANGE NOTICE

Title: PPS Current Limit Mode Vbus Shut Down Threshold
Applied to: USB Power Delivery Specification Revision 3.0
Version 1.1

A brief description of the functional changes proposed:
The PPS APDO is used by a Source to declare its operational box's range including the maximum and minimum voltage as well as the maximum current the Source can output. When the Source receives and RDO, it refines the operational box's maximum voltage and current limit, but the operational box's minimum voltage is fixed as declared by the APDO declared minimum voltage. The PD spec requires PPS to shut down the Vbus when the output voltage is lower than Vmin. However, there is no clear definition of 'lower' in the spec. This ECR defines 'lower' as less than 90% of vMin.

Benefits as a result of the proposed changes:
Clarifies the definition of the operational box's behavior when the output voltage drops below vMin.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
No impact

An analysis of the hardware implications:
No change

An analysis of the software implications:
No change

An analysis of the compliance testing implications:
No change.

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Actual Change Requested

(a). Section 7.1.4.4, Programmable Power Supply Current Limit, Page 253

From Text:

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 *Error! Reference source not found.* Signaling and **Error! Reference source not found.** discharge V_{BUS} to *Error! Reference source not found.* then resume default operation at *Error! Reference source not found.*.
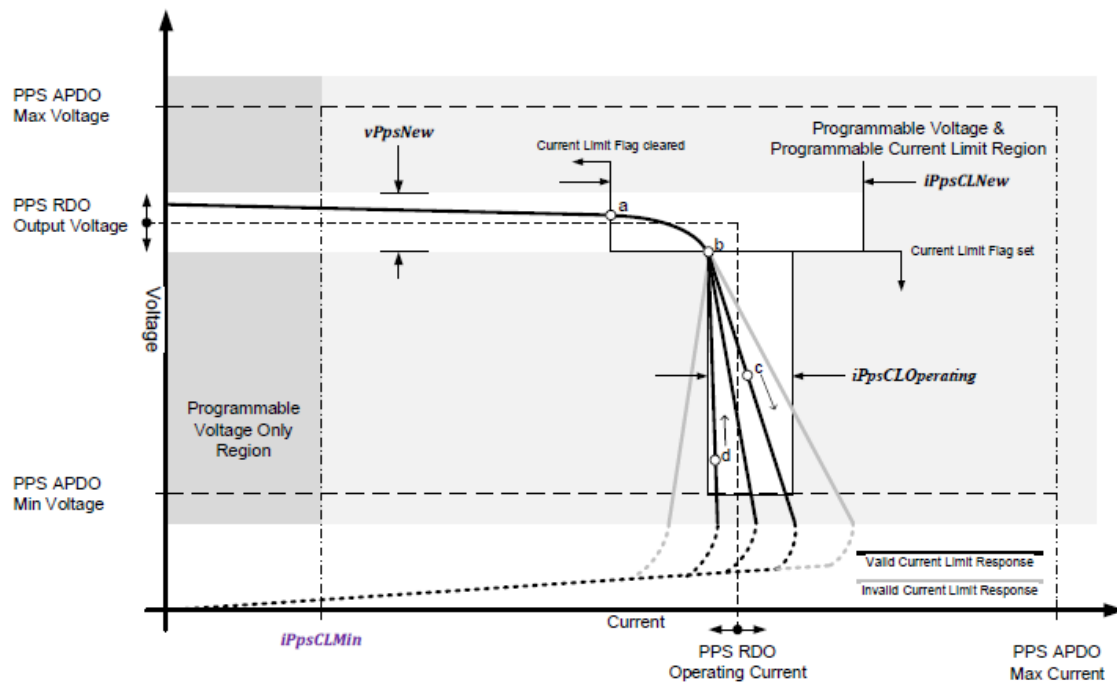
To Text:

The PPS Shall maintain its output voltage at the value requested in the PPS RDO for all static and dynamic load conditions except when in Current Limit operation. In response to any static or dynamic load condition during Current Limit operation that causes the PPS output voltage to drop below ***vPpsShutdown*** the Source May send *Error! Reference source not found.* Signaling and **Error! Reference source not found.** discharge V_{BUS} to *Error! Reference source not found.* then resume default operation at *Error! Reference source not found.*.

