

TPS65988 and TPS65987D PD3.0 Fast Role Swap

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ABSTRACT

The TPS65988 and TPS65987D are PD3.0 capable PD controllers. One of the most difficult features to implement from the PD3.0 specification is the Fast Role Swap (FRS). FRS is useful particularly in the case of a dongle connected to a laptop. Most dongles have a pass through charge function that allows users to connect their PD charger to the dongle and charge the laptop through the Type-C connection from the dongle. In this case, the dongle is the power source and the laptop is the power sink. When the user disconnects the PD adapter from the dongle, the laptop needs to become the power source and the dongle becomes the power sink. FRS allows this to happen without VBUS dropping to 0 V which maintains the data connection. In the past, PD2.0 systems would implement a regular power role swap in these situations, which requires VBUS to drop to 0 V before the laptop can start sourcing power. This would interrupt the data connection from the laptop to the dongle and create a poor user experience. FRS is supported on the TPS65988 and TPS65987D in the notebook application (FRS old sink, new source).

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1 Introduction

Fast Power Role Swap (FRS) was introduced as a protocol in USB PD 3.0. FRS allows for the power roles of devices to change without data being interrupted. In this application report, a TPS65988EVM is used to emulate a laptop and a Huawei multiport adapter is used as the dongle. Initially, the laptop is the power sink and the dongle is the power source. However, when power is removed from the Huawei™ dongle, the power roles of the devices swap. During testing, data is constantly streamed to and from the Huawei dongle to ensure that there are no data interruptions during an FRS event.

2 Test Setup

2.1 Configuring the TPS65988EVM

Settings for the TPS65988EVM should be updated to support FRS.

1. Open the TPS6598x configuration tool.
2. Select an Advanced DRP Host template for the TPS65988 that does not support an external controller.
3. Change the configuration settings as highlighted in [Table 1](#) after loading that configuration.

Table 1. TPS65988EVM FRS Settings

REGISTER	FIELD	DEFAULT TEMPLATE SETTING	FRS SETTING
Port Control (0x29)	Automatic Sink Cap	Disabled	Enabled
Transmit Source Capabilities (0x32)	Number of Bank 0 Source PDOs	4	1
PD3 Configuration Register (0x42)	Fast Role Swap Supported	Disabled	Enabled

NOTE: Ensure the same settings are changed on Port 0 and Port 1 of the TPS65988EVM configuration file.

2.2 Initiating a Fast Role Swap

Complete the following steps when setting up the EVM and dongle to complete a Fast Role Swap:

1. Connect 20-V Barrel Jack Connector to TPS65988EVM.
2. Connect 20-V PD Adapter to Huawei Dongle.
3. Connect TPS65988EVM to Huawei Dongle through the tethered USB Type-C cable.

After these steps have been completed, the two EVMs should be setup in the same method as [Figure 1](#).

