Inrush Current Test Procedure

V9

Fixture Solution

Inrush current reference

Fixture Solution

- Both USB2.0 and Type-C spec should be taken into account
- USB 2.0 Specification, Section 7.2.4.1 Inrush Current Limiting
- USB Type-C R2.0 Table 4-2

Table 4-2 VBUS Source Characteristics

	Minimum	Maximum	Notes
VBUS Leakage Impedance	72.4 kΩ		Leakage between VBUS pins and GND pins on receptacle when VBUS is not being sourced.
VBUS Capacitance		3000 µF	Capacitance for source-only ports between VBUS and GND pins on receptacle when VBUS is not being sourced.
		10 µF	Capacitance for DRP ports between VBUS and GND pins on receptacle when VBUS is not being sourced.

Under what condition to test Inrush Current

- When the UUT have an external power that can be removed the Inrush test shall be done with and without external power.
- When the UUT is a Type-C DRP the Inrush test shall be done in SNK mode. (SNK mode = Rp by tester)
- When the UUT is a Type-C DRP or Type-C SNK the test shall be done with the 3 different Rp values (default, 1.5A and 3A)
- When the UUT is a Type-C DRP or Type-C SNK the Inrush test shall be done in Unattached mode. (Unattached mode = No Rp by tester)
- Due to the high maximum capacitance value for source-only the Inrush test is not required for Type-C SRC only.
- An A-receptacle source always have Vbus on, therefore the Inrush test is not applicable.
- Above is applicable for all accessible ports of the UUT.

Fixture Solution

Compliance.usb.org update

Fixture Solution

https://compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard#45

USB-C DRPs must be tested in 8 configurations	USB-C Sinks must be tested in 8 configurations
DRP unpowered with Rp default by tester	Sink unpowered with Rp default by tester
DRP unpowered with Rp 1.5 by tester	Sink unpowered with Rp 1.5 by tester
DRP unpowered with Rp 3 by tester	Sink unpowered with Rp 3 by tester
DRP powered with Rp default by tester	Sink powered with Rp default by tester
DRP powered with Rp 1.5A default by tester	Sink powered with Rp 1.5A default by tester
DRP powered with Rp 3A default by tester	Sink powered with Rp 3A default by tester
DRP unpowered in the Unattached state	Sink unpowered in the Unattached state
DRP powered in the Unattached state	Sink powered in the Unattached state

What is needed

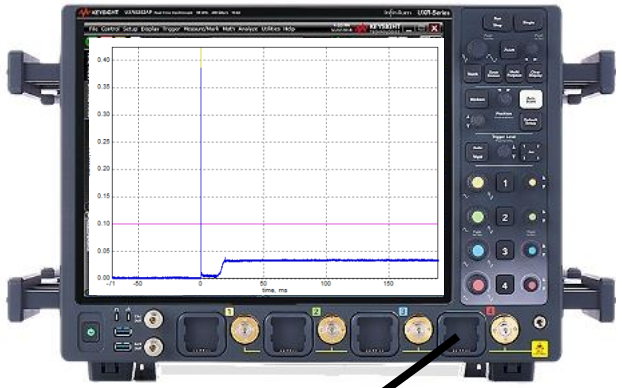
Fixture Solution

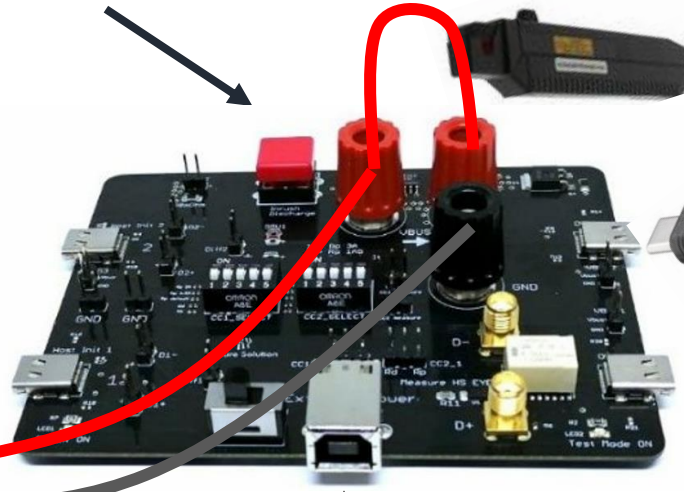
- Oscilloscope (≥ 1 Mega Samples for 100ms)
- Current clamp probe (or differential probe)
- Fixture FS-HUCR and Std-B to A cable to power the fixture
- C-plug to C-plug Cable without emarker or active part inside the cable to avoid triggering on capacitor in the cable
- Adapter C-plug to A-receptacle for testing non-USB-C device
- 5V external power supply to external
- USBET20 to calculate Inrush or Scope automation tool that use USBET20 in the background

Setup Inrush Device non-USB-C (current clamp)

Fixture Solution

Press the inrush button for several second
to discharge the capacitor from the DUT.
At release the inrush event occur.





