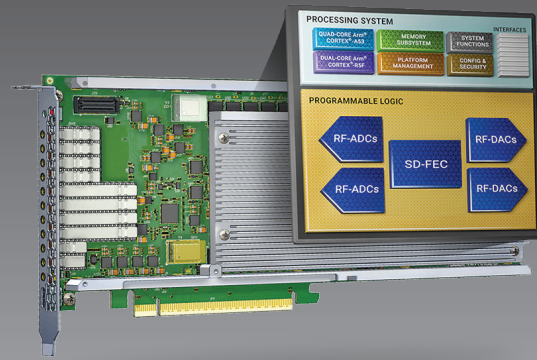**BittWare** a **molex** company

RFX 770
RFSoC PCIe Card

# RFSoC Amplified Transceiver Card with PCIe Data Plane
Available with optional amplification and filtering on the card

The BittWare RFX 770 card is a digital direct sampling transceiver featuring the third generation AMD Zynq® UltraScale+™ RFSoC. This innovative solution uses the RFSoC for direct sampling between 50 MHz and 6 GHz. BittWare's card implementation optionally integrates filters and amplification, displacing external devices. Integrating this on the card results in higher performance and reduced cost. The RFX 770 uses PCIe for data movement. The card is available integrated in our optional WaveBox Sigma, a server specifically optimized for the RFX 770.

The AMD Zynq® UltraScale+™ RFSoC integrates RF-class A/D and D/A converters into the Zynq® FPGA fabric and multi-core ARM processor subsystem, creating a multi-channel data conversion and processing solution on a single chip.

The RFX 770 offers PCIe Gen3 x16 bandwidth, which is 16 GB/sec at the physical level. Sending packets through a host CPU to host DRAM will deliver roughly 10 GB/sec. Get twice that bandwidth by configuring PCIe as dual Gen4 x8 paths; however, this option comes with a few restrictions and errata. If you need even more bandwidth, talk to us about our RFX 880 product that uses Ethernet as its data plane instead of PCIe.

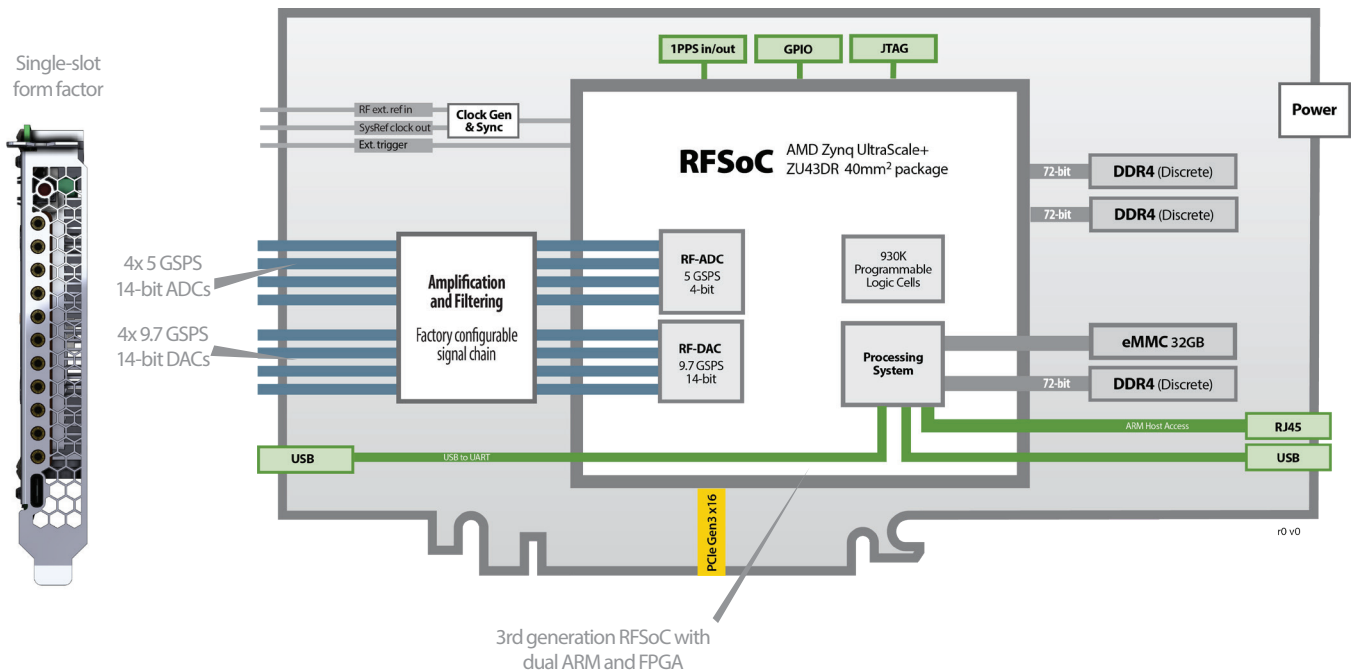The RFX 770 is popular with customers creating devices that include analog recording and playback.
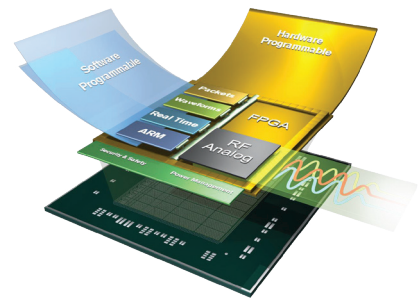
key features