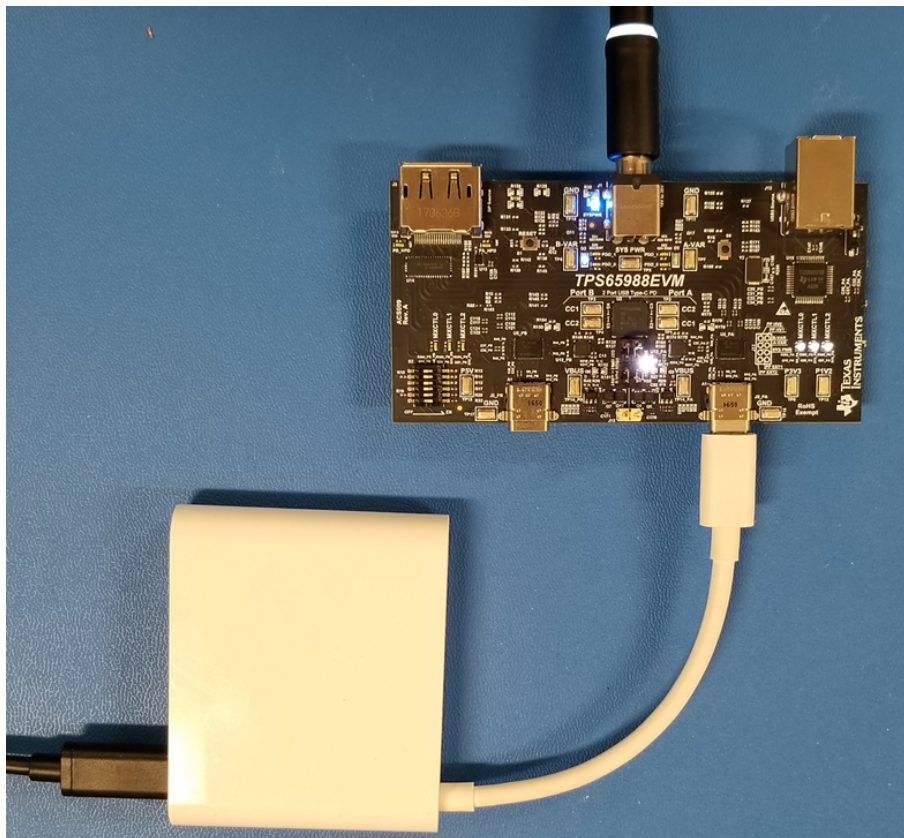


Figure 1. TPS65988EVM and Huawei Dongle Before an FRS

You can see on the TPS65988EVM that D5 is off. D5 is the LED connected to the DC/DC supply used to source power on Port A. This DC/DC supply is only off when the TPS65988EVM is acting as a power sink.

To initiate the Fast Role Swap, remove the PD adapter from the Huawei Dongle. This causes the dongle to trigger the Fast Role Swap PD message as the dongle is no longer able to source power. The TPS65988EVM then monitors the voltage on VBUS and closes its source power path once the voltage on VBUS is within the VSafe5V maximum of 5.5 V as defined in the USB Type-C PD specification. A successful FRS can be easily observed by monitoring the VBUS LED on either EVM. The LED never turns off and only dims slightly as VBUS goes from 20 V to 5 V.

[Figure 2](#) highlights what the TPS65988EVM and Huawei Dongle looks like after the FRS has successfully completed.

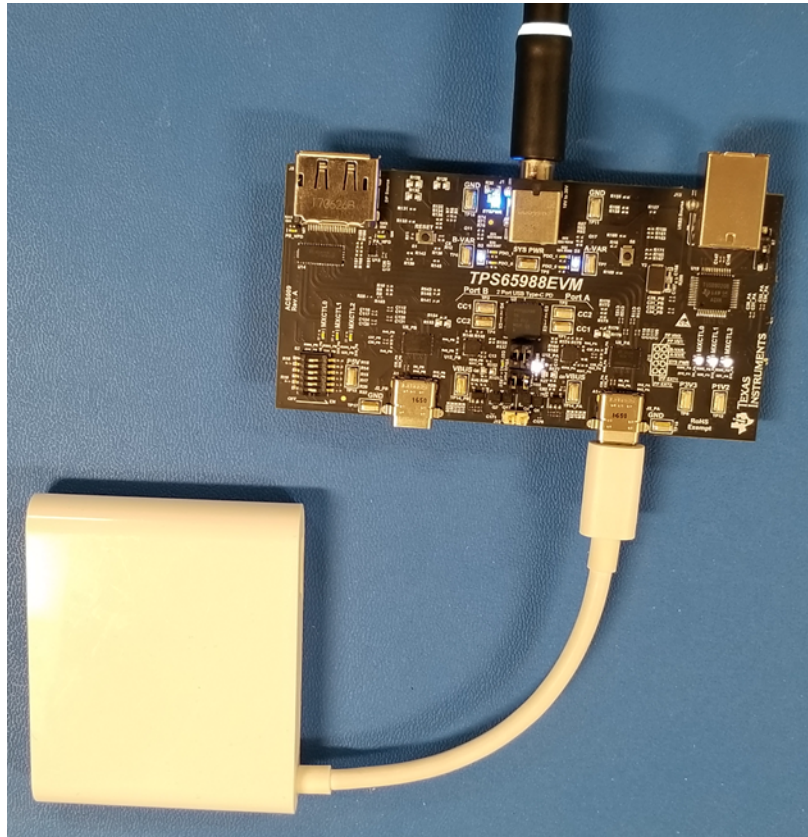


Figure 2. TPS65988EVM and Huawei Dongle After an FRS

2.3 *FRS messages*

During a Fast Role Swap event, you see the VBUS voltage transfer from 20 V to 5 V. There is also numerous messages sent over CC to indicate a successful FRS. [Figure 3](#) highlights an oscilloscope capture of VBUS and CC during a successful Fast Role Swap.

