## macOS with UHD

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## AN-444 by Michael Dickens

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	bout This	Мас					
S) Ap	vstem Prei op Store	ference	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 ATA Audio Bluetooth Camera Card Reader Diagnostics Disc Burning Ethernet Cards Fibre Channel FireWire Graphics/Displays Hardware RAID Memory N//ME	Hardware Overview: 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:	MacBook Pro MacBook Pro MacBookPro10,1 Intel Core i7 2.6 GHz 1 4 256 KB 6 MB 8 GB <b>XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX</b>	
NVMExpress PCI Parallel SCSI Power Printers SAS SATA/SATA Express SPI Storage Thunderbolt USB iBridge			
<ul> <li>Network</li> <li>Firewall</li> <li>Locations</li> <li>Volumes</li> <li>mpbr15-10-12 &gt; Hard</li> </ul>	ware		

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		0		
ATA					
Audio	VUSB 2.0 Bus				
Bluetooth	▼ Hub				
Camera	FaceTime HD Camera (Built-in)				
Card Reader	▼ USB 2.0 Bus				
Diagnostics	▼ Hub				
Diec Burning	₩ Hub				
Ethernet Carde	Apple Internal Keyboard / Trackpad				
Ethernet Cards	▼ BRCM20702 Hub				
Fibre Channel	116B 2 0 Buss	0			
Firewire	USB 2.0 Bus:				
Graphics/Displays	Host Controller Driver: AppleUSBEHCIPCI PCI Device ID: 0x1e2d				
Hardware RAID					
Memory	PCI Revision ID: 0x0004				
NVMExpress	PCI Vendor ID: 0x8086				
PCI					
Parallel SCSI	Hub:				
Power	Product ID:	0x0024			
Printers	Vendor ID:	0x8087 (Intel Corporation)			
SAS	Version:	0.00			
SATA/SATA Express	Speed:	Up to 480 Mb/sec			
SPI	Location ID:	0x1a100000 / 1			
Storage	Current Required (mA):	0			
Thunderbolt	Extra Operating Current (mA):	0			
USB	Built-In:	Yes			
iBridge					
Network	FaceTime HD Camera (	Built-in):			
Firewall	Product ID:	0~8510			
Locations	Vendor ID:	0x05ac (Apple Inc.)			
Volumes	Version:	80.25			
mpbr15-10-12 > Hardv	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.

• • •	,	AacBook Pro	
▼ Hardware	USB Device Tree		^
ATA	▼ USB 2.0 Bus		
Audio	▼ Hub		
Bluetooth	▼ Hub		
Camera	Apple Internal Keybo	ard / Trackpad	
Card Reader	▼ BRCM20702 Hub		
Diagnostics Bluetooth USB Host Controller			
Disc Burning	▼ USB 3.0 Bus		
Elbre Changel	WestBridge		
FireWire	WestBridge :	0	
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	Product ID: Vendor ID: Version: Serial Number: Speed: Manufacturer: Location ID: Current Available (mA): Current Required (mA): Extra Operating Current (mA):	0x0020 0x2500 1.00 0000000004BE Up to 480 Mb/sec Cypress 0x14100000 / 18 500 200 0	
Volumes mpbr15-10-12 > Hardv	vare > USB > USB 3.0 Bus > We	stBridge	_

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 iBridge ▼ Network	VUSB 2.0 Bus ♥ Hub Apple Internal Keyboard / Trackpad ♥ BRCM20702 Hub Bluetooth USB Host Controller ♥ USB 3.0 Bus USRP B200 Version: 0x0020 Vendor ID: 0x2500 Version: 0.00 Serial Number: ECR04Z8BT Speed: Up to 5 Gb/sec Manufacturer: Ettus Research LLC Location ID: 0x14300000 / 19 Current Available (mA): 900 Current Available (mA): 8 Extra Operating Current (mA): 0	
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.
- 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] Defecting internal GSDD.... [GFS] 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 INFO [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 1e6 --tx_rate 1e6 --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.