

# 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

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

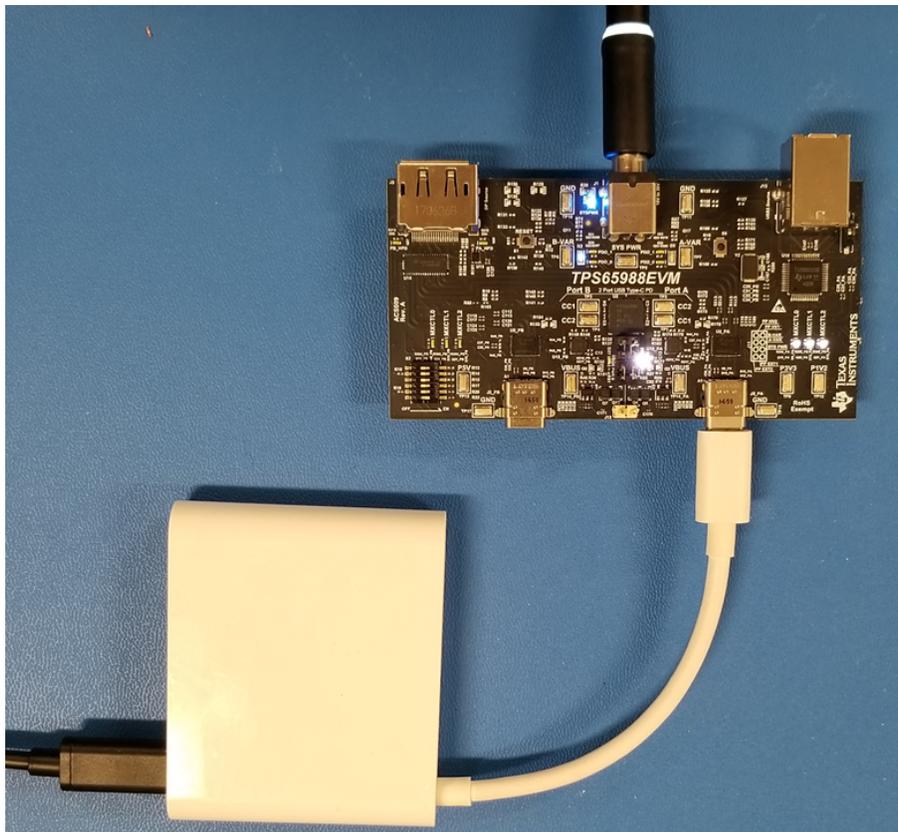
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## 2.2 Initiating a Fast Role Swap

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](#).

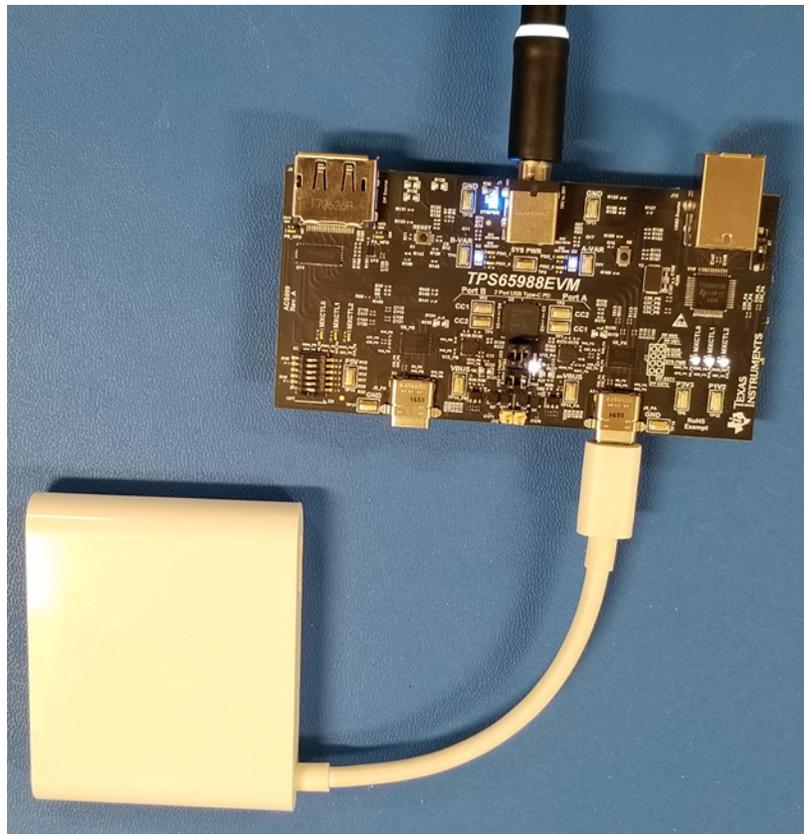


**Figure 1. TPS65988EVM and Huawei Dongle Before an FRS**

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.

