Application Note

TPS257xx/TPS267xx Autonegotiate Sink Configuration

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ABSTRACT

TPS257xx/TPS267xx devices have a Autonegotiate Sink register that provide fine control on how power can be delivered to the system. With USB Power Delivery (USB-PD) now capable of delivering up to 240 Watts (48V at 5A) there is more emphasis to make sure a system is getting the correct power. This document covers the fields within the Autonegotiate Sink register common among these devices, how these fields control the USB-PD Contract, and how the fields can provide and limit system power.

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1 Applicability to other TI USB-PD Controllers

The fields covered in this application note details the behavior of the TPS257xx and TPS267xx devices. This information is applicable to any device that contains the Autonegotiate Sink register; however, the complete register implementation can vary across different product families.

Not all devices share identical Autonegotiate Sink register fields. While the fields documented herein operate identically across all devices that include them, additonal fields, reserved bits, or alternate field configurations present in other devices can introduce supplementary functionality or constraints not described in this application note. The presence of these additional or modified fields in other devices can result in system-level behavior that differs from the behavior observed when operating solely with the fields documented in this datasheet.

For complete register definitions applicable to a specific device, refer to the corresponding device-specific technical reference manual (TRM).

1.1 USB-PD Sink Introduction

USB Power Delivery (USB-PD) is an open protocol that enables intelligent, high-power transmission over a USB Type-C connector. In every USB-PD connection, two primary roles are defined:

- Source: The device that actively provides power. Examples include a wall charger, a laptop's Type-C port, or a power bank. The source broadcasts the available voltage and current combinations (example 5V at 3A, 20V at 3A) over the Configuration Channel (CC) pin. The source is also responsible for detecting the connection or disconnection of a sink device.
- Sink: The device that consumes power. Examples include but are not limited to a smartphone, tablet, headset, or a cordless power tool. The sink reads the power capabilities of the source and selects the best option for operation.

Once a connection is established, the source first outputs vSafe5V (default 5V) over VBUS. Then both devices being USB-PD negotiation by sending messages over the CC pin. The source sends a Source_Capabilities message containing one or more Power Data Objects (PDOs). Each PDO describes a specific voltage-current pair. The first PDO is always a 5V PDO with varying current depending on the USB-PD source the other PDOs can be anything from 5V up to 48V with currents ranging from 0.1A to 5A.

The sink selects the best PDO from the Source_Capabilities list and sends a Request Data Object (RDO) back to the source. The source either accepts or rejects the request. If accepted, the source adjusts the VBUS output to the negotiated voltage and current, and then sends a PS Ready signal indicating that the sink can safely consume the agreed power. For system designers, the sink side relies on a dedicated PD port controller to perform this negotiation. The controller can be pre-configured to request power autonomously, without involving a main processor. That is exactly where the Autonegotiate Sink Register becomes valuable – by allowing designers to pre-set voltage limits, minimum power, and other parameters, the PD controller can safely and automatically secure a power contract, simplifying system design and improving reliability.

1.2 Autonegotiate Sink Purpose

For system designers, the sink side relies on a dedicated USB-PD port controller to perform this negotiation. The controller can be pre-configured to request power autonomously without system intervention. That is exactly where the Autonegotiate Sink Register becomes valuable as it allows designers to pre-set voltage limits, minimum power, and other parameters, the PD controller can safely and automatically secure a power contract, simplifying system design and improving reliability.

Autonegotiate Sink Register is a critical component for any system acting as a USB-PD sink. The primary purpose is to define the power requirements that the device can request from a connected USB-PD source, providing the system receives safe and sufficient power for operation. By configuring the Autonegotiate Sink register fields, the PD device can autonomously negotiate a power contract without host intervention, which is essential for robust system design.

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1.3 Definitions

This section reviews some keywords and definitions within this document. Definitions based on the USB Power Delivery Specification Revision 3.1 www.usb.org/developers/docs.

PD Controller/Device Power Delivery Controller/Device	Refers to the USB-PD capable device sending/receiving USB-PD protocol comunications
PDO Power Data Object	Data Object used to expose a Source Port's or Sink Port's power Capabilities as part of a Source_Capabilities/EPR_Source_Capabilities or Sink_Capabilities/ EPR_Sink_Capabilities Message respectively.
RDO Request Data Object	Data Object the PD sink uses to request a specific PDO from the PD source
SPR Standard Power Range	Only the Source_Capabilities and the Request Messages are allowed to Negotiate SPR Explicit Contracts. The EPR Messages (the EPR_Source_Capabilities Message and the EPR_Request Message) are not allowed to be used while in SPR Mode. SPR range is 5V-20V going up to 100W (20V at 5A)
EPR Extended Power Range	Extends the power range from a maximum of 100W (SPR) to a maximum of 240W (EPR). When operating in the EPR Mode, only EPR specific Messages (the EPR_Source_Capabilities Message and the EPR_Request Message) are used to Negotiate Explicit Contracts. EPR range is 5V-48V going up to 240W (48V at 5A)
PP_EXT/PPHV_EN/PP_EN Power Path External/Power Path High Voltage Enable/Power Path Enable	These are generic names for the power path used in TI PD Controllers to designate the high-voltage (>5V) when the PD controller is conusming power (PD is the sink)

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2 Fields Covered

Table 2-1 references the TPS25751 TRM and covers most of these fields.

Table 2-1. Autonegotiate Sink Register Field Descriptions

Bit	Field	Type	Reset	Description
191-116	RESERVED	R/W	0h	Reserved
115-105	PPS Output Voltage	R/W	0h	This is the desired output voltage in 20mV units. This is inserted as-is into the Request USB PD message. Note that some PD controllers are unable to turn on the gate-drivers if VBUS less than 3.8V, check the VBUS UVLO value in the data-sheet.
104-103	RESERVED	R/W	0h	Reserved
102-96	PPS Operating Current	R/W	0h	Operation current in Sink PPS mode. This is the desired operating current in 50mA units. This is inserted as-is into the Request USB PD message.
95-70	RESERVED	R/W	0h	Reserved
69	PPS Disable Sink Upon Non APDO Contract	R/W	0h	Sink path handling during supply type transition. If this bit is asserted and the selected supply type is NOT a PPS APDO, then the sink path is disabled before sending the Request message. The host should only assert this bit after a PPS contract has been negotiated. This bit has no effect unless PPSEnableSinkMode is asserted.
68	PPS Required Full Voltage Range	R/W	0h	Select only a source with full voltage range. If this bit is asserted, a PPS supply type is not selected unless the APDO.MinVoltage ≤ TX_SINK_CAPS.MinPpsVoltage, APDO.MaxVoltage ≥ TX_SINK_CAPS.MaxPpsVoltage, and APDO.MaxCurrent ≥ TX_SINK_CAPS.MaxPpsCurrent. This bit has no effect unless PPSEnableSinkMode is asserted.
67	PPS Source Operating Mode	R/W	0h	Selection for CV or CC mode. If this bit is set to 1, then the PD controller assumes the system is in constant voltage mode and sets the VBUS disconnect threshold accordingly. If this bit is set to 0, then the PD controller assumes the system is in current limit mode and it lowers the VBUS disconnect threshold accordingly.
66-65	PPS Request Interval	R/W	0h	Sink PPS request interval. This field sets the frequency at which the PD controller sends a new request to the source even if the host has not made any change in the request. 0h = 8 seconds 1h = 4 seconds 2h = 2 seconds 3h = 1 second
64	PPS Enable Sink Mode	R/W	0h	Enable Sink PPS mode. If this bit is asserted, then the PD controller attempts to negotiate a PPS sink contract. PPS contracts are prioritized over any other supply type.
63-62	RESERVED	R/W	0h	Reserved
61-52	Auto Neg Capabilities Mismatch Power	R/W	2h	Capabilities Mismatch Power Threshold. If the selected PDO offers less power than what is specified in this register, then the PD controller asserts the Capability Mismatch bit in its Request message unless NoCapabilityMismatch is set to 1. (250mW per LSB)
51-42	Auto Neg Min Voltage	R/W	64h	Minimum voltage to request. During PD power contract negotiation, the PD controller only selects voltages that are greater than or equal to the value specified in this field. Not used unless AutoComputeSinkMinVoltage=0. (50mV per LSB)
41-32	Auto Neg Max Voltage	R/W	190h	Maximum voltage to request. During PD power contract negotiation, the PD controller only selects voltages that are less than or equal to the value specified in this field. Not used unless AutoComputeSinkMinVoltage=0. (50mV per LSB) See description in AutoComputeSinkMinPower.
31-22	Auto Neg Sink Min Required Power	R/W	104h	Minimum operating power required by the Sink. The PD Controller attempts to receive this power level from the Source. (250mW per LSB)

