

ERNIC 参考设计用户指南

**250-SoC**

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版本详细信息

| **版本号** | **描述** |
| --- | --- |
| 1.0 | 带有 ERNICv2 的 250-SoC 的用户设置文档和优化软件数据路径的软件支持。JTAG-boot已验证。 |
| 1.1 | 更新了更正并添加了应用程序开发指南 |
| 1.2 | 使用新的应用程序名称和新的 CLI 选项更新了文档。ERNIC IP 和 Yocto Linux 版本基于 2020.2 |
| 1.3 | 更新了 2021.1 的文档、更新的 Petalinux 构建说明和 SPI 闪存启动指令 |

词汇表

| **缩略语/术语** | **描述** |
| --- | --- |
| 厄尼克 | 启用 RDMA 的嵌入式网卡 |
| 中国驻地协调员 | 赛灵思集成 100G 以太网 MAC |
| RoCEv2 | 融合以太网上的 RDMA，版本 2 |
| 德玛 | 远程直接内存访问 |
| 王秦 | 工作队列元素/工作队列条目 |
| QP | 队列对 |
| 平方 | 发送队列 |
| RQ | 接收队列 |
| 重庆 | 完成队列 |

# **介绍**

本文档介绍使用 Bittware 250-SoC 板 （<https://www.bittware.com/fpga/250-soc/>） 在赛灵思 Zynq MP SoC FPGA 上的赛灵思 ERNIC IP 参考设计。它描述了构建 ERNIC 系统硬件设计（位文件）、ERNIC 软件驱动程序、测试应用程序和测试设置的步骤，以验证参考平台上的 ERNIC IP 功能和性能。 在此版本的 ERNIC 参考设计版本中，提供了新的软件模块，通过实施保留内存并将其映射到用户空间，为在 Zynq MP SoC 的 ARM （Cortex-A53） 上运行的应用程序提供更好的性能。 本文档还介绍了硬件握手（HWHS）模式的详细信息，该模式使FPGA中的硬件应用能够使用ERNIC进行RDMA操作。