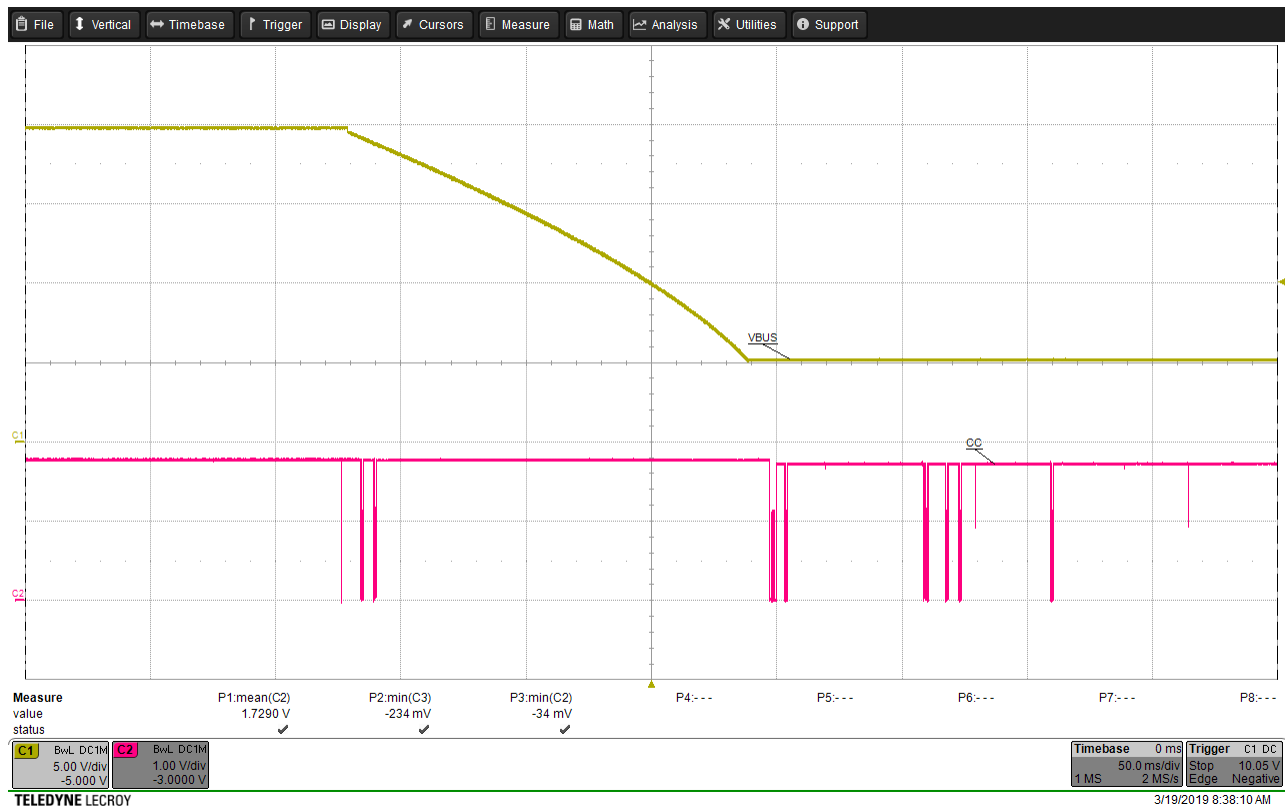


Figure 3. FRS Oscilloscope Capture

The Scope capture in Figure 3 highlights what you can expect to see on the VBUS and CC lines during a Fast Role Swap transaction. The FRS request message is sent from the initial source on the CC line by pulling CC to ground for 60 μ s to 120 μ s. Figure 4 highlights the PD messaging between two devices when an FRS transaction happens.