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Table 2-1. Autonegotiate Sink Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
21-12	Auto Neg Max Current	R/W	145h	Maximum current to request. The PD controller will not request more current than indicated by this field. The host should ensure that the max current for all PDO's in the TX_SINK_CAPS register do not exceed this value. (10mA per LSB).
11-8	RESERVED	R/W	0h	Reserved
7	RESERVED	R/W	0h	Reserved
6	Auto Disable Sink Upon Capability Mismatch	R/W	1h	Sink path and capability mismatch settings. If this bit is asserted, then any time the implicit or explicit power contract can cause the Capability Mismatch bit to be set the PD controller will disable the sinking path. This bit should only be asserted if the NoCapabilityMismatch bit is set to 0.
5	Auto Compute Sink Max Voltage	R/W	1h	Configuration for maximum voltage. The PD controller can automatically compute ANMaxVoltage, or allow the host to specify it. 0h = Provided by host 1h = Computed by PD controller
4	Auto Compute Sink Min Voltage	R/W	1h	Configuration for minimum voltage. The PD controller can automatically compute ANMinVoltage, or allow the host to specify it. 0h = Provided by host 1h = Computed by PD controller
3	No Capability Mismatch	R/W	0h	Configuration for capability mismatch in RDO. There are two conditions that will trigger a capability mismatch: • If the attached source does not offer a PDO whose power is greater or equal to the ANSinkCapMismatchPower field in this register. • PPS is enabled in this register and the attached source did not offer a PPS PDO that matches the requirements in TX_SINK_CAPS. If either condition is true, then the PD controller asserts the capability mismatch bit in its request unless this bit is asserted. 0h = Capabiltiy mismatch enabled 1h = Capability mismatch disabled.
2	Auto Compute Sink Min Power	R/W	1h	Minimum power sink requires. The minimum sink power is the largest power reported in any valid PDO in the TX_SINK_CAPS (0x33). The power for a particular PDO from the TX_SINK_CAPS follows for each supply type: • Battery Supply: OperatingPower • Variable Supply: MaxVoltage*OperatingCurrent • Fixed Supply: Voltage*OperatingCurrent. However, if the TX_SINK_CAPS register includes Battery supply type PDO(s), then ANSinkMinRequiredPower = maximum OperatingPower in a Battery supply type PDO. 0h = Provided by host 1h = Computed by PD controller
1	No USB Suspend	R/W	1h	Value used for the NoUSBSusp Flag in the RDO. This is as defined by USB PD.
0	Auto Neg RDO Priority	R/W	0h	Configuration for tie-breaker in PDO selection. The PD controller will find the set of PDO's that fulfill the voltage requirements. From that set of PDO's it will pick the one with higher power. If two acceptable PDO's have the same power, Fixed Supply Type is preferred, and then Variable Supply has second preference. If two PDO's have the same power and the same type, then this bit determines which PDO is selected. 0h = Higher voltage 1h = Lower voltage

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3 Autonegotiate Sink Basics with Examples

Default Values

The PD Controller can have these settings by default and each section below shows what happens when the field is changed. Refer to the Autonegotiate Sink Register Field Descriptions for details on each field.

- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 2d (0.5W)
- AUTO_NEGOTIATE_SINK.AutoNegMinVoltage = Set by PD
- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = Set by PD
- AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = Set by PD
- AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 1
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1
- AUTO_NEGOTIATE_SINK.NoUSBSuspend = 1
- AUTO_NEGOTIATE_SINK.ANRDOPriority = 0

3.1 Auto Neg RDO Priority (ANRDOPriority)

Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.ANRDOPriority = Varied
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 0 *Allow the ANSinkMinRequiredPower to be static (set by configuration default or by EC if needed)*
- AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = 120d (30W) *The amount of minimum power required by the system set by configuration of modified by EC if needed).* ***When AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower is set to 1, this is overwritten.***

Some Source devices can offer PDOs with different voltage/current but identical power. For instance a 30W Source is used which offers:

- PDO1: 5V at 3A (15W)
- PDO2: 9V at 3A (27W)
- **PDO3: 15V at 2A (30W)**
- **PDO4: 20V at 1.5A (30W)**

This fields helps when systems need more current over voltage or vice-versa. When AUTO_NEGOTIATE_SINK.ANRDOPriority = 0, the higher voltage (PDO4) is selected.

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Figure 3-1. 20V PDO being chosen when AUTO_NEGOTIATE_SINK.ANRDOPriority = 0

When AUTO_NEGOTIATE_SINK.ANRDOPriority = 1, the lower voltage (PDO3) is selected.

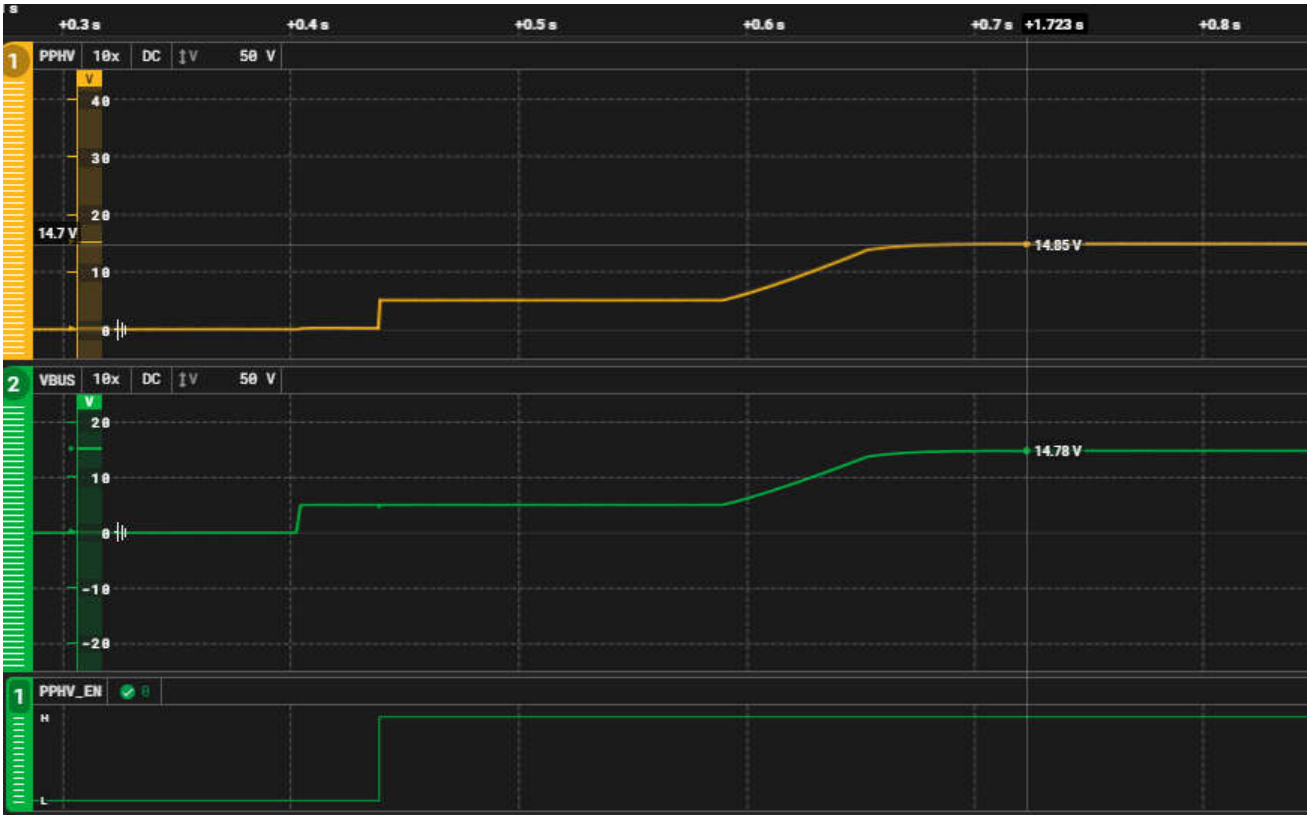

Figure 3-2. 15V PDO being chosen when AUTO_NEGOTIATE_SINK.ANRDOPriority = 1

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3.2 Auto Compute Sink Min Power and Auto Neg Sink Min Required Power

Auto Compute Sink Min Power and Auto Neg Sink Min Required Power
Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = Varied
- AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = Varied

When AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1, the PD automatically sets this value based on the TX_Sink_Caps register.

- Highest Power PDO: 20V at 3A, AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = 60W
- Highest Power PDO: 20V at 2.25A, AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = 45W
- Highest Power PDO: 15V at 2.4A, AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower = 36W

When AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 0, the value in AUTO_NEGOTIATE_SINK.ANSinkMinRequiredPower set by configuration or by the EC determines the minimum power for the system regardless of the supported TX_Sink_Caps register.

3.3 No Capability Mismatch and Auto Disable Sink Upon Capability Mismatch

Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)
- AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = Varied
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = Varied

Table 3-1. Capability Mismatch Fields Effects on the Sink Path

NoCapabilityMismatch	AutoDisableSinkUponCapabilityMismatch	Sink Path Effects
0	0	Request PDO **asserts Capability Mismatch** but **sink path is still enabled** regardless of ANSinkCapMismatchPower.
0	0	Request PDO **asserts Capability Mismatch** and **sink path disabled** when PDO Power < ANSinkCapMismatchPower
1	0	Request PDO **does NOT assert Capability Mismatch**. AutoDisableSinkUponCapabilityMismatch **ignored**
1	1	Request PDO **does NOT assert Capability Mismatch**. AutoDisableSinkUponCapabilityMismatch **ignored**

If the system requires a minimum of power from USB-PD, then make sure to set the AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower to the minimum value of the system. Make sure the AUTO_NEGOTIATE_SINK.NoCapabilityMismatch is = 0 to keep Capabiltiy Mismatch assertion behavior. Finally set AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1 to allow PD to disable sink path automatically if system requirements are not met.

