macOS with UHD

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This AN provides a basic guide for what to expect when using a USB-based B-series USRP on OSX / macOS with UHD. This AN assumes you have UHD installed on your Mac already; if not, please follow the UHD OSX install guide to do so before proceeding with this AN.

For the purposes of this AN, we will be using a commandline interface to UHD. On OSX you can obtain the commandline interface via executing a terminal application such as Apple's Terminal.app (found in the Applications/Utilities/ directory) or iTerm2.app. You should already have such an application installed and in use from the UHD OSX install guide.

On OSX / macOS, Apple provides System Information or System Profiler applications that provide a variety of system information about the hardware and software. The easiest way to find this application is to click on the Apple (logo) menu in the upper left of the main screen, which will pop up a menu with the top entry always being About This Mac.

Ú	Finder	File	Edit	View	Go	Window	Help
Ak	out This	Мас					
	vstem Prei op Store		es				
Re	ecent Item	IS					
Fo	orce Quit F	inder			τí	C#{	
SI	еер						
Re	estart						
Sł	nut Down.	••				1	
Lo	g Out 🔜	****	****	****	í í	}#Q	

Selecting this entry will execute the system information application for your specific OSX / macOS version, with the "Hardware" section initially selected.

• • •		MacBook Pro	
▼ Hardware	Hardware Overview:		
ATA Audio Bluetooth Camera Card Reader Diagnostics Disc Burning Ethernet Cards Fibre Channel FireWire Graphics/Displays Hardware RAID Memory NVMExpress PCI Parallel SCSI Power Printers SAS SATA/SATA Express SPI Storage Thunderbolt USB iBridge ▼ Network Firewall Locations Volumes	Model Name: Model Identifier: Processor Name: Processor Speed: Number of Processors: Total Number of Cores: L2 Cache (per Core): L3 Cache: Memory: Boot ROM Version: SMC Version (system): Serial Number (system): Hardware UUID:	256 KB 6 MB 8 GB XXXXXX XXXXX	
mpbr15-10-12 > Hardw	vare		

Clicking on the USB option shows the USB device tree in the upper pane and information for the first instantiated bus in the lower pane.

▼ Hardware	USB Device Tree			
ATA			^	
Audio	VSB 2.0 Bus			
Bluetooth	▼ Hub			
Camera	FaceTime HD Camera (Built-in			
Card Reader	▼ USB 2.0 Bus			
Diagnostics	▼ Hub			
	▼ Hub			
Disc Burning Ethernet Cards	Apple Internal Keyboard / Trackpad			
	▼ BRCM20702 Hub			
Fibre Channel		0		
FireWire	USB 2.0 Bus:			
Graphics/Displays Hardware RAID Memory NVMExpress PCI Parallel SCSI Power Printers SAS SATA/SATA Express	Host Controller Driver: AppleUSBEHC PCI Device ID: 0x1e2d PCI Revision ID: 0x0004 PCI Vendor ID: 0x8086 Hub: Product ID: Vendor ID: Version: Speed:	0x0024 0x8087 (Intel Corporation) 0.00 Up to 480 Mb/sec		
SPI	Location ID: Current Available (mA):	0x1a100000 / 1 500		
Storage	Current Available (mA): Current Required (mA):	0		
Thunderbolt	Extra Operating Current (mA):	-		
USB	Built-In:	Yes		
iBridge ▼ Network	FaceTime HD Camera (Built-in):			
Firewall Locations Volumes	Product ID: Vendor ID: Version:	0x8510 0x05ac (Apple Inc.) 80.25		
	vare > USB > USB 2.0 Bus			

In the upper pane, scroll down until you find an entry for either Westbridge or USRP B2*. The following screenshot shows the hardware information of a USRP B210 immediately after it is plugged in and powered up.

F Hardware ATA	USB Device Tree		
			^
	▼ USB 2.0 Bus		
Audio	▼ Hub		
Bluetooth	▼ Hub		
Camera	Apple Internal Keybo	oard / Trackpad	
Card Reader	T BRCM20702 Hub		
Diagnostics Disc Burning	Bluetooth USB H	ost Controller	
Ethernet Cards	▼ USB 3.0 Bus		
Fibre Channel	WestBridge		
FireWire	WestBridge :	0	
Graphics/Displays	freetoninge .		
Hardware RAID	Product ID:	0x0020	
Memory	Vendor ID:	0x2500	
NVMExpress	Version: Serial Number:	1.00 000000004BE	
PCI	Speed:	Up to 480 Mb/sec	
Parallel SCSI	Manufacturer:	Cypress	
Power	Location ID: Current Available (mA):	0x14100000 / 18	
Printers	Current Required (mA):	500 200	
SAS	Extra Operating Current (mA):		
SATA/SATA Express			
SPI			
Storage			
Thunderbolt			
USB			
iBridge			
Network			
Firewall			
Locations			
Volumes			
mpbr15-10-12 > Hardwa	are > USB > USB 3.0 Bus > We	estBridge	_

Once the USRP firmware is loaded -- more on this in the next section -- the device with "morph" on the bus, which will change the device name and capabilities. The following screenshot shows the hardware information of a USRP B210 after the firmware was successfully loaded.