Packet	Port	PD Event	Event Type	Duration	Idle	Time Stamp								
1	"???"		Fast Role Swap	82.000 us	7.632 ms	3 . 587 989 160								
2	Left "Left"	SOP SNK	PD Msg FR Swap	DFP SNK	7	0	No	Duration 495.425 us	Idle 46.935 us	Time Stamp 3 . 595 702 712				
3	Right "Right"	SRC	PD Msg GoodCRC	UFP SRC	7	0		Duration 493.786 us	Idle 4.116 ms	Time Stamp 3 . 596 245 072				
4	Right "Right"	SRC SOP	PD Msg Accept	UFP SRC	1	0	No	Duration 493.488 us	Idle 47.296 us	Time Stamp 3 . 600 855 168				
5	Left "Left"	SOP SNK	PD Msg GoodCRC	DFP SNK	1	0		Duration 495.276 us	Idle 1.651 ms	Time Stamp 3 . 601 395 952				
6	Left "Left"	SOP SNK	PD Msg PS Ready	UFP SNK	2	0	No	Duration 486.864 us	Idle 53.500 us	Time Stamp 3 . 603 542 192				
7	Left "Left"	SOP SNK	PD Msg GoodCRC	DFP SNK	2	0		Duration 489.216 us	Idle 4.135 ms	Time Stamp 3 . 604 082 556				
8	Right "Right"	SRC SOP	PD Msg PS Ready	DFP SRC	0	0	No	Duration 495.872 us	Idle 43.128 us	Time Stamp 3 . 608 707 048				
9	Left "Left"	SOP SNK	PD Msg GoodCRC	UFP SNK	0	0		Duration 493.339 us	Idle 55.470 ms	Time Stamp 3 . 609 246 048				
10	Right "Right"	SRC SOP	PD Msg Source Cap	DFP SRC	0	1	No	Fixed Max Cur 3.00A	Voltage 5.00 V	Dual Role 1	Duration 628.425 us	Idle 46.791 us	Time Stamp 3 . 665 209 832	
11	Left "Left"	SOP SNK	PD Msg GoodCRC	UFP SNK	0	0		Duration 493.786 us	Idle 4.098 ms	Time Stamp 3 . 665 885 048				
12	Left "Left"	SOP SNK	PD Msg Request	UFP SNK	0	1	No	Request Max Opr Cur 3.00A	Opr Cur 3.00A	Cap Mismatch 1	Obj Pos 1	Duration 625.779 us	Idle 54.397 us	Time Stamp 3 . 670 476 352
13	Right "Right"	SRC SOP	PD Msg GoodCRC	DFP SRC	0	0		Duration 495.276 us	Idle 4.115 ms	Time Stamp 3 . 671 156 528				
14	Right "Right"	SRC SOP	PD Msg Accept	DFP SRC	1	0	No	Duration 495.425 us	Idle 51.855 us	Time Stamp 3 . 675 766 888				
15	Left "Left"	SOP SNK	PD Msg GoodCRC	UFP SNK	1	0		Duration 493.190 us	Idle 35.745 ms	Time Stamp 3 . 676 314 168				
16	Right "Right"	SRC SOP	PD Msg PS Ready	DFP SRC	2	0	No	Duration 495.872 us	Idle 54.824 us	Time Stamp 3 . 712 552 192				

Figure 4. FRS PD Messaging Sequence

From the FRS PD messaging, you can see the first request message indicated in Packet 1 as the Fast Role Swap PD event. This is the 60 μ s to 120 μ s CC pull-down from the oscilloscope capture. The next message in the sequence is the "FR Swap" PD message sent from original sink device. The old source then sends an accept message to the old sink and changes its Rp advertisement to Rd so that the old source can become the new sink. Once the CC termination on the old source new sink has changed, it sends a PS Ready message to the old sink new source. Upon receiving this message, the old sink new source changes its CC termination from an Rd to an Rp to prepare to become the power source. After the CC termination on the new source has changed, it sends a PS Ready message to the new sink to indicate that it is now ready to be the source. After this transaction has occurred, the new source sends its source capabilities to the new sink and negotiate a PD power level. The list below highlights this sequence:

1. Fast Role Swap Signal (60 μ s–120 μ s) pull-down on CC
2. FR Swap PD Message
3. Accept message from Old Source to Old Sink.
4. Old Sink changes Rp advertisement to Rd and sends PSReady PD message.
5. Old Source changes Rd advertisement to Rp and sends PSReady PD message.
6. Source capabilities from New Source to New Sink
7. Regular PD Power negotiation

During the Fast Role Swap, the PD devices enters a USB Type-C current level of up to 5 V or 3 A until the new source sends source capabilities to negotiate a new PD Contract.