(b). Figure 7-7, Page 238

From Text:

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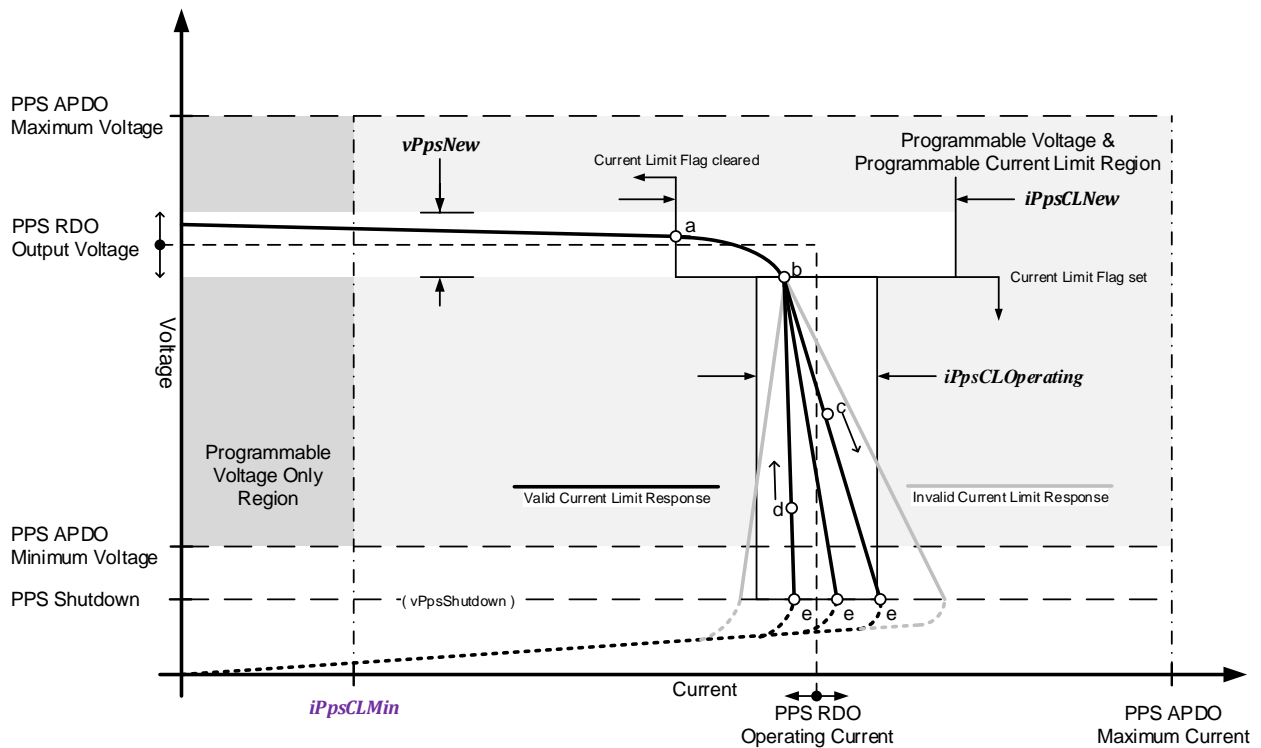**Figure 7-7 PPS Programmable Voltage and Current Limit**

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:

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 **Error! No text of specified style in document.**-1 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 **Error! No text of specified style in document.**-1 for the allowed change in Operating Current (*iPpsCLOperating*) during this behavior.
- Point *e* represents the PPS shutdown voltage during Current Limit operation.

(c). Table 7-22, Source Electrical Parameters, Page 298

From Text:

