Selecting a RF Daughterboard

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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.

This application note by Ettus Research? helps users select the most appropriate daughterboard for their use of the USRP? (Universal Software Radio Peripheral) family of software defined radio hardware. RF daughterboard selection is made based on the application requirements for frequency coverage, bandwidth and number of channels. This note is organized in an FAQ style to help identify which RF daughterboard is right for specific applications.

In many cases, the selection of an RF daughterboard is made solely on the application requirements for frequency coverage. For example, GSM applications such as OpenBTS usually use the 900 MHz and 1800 MHz cell phone bands. If the user wants to cover these bands, the WBX, SBX and UBX boards are good candidates. A table showing the frequency coverage of the RF daughterboards is shown in Table 2.

Many USRP hardware users involved in general experimentation may not have a specific frequency or band of interest. In this case, Ettus Research recommends the WBX, SBX and UBX daughterboards, which provide wide frequency coverage.

Application Area	Frequency Range(s)	Transmit/Receive	Recommended Daughterboard
TV Broadcast Reception	54-806 MHz	RX Only	WBX
GPS Reception	L1 - 1575.42 MHz L2 - 1227.60 MHz And others	RX Only	WBX, SBX, CBX, UBX
GPS Record and Playback	L1 - 1575.42 MHz L2 - 1227.60 MHz And others	RX/TX	WBX, SBX, CBX, UBX
OpenBTS GSM Basestation	GSM900 - 890-960 MHz GSM1800 - 1850-1989 MHz	RX/TX	WBX, SBX, UBX
WiMAX	2.5 GHz	RX Only	SBX, CBX, UBX
Broadcast FM Reception	88-108 MHz	RX Only	WBX, UBX
802.11 B/G/N Development	2.4 GHz, 5 GHz	RX/TX	UBX
HF Communications	3-30 MHz	RX/TX	LFRX + LFTX
Amateur Radio (2m, 70cm, 33cm, 23cm)	144 MHz, 430 MHz, 915 MHz, 1.2 GHz	RX/TX	WBX, UBX
Public Safety/P25 VHF Transceiver	136-174 MHz	RX/TX	WBX, UBX
Radar Research	2-4 GHz	RX/TX	SBX, UBX

Table 1 - Command Applications and Suggested Daughterboards

Daughterboard	Frequency Range(s)	Channel Count/Features	Bandwidth
		Receive Only	
LFRX	0 - 30 MHz	2 RX IF or 1 IQ	30 MHz/Channel
BasicRX	1 - 250 MHz	2 RX IF or 1 IQ	100 MHz/Channel
		Transmit Only	
LFTX	0 - 30 MHz	1 TX IF or 1 IQ	30 MHz/Channel
BasicTX	1 - 250 MHz	1 TX IF or 1 IQ	100 MHz/Channel
		Transmit/Receive	
WBX-40	50 MHz - 2.2 GHz	1 TX IQ, 1 RX IQ, FD	40 MHz
WBX-120	50 MHz - 2.2 GHz	1 TX IQ, 1 RX IQ, FD	120 MHz

SBX-40	400 MHz - 4.4 GHz	1 TX IQ, 1 RX IQ, FD	40 MHz
SBX-120	400 MHz - 4.4 GHz	1 TX IQ, 1 RX IQ, FD	120 MHz
CBX-40	1.2 GHz - 6 GHz	1 TX IQ, 1 RX IQ, FD	40 MHz
CBX-120	1.2 GHz - 6 GHz	1 TX IQ, 1 RX IQ, FD	120 MHz
UBX-40	10 MHz - 6 GHz	1 TX IQ, 1 RX IQ, FD	40 MHz
UBX-160	10 MHz - 6 GHz	1 TX IQ, 1 RX IQ, FD	160 MHz

Table 2 - Ettus Research Daughterboard Characteristics

FD = full duplex, HD = half duplex, IF = intermediate frequency, IQ = quadrature interface

After selecting a daughterboard based on frequency coverage, users must also ensure the daughterboard can meet the bandwidth requirements for the application(s) of interest. Most of the transceiver daughterboards provide 40 MHz or 120 MHz of instantaneous RF bandwidth in both the transmit and receive directions. The ability to utilize the full bandwidth depends on the USRP device the daughterboard is paired with and the resolution of the data transferred over the host interface.

As with frequency coverage, many users are looking to experiment without any specific application in mind. Once again, the WBX, SBX and UBX transceiver daughterboards are a good choice because they provide full-duplex capability with bandwidth that is more than sufficient for many applications.

One important thing to consider is the bandwidth capability of the USRP device selected. While a daughterboard may provide up to 40 MHz of RF bandwidth the, this does not guarantee the USRP device can transfer an equal bandwidth to the host machine. If a user requires a specific maximum bandwidth, they should ensure both the daughterboard and USRP device meet those requirements. If you are not sure about the capabilities of various USRP devices, see Selecting an USRP Device application note in the knowledge base.

Currently, all of the daughterboards available from Ettus Research accept reference clock(s) from the USRP device. Therefore, all daughterboards can be used for MIMO applications requiring frequency alignment and sample clock alignment. For more information on how to assemble a MIMO system with USRP devices, see the ?MIMO and Synchronization? application note in the knowledge base.

If the application requires full-duplex capability, all transceiver daughterboards except the XCVR2450 are appropriate.

While all daughterboards can be used in a MIMO configuration, this does not necessarily imply there is phase alignment between the RF chains of one or more daughterboards. The BasicRx, BasicTX, LFRX and LFTX are exceptions to this, since they do not include local oscillators that contribute to phase ambiguity between channels.

The Ettus Research SBX daughterboard utilizes an RF PLL that includes a resynchronization feature, which can be used to align the LOs across multiple SBXs, and multiple USRP hardware devices. Using the UHD (USRP Hardware Driver?), timed SPI commands can drive this re-synchronization feature. At the time of this writing, this feature is not supported in the mainline UHD. However, this feature is planned for release in 2012.

Use of any other daughterboard requires channel-to-channel phase calibration after each PLL re-tune. Therefore, the SBX is the preferred solution for beamforming or DF applications.

Many users often ask about choosing the SBX or WBX daughterboard versus the RFX daughterboard, when the RFX can meet the frequency coverage requirements for the application in question. In general, the SBX and WBX provide better performance, particularly when it comes to noise figure (NF). The typical NF of SBX/WBX is 5 dB, versus 8 dB for the RFX series. IP3 is also improved. The WBX and SBX provide power control with variable attenuators.

The ISM band filters present on the TX/RX port of the RFX900 and RFX2400 boards may make them ideal for use in those particular bands, as these specifications increase selectivity and reduce spurious emissions. Aside from this scenario, the SBX and WBX outperform a daughterboard from the RFX series.

Some USRP radio users elect to use an external front end providing upconversion, downconversion, amplification and filtering functionality. In these cases, the frontend often outputs an intermediate frequency (IF). It is also possible for the frontend to provide an analog, quadrature interface. In either case the BasicRX/BasicTX and LFRX/LFTX daughterboards are good candidates, as they provide a unity gain interface to the ADC(s) and DAC(s) of the USRP hardware.

These boards can also be used without a complete frontend, but external amplifiers and filters may be required to improve noise figure (NF) and inter-modulation performance.

This application note has provided guidance on considerations for selecting a daughterboard to use with the Ettus Research USRP. Using this guide, users should be able to choose an appropriate RF daughterboard for their specific application. If you have any questions regarding this information, please contact at support@ettus.com.