下图显示了如何将 ERNIC IP 与其他组件结合使用以构建参考设计。

![图

自动生成说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAkACQAAD/4RC0RXhpZgAATU0AKgAAAAgABAE7AAIAAAAWAAAISodpAAQAAAABAAAIYJydAAEAAAAsAAAQgOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFuamFuZXl1bHUgUmVkZHkgTXVsZQAAAeocAAcAAAgMAAAIcgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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NCQ6TaLaWEC3UckDMVRVYBWUtz9Aa3fKjExlEa+YVCl9vzEDnGfTk06s/Zq2pv7aV7o5bXLHVb7+0oBBcTLKuLUx3CpEF2jIYZBJznqCOnSta2s5o/EVzdPHiJ7WKNWyOWBbI9e4rTooUEncTrNx5bf1p/kcpPYaoug3OjxWBkzMzpceagV0Mm/pnO7nGMY96uanpNzca9E8MYazuhGLwlhx5bbl46nPTit+il7ND9vK97d/wAf+GOa03StTtIb07VSeG3NrYMzAgoCxVj6Zyo5/u0un2F8dYt7qa3ukRbWSORrm4VzvJXoASAOD0/IcV0lFHs0rA68nfTc54aPdP4Ht9OZNlzEkZMe/GWVg23cOmcdRVrSrRFvmuW068t5RF5fmXV0ZcjIJUfO3GR14rXopqCTTJdaTTXf9TJuNLF14mS5ubaOa2WzMeZArAPvB6H2zzVRtNvrMa0dKhWAzyRNbiMquQFUPjsDw3XvXQ0UOCBVpL+vO5y40y9mGqutrcILnTjBELm4V3Z/n4PzHH3h3xWi1jcG90SQR/Laq4mO4fLmPA+vPpWvRQqaQ3Wk/wCvKxyp0/VF0SPSFsN3k3Cv9o81QroJd2QM5zjqDjvz0FXJrW6GvLNYWtxbM0ym4l81TDNGBgkrnO7Ax0B963qKXs0N12+nf8TnZdKvG8P6xbCHM1zdSyRLuHzKWBBznA/Gm63Z6peTahAsNxNDNBstfKnWONSVw28ZBPP1BHpzXSUU3TTVgVeSd7f1p/kcxeaFeXOoQXEShJLWyi8pmYFTMrE7WHcYPXt1FS3lncy6nDqU1jdsJLURSwW115ckTBieodQw59e1dFRS9mg9vI527tkhsdIsLe3e2Ml8snkvJvZQrGRiWyfT1710VNMUbSrIyKZEBCuRyoPUA++B+VOqoxsZznzJBRRRVkBRRRQAUUUUAFFFFABRRRQAUUUUAFegfBX/AJG3W/8Arxt//Rklef16B8Ff+Rt1v/rxt/8A0ZJXNif4Z35f/HR7NRRRXln0YUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAV5z8VvCOt+JbjRbjQbaG5Nn56ypJOIz8+zBGRz9w16NRTjJxd0TOCnFxlsz59/4Vr43/wCgNbf+B6f4Uf8ACtfG/wD0Brb/AMD0/wAK+gqK3+s1O5x/UMP2/E+ff+Fa+N/+gNbf+B6f4Uf8K18b/wDQGtv/AAPT/CvoKij6zU7h9Qw/b8T59/4Vr43/AOgNbf8Agen+FH/CtfG//QGtv/A9P8K+gqKPrNTuH1DD9vxPn3/hWvjf/oDW3/gen+FH/CtfG/8A0Brb/wAD0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/wDoDW3/AIHp/hR/wrXxv/0Brb/wPT/CvoKij6zU7h9Qw/b8T59/4Vr43/6A1t/4Hp/hR/wrXxv/ANAa2/8AA9P8K+gqKPrNTuH1DD9vxPn3/hWvjf8A6A1t/wCB6f4Uf8K18b/9Aa2/8D0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/+gNbf+B6f4Uf8K18b/wDQGtv/AAPT/CvoKij6zU7h9Qw/b8T59/4Vr43/AOgNbf8Agen+FH/CtfG//QGtv/A9P8K+gqKPrNTuH1DD9vxPn3/hWvjf/oDW3/gen+FH/CtfG/8A0Brb/wAD0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/wDoDW3/AIHp/hR/wrXxv/0Brb/wPT/CvoKij6zU7h9Qw/b8T59/4Vr43/6A1t/4Hp/hR/wrXxv/ANAa2/8AA9P8K+gqKPrNTuH1DD9vxPn3/hWvjf8A6A1t/wCB6f4Uf8K18b/9Aa2/8D0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/+gNbf+B6f4Uf8K18b/wDQGtv/AAPT/CvoKij6zU7h9Qw/b8T59/4Vr43/AOgNbf8Agen+FH/CtfG//QGtv/A9P8K+gqKPrNTuH1DD9vxPn3/hWvjf/oDW3/gen+FH/CtfG/8A0Brb/wAD0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/wDoDW3/AIHp/hR/wrXxv/0Brb/wPT/CvoKij6zU7h9Qw/b8T59/4Vr43/6A1t/4Hp/hR/wrXxv/ANAa2/8AA9P8K+gqKPrNTuH1DD9vxPn3/hWvjf8A6A1t/wCB6f4Uf8K18b/9Aa2/8D0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/+gNbf+B6f4Uf8K18b/wDQGtv/AAPT/CvoKij6zU7h9Qw/b8T59/4Vr43/AOgNbf8Agen+FH/CtfG//QGtv/A9P8K+gqKPrNTuH1DD9vxPn3/hWvjf/oDW3/gen+FH/CtfG/8A0Brb/wAD0/wr6Coo+s1O4fUMP2/E+ff+Fa+N/wDoDW3/AIHp/hR/wrXxv/0Brb/wPT/CvoKij6zU7h9Qw/b8T59/4Vr43/6A1t/4Hp/hR/wrXxv/ANAa2/8AA9P8K+gqKPrNTuH1DD9vxPn3/hWvjf8A6A1t/wCB6f4V23wt8Ha94d1rVb3XrWG2S4t4YoljnEhYqzkngcfeFemUVMq05qzNKeEpUpc0VqFFFFYnUFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAH/2Q==)