USB Cable

Device Under Test

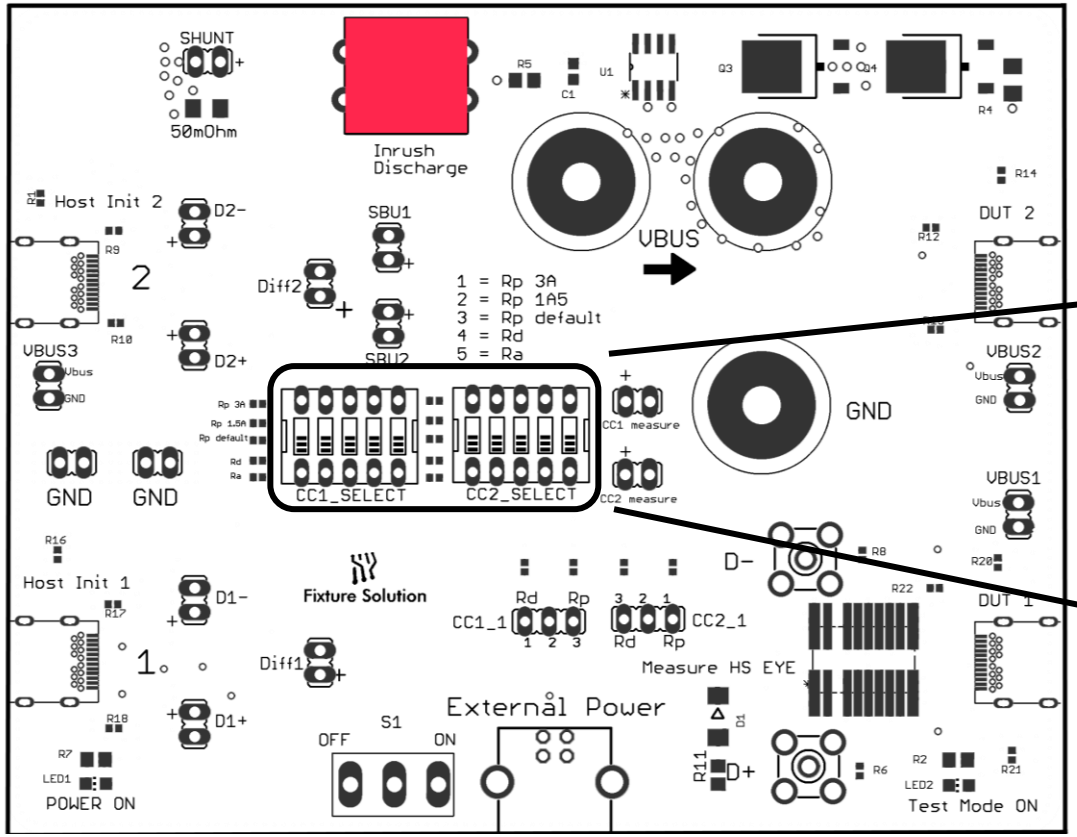
Use external 5V power supply

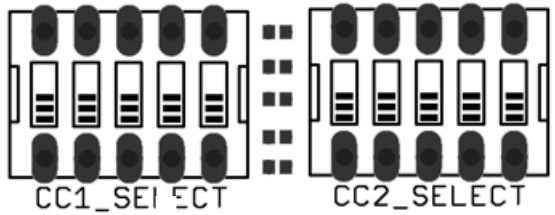
Any USB-Port (5V)

- Use the FS-HUCR fixture
- Current clamp probe
- Oscilloscope
- 5V Externally Power Supply the fixture
- USB cable to any USB port at the B-Receptacle
- **USB C-A adapter to DUT**

DIP settings non-USB-C

Fixture Solution





All DIP switches are OFF (LOW)