• • •	MacBook Pro
▼ Hardware	USB Device Tree
ATA Audio Bluetooth Camera Card Reader Diagnostics Disc Burning Ethernet Cards Fibre Channel FireWire Graphics/Displays Hardware RAID Memory NVMExpress PCI Parallel SCSI Power Printers SAS SATA/SATA Express SPI Storage Thunderbolt USB	▼USB 2.0 Bus ▼Hub ▲pple Internal Keyboard / Trackpad ▼BRCM20702 Hub Bluetooth USB Host Controller ▼USB 3.0 Bus USRP B200 USRP B200 USRP B200 Version: 0.00 Serial Number: ECR0428BT Speed: Up to 5 Gb/sec Manufacturer: Ettus Research LLC Location ID: 0x14300000 / 19 Current Available (mA): 900 Current Required (mA): 8 Extra Operating Current (mA): 0
iBridge ▼ Network Firewall Locations Volumes	
mpbr15-10-12 > Hardv	ware > USB > USB 3.0 Bus > USRP B200

When a USRP B-series device is plugged into a USB port and powers up, both the firmware and FPGA images need to be loaded for it to work with UHD. These binaries will be loaded when UHD is started and pointed to the B-series USRP, regardless of the application, host computer, or OS.

Executing uhd_find_devices will load up just the firmware. Typical terminal information would look like the following, which uses UHD 4.0.0.0 release as installed by MacPorts on macOS 11 Big Sur; this information will be roughly the same regardless of the version of UHD or OSX / macOS. Note that the actual serial number for your USRP will be printed; we have X'd it out here. Also note that in this case UHD succeeded in loading the firmware and macOS also successfully reënumerated USB. The name entry is likely to be different for each USRP, as it is user-settable.

% uhd_find_devices

[INFO] [UHD] Mac OS; Clang version 12.0.0 (clang-1200.0.32.28); Boost_107100; UHD_4.0.0.0-MacPorts-20201218-3b9ced8f [INFO] [B200] Loading firmware image: /opt/local/share/uhd/images/usrp_b200_fw.hex...

-- UHD Device 0 Device Address: serial: XXXXXX name: MyB210 product: B210 type: b200

For older revision B-series USRPs such as the white B200/B210, the USB morphing / reënumeration fails around 50% of the time upon initial USRP power up. When this event occurs, any UHD-based application will fail to find the USRP once the firmware is loaded; here is an example with the same USRP B210 as just above.

% uhd_find_devices [INFO] [UHD] Mac OS; Clang version 9.0.0 (clang-900.0.39.2); Boost_107100; UHD_3.15.0.0-MacPorts-Release [INFO] [B200] Loading firmware image: /opt/local/share/uhd/images/usrp_b200_fw.hex... No UHD Devices Found

When USB and the USRP fail in this way, the USRP must be *reset* for it to work. There are 3 primary options for resetting that seem to work reliably on OSX / macOS.

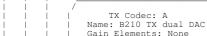
- 1. Unplug the USB cable from the host computer and plug it back into the exact same USB port. This technique works most of the time, and is applicable to all B-series USRPs.
- 2. B200/B210 : Use an external power supply, and then unplug / replug the USB connection; note that you can use any USB port in this option. The USRP will reset USB, but will not power cycle since it is powered throughout the procedure.
- 3. B200/B210 : Leave the USRP plugged into the host computer via USB, and press the USB reset button (S700) on the USRP. The following images show the switch location on two revisions of the B200/B210.