图 1：ERNIC 参考设计

# **包装详情s**

该参考设计包包含软件、硬件组件的目录，可随时下载 250-SoC 板的二进制映像。

## **硬件组件**

硬件目录的内容如下所示：

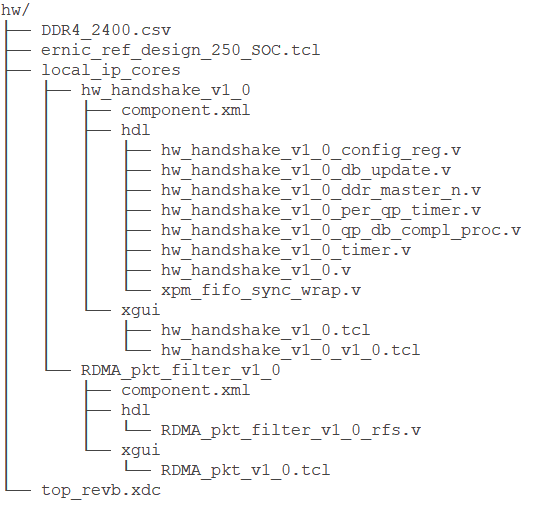


图 2 ERNIC 参考设计包 硬件内容

* ***local\_ip\_cores/hw\_handshake\_v1\_0：***

此目录包含参考硬件应用程序的设计文件，该应用程序直接与 ERNIC IP 交互，用于发布 RDMA 工作请求和处理 RDMA 完成，而无需处理器 参与（Zynq MP-SoC 上的 ARM）

* ***local\_ip\_cores/RDMA\_pkt\_filter\_v1\_0：***

此目录包含硬件 IP 块的设计文件，用于过滤 RDMA 数据包与非 RDMA 数据包。RDMA 数据包被传递到 ERNIC IP，而非 RDMA 数据包被传递给处理器（Zynq MP-SoC 上的 ARM）

