

## Remote FPGA Upgrades with Fail-Safe Booting

Future LLRF controllers can benefit from direct access to their digital signal processing fabric via a gigabit Ethernet (GBE) communication interface. That GBE interface can be implemented within most mainstream FPGAs, connecting a high-performance on-chip bus to a well-understood and widely deployed network backbone. Since the LLRF hardware is expected to run unattended, in a remote location, for decades, and still support gateway upgrades and bugfixes, it is important for the remote administration process to have a firm foundation. This administration, including the in-place upgrading of gateway, should take place through GBE, to avoid additional accelerator-wide cabling. This paper demonstrates a fail-safe remote upgrade scheme consisting of a UDP packet switch engine, an SPI flash interface, and an MCU watchdog.

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