Third Generation AMD Zynq® Ultra-Scale+™ RFSoC	Integrated amplification and filtering	Gen3 x16 or dual Gen4 x8 PCIe

Single-slot form factor

4x 5 GSPS 14-bit ADCs

4x 9.7 GSPS 14-bit DACs

1PPS in/out · GPIO · JTAG

RF ext. ref in · SysRef clock out · Ext. trigger · Clock Gen & Sync

RFSoC AMD Zynq UltraScale+ ZU43DR 40mm² package

Amplification and Filtering — Factory configurable signal chain

RF-ADC 5 GSPS 4-bit

RF-DAC 9.7 GSPS 14-bit

930K Programmable Logic Cells

Processing System

Power

72-bit DDR4 (Discrete)
72-bit DDR4 (Discrete)

eMMC 32GB
72-bit DDR4 (Discrete)

ARM Host Access · RJ45
USB

USB · USB to UART
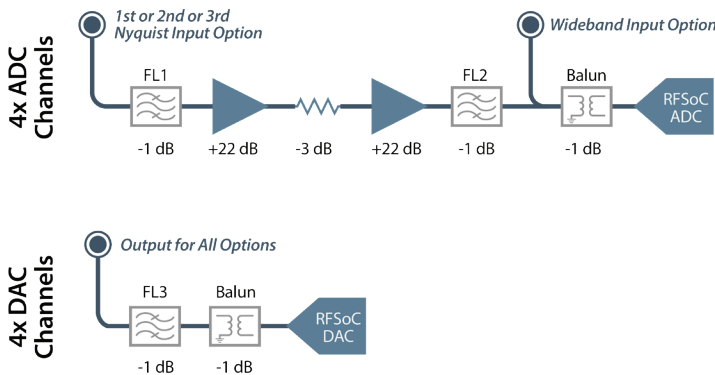
PCIe Gen3 x16

3rd generation RFSoC with dual ARM and FPGA

r0 v0

ADC Options

The RFSoC chip at 5 GSPS offers a 2.5 GHz bandwidth at up to 6 GHz. Aliasing challenges require filtering in the path. The card's Wideband configuration targets customers willing to provide most filtering and amplification external to the card. BittWare provides a DC block and a 6 GHz LPF. The RFX 770 has build options for on-card bandpass filtering and amplification with filters available for Nyquist 1, 2, and most of 3. BittWare also offers the RFX 771 with a mixer and LO for up and down conversion up to 35 GHz.