* ***ernic\_ref\_design\_250\_SOC.tcl***

此文件包含用于构建系统和生成位文件的命令。

* ***top\_revb.xdc***

此文件包含参考设计的约束定义

## 软件组件

下图显示了 SW 目录中的各种组件

![包含图表的图片

自动生成说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4REYRXhpZgAATU0AKgAAAAgABQESAAMAAAABAAEAAAE7AAIAAAAWAAAIVodpAAQAAAABAAAIbJydAAEAAAAsAAAQ5OocAAcAAAgMAAAASgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEFuamFuZXl1bHUgUmVkZHkgTXVsZQAABZADAAIAAAAUAAAQupAEAAIAAAAUAAAQzpKRAAIAAAADOTkAAJKSAAIAAAADOTkAAOocAAcAAAgMAAAIrgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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PxX/wCCkHxMm/4J1fstfFDwuuj23iz4weMvDmjapDJarLb3EN8ZFnRM/c37Bh+1evfFX/gjx8KPjF8ddc+IGrXni5Nc17XrXxDdJb6gkduLmDTH06Panl/c8iR+P7/PtXTS/wDBNj4e/wDDPnwj+Gf2jxIPDPwV1zTPEGgP9qT7RLPYO7wee+z50+c7wAmeKzL5oHTy6542/Zu+HXjLxN4z1PWPiZZaZbJf2VjoGhJ/a/GfOghgjI8/nZs/j6itP4FfHST9q34ByeItL0Px98ObrUxc2kFv4n0T+z9V090ynnm2feMZ+dA/3x2wa9WHFB5rQxPzU/4I5aV4n+GPg/8AaU8U33jbVdY0jwz8XPGTX2jjS7SOPVriAxu9xvRN6O/9yP5Kp/s4/wDBTn4v/F6P4S+NrSz8TeJdL+JHiBLDV/DNp8O9RjsvD2nTPIkd2mp+T5cnl/u/MfzHjr7B+D/7D3hv4H/E7xZ4h8Na94psdM8canda1rXhl54JNIu766X9/PsaHzkkfjOJPwqv8K/2CdB+COo29r4X8YfEPSfCNnefb7bwtDqiDS7aTzN+xP3fniPfz5fmbPaszbngfIvxr/4KX/E74DftFeN9P+LQ+IHwp8G6drsll4a1jTvBUOseG7yx/wCWM93en94kkn9yP7lbv/BbfR9c8a/Df9m/VtN8bTWtjffFjwnGiWmnwSwyTvPI8d8pdN/THyfcwea+lPjV+wLov7Qen6voviTxv8R7rwf4gmkm1Hwz/acH9n3Zd97puaAziP8A6ZpIErp/2iP2OfB/7Sfwe0nwTrSX+n6f4bvrLU9FudNm8i60e6tc/Z5oHcPh4/fNA+eB3vw88Pap4W8IWtjq3iC68T6jEW87Ubm3gt5Lg7v7kKJGOMLwB0ro65v4d+E7nwT4Qs9LvPEGseJri13B9R1TyPtdz82fn8lI4+Pu8IK6StDAKKKKACiiigAooooAKKKKACiiigAooooA5P45/wDJE/GH/YEvv/RD15//AME6P+TFvhT/ANi3af8AoAr0D45/8kT8Yf8AYEvv/RD15/8A8E6P+TFvhT/2Ldp/6AKCl8J7ZRRRQSFfMH/BTrXLPwx4N+Et/qF1b2VjZfFPw7JPc3EnlxwJ55+d37V9P1zHxJ+FHhn4yeGjo/izQNF8TaS7rJ9j1SyjurfevR9kgIoAwIv2uPhXNcSRr8SvAbPF99f7ftfk/wDH6T/hrv4U/a/J/wCFleAvtHl+Zs/t6137f++6wIv+CePwFhlkdfgr8KUeX75/4RSx+f8A8h0f8O8fgL9o87/hSvwo8zZs3f8ACKWPT/v3QX7h2fhr4/8AgXxrq8enaL4z8LarqUw+S2tNVguJH/4Ajmuxkfy0/vV5r4G/Y7+E/wAL/EsOt+Gfhn4A8PaxbjEN9pugWtpcR/R40Br0iX5Im2ru/wBmgg+R/CP/AAWQ+FvjT44WvwxsdH8df8LKk1+fQ7nw2+lJ/aGneWN73U/7zy0tf+mm+vQPiv8At8eEvhL+0xY/CSbSvFGseONY8OyeJbCz0yyjkF7DHcfZzGjvImJAcud+E2A/PXyr8MP2Sf2kvDH/AAUuuv2jNQ8P+DvsPi29fwtqfhiC6g+0aZoKcwX32r/lpPv/ANZHXv2s/steKdW/4K+6H8YfsFm3gvS/hZdeFhcmdPPTUH1KOcIE+/jy9/z9O1ZmvuFXUP8AgrH4Qj+LVx4DtfAvxU1Dxlb+HR4kl0q10eHz7a18+SCTfvnCeYkkMnGfn/5Z769W8JftU6F8X/2Zofid4Hsda8XaVqFr5lrZabHAmoD95sdCk8iIkkZzvR3GNn5/G/jXxH448Lf8F4PiBceB/Ctv4svl+DmnRTWb6glnJHvv7jy3Dyfu8eZ9+vbv2Pv2fvGn7Cf7Cuk+D4vDsnjvxbc3t7fahYabqFvax2kl7PJPIEed0R0jeQJ15oHywsc78E/+CivgT4Ef8EvfAfxf1jXviV468K6tex6dBqusWUEniC8nnv5IE8+ON/L+R8p8h+5GOK9Y8Af8FB/Bvi74qa94L1fT/FHgnXvD+g/8JPJF4gtY7eO60sffu43jd/3ad/M2Px0618R+D/2BPjlP/wAEnPhv8A9Q+HsOm+JPAfijStYnv31+xks7uGHWZLuby9km/wCSN/4+tfRH7VH7Bnir9oP9vfWPEyLb2fgXX/glq/w8uNRF0guLe+u7sOhCf6ziP+MUB7hveGv+CvPw88S+KvhjpqeGfiJY2vxf1P8As3wpqV5pEcdnqvyOfO3+dvjj+Q/fQSf7HcfWq/dr8jvGGi/Ejwv8Rf2Bvhv4o8O6Ha/8K/8AFcNol/pmqQ3x1iC1sZIPtSJHzHB5f39//LSv1xT7taESFooooICiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigCnr+hWvijQ7zTb6Lz7LUIHtp49xXzI3UqwypBGQSMgg1n/Df4b6L8I/AWk+GPD9n9g0PQ7ZLOytjNJN5MSjCrvkZnbA7sSfeiigDcooooACM00QqD92iigA8pSc/1o8pf7tFFAAIlH8Io8sD/APXRRQAeUv8Ad69fegRKG3c8+5oooA5mx+CnhPTfi5fePbfQdPh8ZanpsWj3erqmLm4tInMkcLN3VWYkd+a6jFFFAARmmNArjkfrRRQB554D/ZF+Gvwx8dSeJtB8G6Pp+vyRtEL5Iy0saN1VCxPlg+iYr0aiigAooooAKKKKACiiigAooooAKKKKACiiigAooooA/9k=)