Table Error! No text of specified style in document.**-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 **Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
cSrcBulkShared[1]	Source bulk capacitance when a Port is powered from a shared supply.	120			µF	Section **Error! Reference source not found.**
iPpsCLMin	Minimum Current Limit setting.	1			A	Section **Error! Reference source not found.**
iPpsCLNew	Current Limit accuracy					Section **Error! Reference source not found.**
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCLOperating	Total allowed change in Operating Current from point b in **Error! Reference source not found.** as the load resistance decreases during Current Limit mode.	0		100	mA	**Error! Reference source not found.**
iPpsCLStep	PPS Current Limit programming step size.		50		mA	Section **Error! Reference source not found.**
iPpsCLTransient	Allowed output current overshoot when a load increase occurs while in CL mode.			New load + 100	mA	Section **Error! Reference source not found.**
	Allowed output current undershoot when a load decrease occurs while in CL mode.	New load – 100				
iPpsCVCLTransient	CV to CL transient current bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	*iPpsCLNew* - 100		New load + 500	mA	Section **Error! Reference source not found.**
tNewSnk	Time allowed for an initial Source in Swap Standby to transition new Sink operation.			15	ms	**Error! Reference source not found., Error! Reference source not found.**
tPpsCLCVTransient	CL to CV transient voltage settling time.			25	ms	Section **Error! Reference source not found.**
tPpsCLProgramSettle	PPS Current Limit programming settling time	125		250	ms	Section **Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tPpsCLSettle	CL load transient current settling time.	125		250	ms	Section **Error! Reference source not found.**
tPpsCVCLTransient	CV to CL transient settling time.	125		250	ms	Section **Error! Reference source not found.**
tPpsSrcTransLarge	The time the Programmable Power Supply's set-point **Error! Reference source not found.** transition between requested voltages for steps larger than *vPpsSmallStep*.	0		275	ms	Section **Error! Reference source not found.** Section **Error! Reference source not found.**
tPpsSrcTransSmall	The time the Programmable Power Supply's set-point **Error! Reference source not found.** transition between requested voltages for steps less than or equal to *vPpsSmallStep*.	0		25	ms	Section **Error! Reference source not found.** Section **Error! Reference source not found.**
tPpsTransient	The maximum time for the Programmable Power Supply to be between vPpsNew and vPpsValid in response to a load transient			5	ms	Section **Error! Reference source not found.**
tSrcFRSwap	Time from the initial Sink detecting that V$_{BUS}$ has dropped below *Error! Reference source not found.* until the initial Sink/new Source is able to supply USB Type-C Current (see **Error! Reference source not found.**)			150	µs	Section **Error! Reference source not found.**
tSrcReady	Time from positive/negative transition start (t0) to when the Source is ready to provide the newly negotiated power level.			285	ms	**Error! Reference source not found., Error! Reference source not found.**
tSrcRecover	Time allotted for the Source to recover.	0.66		1	s	Section **Error! Reference source not found.**
tSrcSettle	Time from positive/negative transition start (t0) to when the transitioning voltage is within the range *vSrcNew.*			275	ms	**Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tSrcSwapStdby	The maximum time for the Source to transition to Swap Standby.			650	ms	**Error! Reference source not found. Error! Reference source not found.**
tSrcTransient	The maximum time for the Source output voltage to be between *vSrcNew* and *vSrcValid* in response to a load transient.			5	ms	Section **Error! Reference source not found.**
tSrcTransition	The time the Source **Error! Reference source not found.** wait before transitioning the power supply to ensure that the Sink has sufficient time to prepare.	25		35	ms	Section **Error! Reference source not found.**
tSrcTurnOn	Transition time from *Error! Reference source not found.* to *Error! Reference source not found..*			275	ms	**Error! Reference source not found. Error! Reference source not found.**
vPpsCLCVTransient	CL to CV load transient voltage bounds.	Operating Voltage * 0.95 – 0.1V		Operating Voltage * 1.05 + 0.1V	V	Section **Error! Reference source not found.**
vPpsCVCLTransient	CL to CF transient voltage bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	Operating Voltage – 1.0V		Operating Voltage + 0.5V	V	Section **Error! Reference source not found.**
vPpsMaxVoltage	Maximum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section **Error! Reference source not found.**
vPpsMinVoltage	Minimum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section **Error! Reference source not found.**
vPpsNew	Programmable RDO Output Voltage measured at the Source receptacle.	RDO Output Voltage *0.95	RDO Output Voltage	RDO Output Voltage *1.05	V	Section **Error! Reference source not found.**
vPpsSlewNeg	Programmable Power Supply maximum slew rate for negative voltage changes			-30	mV/µs	Section **Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vPpsSlewPos	Programmable Power Supply maximum slew rate for positive voltage changes			30	mV/μs	Section **Error! Reference source not found.**
vPpsSmallStep	PPS Step size defined as a small step relative to the previous *vPpsNew*.	-500		500	mV	Section **Error! Reference source not found.**
vPpsStep	PPS voltage programming step size.		20		mV	Section **Error! Reference source not found.**
vPpsValid	The range in addition to *vPpsNew* which the Programmable Power Supply output is considered **Error! Reference source not found.** in response to a load step.	-0.1		0.1	V	Section **Error! Reference source not found.**
vSrcNeg	Most negative voltage allowed during transition.			-0.3	V	**Error! Reference source not found.**
vSrcNew	Fixed Supply output measured at the Source receptacle.	PDO Voltage *0.95	PDO Voltage	PDO Voltage *1.05	V	*Error! Reference source not found.*
	Variable Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	*Error! Reference source not found.*
	Battery Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	
vSrcPeak	The range that a Fixed Supply in Peak Current operation is allowed when overload conditions occur.	PDO Voltage *0.90		PDO Voltage *1.05	V	**Error! Reference source not found. Error! Reference source not found.**
vSrcSlewNeg	Maximum slew rate allowed for negative voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 μF.			-30	mV/μs	Section **Error! Reference source not found. Error! Reference source not found.**
vSrcSlewPos	Maximum slew rate allowed for positive voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 μF.			30	mV/μs	Section **Error! Reference source not found. Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vSrcValid	The range in addition to *vSrcNew* which a newly negotiated voltage is considered **Error! Reference source not found.** during and after a transition. This range also applies to *Error! Reference source not found.*.	-0.5		0.5	V	*Error! Reference source not found.* *Error! Reference source not found.*
Note 1: The Source **Error! Reference source not found.** charge and discharge the total bulk capacitance to meet the transition time requirements.						

