

Ultra-Energy-Efficient Polar Decoder ASIC IP Core

POLARAN Inc.

I. HIGHLIGHTS

- **0.68 pJ/b energy efficiency** with 128 Gb/s throughput at 150 MHz clock frequency
- Optimized for minimum area and low power
- Full timing-clean implementation in EPIC¹ project at 16nm TSMC FinFET technology
 - 0.22 mm² area, 86.76 mW power dissipation
- 6.21 dB coding gain at 10⁻¹² Bit Error Rate (BER)
 - Much higher coding gain options are available with low power outer codes.
- 80 ns latency (12 pipeline stages)
- Potential use-cases for the IP core include fiber-optic, wireline and intra-chip communications
- White box licensing available

II. ARCHITECTURE DETAILS

- Block length (N) of 1024 bits and the payload (K) of 854 bits with 20% coding overhead
- Successive Cancellation (SC) decoding algorithm
 - Unrolled pipelined architecture
 - Pipeline optimization, register reduction and retiming
 - Optimized multi-bit parallel decision shortcuts
 - Adaptive quantization of LLR metrics
- Fully verified end-to-end FPGA implementation with 9 sigma AWGN simulator (demonstrated at EUCNC-2019)
- Testbench, test-vectors, indicator vector of the frozen/free bits and support files are available on demand
- Customizable to other N and K on demand

III. IP BLOCK DESCRIPTION

The input-output block diagram of the decoder IP core is shown in Fig. 1.

- All synchronous logic operations are triggered by the rising edge of system clock at the clk pin.
- The clk_en input marks the beginning of valid input data.
- A synchronous active-high $reset$ signal resets all registers within 5 clock cycles.
- The $data_in$ is a 5120-bit wide input port for receiving 1024 input log-likelihood ratio (LLR) metrics, with 5-bit precision per LLR

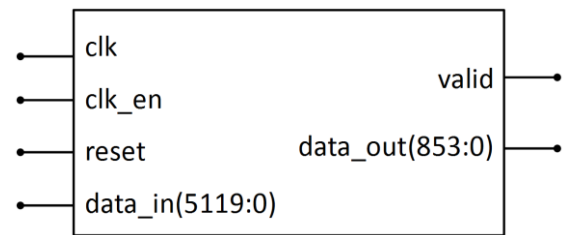


Figure 1: Block diagram of the IP core

- The $data_out$ is a 854-bit output port for outputting the decoded data bits.
- The $valid$ output signal marks valid signals at the $data_out$ port.

FPGA simulation results for the BER and Frame Error Rate (FER) performance of the IP core are shown in Fig. 2.

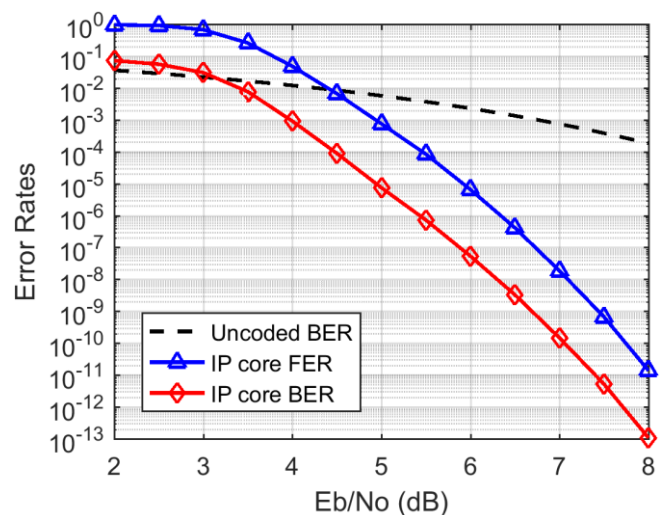


Figure 2: Error correction performance of the IP core

The IP core has been implemented (virtual tape-out) within the EPIC project using 16nm technology and the following results were obtained.

Parameter	Result
Throughput	128.1 Gb/s
Area	0.217 mm ²
Power	86.76 mW
Energy-per-bit	0.68 pJ/bit
Latency	80 ns

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POLARAN Inc. (www.polaran.com) offers a full range of IP cores for implementation of polar codes on FPGA or ASIC platforms. For further information, please contact Polaran at info@polaran.com or at +90-312-2650224.