图 3：ERNIC 参考设计包软件内容

## **准备下载二进制文件**

此文件夹包含硬件和软件二进制文件，可将其下载到 250-SoC 板上并运行测试

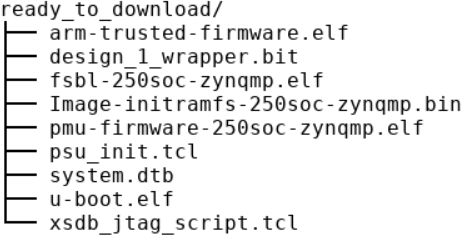


图 4：准备下载二进制文件

# **硬件要求**

此参考设计基于具有以下硬件组件的 250-SoC FPGA 板开发：

* 比特软件 250-SoC 板 （<https://www.bittware.com/fpga/250-soc/>）
* 2GB DDR4
* ATX 电源连接器/ 12V 电源适配器
* 赛灵思 智能林克 数据线 和分线卡
* A 型 USB2.0 公对母连接器，用于调试 UART 连接
* 100G QSFP E服务器电缆 （https://www.mellanox.com/products/interconnect/ethernet-direct-attach-copper-cables）

# **软件要求**

需要以下软件工具来构建参考设计的 SW 组件

* Xilinx Vivado 设计套件，版本 2021.1
* 搭载版本 202 的赛灵思 SDK 工具1.1
* 赛灵思约克托 2021.1 构建环境

# **生成硬件映像（位文件）**的步骤

* 解包后，转到硬件目录
* 启动 Vivado 设计套件 2021.1 个版本
* 在 Vivado 集成设计环境 （IDE） 中打开 Tcl 控制台。
* 如果看不到 Tcl 控制台，请选择窗口>Tcl 控制台。
* *来源 ERNIC\_ref\_design\_250\_SOC.tcl*
* 创建项目后，单击“流”导航器窗口中的“生成位流”按钮。
* Vivado 设计套件生成输出产物，合成，

实现并生成位流。应选择使用的实现策略作为“*性能优化位置*”

* 生成的比特流将在以下位置可用：

*<包路径>/hw/myproj/project\_1.runs/impl\_1*，名称为 *design\_1\_wrapper.bit*

# **构建软件映像**的步骤

本节介绍构建要在参考板上运行的软件映像的步骤。软件映像包含 Linux 内核、根文件系统以及 ERNIC IP 驱动程序和测试应用程序。

参考设计包包含驱动程序和测试应用程序的源代码（请参阅第 2.2 节）。它还包含应用于开源软件包/代码的补丁文件，当最终用户执行下面描述的命令时，这些软件包/代码会自动从互联网上获取。 ***如果***最终用户选择通过***输入必要的构建说明来 执行命令***，则最终用户***承认将从互联网下载以下各种软件并安装在映像中，并且最终用户同意***最终用户***全权负责审查和遵守管理此类软件的许可协议条款。 命令并安装到映像中***

软件构建过程获取以下开源包/代码并对其应用补丁。

* OFED 性能测试 包来自： <git://github.com/lsgunth/perftest.git>
* Linux rdma-core： <git://github.com/linux-rdma/rdma-core.git>
* Xilinx Linux 源代码： git://github.com/Xilinx/yocto-manifests.git

## 设置 Yocto 构建环境：

软件映像是使用 Xilinx Yocto 构建环境构建的。下面给出了设置构建环境的步骤

1. 若要使生成过程干净，请创建一个目录来克隆所需的文件，并用作生成输出的目标目录。将软件包解压缩到此目录中，然后切换到软件包的“SW”目录

|  |
| --- |
| *$ MKDIR ernic\_ip && CD ernic\_ip*  *$ CD sw* |

1. 下载存储库脚本并授予下载 Xilinx yocto 清单的可执行权限。

|  |
| --- |
| *$ curl https://storage.googleapis.com/git-repo-downloads/repo-1 > 回购*  $ *chmod a+x ./repo* |

1. 使用所需的清单版本 （2021.1） 要克隆并同步存储库

*$ python3*  .*/repo init -u git://github.com/Xilinx/yocto-manifests.git -b rel-v20* ***21.1***

*$ python3 ./repo sync*

所有存储库都将下载到名为 *sources* 的目录中

### 添加参考设计元层并构建映像

1. 如果您计划使用提供的参考设计的硬件描述文件 systems/250soc\_ernic\_system/hw\_design/design\_1\_wrapper.xsa，请跳过此步骤。如果您已创建由 Vivado 生成的新的或更新的 .xsa 文件，请包含此步骤。

|  |
| --- |
| *$ cp -f <xsa\_file path*>/*<xsa\_file\_name>.XSA Systems/250soc\_ernic\_system/hw\_design/design\_1\_wrapper.xsa* |