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1*

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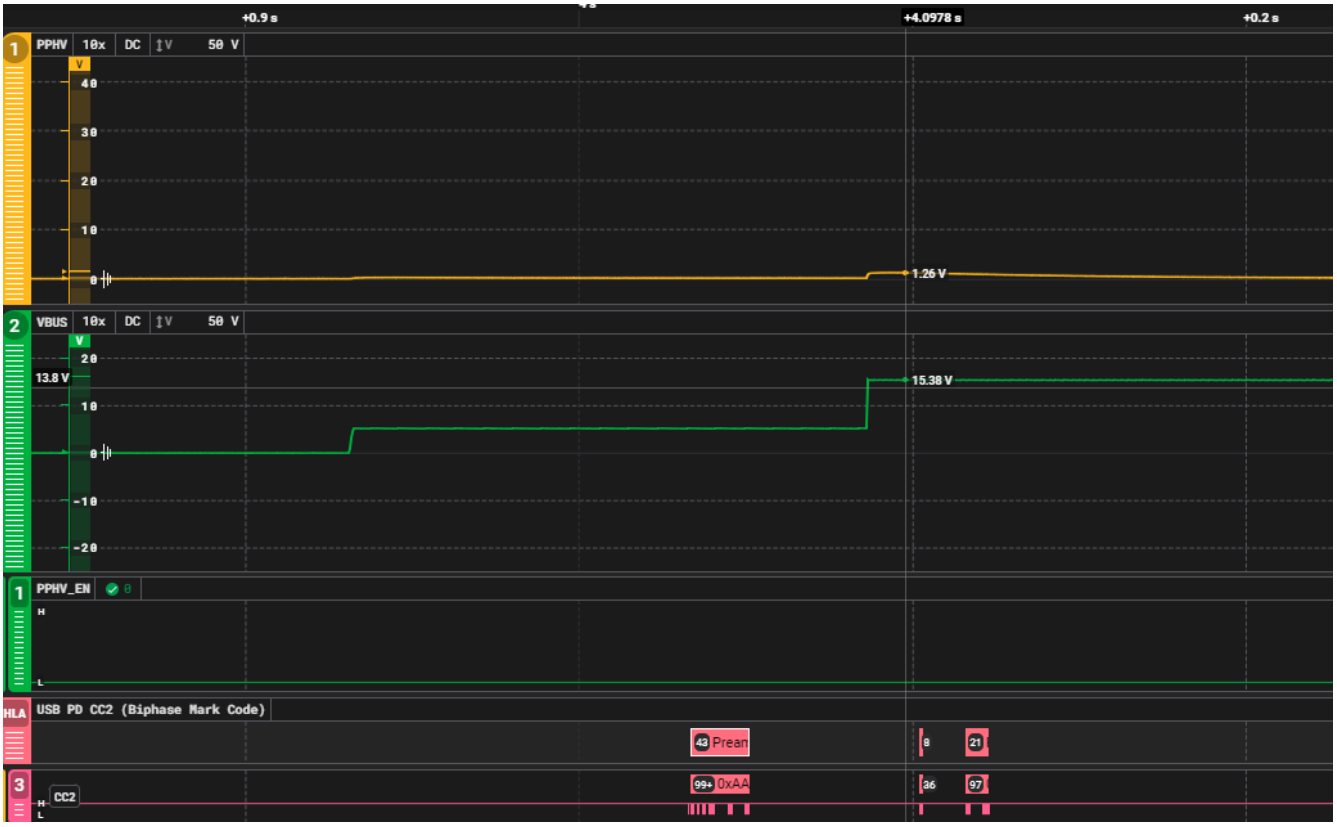

Figure 3-3. Capability Mismatch is asserted in the Request Message causing PD device to not enable the PPHV_EN

The Capability mismatch flag is set here which causes the PD Device to NOT enable the PPHV_EN above.

Figure 3-4. Request Data Object from the PD Device to the PD Source

If the system can still be powered at less than the AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower value, then set AUTO_NEGOTIATE_SINK.NoCapabilityMismatch to 0 or 1 depending on if system needs to assert Capability Mismatch in the Request PDO. And AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch to 0.

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 0*

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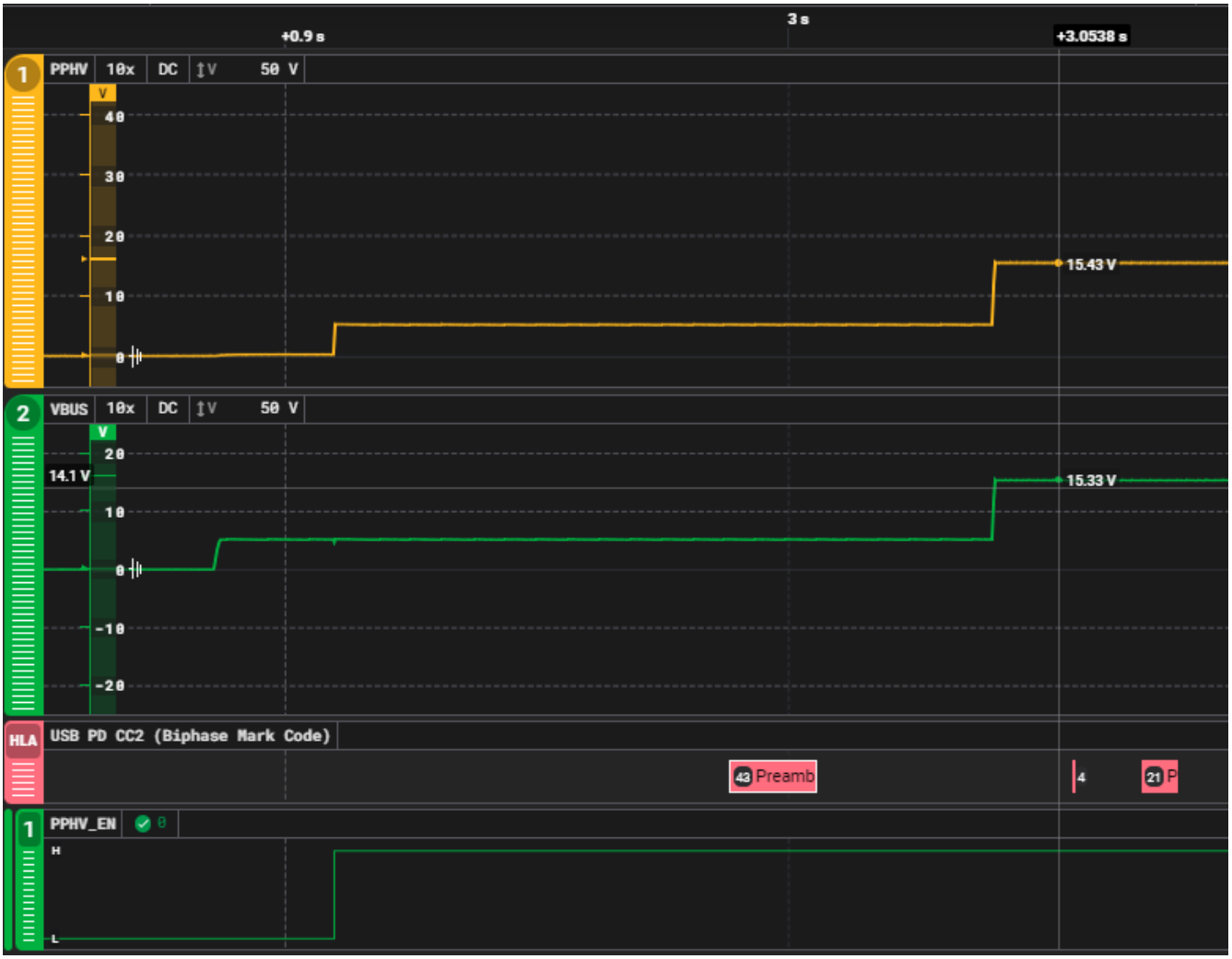

Figure 3-5. Capability Mismatch is asserted in the Request Message but PD device still enables PPHV_EN

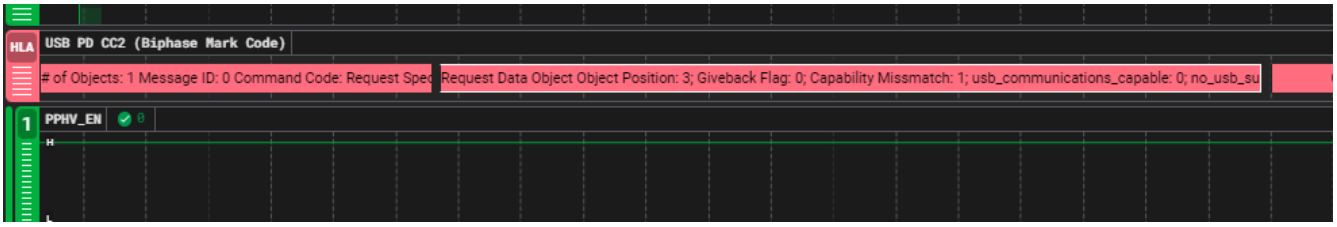

Figure 3-6. Request Data Object from the PD Device to the PD Source

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 1*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 0*

