Application Notes

Application Notes (AN) and technical articles written by engineers, for engineers. These articles offer experienced analysis, design ideas, reference designs, and tutorials?to make you productive and successful using USRP devices.

Application Notes

Number	Title	Abstract	Author(s)
AN-009	Declaration of Conformity	This application note describes how to find Declaration of Conformity information for a given Ettus device.	Michael Dickens
AN-010	Trade Compliance and Export Control Classification Number (ECCN)	This application note describes how to find trade compliance information including the ECCN for a given Ettus device.	Michael Dickens
AN-055	About Sampling Rates and Master Clock Rates for the USRP X440	This application note guides users through the selection process of Master Clock Rates (MCR) for the USRP X440.	Marian Koop
AN-088	USRP Host Performance Tuning Tips and Tricks	This application note provides various tips and tricks for tuning your host computer for best performance when working with USRP devices.	Nate Temple
AN-111	How to Upgrade X410-X440 MCU Firmware	This AN explains how to upgrade the MCU firmware on an X410 and X440 USRP.	Michael Dickens
AN-117	GPSDO Selection Guide	This AN explains how to select and use a GPSDO with the USRP B-, N-, and X-series devices.	Neel Pandeya Nate Temple
AN-121	Debugging FPGA images	This application note covers the basics to get you through the process of probing the signals inside an FPGA. In order to accomplish that, we will review briefly the 'Xilinx ChipScope Analyzer' and will apply it to one of our core RFNoC blocks: the RFNoC Signal generator.	Nicolas Cuervo Sugandha Gupta
AN-142	Transmitting DVB-S2 with GNU Radio and an USRP B210	This application note will demonstrate using an USRP B210 and the GNU Radio DTV example flowgraph to transmit a DVB-S2 video stream to an off-the-shelf satellite receiver.	Nate Temple
AN-158	Using Ethernet-Based Synchronization on the USRP? N3xx Devices	This application note provides instructions for synchronizing multiple USRP N3xx devices using White Rabbit Ethernet-based synchronization.	Dan Baker Wan Liu
AN-177	About USRP Bandwidths and Sampling Rates	This AN provides insight into the topics of USRP architecture, system bandwidth, host interface throughput, and available sampling rates.	Neel Pandeya Nate Temple
AN-178	Resolving Audio Codec Enumeration Issues On The E31x	This application note covers Resolving Audio Codec Enumeration Issues On The E31x.	Logan Fagg
AN-188	Interrogating Passive Wireless SAW Sensors with the USRP	Typical interrogator design for wireless SAW sensor systems require many discrete components and lengthy build times, making it difficult to rapidly adapt to sensor designs in a research environment. We have employed the USRP B200 as a SAW sensor interrogation system. Interrogation of wideband orthogonal frequency coded (OFC) SAW sensors imposes strict requirements on the timing and synchronization of the transceiver. The USRP FPGA has been modified to operate in a synchronous, pulsed mode of operation, allowing rapid data acquisition and the full 56MHz bandwidth to be utilized. Data from the USRP is passed to a custom matched filter correlator routine to extract sensor parameters. The system is capable of interrogating multiple sensors, simultaneously. Demonstration of the system is accomplished by wirelessly interrogating SAW sensors at 915MHz and extracting temperature.	Trip Humphries
AN-204	Getting Started with UHD and C++	This AN explains how to write and build C++ programs that use the UHD API and introduces	Neel Pandeya Nate Temple
AN-244	Direction Finding with the USRP? X-Series and TwinRX?	This application note covers using the USRP? TwinRX? daughterboard in a direction find application using the MUSIC algorithm.	Srikanth Pagadarai Travis Collins Alexander M. Wyglinski
AN-296	Using Dual 10 Gigabit Ethernet on the USRP X300/X310	This short guide is meant to help in quickly setting up an X-series USRP for use over two 10 Gigabit Ethernet links simultaneously.	Paul David
AN-305	X300/X310 Device Recovery	This application note covers the details of recovering the USRP X300/X310 via JTAG.	Nate Temple
AN-309	About the Motherboard and Daughtercard EEPROM on USRP Devices	This AN discusses the EEPROM storage on various USRP devices and daughtercards. This guides explains how to update the EEPROM contents and recover from EEPROM corruption. The product codes, which are also stored in the EEPROM, for all USRP devices and daughtercards are also given for reference.	Trip Humphries
AN-311	Software Development on the E310 and E312	This application note covers the software development process on the USRP E310 and E312.	Martin Braun Nicolas Cuervo
AN-315	Software Development on the E3xx USRP - Building RFNoC UHD / GNU Radio / gr-ettus from Source	This application note is one of a multi-part series which will cover the software development process on the USRP E310, E312 and E313. It will cover building the rfnoc-devel branch of UHD, GNU Radio and gr-ettus from source for the host machine, and cross-compiling the rfnoc-devel branch of UHD, GNU Radio and gr-ettus for the E3xx USRP.	Nate Temple
AN-322	Experiments with the UBX Daughterboard in the HF Band	We show the results of experiments with the UBX daughtercard on an USRP X310 platform for use in the HF frequency range, from 1.8MHz to 30MHz. While the UBX is nominally rated for use only down to 10 MHz, with careful flow-graph design, and pre-filtering, it provides quite-good performance across the HF bands.	Marcus Leech
AN-325	N200/N210 Device Recovery	This application note covers the details of recovering your N200/N210.	Neel Pandeya