Figure 5 is from the USB PD3.0 specification and highlights all of the transitions that occur during a Fast Role Swap.

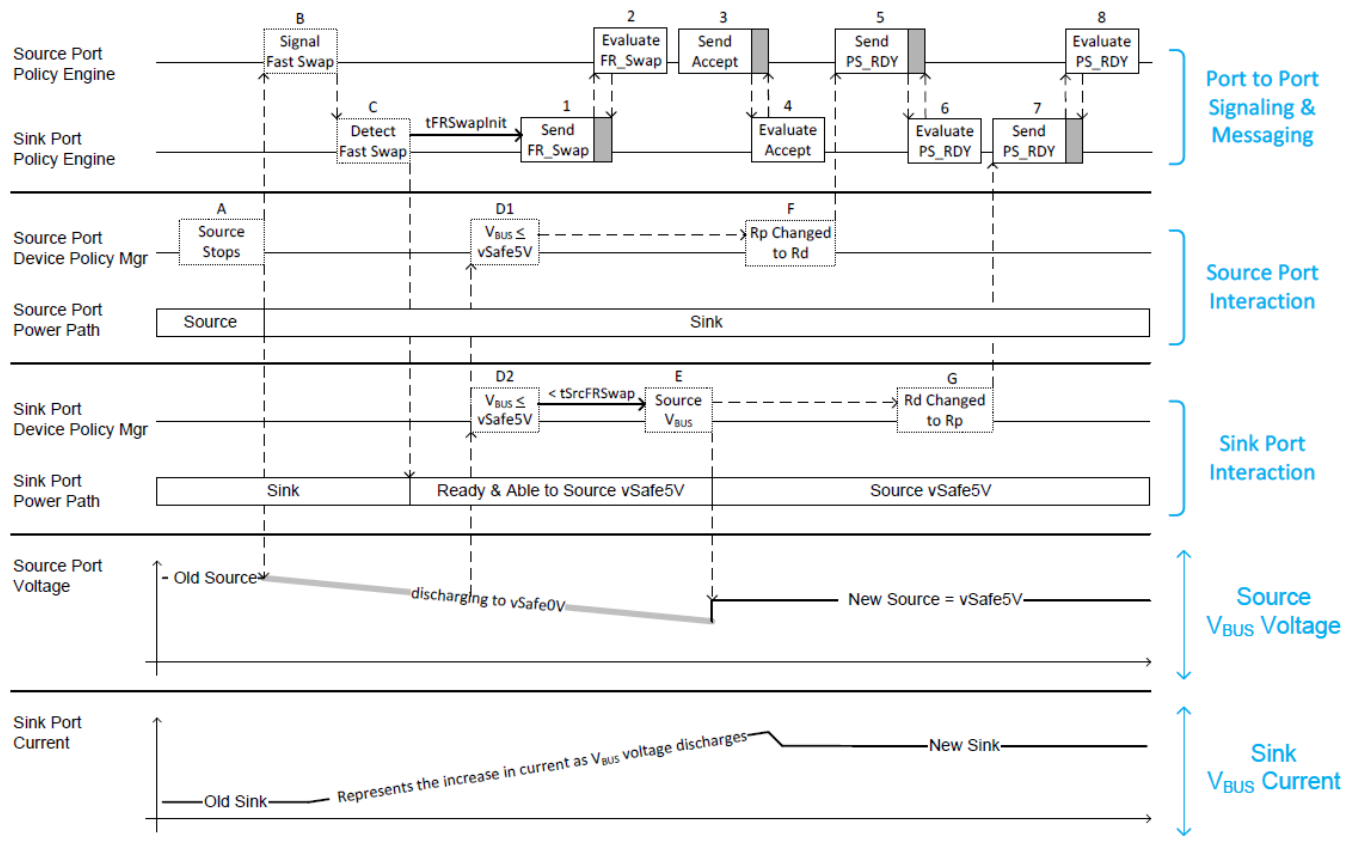


Figure 5. Transition Diagram for Fast Role Swap

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