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Figure 3-7. Capability Mismatch is not asserted in the Request Message

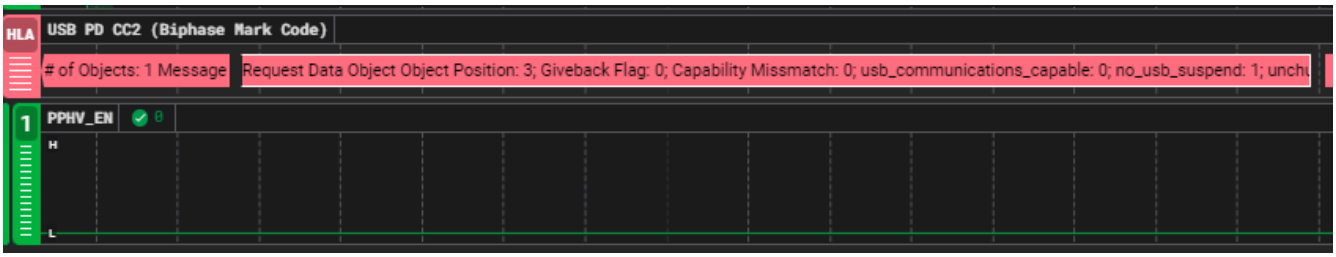

Figure 3-8. Request Data Object from the PD Device to the PD Source

3.4 Auto Compute Sink Min Voltage and Auto Neg Min Voltage

Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.AutoNegMinVoltage = Varied
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = Varied

Typical applications set this to AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 1 to allow PD to compute this value. The PD always sets this to 4.75V. This means PD can always fall-back to the 5V PDO if no other PDO works for PD controller.

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3.5 Auto Compute Sink Max Voltage & Auto Neg Max Voltage

Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 300d (15V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = Varied

If the system can always handle the largest voltage in SPR (up to 20V) or EPR (up to 48V) then leaving AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1 is acceptable. This means PD looks at the source PDOs offered and set this value to the maximum voltage value.

If the system requires a specific maximum and cannot exceed the voltage,
then setting AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0 means the AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage is set by configuration or by the EC regardless of the source PDO voltages.

(Show test 4 with PD setting MaxVoltage

- *AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 300d (15V)*
- *AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1*

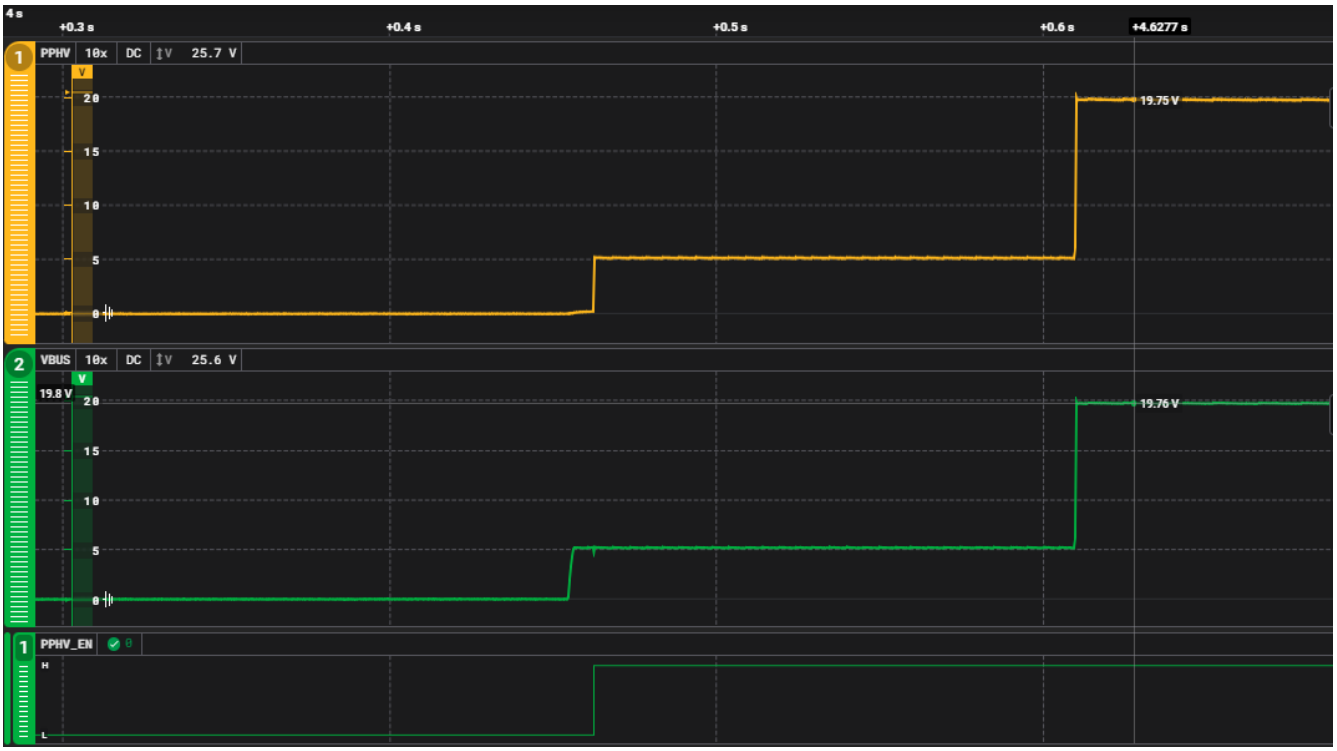

Figure 3-9. PD Device auto computes AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage

- *AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 300d (15V)*
- *AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0*

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Figure 3-10. PD Device Always Requesting 15V PDO

#	MessageType	SOP*	DataRole	PowerRole	MsgID	Sender
0	CONNECT SINK NO VBUS (CC1-Pin = 3p0A, CC2-Pin = RA)					
1	CONNECT CC1 (CC1-Pin = 3p0A, CC2-Pin = RA)					
2	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port
3	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port
4	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port
5	Source_Capabilities (Max: 60W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-3A)	SOP	DFP	SOURCE	0	Port
7	Request (RDO: Pos=3, Pow=45W,Ioc=3A; Src PDO: Fixed 15V-3A)	SOP	UFP	SINK	0	Port
9	Accept	SOP	DFP	SOURCE	1	Port
11	PS_RDY	SOP	DFP	SOURCE	2	Port

Figure 3-11. USB-PD Capture of the 20V PDO Offered

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4 Autonegotiate Sink Basics with EPR Examples

Default Values

Most values are the same as the previous section. However the TPS26750 device is used for these demonstrations to show how Autonegotiate Sink effects USB-PD contract negotation for EPR ranges (21V - 48V).

4.1 Systems Requiring ≥140W

Changed fields from the default values for this example:

- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 560d (140W)

The AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0 so the PD does not turn on the sink path unless EPR 28V or higher is available. The PD also sets the maximum voltage to 20V during SPR negotiation due to AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1, and the maximum EPR voltage once EPR entry happens to allow PD to always request the highest possible voltage.

4.2 Sink Path SPR to EPR Transitions

Some systems do not want to handle the sink path going from 0V to 28V+. This section reviews examples of how the to smoothly transition from SPR to EPR or only allow EPR.

Suppose the system requires EPR voltages (36V at 5A) but the transition from 0V to 36V on the sink path can be detrimental. Setting the following turns on the sink path at 5V and keep the sink path on until the 36V EPR contract is achieved. These settings also keep the Capabilites Mismatch bit asserted in the Request PDO until 36V EPR entry.

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 720d (180W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 0*