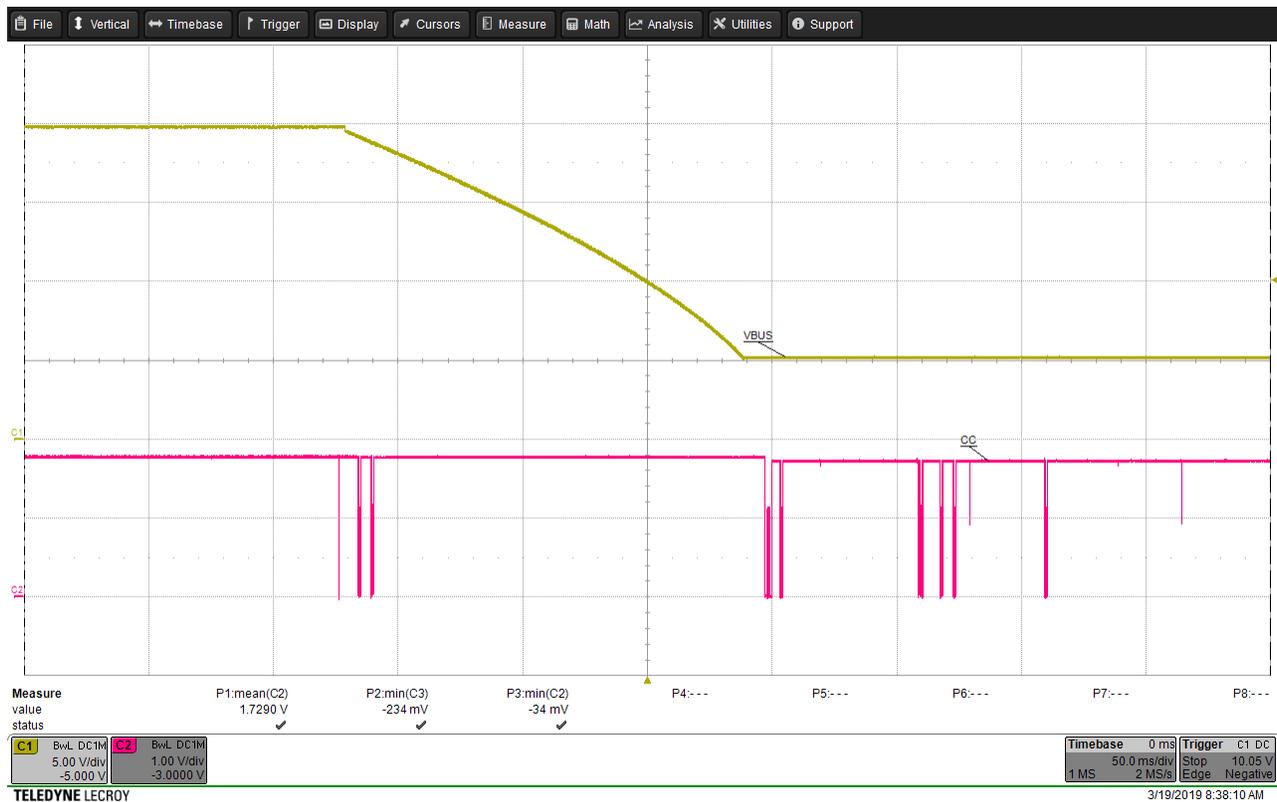


Figure 3. FRS Oscilloscope Capture

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  $\mu$ s to 120  $\mu$ 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	Port "???"		Fast Role Swap	82.000 us	7.632 ms	3 . 587 989 160
2	Left "Left"	← SNK	PD Msg FR Swap	495.425 us	46.935 us	3 . 595 702 712
3	Right "Right"	→ SRC	PD Msg GoodCRC	493.786 us	4.116 ms	3 . 596 245 072
4	Right "Right"	→ SRC	PD Msg Accept	493.488 us	47.296 us	3 . 600 855 168
5	Left "Left"	← SNK	PD Msg GoodCRC	495.276 us	1.651 ms	3 . 601 395 952
6	Left "Left"	← SNK	PD Msg PS Ready	486.864 us	53.500 us	3 . 603 542 192
7	Left "Left"	← SNK	PD Msg GoodCRC	489.216 us	4.135 ms	3 . 604 082 556
8	Right "Right"	→ SRC	PD Msg PS Ready	495.872 us	43.128 us	3 . 608 707 048
9	Left "Left"	← SNK	PD Msg GoodCRC	493.339 us	55.470 ms	3 . 609 246 048
10	Right "Right"	→ SRC	PD Msg Source Cap	Fixed 3.00A	5.00 V	628.425 us
11	Left "Left"	← SNK	PD Msg GoodCRC	493.786 us	4.098 ms	3 . 665 885 048
12	Left "Left"	← SNK	PD Msg Request	Request 3.00A	3.00A	625.779 us
13	Right "Right"	→ SRC	PD Msg GoodCRC	495.276 us	4.115 ms	3 . 671 156 528
14	Right "Right"	→ SRC	PD Msg Accept	495.425 us	51.855 us	3 . 675 766 888
15	Left "Left"	← SNK	PD Msg GoodCRC	493.190 us	35.745 ms	3 . 676 314 168
16	Right "Right"	→ SRC	PD Msg PS Ready	495.872 us	54.824 us	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  $\mu$ s to 120  $\mu$ 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  $\mu$ s–120  $\mu$ 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.