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To Text:

Table Error! No text of specified style in document.-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 **Error! Reference source not found.**
cSrcBulkShared[1]	Source bulk capacitance when a Port is powered from a shared supply.	120			µF	Section **Error! Reference source not found.**
iPpsCLMin	Minimum Current Limit setting.	1			A	Section **Error! Reference source not found.**
iPpsCLNew	Current Limit accuracy					Section **Error! Reference source not found.**
	1A ≤ Operating Current ≤ 3A	-150		150	mA	
	Operating current > 3A	-5		5	%	
iPpsCLOperating	Total allowed change in Operating Current from point b in **Error! Reference source not found.** as the load resistance decreases during Current Limit mode.	0		100	mA	**Error! Reference source not found.**
iPpsCLStep	PPS Current Limit programming step size.		50		mA	Section **Error! Reference source not found.**
iPpsCLTransient	Allowed output current overshoot when a load increase occurs while in CL mode.			New load + 100	mA	Section **Error! Reference source not found.**
	Allowed output current undershoot when a load decrease occurs while in CL mode.	New load – 100				
iPpsCVCLTransient	CV to CL transient current bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	*iPpsCLNew* - 100		New load + 500	mA	Section **Error! Reference source not found.**
tNewSnk	Time allowed for an initial Source in Swap Standby to transition new Sink operation.			15	ms	**Error! Reference source not found., Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tPpsCLCVTransient	CL to CV transient voltage settling time.			25	ms	Section **Error! Reference source not found.**
tPpsCLProgramSettle	PPS Current Limit programming settling time	125		250	ms	Section **Error! Reference source not found.**
tPpsCLSettle	CL load transient current settling time.	125		250	ms	Section **Error! Reference source not found.**
tPpsCVCLTransient	CV to CL transient settling time.	125		250	ms	Section **Error! Reference source not found.**
tPpsSrcTransLarge	The time the Programmable Power Supply's set-point **Error! Reference source not found.** transition between requested voltages for steps larger than *vPpsSmallStep*.	0		275	ms	Section **Error! Reference source not found.** Section **Error! Reference source not found.**
tPpsSrcTransSmall	The time the Programmable Power Supply's set-point **Error! Reference source not found.** transition between requested voltages for steps less than or equal to *vPpsSmallStep*.	0		25	ms	Section **Error! Reference source not found.** Section **Error! Reference source not found.**
tPpsTransient	The maximum time for the Programmable Power Supply to be between vPpsNew and vPpsValid in response to a load transient			5	ms	Section **Error! Reference source not found.**
tSrcFRSwap	Time from the initial Sink detecting that V$_{BUS}$ has dropped below *Error! Reference source not found.* until the initial Sink/new Source is able to supply USB Type-C Current (see **Error! Reference source not found.**)			150	µs	Section **Error! Reference source not found.**
tSrcReady	Time from positive/negative transition start (t0) to when the Source is ready to provide the newly negotiated power level.			285	ms	**Error! Reference source not found.**, **Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
tSrcRecover	Time allotted for the Source to recover.	0.66		1	s	Section **Error! Reference source not found.**
tSrcSettle	Time from positive/negative transition start (t0) to when the transitioning voltage is within the range *vSrcNew.*			275	ms	**Error! Reference source not found.**
tSrcSwapStdby	The maximum time for the Source to transition to Swap Standby.			650	ms	**Error! Reference source not found.** **Error! Reference source not found.**
tSrcTransient	The maximum time for the Source output voltage to be between *vSrcNew* and *vSrcValid* in response to a load transient.			5	ms	Section **Error! Reference source not found.**
tSrcTransition	The time the Source **Error! Reference source not found.** wait before transitioning the power supply to ensure that the Sink has sufficient time to prepare.	25		35	ms	Section **Error! Reference source not found.**
tSrcTurnOn	Transition time from *Error! Reference source not found.* to *Error! Reference source not found..*			275	ms	**Error! Reference source not found.** **Error! Reference source not found.**
vPpsCLCVTransient	CL to CV load transient voltage bounds.	Operating Voltage * 0.95 – 0.1V		Operating Voltage * 1.05 + 0.1V	V	Section **Error! Reference source not found.**
vPpsCVCLTransient	CL to CF transient voltage bounds assuming the Operating Voltage reduction of Section 7.2.3.1.	Operating Voltage – 1.0V		Operating Voltage + 0.5V	V	Section **Error! Reference source not found.**
vPpsMaxVoltage	Maximum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section **Error! Reference source not found.**