How the ADC/DAC Configuation Options Work
Each card is factory-configured for one set of 4x input and 4x output options

4x ADC Channels

● 1st or 2nd or 3rd Nyquist Input Option   ● Wideband Input Option

FL1 — -1 dB | +22 dB | -3 dB | +22 dB | FL2 -1 dB | Balun -1 dB | RFSoC ADC

4x DAC Channels

● Output for All Options

FL3 -1 dB | Balun -1 dB | RFSoC DAC

Clock Tree

The RFX 770 card offers a very flexible clock tree. In addition, the default card configuration has a 10 MHz OCXO and a 125 MHz fixed VCXO. Some of the RFX 770 clock tree flexibility is established through build options when the card is manufactured. BittWare will configure optimized cards for each customer, with a minimum quantity requirement in each order.

RFX 770 block diagram: PCIe Reference 100MHz → Low Jitter PCIe Clock Buffer → MGT131, MGT130, MGT129, MGT128 → RFSoC / RFDC. Fixed Ref 10MHz, Selection made by build option, RF Ext Ref In, Prog Ref, PLL, VCXO 125MHz, RF PLL.

Included IP

BittWare RFX cards ship with a reference application that converts between analog data and timestamped, VITA-49.2 packets. It works in both ADC and DAC directions. The application also transfers raw data to and from ARM memory.
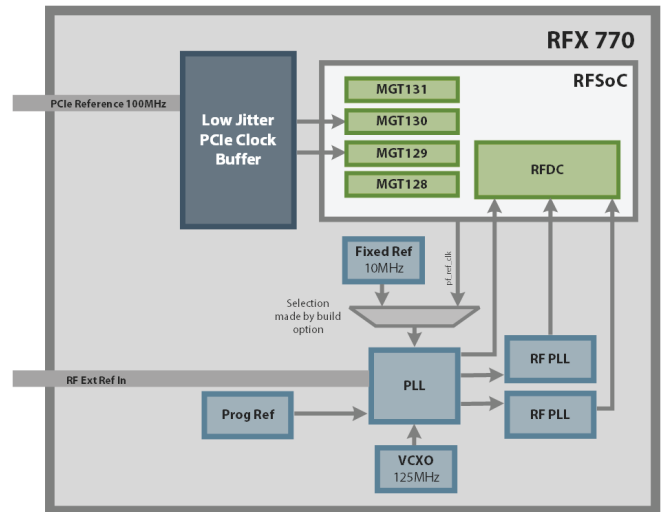
The RFSoC's ARM Processing System runs Linux and acts as a control plane. More specifically, BittWare has integrated card management functions through customized Linux drivers. BittWare has also ported AMD's RF Tool application, a socket library that configures an RFSoC chip. Above both Linux and RF Tool, BittWare provides its own RFUtils commands and examples. RFUtils can generate synthetic waveforms as well as load and stream waveforms from files. All of this is fully supported by BittWare, and we provide source code.

BittWare created a GUI tool called RFX Surfer to help configure and monitor RFX cards, as well as analyze data. We use RFX Surfer to automate RFX performance characterization, including automating external test equipment. It communicates over Ethernet to a socket server running on the ARM PS. RFX cards include this utility, with source code.

BittWare's RFX 770 reference application moves VITA-49 data over PCIe using AMD's QDMA in conjunction with the AMD QDMA Linux drivers. Also available for the RFX 770 is a version of Atomic Rules TK-242 which is higher performance over PCIe and sends the data all the way to disk.

Analog Characterization Data

BittWare fully tests and documents the analog characteristics of each RFX 770 configuration, be it wideband or amplified. That data is available for each significant printed circuit board (PCB) revision, roughly one month after a new PCB passes through manufacturing. The reports are available to customers through developer.bittware.com.

Exceeding the RFSoC Specification

AMD tests each RFSoC chip to 6 GHz. However, BittWare's characterization reports show that the full third Nyquist, up to 7.5 GHz performs well with an additional 3 dB of gain roll-off from 6 to 7.5 Ghz in the ADC. The roll-off between 6 and 7.5 GHz is acceptable for many applications.