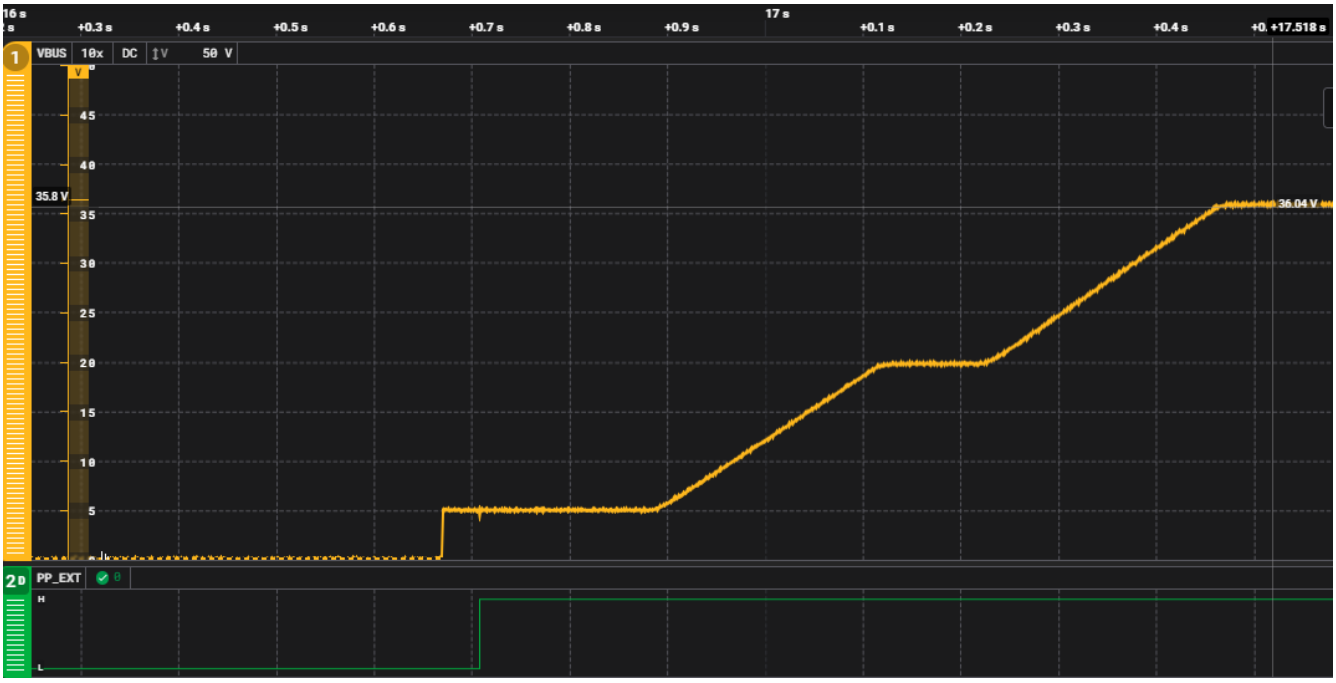

Figure 4-1. PP_EXT Enabled for Whole PD Contract Negotation

Shows the USB-PD messages from initial connection to EPR PDO negotiation.

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Note: EPR Keep-Alive messages are filtered out in this log for readability.

#	MessageType	SOP*	DataRole	PowerRole	MsgID	Sender	TimeStamp
0	CONNECT SINK NO VBUS (CC1-Pin = 1p5A, CC2-Pin = VCONN)						12:34:01.938.169
1	CONNECT CABLE RA OR SINK NO VBUS (CC1-Pin = STD, CC2-Pin = VCONN)						12:34:01.944.534
2	CONNECT CABLE RA OR SINK NO VBUS (CC1-Pin = STD, CC2-Pin = VCONN)						12:34:07.028.481
3	CONNECT DEBUG ACC (CC1-Pin = STD, CC2-Pin = 3p0A)						12:34:07.207.005
4	Source_Capabilities (Max: 100W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-5A)	SOP	DFP	SOURCE	0	Port	12:34:07.369.208
6	Request (RDO: Pos=4, Pow=100W,Ioc=5A; Src PDO: Fixed 20V-5A)	SOP	UFP	SINK	0	Port	12:34:07.374.905
8	Accept	SOP	DFP	SOURCE	1	Port	12:34:07.379.357
10	PS_RDY	SOP	DFP	SOURCE	2	Port	12:34:07.675.821
12	EPR_Mode (Action=Enter)	SOP	UFP	SINK	1	Port	12:34:07.681.521
14	EPR_Mode (Action=Enter_Acknowledged)	SOP	DFP	SOURCE	3	Port	12:34:07.686.093
16	EPR_Mode (Action=Enter_Succeeded)	SOP	DFP	SOURCE	4	Port	12:34:07.691.446
18	EPR_Source_Capabilities (Chunk Response #0)	SOP	DFP	SOURCE	5	Port	12:34:07.697.236
20	EPR_Source_Capabilities (Chunk Request #1)	SOP	UFP	SINK	2	Port	12:34:07.703.379
22	EPR_Source_Capabilities (Max: 180W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-5...	SOP	DFP	SOURCE	6	Port	12:34:07.708.103
24	EPR_Request (RDO: Pos=9, Pow=180W,Ioc=5A; Src PDO: Fixed 36V-5A)	SOP	UFP	SINK	3	Port	12:34:07.713.854
26	Accept	SOP	DFP	SOURCE	7	Port	12:34:07.718.369
28	PS_RDY	SOP	DFP	SOURCE	0	Port	12:34:07.996.869

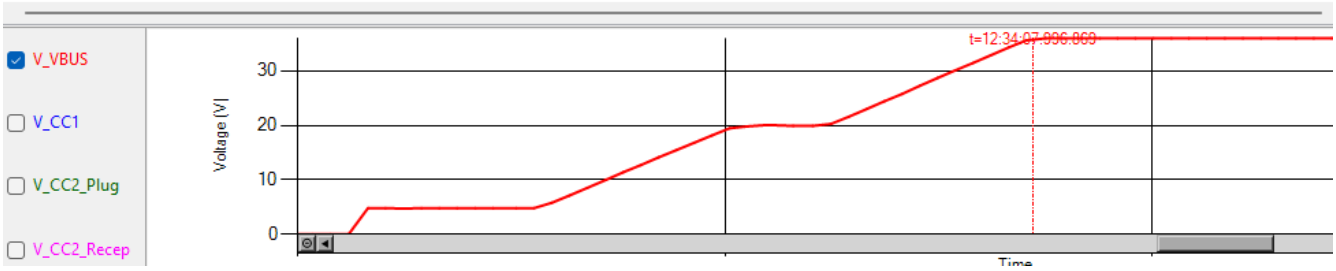

Figure 4-2. USB-PD Capture of the PD Contract Negotiation

Suppose the system requires at least 60W, but prefers EPR voltages. Setting the following turns on the sink path at 20V at 3A and keep the sink path on after 20V. Setting the following turns on the sink path at 20V and keep the sink path on until the 36V EPR contract is achieved.

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower= 240d (60W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1*

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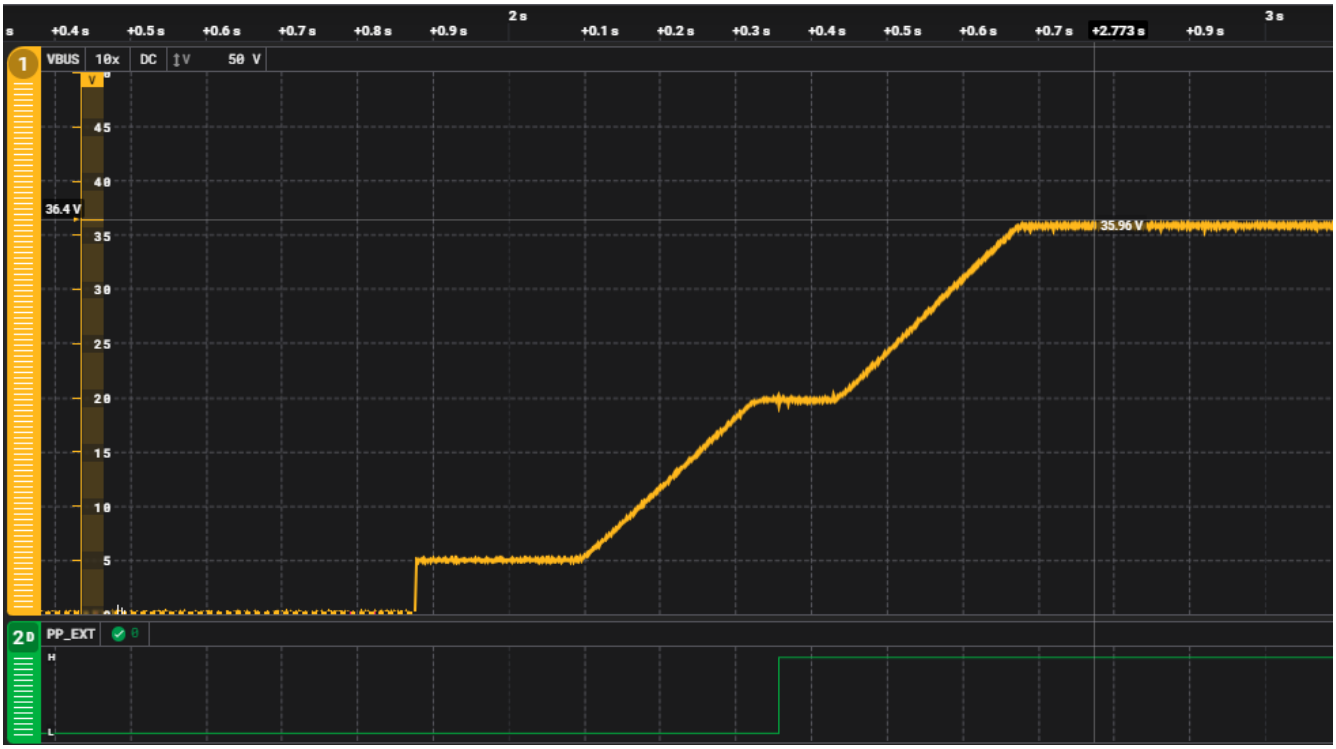

Figure 4-3. PP_EXT Enabled After AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower Met

Suppose the system requires at least 140W to function. Setting the following turns on the sink path at 140W (28V at 5A) and above. Designers must verify the system can handle the inrush of power to avoid damage/ brownouts within the system. Setting the following turns on the sink path at 28V only.

- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 560d (140W)
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0
- AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 560d (140W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1*

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Figure 4-4. PP_EN only enabled for EPR voltage of 28V

- *AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 560d (140W)*
- *AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0*
- *AUTO_NEGOTIATE_SINK.AutoDisableSinkUponCapabilityMismatch = 1*

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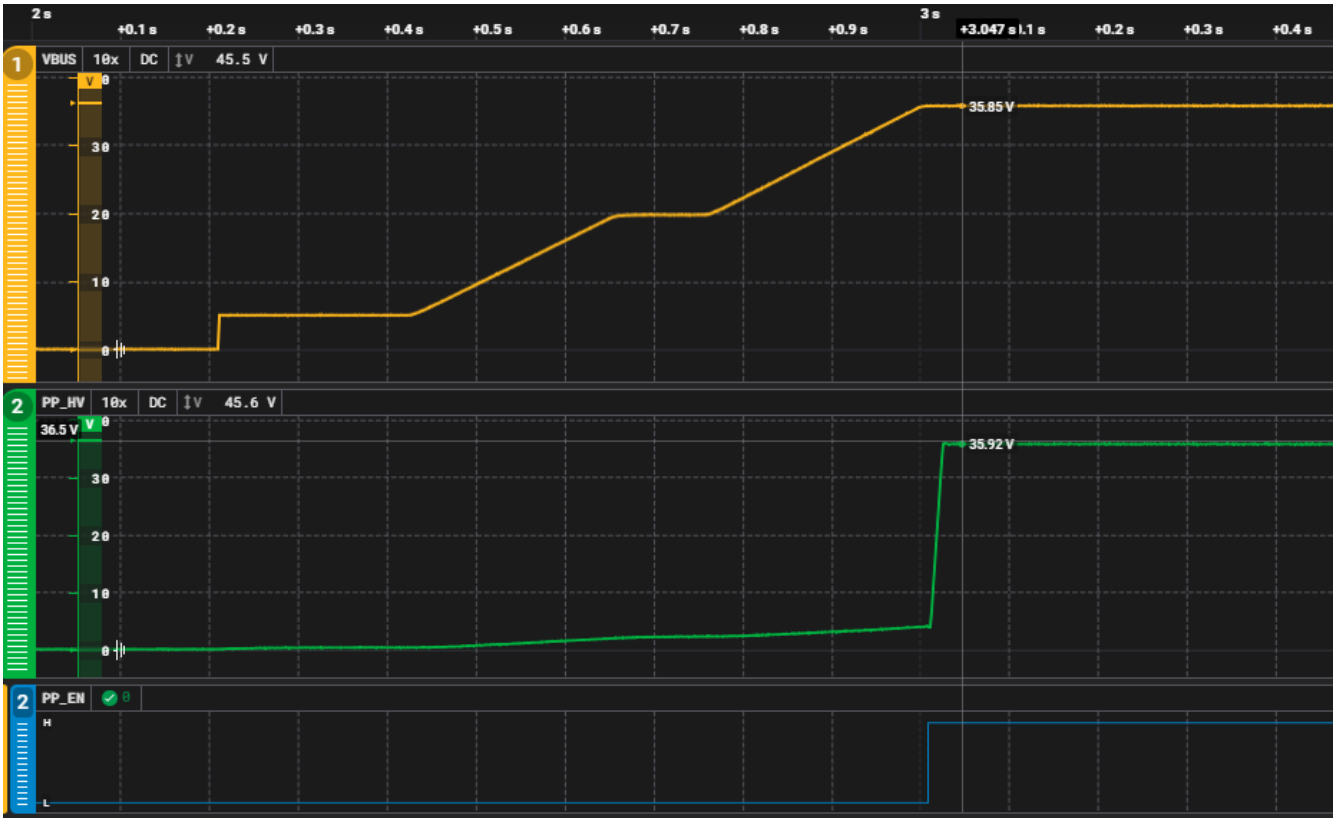

Figure 4-5. PP_EN Only Enabled for EPR Voltage of 36V

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5 Common Mistakes or Unique System Constraints

The Autonegotiate Sink settings are used together can be a very powerful tool to automatically request the correct power for a system and avoid powering on with limited USB-PD supplies. However some of these settings when combined incorrectly can lead to some common mistakes. This section reviews some of the common issues and ways to mitigate.

5.1 System Needs More Power but PD Selects Lower Power PDOs

Assume there is a system that has the default settings discussed however the following are selected:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 300d (15V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0
- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)

When a USB-PD Source is connected that can meet the 60W requirement, the PD device always requests the 15V PDO contract and never goes higher. This is because at configuration (or set by the EC) the PD is being limited to 15V maximum. So regardless of the USB-PD Source offerings, the PD device never accepts more than 15V PDO.

#	MessageType	SOP*	DataRole	PowerRole	MsgID	Sender	TimeStamp
0	CONNECT SINK NO VBUS (CC1-Pin = 3p0A, CC2-Pin = RA)						01:38:12.328.713
1	CONNECT CC1 (CC1-Pin = 3p0A, CC2-Pin = RA)						01:38:12.615.738
2	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:38:12.713.484
3	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:38:12.715.134
4	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:38:12.716.776
5	Source_Capabilities (Max: 60W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-3A)	SOP	DFP	SOURCE	0	Port	01:38:12.718.789
7	Request (RDO: Pos=3, Pow=45W,Ioc=3A; Src PDO: Fixed 15V-3A)	SOP	UFP	SINK	0	Port	01:38:12.724.463
9	Accept	SOP	DFP	SOURCE	1	Port	01:38:12.729.740
11	PS_RDY	SOP	DFP	SOURCE	2	Port	01:38:12.782.021
13	Vendor_Defined (Disc ID REQ)	SOP	DFP	SOURCE	3	Port	01:38:12.795.940
15	Vendor_Defined (Disc ID ACK)	SOP	UFP	SINK	1	Port	01:38:12.801.211

Message Details

Decoded Payload		
RDO		0x3584B1F4
ObjPos	3	0x3
GiveBack	0	0x0
Capability Mismatch	Yes	0x1
USB Communications Ca...	No	0x0
No USB Suspend	Yes	0x1
Unchunked Ext Supported	Yes	0x1
EPR Mode Capable	No	0x0
Reserved		0x0

Figure 5-1. 15V PDO Requested and 20V PDO Ignored

5.2 System Supports EPR Power but PD Keeps Selecting 20V PDOs

Assume there is a system that has the default settings discussed however the following are selected:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 400d (20V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0

This PD device is EPR-capable and can successfully enter into EPR mode with an EPR-capable USB-PD Source. However the PD device only requests 20V even in EPR mode. This is due to the fact that the AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage is configuration (or set by the EC) to 20V meaning the PD device never accepts any voltage higher than 20V.

#	MessageType	SOP*	DataRole	PowerRol
0	CONNECT CABLE RA OR SINK NO VBUS (CC1-Pin = 3p0A, CC2-Pin = STD)			
1	CONNECT DEBUG ACC (CC1-Pin = 3p0A, CC2-Pin = STD)			
2	Source_Capabilities (Max: 100W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-5A)	SOP	DFP	SOURCE
4	Request (RDO: Pos=4, Pow=100W,Ioc=5A; Src PDO: Fixed 20V-5A)	SOP	UFP	SINK
6	Accept	SOP	DFP	SOURCE
8	PS_RDY	SOP	DFP	SOURCE
10	EPR_Mode (Action=Enter)	SOP	UFP	SINK
12	EPR_Mode (Action=Enter_Acknowledged)	SOP	DFP	SOURCE
14	EPR_Mode (Action=Enter_Succeeded)	SOP	DFP	SOURCE
16	EPR_Source_Capabilities (Chunk Response #0)	SOP	DFP	SOURCE
18	EPR_Source_Capabilities (Chunk Request #1)	SOP	UFP	SINK
20	EPR_Source_Capabilities (Max: 180W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-5A, Fixed 28V-5A, Fixed 36V-5A, EPR AVS PDP:180...	SOP	DFP	SOURCE
22	EPR_Request (RDO: Pos=4, Pow=100W,Ioc=5A; Src PDO: Fixed 20V-5A)	SOP	UFP	SINK
24	Accept	SOP	DFP	SOURCE
26	PS_RDY	SOP	DFP	SOURCE

Message Details

Capability Mismatch	No	0x0
USB Communications Ca...	No	0x0
No USB Suspend	Yes	0x1
Unchunked Ext Supported	Yes	0x1
EPR Mode Capable	Yes	0x1
Reserved		0x0
Operating Current	5.00A	0x1F4
Maximum Operating Curr...	5.00A	0x1F4
Source Contract PDO		0x000641F4
SupplyType	Fixed	0x0
Reserved		0x0
Voltage	20.00V	0x190
Maximum Current	5.00A	0x1F4

Figure 5-2. 20V PDO Requested in EPR Mode

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5.3 Setting the Min Voltage and Max Voltage to the Same Values

Assume there is a system that has the default settings discussed however the following are selected:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 300d (15V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0
- AUTO_NEGOTIATE_SINK.AutoNegMinVoltage = 300d (15V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 0

Suppose the system requires only a specific voltage (15V) and cannot work with any other voltage. Then setting the AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = AUTO_NEGOTIATE_SINK.AutoNegMinVoltage can accomplish this. As long as the PD is setup to NOT autocompute these fields, then at configuration (or set by the EC) only the PDOs chosen are set.

Whenever the AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage or AUTO_NEGOTIATE_SINK.AutoNegMinVoltage is not met, the 5V PDO is chosen as a default since USB-PD requires this.