Test steps Inrush Non-USB-C Device

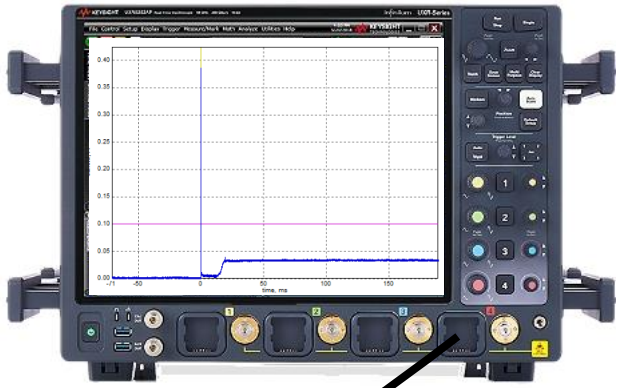
- External power the fixture via B-Receptacle to any USB port (5V)
- Connect external 5V power supply to Vbus and GND of the fixture
- Switch off (low) all DIP switches
- Place the Vbus wire through the current clamp (arrow direction of current probe need to follow the arrow on the fixture)
- Connect DUT to DUT2 port with USB C-A adapter
- Make scope ready for trigger
- Press the Inrush button for ~5 seconds to discharge UUT capacitor
- Release the Inrush button to get the Inrush event

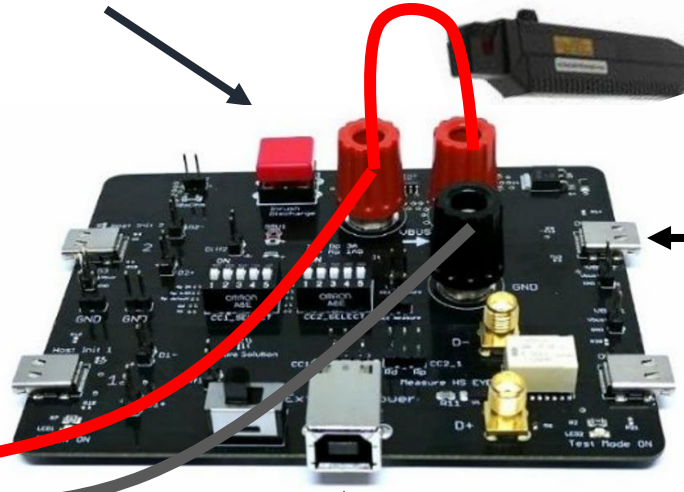
Fixture Solution

Setup Inrush USB-C SNK only and DRP (current clamp)

Fixture Solution

Press the inrush button for several second
to discharge the capacitor from the DUT.
At release the inrush event occur.