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vPpsMinVoltage	Minimum Voltage Field in the Programmable Power Supply APDO.	APDO Voltage *0.95		APDO Voltage * 1.05	V	Section **Error! Reference source not found.**
vPpsNew	Programmable RDO Output Voltage measured at the Source receptacle.	RDO Output Voltage *0.95	RDO Output Voltage	RDO Output Voltage *1.05	V	Section **Error! Reference source not found.**
vPpsShutdown	The voltage at which the PPS shuts down when operating in CL.	APDO Minimum Voltage * 0.85		APDO Minimum Voltage * 0.95	V	Section 7.1.4.4
vPpsSlewNeg	Programmable Power Supply maximum slew rate for negative voltage changes			-30	mV/μs	Section **Error! Reference source not found.**
vPpsSlewPos	Programmable Power Supply maximum slew rate for positive voltage changes			30	mV/μs	Section **Error! Reference source not found.**
vPpsSmallStep	PPS Step size defined as a small step relative to the previous *vPpsNew*.	-500		500	mV	Section **Error! Reference source not found.**
vPpsStep	PPS voltage programming step size.		20		mV	Section **Error! Reference source not found.**
vPpsValid	The range in addition to *vPpsNew* which the Programmable Power Supply output is considered **Error! Reference source not found.** in response to a load step.	-0.1		0.1	V	Section **Error! Reference source not found.**
vSrcNeg	Most negative voltage allowed during transition.			-0.3	V	**Error! Reference source not found.**
vSrcNew	Fixed Supply output measured at the Source receptacle.	PDO Voltage *0.95	PDO Voltage	PDO Voltage *1.05	V	*Error! Reference source not found.*
	Variable Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	*Error! Reference source not found.*
	Battery Supply output measured at the Source receptacle.	PDO Minimum Voltage		PDO Maximum Voltage	V	

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Parameter	Description	MIN	TYP	MAX	UNITS	Reference
vSrcPeak	The range that a Fixed Supply in Peak Current operation is allowed when overload conditions occur.	PDO Voltage *0.90		PDO Voltage *1.05	V	**Error! Reference source not found. Error! Reference source not found.**
vSrcSlewNeg	Maximum slew rate allowed for negative voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 µF.			-30	mV/µs	Section **Error! Reference source not found. Error! Reference source not found.**
vSrcSlewPos	Maximum slew rate allowed for positive voltage transitions. Limits current based on a 3 A connector rating and maximum Sink bulk capacitance of 100 µF.			30	mV/µs	Section **Error! Reference source not found. Error! Reference source not found.**
vSrcValid	The range in addition to *vSrcNew* which a newly negotiated voltage is considered **Error! Reference source not found.** during and after a transition. This range also applies to *Error! Reference source not found.*.	-0.5		0.5	V	*Error! Reference source not found. Error! Reference source not found.*
Note 1: The Source **Error! Reference source not found.** charge and discharge the total bulk capacitance to meet the transition time requirements.						