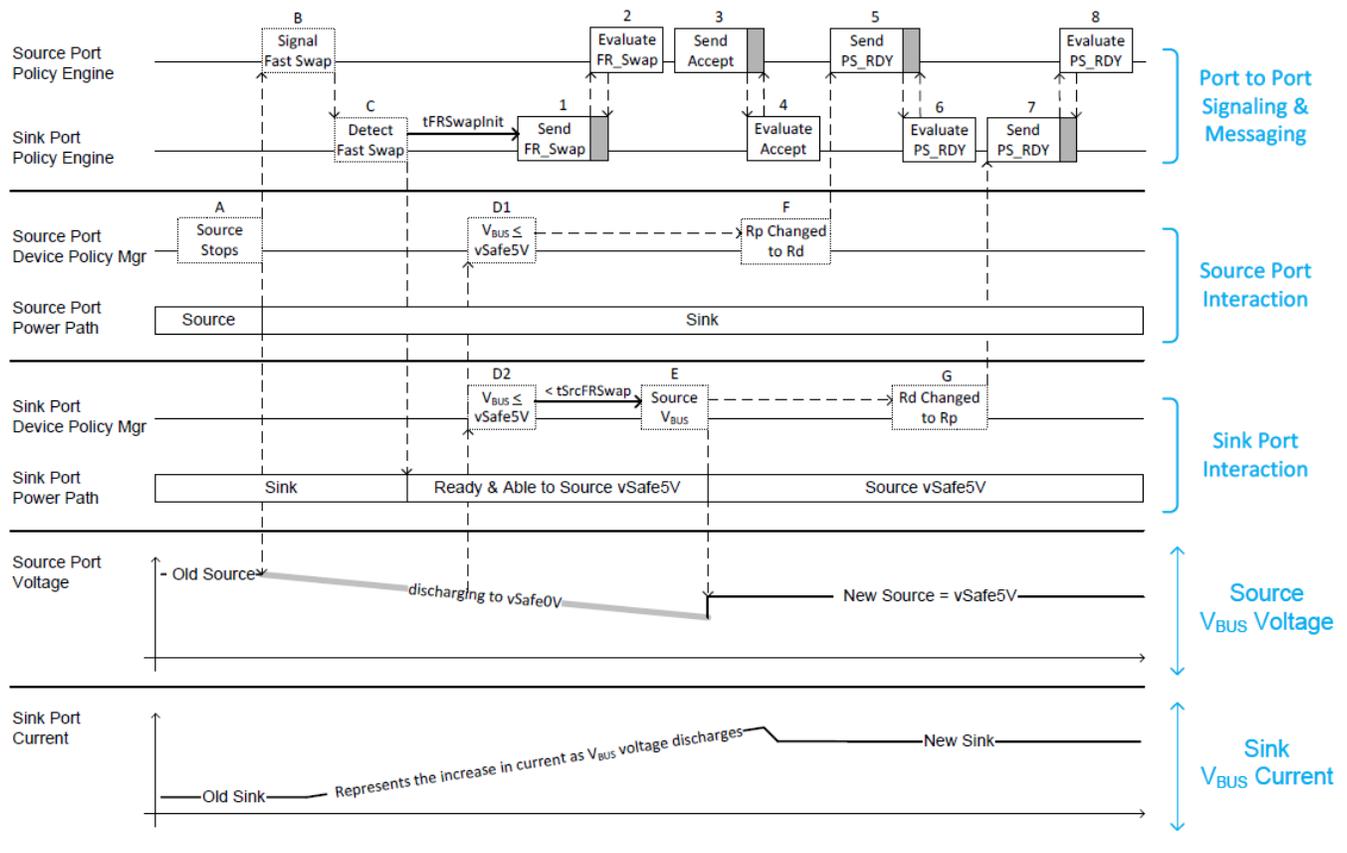


Figure 5. Transition Diagram for Fast Role Swap

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