			Nate Temple
AN-335	Streaming processed data from the E31x with GNU Radio and ZMQ	This application note will demonstrate using the USRP E310 to remotely stream processed data to a host machine.	Nate Temple
AN-345	Daisy-chaining PPS via a USRP to another device	This application note describes this specific use-case for distributing the PPS GPSDO signal.	Michael Dickens
AN-355	Modifying an X310 Chassis for External LO Sharing	This document describes how to modify an X310 chassis to wire the LO out of the back plate. Doing this will allow the user to export and import an LO signal as desired when using a compatible daughterboard such as the TwinRX.	Sam Reiter
AN-363	Implementation of an ADS-B/Mode-S Receiver in GNU Radio	This AN guides the reader through the implementation of an ADS-B receiver using the gr-air-modes Out-of-Tree (OOT) module for GNU Radio. An explanation of ADS-B is also provided, and several real-world, over-the-air examples and profiled.	Nate Temple
AN-400	Getting Started with RFNoC in UHD 4.0	This AN describes how use RFNoC in UHD 4.0, including building FPGA images for RFNoC, changing which blocks are included in the build, and creating your own RFNoC blocks.	Sugandha Gupta Brent Stapleton Wade Fife
AN-401	RFNoC 4 Migration Guide	Guide on how to migrate RFNoC blocks written for RFNoC 3 to RFNoC 4.	Jonathon Pendlum
AN-402	USRPs & NICs, Transceivers & Cables	This AN provides general guidance for pairing USRPs with NICs along with Transceivers and Cables to connect devices together.	Michael Dickens
AN-444	Using B200/B210/B200mini/B205mini on OSX / macOS with UHD	This AN provides a basic guide for what to expect when using a USB-based B-series USRP on OSX / macOS with UHD.	Michael Dickens
AN-445	Building and Installing the USRP Open-Source Toolchain (UHD and GNU Radio) on Linux	This AN provides a comprehensive step-by-step guide for building, installing, and maintaining the open-source toolchain, specifically UHD and GNU Radio, for the USRP from source code on the Linux platform. Other alternate installation methods are also discussed.	Neel Pandeya
AN-452	5G NR EVM Measurements with the USRP N320/N321	Example EVM measurements are shown using the USRP N320/N321 receiver and the 5G New Radio (5G NR) modulation standard. The use of I/Q image calibration and spur-dodging are demonstrated as methods to improve EVM performance.	Drew Fischer
AN-492	Selecting a RF Daughterboard	This AN explores the RF daughterboards used by the N-series and X-series USRP devices at a high level, compares devices across several primary features, and walks the reader through the process of selecting a particular device for the their application.	Neel Pandeya Nate Temple
AN-500	Getting Started with DPDK and UHD	This application note walks through the process to get started with the Data Plane Development Kit (DPDK) driver within UHD.	Nate Temple Alex Williams Wade Fife Matt Prost
AN-504	USRP N Series Quick Start (Daughterboard Installation)	This application note is a detailed step-by-step guide to install a daughterboard into the USRP N200/N210.	Neel Pandeya Nate Temple
AN-524	Building and Installing UHD and GNU Radio in an Offline Environment	This application note will provide step-by-step instructions on building and installing UHD and GNU Radio in an offline environment.	Nate Temple
AN-525	Building and Installing UHD and GNU Radio to a Custom Prefix	This application note provides step-by-step instructions on building and installing UHD and GNU Radio to a local directory.	Nate Temple
AN-561	Implementation of a Simple FM Receiver in GNU Radio	This AN shows a quick and simple implementation of an FM receiver for the USRP using GNU Radio. The goal is to easily demonstrate a practical application, and to verify that the USRP is functioning properly.	Neel Pandeya
AN-611	Building and Installing the USRP Open Source Toolchain (UHD and GNU Radio) on Windows	This AN provides a comprehensive step-by-step guide for building, installing, and maintaining the open-source toolchain, specifically UHD and GNU Radio, for the USRP from source code on the Windows platform.	Derek Kozel
AN-620	Troubleshooting X300/X310 Device Discovery Issues	Troubleshooting guide to intended to cover some of the most commonly recommended steps to enable USRP connectivity.	Sam Reiter
AN-621	Troubleshooting N310/N320 Device Discovery Issues	Troubleshooting guide to intended to cover some of the most commonly recommended steps to enable USRP connectivity. Serves as a supplement to the N3xx getting started guide.	Sam Reiter
AN-630	Writing the USRP File System Disk Image to a SD Card	This application note will provide step-by-step instructions on writing a file system disk image to a SD card using Linux.	Nate Temple
AN-638	Running UHD and GNU Radio on NI USRP-RIO	This AN explains the process to updating your NI USRP-RIO to run UHD and GNU Radio.	Neel Pandeya Nate Temple Michael Dickens
AN-642	Using the RFNoC Replay Block	This application note guides a user through basic use of the RFNoC Replay block in UHD 3.x and explains how to run the UHD Replay example. This example covers use on the X300/X310 and N310 products.	Wade Fife
AN-642b	Using the RFNoC Replay Block in UHD 4	This application note guides a user through basic use of the RFNoC Replay block in UHD 4.x and explains how to run the UHD Replay example.	Martin Braun
AN-666	Mean Time Between Failure (MTBF) of USRPs and Daughterboards	This AN provides information about the MTBF for USRPs and daughterboards	Michael Dickens
AN-725	USRP N320/N321 LO Distribution	This application note provides an overview of using the LO Distribution of the N320/N321 USRPs.	Brian Avenell
AN-732	USRP E312 Battery Replacement Instructions	This application note covers replacing the battery cell inside the USRP E312.	Robin Coxe