#	MessageType	SOP*	DataRole	PowerRole	MsgID	Sender	TimeStamp
0	CONNECT SINK NO VBUS (CC1-Pin = 3p0A, CC2-Pin = RA)						01:52:50.053.589
1	CONNECT CC1 (CC1-Pin = 3p0A, CC2-Pin = RA)						01:52:50.339.549
2	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:52:50.437.423
3	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:52:50.439.091
4	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	0	Port	01:52:50.440.732
5	Source_Capabilities (Max: 15W, Fixed 5V-3A)	SOP	DFP	SOURCE	0	Port	01:52:50.442.693
7	Request (RDO: Pos=1, Pow=15W,Ioc=3A; Src PDO: Fixed 5V-3A)	SOP	UFP	SINK	0	Port	01:52:50.447.981
9	Accept	SOP	DFP	SOURCE	1	Port	01:52:50.453.274
11	PS_RDY	SOP	DFP	SOURCE	2	Port	01:52:50.490.044
13	Vendor_Defined (Disc ID REQ)	SOP	DFP	SOURCE	3	Port	01:52:50.502.986
15	Vendor_Defined (Disc ID ACK)	SOP	UFP	SINK	1	Port	01:52:50.508.259
17	CONNECT CC CHANGE (CC1-Pin = 1p5A, CC2-Pin = RA)						01:52:54.828.061
18	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	1	Port	01:52:54.838.694
19	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	1	Port	01:52:54.840.369
20	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	1	Port	01:52:54.842.022
21	Source_Capabilities (Max: 27W, Fixed 5V-3A, Fixed 9V-3A)	SOP	DFP	SOURCE	4	Port	01:52:54.844.004
23	Request (RDO: Pos=1, Pow=15W,Ioc=3A; Src PDO: Fixed 5V-3A)	SOP	UFP	SINK	2	Port	01:52:54.849.423
25	Accept	SOP	DFP	SOURCE	5	Port	01:52:54.854.704
27	PS_RDY	SOP	DFP	SOURCE	6	Port	01:52:54.891.461
29	CONNECT CC CHANGE (CC1-Pin = 3p0A, CC2-Pin = RA)						01:52:54.899.290
30	CONNECT CC CHANGE (CC1-Pin = 1p5A, CC2-Pin = RA)						01:53:00.280.697
31	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	2	Port	01:53:00.291.563
32	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	2	Port	01:53:00.293.223
33	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	2	Port	01:53:00.294.868
34	Source_Capabilities (Max: 45W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A)	SOP	DFP	SOURCE	7	Port	01:53:00.296.866
36	Request (RDO: Pos=3, Pow=45W,Ioc=3A; Src PDO: Fixed 15V-3A)	SOP	UFP	SINK	3	Port	01:53:00.302.422
38	Accept	SOP	DFP	SOURCE	0	Port	01:53:00.307.702
40	PS_RDY	SOP	DFP	SOURCE	1	Port	01:53:00.359.793
42	CONNECT CC CHANGE (CC1-Pin = 3p0A, CC2-Pin = RA)						01:53:00.368.005
43	CONNECT CC CHANGE (CC1-Pin = 1p5A, CC2-Pin = RA)						01:53:03.498.121
44	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	3	Port	01:53:03.508.581
45	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	3	Port	01:53:03.510.246
46	Vendor_Defined (Disc ID REQ)	SOP'	N/A	N/A	3	Port	01:53:03.511.891
47	Source_Capabilities (Max: 60W, Fixed 5V-3A, Fixed 9V-3A, Fixed 15V-3A, Fixed 20V-3A)	SOP	DFP	SOURCE	2	Port	01:53:03.514.243
49	Request (RDO: Pos=3, Pow=45W,Ioc=3A; Src PDO: Fixed 15V-3A)	SOP	UFP	SINK	4	Port	01:53:03.519.922
51	Accept	SOP	DFP	SOURCE	3	Port	01:53:03.525.498
53	PS_RDY	SOP	DFP	SOURCE	4	Port	01:53:03.562.625
55	CONNECT CC CHANGE (CC1-Pin = 3p0A, CC2-Pin = RA)						01:53:03.570.349

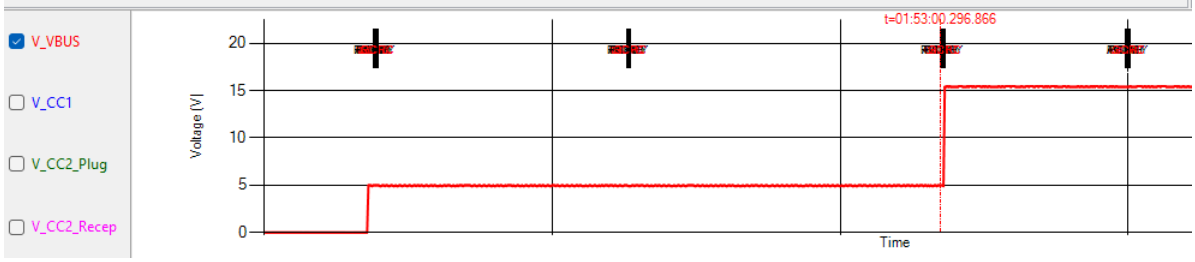

Figure 5-3. PD Device Behavior for Various PD Source Capability Offerings

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The AUTO_NEGOTIATE_SINK.AutoNegMinVoltage and AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage do not have to be the same value so if the system requires a minimum of 9V but a maximum of 20V, then the following always limits the system to the 9V-20V range:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 400d (20V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0
- AUTO_NEGOTIATE_SINK.AutoNegMinVoltage = 180d (9V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 0

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6 Advanced Autonegotiate Sink Examples

This section reviews the benefits of the Autonegotiate Sink register when paired with some embedded controller (EC). There is examples including Autonegotiate Sink examples located on github for public use on various devices.

6.1 Downgrading to 5V Fixed PDO

In some cases, once a system no longer needs full power, the Autonegotiate Sink register can be used to lower the power provided to the system. This requires an EC to change the default settings so cannot be done autonomously. Consider a system that has the default settings then the EC updates the following:

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 100d (5V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0

From the example System supports EPR power but PD keeps selecting 20V PDOs, this forces the USB-PD to always negotiate 5V Fixed PDO. 5V is always offered by USB-PD as a standard. So before the EC updates the above settings, the PD automatically negotiates to the highest voltage.

Figure 6-1. 20V USB-PD Source being plugged into TPS25751

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Figure 6-2. 28V USB-PD EPR Source being plugged into TPS26750

Initially the AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage is set to 1 so PD computes and fills out AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage to whatever the maximum voltage offered is. Some time later, system determines the power is no longer needed and can reduce the USB-PD contract by setting the AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage to 5V and AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage to 0 for EC controlled value.

Race Condition Warning: The PD does not overwrite the Autonegotiate Sink setting AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage until a new contract is negotiated OR if AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage is 0. So if a USB-PD source sends new Source Capabilities message while EC is modifying the Autonegotiate Sink register, this can lead to EC changes being overwritten.

Once the Autonegotiate Sink register is changed, the EC can now send the 4CC command 'ANeg'. For details on how to send 4CC commands, consult the USB-PD Controller Technical Reference Manual (TPS25751 TRM). This can cause the PD to re-evaluate the Autonegotiate Sink register and the changes made by the EC to take effect.

(20V to 5V and 28V to 5V)

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 100d (5V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0

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Figure 6-3. 4CC 'ANeg' command sent reducing USB-PD to 5V

- AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 100d (5V)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0

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Figure 6-4. 4CC 'ANeg' command sent reducing USB-PD to 5V

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6.2 Autonegotiate Sink With Interrupt Driven EC

Most ECs rely on interrupts to service many devices. Most TI PD controllers offer an I2Ct_IRQ (interrupt) line typically asserts low when PD has information for the EC. Take the example Downgrading to 5V Fixed PDO can be interrupt driven and there is an example of this on the USB-PD github. Below is the pseudo code and basic information about the EC/PD flow for this example.

```
while(true){
  if (connection_present() )
    break
}
// begin example code
// connection of USB-PD capable charger causes
// Plug Insert or Removal
// New Contract as Consumer
// Source Capabilities Message Received
// to assert.
interrupt_events = read_i2c1_irq()
if ( interrupt_events.plug_insert_or_removal ){
  // do something
} else if ( .... ){
   ...
}
// clear the interrupts by writing back the same bits
write_i2c1_clear(interrupt_events)
// setup the autonegotiate sink register to 5V max
reduce_power_5v()
// sets AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 0
// sets AUTO_NEGOTIATE_SINK.AutoNegMaxVoltage = 100
write_4CC("ANeg")
```

6.3 *ANeg*: Auto Negotiate Sink Update

Table 6-1. *ANeg*: Re-evaluate the auto-negotiate sink register

Description	The 'ANeg' Task instructs PD Controller to re-evaluate the *Auto Negotiate Sink* register (0x37). If the re-evaluation produces a different RDO than the Active Contract RDO then a new Request message is sent.
INPUT DATAX	None
OUTPUT DATAX	Byte 1: Standard Task Return Code. See also Standard Task Response.
Task Completion	The *ANeg* Task completes after the new RDO is calculated and PD Controller either decides to send a new request message (and that message is sent and the GoodCRC received) or determines that no request is necessary. The task is rejected if the PD controller is not in a sink power role.
Side Effects	The side effects include a new PD contract negotiation and updates to the associated registers.
Additional Information	None

6.4 AUTO_NEGOTIATE_SINK Register

In general, writing to AUTO_NEGOTIATE_SINK register while a sink contract is in place does not cause an automatic renegotiation, and changes take effect the next time a contract is negotiated. The ANeg command forces a re-evaluation of this register and a new Request message is issued if appropriate.