USB-C Cable

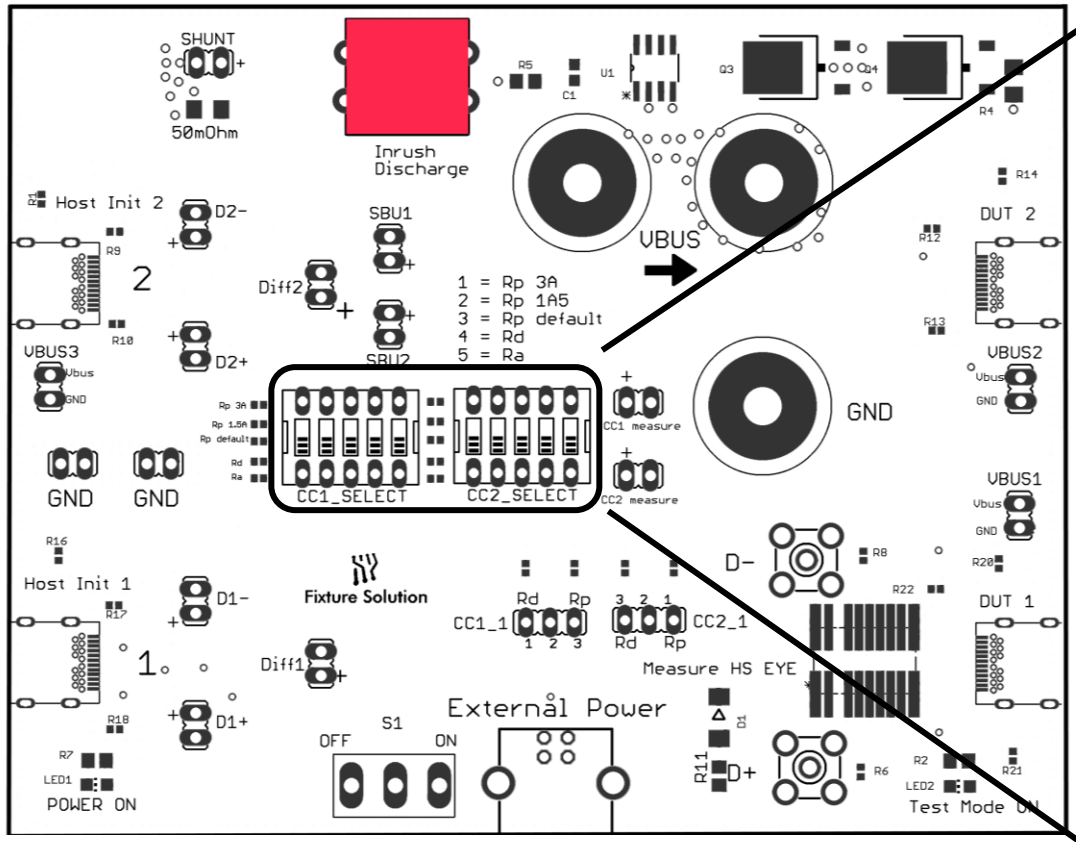
USB-C
SNK or DRP
Under
Test

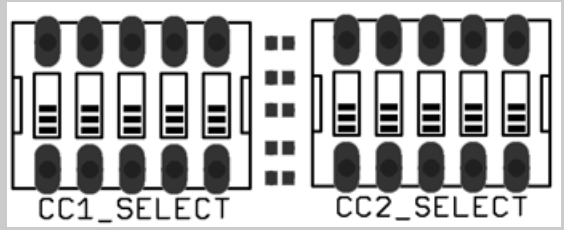
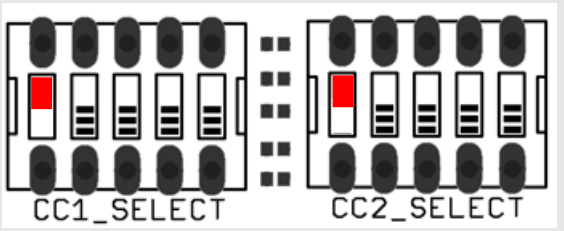
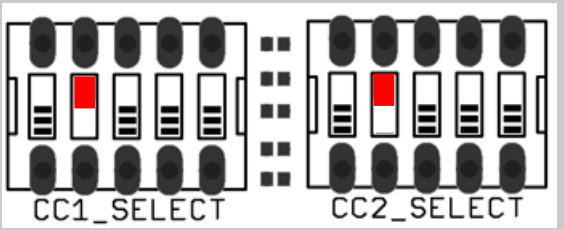
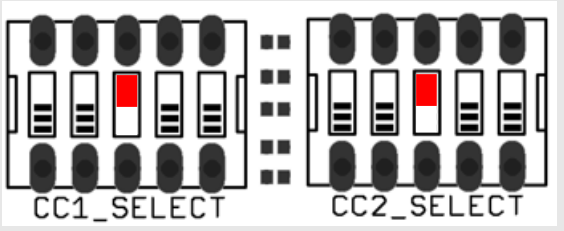
Use external 5V power supply

Any USB-Port (5V)

- Use the FS-HUCR fixture
- Current clamp probe
- Oscilloscope
- 5V Externally Power Supply the fixture
- USB power to any USB port at the B-Receptacle
- USB C-C cable to DUT

DIP settings USB-C SNK only and DRP



DIP Setting	
	Unattached mode
	3A Mode
	1.5A Mode
	Default Mode

Fixture Solution

Test steps USB-C Inrush SNK only and DRP SNK mode

- External power the fixture via B-Receptacle to any USB port (5V)
- Connect external 5V power supply to Vbus and GND of the fixture
- Place the Vbus wire through the current clamp (arrow direction of current probe need to follow the arrow on the fixture)
- Connect DUT to DUT2 port via USB C-C cable
- Switch off (low) all DIP switches (Unattached mode)
- Make scope ready for trigger
- Press the Inrush button for ~5 seconds to discharge UUT capacitor
- Release the Inrush button to get the Inrush event
- Place DIP switch to 3A mode
- Repeat Inrush again from trigger scope
- Place DIP switch to 1.5A mode
- Repeat Inrush again from trigger scope
- Place DIP switch to Default mode
- Repeat Inrush again from trigger scope
- If UUT can be switched off/on, do the above tests under both conditions

Fixture Solution

Oscoliloscope requirements and settings

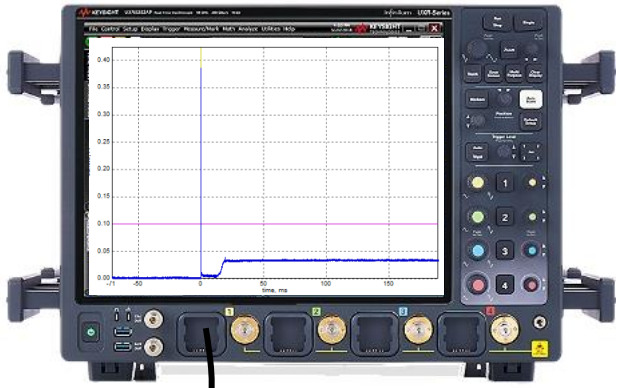
Fixture Solution

- Capture at least 100ms after the trigger event
- Use a minimum sample rate of 1 Mega Samples per second
- Save waveform in format that USBET20 can handle
- Calculate with USBET20 the inrush current value
- OR use approved USB2.0 automation solution from scope vendor