Once the B2* USRP has the firmware loaded properly, uhd_find_devices will find it properly. Next up, execute uhd_usrp_probe to load the FPGA image and return basic information about this USRP. For the B210, the following is typical information printout for UHD 3.15:

% uhd_usrp_probe [INFO] [UHD] Mac OS; Clang version 9.0.0 (clang-900.0.39.2); Boost_107100; UHD_3.15.0.0-MacPorts-Release [INFO] [B200] Detected Device: B210 [INFO] [B200] Loading FPGA image: /opt/local/share/uhd/images/usrp_b210_fpga.bin... [B200] Operating over USB 3. [B200] Detecting internal GPSDO.... [INFO] [INFO] [B200] Detecting internal GSDD.... [GPS] No GPSDD found [B200] Initialize CODEC control... [B200] Initialize Radio control... [B200] Performing register loopback test... [B200] Register loopback test passed [B200] Performing register loopback test... [INFO] [INFO] [INFO] [INFO] INFO] INFO INFO [B200] Register loopback test passed [B200] Setting master clock rate selection to 'automatic'. [B200] Asking for clock rate 16.000000 MHz... [B200] Actually got clock rate 16.000000 MHz. [INFO] [INFO] [INFO] Device: B-Series Device Mboard · B210 revision: 4 product: 2 serial: XXXXXXX FW Version: 8.0 FPGA Version: 16.0 Time sources: none, internal, external, gpsdo Clock sources: internal, external, gpsdo Sensors: ref_locked RX DSP: 0 Freq range: -8.000 to 8.000 MHz RX DSP: 1 Freq range: -8.000 to 8.000 MHz RX Dboard: A RX Frontend: A Name: FE-RX2 Name: FE-RX2 Antennas: TX/RX, RX2 Sensors: temp, rssi, lo_locked Freq range: 50.000 to 6000.000 MHz Gain range PGA: 0.0 to 76.0 step 1.0 dB Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz Connection Type: IQ Uses LO offset: No RX Frontend: B Name: FE-RX1 Name: FE-RX1 Antennas: TX/RX, RX2 Sensors: temp, rssi, lo_locked Freq range: 50.000 to 6000.000 MHz Gain range PGA: 0.0 to 76.0 step 1.0 dB Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz Connection Type: IQ Uses LO offset: No RX Codec: A Name: B210 RX dual ADC Gain Elements: None TX DSP: 0 Freq range: -8.000 to 8.000 MHz TX DSP: 1 Freq range: -8.000 to 8.000 MHz TX Dboard: A TX Frontend: A Name: FE-TX2 Antennas: TX/RX Sensors: temp, lo_locked Freq range: 50.000 to 6000.000 MHz Gain range PGA: 0.0 to 89.8 step 0.2 dB Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz Connection Type: IQ Uses LO offset: No TX Frontend: B Name: FE-TX1 Name: FE-TX1 Antennas: TX/RX Sensors: temp, lo_locked Freq range: 50.000 to 6000.000 MHz Gain range PGA: 0.0 to 89.8 step 0.2 dB Bandwidth range: 200000.0 to 56000000.0 step 0.0 Hz Connection Type: IQ Uses LO offset: No



uhd usrp probe

For UHD 4.0.0.0 release there is a Clang-specific bug that prevents uhd_usrp_probe from functioning as desired; this bug is already fixed and will be part of the next UHD 4 release. If you have more than one B-series USRP attached to this host computer, you will need to specify --args that include the type and serial number of the specific USRP of interest; for example with the USRP here, we would use und_usrp_probe --args type=b200, serial=xxxxxxx but using the actual serial number as returned by und_find_devices. The following is typical for the information printout for this version of UHD:

[UHD] Mac OS; Clang version 12.0.0 (clang-1200.0.32.28); Boost_107100; UHD_4.0.0.0-MacPorts-20201218-3b9ced8f [B200] Detected Device: B210 [INFO] [INFO] [B200] Loading FPGA image: /opt/local/share/uhd/images/usrp_b210_fpga.bin...
[B200] Operating over USB 3.
[B200] Detecting internal GPSDO.... INFO [INFO] INFO] [GPS] Found an internal GPSDO.... [GPS] Found an internal GPSDO: GPSTCXO, Firmware Rev 0.929b [B200] Initialize CODEC control... [INFO] INFO [B200] Initialize Radio control.. [TNFO] Performing register loopback test... Register loopback test passed INFO [B200] INFO [B200] [B200] Performing register loopback test ... INFO Register loopback test passed Setting master clock rate selection to 'automatic'. TNFOI [B200] INFO [B200] (B200) Setting master clock rate 16.000000 MHz..
(B200) Actually got clock rate 16.000000 MHz.
(UHD) Device discovery error: send_to: No route to host
(USRP2) USRP2 Network discovery error send_to: Host is down
(X300) X300 Network discovery error send_to: Host is down
(OCTOCLOCK] OctoClock network discovery error - send_to: Host is down INFOI [B200] [B200] [INFO] [ERROR] [ERROR] . FRROR 1 [ERROR] Error: RuntimeError: Cannot access! Property types do not match at: /mboards/0/eeprom

Note that most UHD-based applications will still work properly even with this specific bug in uhd_usrp_probe.