However, if a Sink PPS Contract is already in place there are some fields that do cause the PD controller to automatically reevaluate the register and send a new Request message if appropriate:

- PPSOutputVoltage
- PPSOperatingCurrent
- PPSEnableSinkMode
- PPSRequestInterval
- RequireFullVoltageRange
- PPSSourceMode

If PPSEnableSinkMode is changed while a Sink PPS Explicit Contract is not already in place the PD controller also automatically re-evaluates the register and sends a new Request message if appropriate.

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If the first four bytes of this register are written as zero, then the PD controller always requests a 5V Fixed Supply contract at 100mA ; unless PPSEnableSinkMode is asserted in which case an APDO can be selected.

To implement Sink PPS features in this register, the host shall provide an APDO in the TX_SINK_CAPS register. If the PD controller is evaluating a PPS supply type, it only uses the first APDO in the TX_SINK_CAPS register to determine when to assert the Capability Mismatch bit. Therefore, it is recommended that the host only have one APDO in the TX_SINK_CAPS register. In order to not assert the Capability Mismatch bit, the source APDO advertised by the source must meet these conditions:

- RX_SOURCE_CAPS.APDO.MinVoltage <= TX_SINK_CAPS.APDO.MinVoltage
- RX_SOURCE_CAPS.APDO.MaxVoltage >= TX_SINK_CAPS.APDO.MaxVoltage
- RX_SOURCE_CAPS.APDO.MaxCurrent >= TX_SINK_CAPS.APDO.MaxCurrent

If the source fails any of the conditions above, a sink PPS contract is still requested if one of the source APDOs meets these conditions:

- RX_SOURCE_CAPS.APDO.MinVoltage <= AUTO_NEGOTIATE_SINK.PPSOutputVoltage
- RX_SOURCE_CAPS.APDO.MinVoltage >= AUTO_NEGOTIATE_SINK.PPSOutputVoltage
- RX_SOURCE_CAPS.APDO.MaxCurrent >= AUTO_NEGOTIATE_SINK.PPSOperatingCurrent

During PPS operation, if the host sets the PPSOutputVolage field to a value outside what the source APDO can deliver as reported in the RX_SOURCE_CAPS register, then a Fixed Supply PDO is selected and the sink path can be automatically disabled (see AUTO_NEGOTIATE_SINK.PPSDisableSinkUponNonAPDOContract).

If PPS is enabled, then an APDO that fulfills the requirements is given highest priority.

The following is a high-level summary of how this register drives the PDO selection when PPS is disabled or no matching APDO is found.

- Parse the received PDOs in the register RX_SOURCE_CAPS. Discard any PDO whose voltage range is below ANMinVoltage or above ANMaxVoltage.
- Calculate the PDO power for each received PDO (RX_SOURCE_CAPS.SourcePdoX). Rank all PDOs according to the PDO power.
  - PDO Power = Voltage × MaximumCurrent (Fixed Supply)
  - PDO Power = MinimumVoltage × MaximumCurrent (Variable Supply)
  - PDO Power = MaximumPower (Battery Supply)
- The PDO with maximum PDO Power that also passes the voltage check is selected. In case there are multiple PDOs that pass the voltage check and have the same maximum PDO Power, tie breakers are applied as described below:
  - A Fixed supply type is preferred, and Variable supply type is preferred over Battery supply type.
  - If the PDOs being compared have the same supply type, then ANRDOPriority specifies how to break the tie.

6.4.1 AUTO_NEGOTIATE_SINK Usage Example 1

When attached to a 36W source the PD controller has RX_SOURCE_CAPS:

- PDO1: 5V at 3A
- PDO2: 9V at 3A
- PDO3: 15V at 2.4A
- PDO4: 20V at 1.8A

The PD controller has TX_SINK_CAPS set as:

- PDO1: 5V at 3A (fixed)
- PDO2: 20V at 3A (fixed)

The PD controller has AUTO_NEGOTIATE_SINK set as:

- AUTO_NEGOTIATE_SINK = 0
- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 1

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- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = x (see table below)
- AUTO_NEGOTIATE_SINK.ANRDOPriority = y (see table below)

The settings give the following results:

- ANSinkMinRequiredPower computed as 60W
- ANMaxVoltage computed as 20V
- ANMinVoltage computed as 4.75V

Table 6-2. AUTO_NEGOTIATE_SINK Usage Example 1

AUTO_NEGOTIATE_SINK		ACTIVE_CONTRACT_RDO			
NoCapabilityMismatch	ANRDOPriority	OperatingX	MinMaxOperatingX	ObjectPosition	Capability Mismatch
0	0	1.8A	3.0A	4	1
1	0	1.8A	1.8A	4	0
1	1	2.4A	2.4A	3	0

6.4.2 AUTO_NEGOTIATE_SINK Usage Example 2

When attached to a 36W source the PD controller has RX_SOURCE_CAPS:

- PDO1: 5V at 3A
- PDO2: 9V at 3A
- PDO3: 15V at 2.4A

The PD controller has TX_SINK_CAPS set as:

- PDO1: 5V at 0.1A (fixed)
- PDO2: 20V at 3A (fixed)

The PD controller has AUTO_NEGOTIATE_SINK set as:

- AUTO_NEGOTIATE_SINK = 0
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 0
- AUTO_NEGOTIATE_SINK.ANMinVoltage = 20V
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = x (see table below)
- AUTO_NEGOTIATE_SINK.ANRDOPriority = 0

The settings give the results in the table below. Note that ANMaxVoltage computed as 20V, but this does not affect the result. Because the ANMinVoltage was set to 20V, and the source is not offering 20V none of the source PDOs fulfill the sink requirements. Even though ANSinkCapMismatchPower=0 in this example, because the voltages offered are insufficient, the capability mismatch bit can still be set.

Table 6-3. AUTO_NEGOTIATE_SINK Usage Example 2

AUTO_NEGOTIATE_SINK	ACTIVE_CONTRACT_RDO			
NoCapabilityMismatch	OperatingX	MinMaxOperatingX	ObjectPosition	Capability Mismatch
0	3.0A	3.0A	1	1
1	3.0A	3.0A	1	0

6.4.3 AUTO_NEGOTIATE_SINK Usage Example 3

When attached to a 45W source the PD controller has RX_SOURCE_CAPS:

- PDO1: 5V at 3A
- PDO2: 9V at 3A
- PDO3: 15V at 3A
- PDO4: 20V at 2.25A

The PD controller has TX_SINK_CAPS set as:

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- PDO1: 5V at 3A (fixed)
- PDO2: 20V at 2.25A (fixed)

The PD controller has AUTO_NEGOTIATE_SINK set as:

- AUTO_NEGOTIATE_SINK = 0
- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 180d (45W)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0
- AUTO_NEGOTIATE_SINK.ANRDOPriority = y (see table below)

The settings give the following results:

- ANSinkMinRequiredPower computed as 45W
- ANMaxVoltage computed as 20V
- ANMinVoltage computed as 4.75V

Table 6-4. AUTO_NEGOTIATE_SINK Usage Example 3.

AUTO_NEGOTIATE_SINK	ACTIVE_CONTRACT_RDO			
ANRDOPriority	OperatingX	MinMaxOperatingX	ObjectPosition	Capability Mismatch
0	2.25A	2.25A	4	0
1	3.0A	3.0A	3	0

6.4.4 AUTO_NEGOTIATE_SINK Usage Example 4

When attached to a 100W source the PD controller has RX_SOURCE_CAPS:

- PDO1: 5V at 3A
- PDO2: 9V at 3A
- PDO3: 15V at 3A
- PDO4: 20V at 5A

The PD controller has TX_SINK_CAPS set as:

- PDO1: 5V at 3A (fixed)
- PDO2: 20V at 5A (fixed)

The PD controller has AUTO_NEGOTIATE_SINK set as:

- AUTO_NEGOTIATE_SINK = 0
- AUTO_NEGOTIATE_SINK.ANSinkCapMismatchPower = 240d (60W)
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinPower = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMinVoltage = 1
- AUTO_NEGOTIATE_SINK.AutoComputeSinkMaxVoltage = 1
- AUTO_NEGOTIATE_SINK.NoCapabilityMismatch = 0
- AUTO_NEGOTIATE_SINK.ANRDOPriority = y (see table below)

The settings give the following results:

- ANSinkMinRequiredPower computed as 100W
- ANMaxVoltage computed as 20V
- ANMinVoltage computed as 4.75V

Table 6-5. AUTO_NEGOTIATE_SINK Usage Example 3.

AUTO_NEGOTIATE_SINK	ACTIVE_CONTRACT_RDO			
ANRDOPriority	OperatingX	MinMaxOperatingX	ObjectPosition	Capability Mismatch
0	5A	5A	4	0
1	5A	5A	4	0

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7 References

- Texas Instruments, TPS25751, product page.
- Texas Instruments, TPS26750, product page.
- Texas Instruments, TI USB-PD Github, webpage.

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