AN-788	Building and Installing the USRP Open-Source Toolchain (UHD and GNU Radio) on OS X	This AN provides a comprehensive step-by-step guide for building, installing, and maintaining the open-source toolchain, specifically UHD and GNU Radio, for the USRP from source code on the Mac OS X platform.	Michael Dickens
AN-800	Enabling Ethernet Connectivity on Octoclock and Octoclock-G	This document supplements the UHD Manual's guide for updating the Octoclock bootloader to allow for Ethernet communications with the device.	Sam Reiter Michael Dickens
AN-822	Multichannel RF Reference Architecture	This application note provides guidance for designing a system that uses the NI Multichannel RF Reference Architecture.	Michael Dickens Neel Pandeya Jovian Wysocki
AN-823	Getting Started with RFNoC Development	This application note gives a brief introduction into the steps required to start developing RFNoC blocks on your computer with UHD 3.	Martin Braun Nicolas Cuervo
AN-832	Mapping Between ER-USRP and NI-USRP Product Numbers	This application note covers the details of the mapping between Ettus Research USRP and National Instruments USRP product numbers.	Nate Temple
AN-881	Selecting a USRP Device	This AN explores the USRP family at a high level, compares devices across several primary features, and walks the reader through the process of selecting a particular device for the their application.	Neel Pandeya Nate Temple
AN-882	Synchronization and MIMO Capability with USRP Devices	Discusses the requirements for Multiple-In-Multiple-Out (MIMO) and phased-array systems. Summarizes the MIMO capability of each USRP device and daughterboard, and shows how to build MIMO systems with the USRP product family.	Neel Pandeya Nate Temple
AN-883	Synchronizing USRP Events Using Timed Commands in UHD	Guide to cover common USRP synchronization scenarios and deep-dive into the use of timed commands within USRPs.	Sam Reiter
AN-888	Getting Started with 4G LTE using Eurecom OpenAirInterface (OAI) on the USRP 2974	Discusses how to install and configure the OpenAirInterface (OAI) software on the USRP 2974 hardware to implement a 4G LTE cellular basestation (eNodeB).	Neel Pandeya
AN-904	USRP X Series Quick Start (Daughterboard Installation)	This application note is a detailed step-by-step guide to install a daughterboard into the USRP X300/X310.	Neel Pandeya Nate Temple
AN-936	Verifying the Operation of the USRP Using UHD and GNU Radio	This AN explains how to use UHD and GNU Radio, once installed, to verify the correct operation of the USRP. Several test procedures are explained in detail. Several tests make use of an optional spectrum analyzer and signal generator.	Neel Pandeya
AN-956	OAI Reference Architecture for 5G and 6G Research with USRP	This application note discusses how to build and implement 5G networks using USRP radios and the Eurecom OAI software stack.	Neel Pandeya Bharat Agarwal Gerardo Trevino