With the USRP information as provided by uhd_usrp_probe, we can do some throughput testing via the benchmark_rate example. MacPorts installs this example into /opt/local/share/uhd/examples/; the default install location as provided by CMake is /usr/local/lib/uhd/examples/. Here is an example execution from within the examples directory, showing 2x2 at 1e6 Samples/second (often written as "1 MS/s" or "1 MS/s") per channel for an aggregate throughput of 4 MS/s.

```
% ./benchmark_rate --args type=b200 --rx_rate le6 --tx_rate le6 --channels 0,1
[INFO] [UHD] Mac OS; Clang version 12.0.0 (clang-1200.0.32.28); Boost_107100; UHD_4.0.0.0-MacPorts-20201218-3b9ced8f
[00:00:00.019563] Creating the usrp device with: type=b200...
[INFO] [B200] Detected Device: B210
  [INFO]
                   [B200] Operating over USB 3.
[B200] Detecting internal GPSDO...
  [INFO]
                   [GPS] Found an internal GPSDO: GPSTCXO, Firmware Rev 0.929b
[B200] Initialize CODEC control...
  [INFO]
[INFO]
                   [B200] Initialize Radio control...
[B200] Performing register loopback test...
   INF01
   INFOI
   INF0]
                    [B200] Register loopback test passed
[INFO] [B200] Register loopback test passed
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Setting master clock rate selection to 'automatic'.
[INFO] [B200] Asking for clock rate 16.000000 MHz...
[INFO] [B200] Actually got clock rate 16.000000 MHz.
Using Device: Single USRP:
    Device: B-Series Device
      Mboard 0: B210
     RX Channel: 0
RX DSP: 0
           RX Dboard: A
           RX Subdev: FE-RX2
     RX Channel: 1
RX DSP: 1
RX Dboard: A
           RX Subdev: FE-RX1
     TX Channel: 0
TX DSP: 0
     TX Dboard: A
TX Subdev: FE-TX2
TX Channel: 1
          TX DSP: 1
           TX Dboard: A
TX Subdev: FE-TX1
TX Subdev: FE-TX1

[00:00:02.482435284] Setting device timestamp to 0...

[INFO] [MULTI_USRP] 1) catch time transition at pps edge

[INFO] [MULTI_USRP] 2) set times next pps (synchronously)

[INFO] [B200] Asking for clock rate 32.000000 MHz...

[INFO] [B200] Asking for clock rate 32.000000 MHz...

[INFO] [B200] Asking for clock rate 16.000000 MHz...

[INFO] [B200] Actually got clock rate 16.000000 MHz...

[INFO] [B200] Actually got clock rate 16.000000 MHz.

[0:00:05.221018875] Testing receive rate 1.0000000 Msps on 2 channels

Setting TX spp to 2040

[00:00:05.247918999] Testing transmit rate 1.000000 Msps on 2 channels

[00:00:15.537108088] Benchmark complete.
Benchmark rate summary:
     Num received samples:
                                                                           20461952
     Num dropped samples:
     Num overruns detected:
Num transmitted samples:
                                                                           0
                                                                           20077680
     Num sequence errors (Tx): 0
Num sequence errors (Rx): 0
                underruns detected:
     Num
                                                                           0
     Num late commands:
                                                                           0
     Num timeouts (Tx):
Num timeouts (Rx):
                                                                           0
                                                                           0
Done!
```

If your UHD-based application results in USB errors such as ERROR_CODE_TIMEOUT, underruns (u), overflows (o), sequence errors, or the like, then your USRP might need to be reset as noted above in uhd_find_devices. You will also want to find ways to reduce the aggregate TX (if underrun issues) and/or RX (if overflow issues) throughput so that your application consumes and/or produces data in real time for what the USRP expects.

OSX / macOS does not provide tuneable OS, thread, or USB options beyond buffer sizes within UHD. These buffers are generally set via the number of samples per frame, and the number of frames, which are provided as --args as num_recv_frames, num_send_frames, recv_frame_size, and send_frame_size. Defaults for these variables with the B-series USRPs are as follows: the number of frames is 16; the frame size (in bytes) is 512 for when using USB 2 and 1024 when using USB 3. One can easily and safely increase these to gain more throughput, though larger frames will also increase the latency between USRP antenna to data on the host computer (and vice versa) as more data must be collected before transmission between the host and USRP.

Some errors such as USBError -4: usb rx8 submit failed: LIBUSB_ERROR_NO_DEVICE generally require the USRP to be reset before it can be used again, though for some USB errors the USB controller on the USRP will properly reset itself.