AMD also offers RFSoC chips screened for faster rates. AMD SCD 5814 increases the DAC from 9.8 GSPS to 10 GSPS. In addition, The ZU58DR, a limited distribution version of the ZU48DR, can run the ADCs at 5.4GSPS. These and other options are available for minimum order quantities and at different price points and business terms, passed through from AMD.

Chassis Options

BittWare offers a WaveBox Sigma chassis that holds up to two RFX 770 cards in 1U. There is an x86 motherboard inside qualified to communicate with the RFX 770 in bifurcated Gen4 x8 mode.

WaveBox

Board Specifications

RFSoC	• AMD Zynq UltraScale+ RFSoC • ZU43DR (G1517package), core speed grade -2
Processing Subsystem (PS)	• Application Processing Unit Quad-core Arm Cortex-A53 MPCore at 1.2 GHz • Real-Time Processing Unit Dual-core Arm Cortex-R5F MPCore at 525 MHz

Analog	• 4x 5 GSPS 14-bit ADCs
	  • **Wideband build option** provides +0 to -27 dB gain from 50 MHz to 6 GHz (or 7.5 GHz) with no filtration
	  • **1st Nyquist (L-Band) build option** provides +41 to -29 dB on all 4 channels, constrained between 400 MHz and 2.5 GHz by filters FL1 and FL2
	  • **2nd and 3rd Nyquist** filters are also available on amplified channels as a special order
	  • Max input power -22 dBm on the amplified version and +15 dBm on the wideband
	• 4x 9.7 GSPS 14-bit DACs
	  • Range of +3 to -24 dBm (high power end of this range is a function of frequency)
	  • Constrained by a 4.8 GHz LPF (FL3)
	• Balun used in both ADC and DAC channels begins its frequency roll-off at 6 GHz
	• Programmable clocks
	• External reference and triggers
	• Push-on SMPM connectors with optional SMA pigtails

Host interface	• x16 Gen3 or bifurcated dual x8 Gen4 interfaces direct to PL (dual PCIe Gen 4 x8 with restrictions and errata)
On-board flash	• PS connects to a pair of 2Gb QSPI parts configured in "Dual Parallel" mode. The PS boots from the QSPI to configure itself, then pulls the logic bitstream from the QSPI and configures the PL • 32GB eMMC for ARM disk
External memory	• Processing system: 16GB, 64-bit DDR4-2400 with ECC • Programmable logic: 32GB, 2x banks 64-bit DDR4-2666 with ECC (our example uses it as 36GB no ECC, 72-bit)

External digital interfaces	• Processing system
	  • RJ45 Ethernet inside the chassis
	  • Single USB for UART and JTAG, dual connectors (one on the front panel, second inside the chassis)

Cooling	• Standard: single-width passive heatsink • Contact BittWare for other cooling options
Electrical	• On-board power derived from a 6-pin AUX connector (i. e. not from the PCIe slot). This physically separates the card's power circuits from the card's analog circuits • Power dissipation is application dependent • Typical max power consumption 50W
Environmental	• Designed to operate between +5C and +40C chassis air inlet temperature, noncondensing (air temperature inside the chassis between +5C and +60C)
Quality	• Manufactured to IPC-A-610 Class 2 • RoHS compliant • CE, FCC, UKCA & ICES approvals
Form factor	• ¾-length, standard-height PCIe single-slot card (x16 mechanical) • BittWare's WaveBox Sigma chassis was specifically designed to house RFX 770 cards

Development Tools

Firmware development	Bittware provides interface software support for an example bitstream that fully configures the RFSoC chip using a scripting language running on the RFSoC's ARM. AMD Vivado development tools are fully supported for development of custom designs.

Deliverables

• RFX 770 RFSoC Transceiver
• Data capture and relay example - Full source code
• 1-year hardware warranty

Sales Order Numbers

For **initial evaluation**, we urge customers to buy an RFX 770 integrated into a WaveBox Sigma chassis.

RFX-770-0001	RFX 770 Wideband card
RFX-770-0002	RFX 770 1st Nyquist amplified card

Interested in purchasing? We offer direct sales at BittWare.com, or you can check stock with our distributors at BittWare.com/rfx770.

To learn more, visit **www.BittWare.com**

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