

WIB FPGA CD-3A Procurement for FD1-HD

Introduction

A Warm Interface Board (WIB) designed with Intel/ALTERA Arria V FPGA (5AGTFD3H3F35I5N) has been used in ProtoDUNE-I successfully. Total 30 WIBs have been installed in 6 WIECs for the ProtoDUNE-I operation from 2018 to 2020.

After ProtoDUNE-I construction, a market survey was carried out in early 2019 to identify a proper FPGA for DUNE far detector WIB design. This was discussed during the DUNE collaboration meeting at CERN in January 2019, see slide 21 of the [presentation](#). The AMD/Xilinx Zynq UltraScale+ MPSoC (XCZU6CG-1FFVB1156E) offers a cost effective alternative, with additional features, e.g. ARM processor, TCP/IP etc.

A new WIB with Zynq UltraScale+ MPSoC ZU6CG has been developed since 2019. ***The latest version (WIBv3) has been used in the ProtoDUNE-II APA cold box tests and CRP cold box tests successfully.*** 20 WIBs were installed on ProtoDUNE-HD in 2022, and 12 WIBs are being installed on ProtoDUNE-VD in 2023.

Technical Justification

WIB firmware used in ProtoDUNE-II so far has the interface for the FELIX readout, which has been working reliably since 2022. The resource utilization of the WIB firmware with FELIX interface is shown in Table 1 and Figure 1 below.

Resource	Utilization	Available	Utilization %
LUT	67291	214604	31.36
LUTRAM	20977	144000	14.57
FF	88688	429208	20.66
BRAM	584.50	714	81.86
IO	122	328	37.20
GT	18	24	75.00
BUFG	15	404	3.71
MMCM	2	4	50.00

Table 1. Resource utilization table of WIB FPGA firmware with FELIX interface

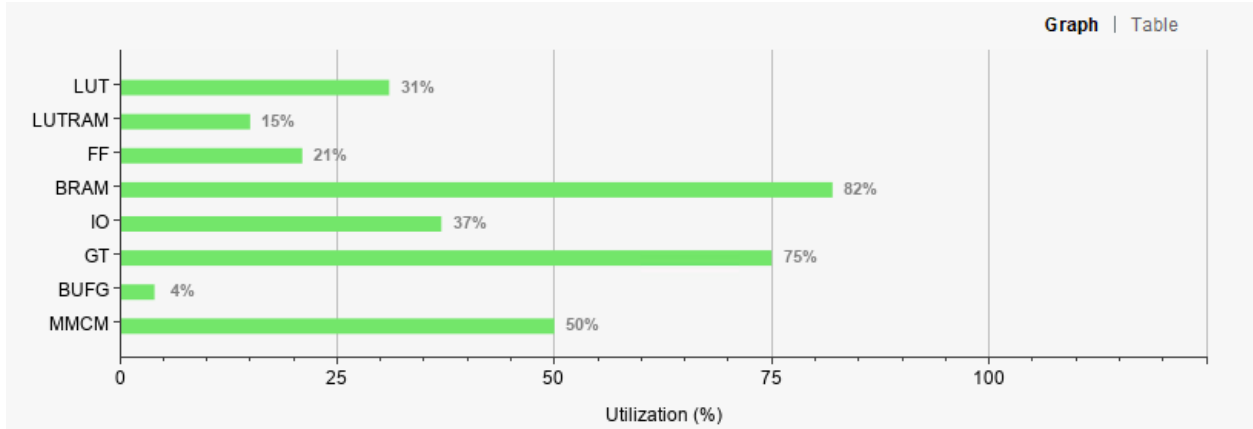


Figure 1. Resource utilization graph of WIB FPGA firmware with FELIX interface

The DUNE DAQ system plans to migrate to Ethernet based readout in 2023. The WIB firmware needs to be updated with the interface for the Ethernet readout. A preliminary build of the WIB firmware with Ethernet interface is available, the resource utilization is shown in Table 2 and Figure 2 below.

Resource	Utilization	Available	Utilization %
LUT	148475	214604	69.19
LUTRAM	66648	144000	46.28
FF	138527	429208	32.28
BRAM	627	714	87.82
IO	123	328	37.50
GT	18	24	75.00
BUFG	26	404	6.44
MMCM	3	4	75.00

Table 2. Resource utilization table of WIB FPGA firmware with Ethernet interface

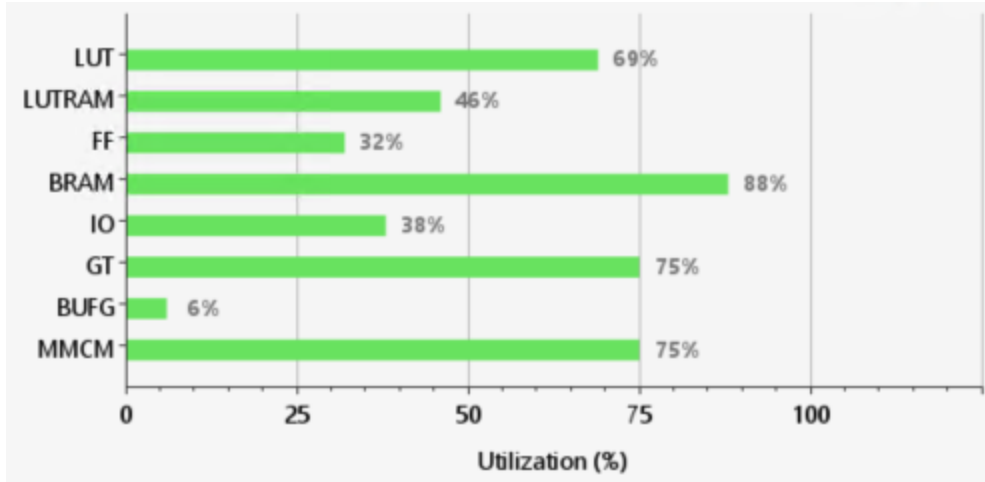


Figure 2. Resource utilization graph of WIB FPGA firmware with Ethernet interface

One may notice the resource utilization of WIB firmware is quite reasonable, with < 70% LUT usage. The LUT usage can be further optimized with improved design of the data alignment module for the Ethernet interface if necessary. The usage of BRAM is relatively high, which is caused by the ILA cores for debug purposes in the current firmware build, and will be optimized out to reduce the usage in the production firmware build. Therefore, ***the WIB FPGA ZU6CG has sufficient resources for the production needs of DUNE far detector cold electronics readout system.***

Procurement Plan

The quote of XCZU6CG-1FFVB1156E was updated in early 2023 by Avnet, with Step 2 price of \$1,322.31 each (up to 125 pieces) and Step 3 price of \$444.92 each (after 125 pieces). Avnet has checked past orders and confirmed 23 pieces will be consumed in Step 2 before unit price moves to Step 3.

For CD-3A procurement for FD1-HD, a total 800 WIB FPGAs will be ordered. The total cost will be $23 \times \$1,322.31 + 777 \times \$444.92 = \$376,115.97$. The order is planned to be submitted at BNL.