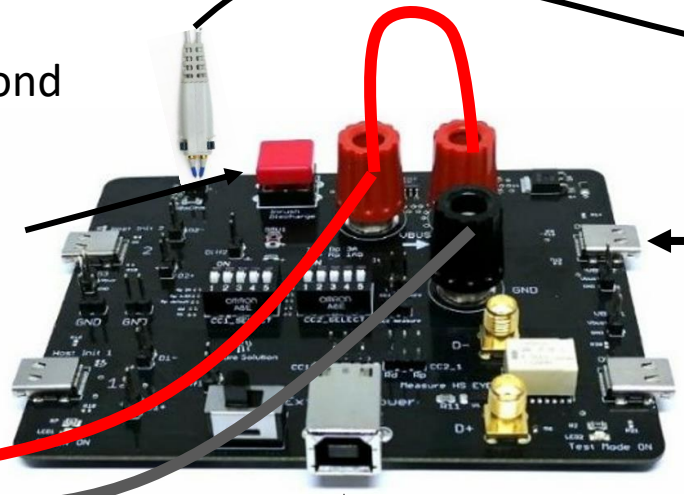
Fixture Solution

Setup Inrush with differential probe over shunt

It is also possible to measure the Inrush current with a differential probe instead of current clamp over the shunt resistor on the fixture



Press the inrush button for several second to discharge the capacitor from the DU
At release the inrush event occur.



USB-C Cable

USB-C
SNK or DRP
Under
Test

Use external 5V power supply

Any USB-Port (5V)

- Use the FS-HUCR fixture
- Current clamp probe
- Oscilloscope
- 5V Externally Power Supply the fixture
- USB power to any USB port at the B-Receptacle
- USB C-C cable to DUT

Example 1
“USB-C External HDD with external power”

Fixture Solution

Inrush shall be measured under following conditions:

1) SNK only with external power connected Rp default
2) SNK only with external power connected Rp 1.5A
3) SNK only with external power connected Rp 3A
4) SNK only without external power connected default
5) SNK only without external power connected 1.5A
6) SNK only without external power connected 3A
7) SNK only in Unattached mode with external power connected
8) SNK only in Unattached mode without external power connected

Example 2
“Battery powered mobile phone with one Type-C DRP port”

Inrush shall be measured under following conditions:

1) DRP SNK mode, mobile ON, Rp default
2) DRP SNK mode, mobile ON, Rp 1.5A
3) DRP SNK mode, mobile ON, Rp 3A
4) DRP Unattached mode, mobile ON
5) DRP SNK mode, mobile OFF, Rp default
6) DRP SNK mode, mobile OFF, Rp 1.5A
7) DRP SNK mode, mobile OFF, Rp 3A
8) DRP Unattached mode, mobile OFF

Fixture Solution

Example 3
“HUB with two Type-C DRP ports and external power”

Inrush shall be measured under following conditions:

1) DRP SNK mode port 1, with external power connected, Rp default
2) DRP SNK mode port 1, with external power connected, Rp 1.5A
3) DRP SNK mode port 1, with external power connected, Rp 3A
4) DRP Unattached mode port 1, with external power connected
5) DRP SNK mode port 1, without external power connected, Rp default
6) DRP SNK mode port 1, without external power connected, Rp 1.5A
7) DRP SNK mode port 1, without external power connected, Rp 3A
8) DRP Unattached mode port 1, without external power connected

Repeat the above tests for port 2

Fixture Solution

Example 4
“Laptop with two Type-C DRP ports that charge over Type-C”

Inrush shall be measured under following conditions:

1) DRP SNK mode port 1, without external power connected, Rp default
2) DRP SNK mode port 1, without external power connected, Rp 1.5A
3) DRP SNK mode port 1, without external power connected, Rp 3A
4) DRP Unattached mode port 1 without external power connected
5) DRP SNK mode port 1, with external power connected to port 2, Rp default
6) DRP SNK mode port 1, with external power connected to port 2, Rp 1.5A
7) DRP SNK mode port 1, with external power connected to port 2, Rp 3A
8) DRP Unattached mode port 1, with external power connected to port 2

Repeat the above tests for port 2

Fixture Solution