1. 复制机器支持配置文件 *250soc-zynqmp.conf*

|  |
| --- |
| *$ cp -f systems/250soc\_ernic\_system*/*bsp\_layer*/*250soc-zynqmp.conf sources/meta-xilinx/meta-xilinx-bsp/conf/machine/* |

1. 复制设备树 bbappend 文件 & tcl 文件

|  |
| --- |
| *$ cp -f systems/250soc*\_ernic\_system/bsp\_layer/bsp-device-tree.bbappend sources/meta-xilinx*/meta-xilinx-bsp/recipes-bsp/device-tree/device-tree.bbappend*  *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/device\_tree\_ernic\_tcl.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-bsp/device-tree/files/device\_tree\_ernic\_tcl.patch* |

1. 复制包含参考设计特定器件树更改的系统 ***用户.dtsi*** 文件。在参考设计中，100G 接口的 MAC 地址是从 system-user.dtsi 文件中指定的值分配的。用户必须确保此 MAC 地址在与网络中的其他 ERNIC 板连接时每个板都是唯一的。这可以通过修改system-user.dtsi文件的“local-mac-address”属性来实现。

|  |
| --- |
| *$ cp -f systems/250soc\_ernic\_system*/bsp\_layer/system-user.dtsi *sources/meta-xilinx/meta-xilinx-bsp/recipes-bsp/device-tree/files/system-user.dtsi* |

1. 复制 *fsbl\_git.bbappend* （以修复 250-SoC 板上的 UART 编号）

|  |
| --- |
| *$ cat systems/250soc\_ernic\_system/bsp\_layer/fsbl\_git.bbappend >> sources/meta-xilinx-tools/recipes-bsp/emebeddedsw/fsbl.bbappend* |

1. 复制 qemu b b追加和补丁文件以添加缺少的 Linux 头文件名 以进行编译错误

|  |
| --- |
| *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/qemu-xilinx-native\_ %.bbappend sources/meta-xilinx/meta-xilinx-bsp/recipes-devtools/qemu/*  *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/0001-QEMU-add-linux-header-file-to-fix-compilation-error.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-devtools/qemu*/*files/* |

1. 复制参考设计的 Linux 内核补丁的 Linux 内核 bbappend 文件

|  |
| --- |
| *$ cp -f systems/250soc\_ernic\_system*/*bsp\_layer/linux-xlnx\_2021.1.bbappend sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/* |

1. 为 linux 内核源代码创建一个名为 files 的目录，以从软件包中复制所有内核补丁

|  |
| --- |
| *$ mkdir -p sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files* |

1. 复制所有内核补丁

|  |
| --- |
| *$ cp -f systems/250soc\_ernic\_system*/*bsp\_layer*/*0001-ERNIC-kernel-configs.patch* sources/meta-xilinx  */meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f systems*/*250soc\_ernic\_system*/bsp\_layer/*0001-cmac-100G.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/0001-update-create-qp-data-structure.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/0001-update-create-qp-response.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f systems/250soc\_ernic\_system/bsp\_layer/0001-arm64-zone-dev-support.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches/002-Adding-xib-abi-header.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches/0001-removed-warn\_on-on-disconnect.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches*/*0001-xib-nvmf-addons.patch* sources/meta-xilinx  */meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches/0001-Support-to-enable-hw-accl.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches/0001-Add-RDMA-driver-ID-for-ERNIC.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches/0001-Kernel-patch-for-separd-RQ-PI-CQ-CI-DB-memory.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches*/*0001-Add-new-rdma-core-verb-ibv\_reg\_mr\_ex.patch* sources/meta-xilinx  */meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches*/*0001-imm-data-alloc-in-user-space.patch sources/meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/*  *$ cp -f ernic/driver/linux-patches*/*0001-support-for-hw-hs-qp-attr.patch sources*/*meta-xilinx/meta-xilinx-bsp/recipes-kernel/linux/files/* |

1. 复制 ERNIC IP 核驱动程序模块及其 bbappend 文件

|  |
| --- |
| *$ cp -rf ernic/driver/xib-module/ sources/meta-petalinux/recipes-kernel/*  *$ cp -rf ernic/driver/xib-kmm*/ *sources/meta-petalinux/recipes-kernel/*  *$ cp -rf ernic/driver/pl-allocator*/ *sources/meta-petalinux/recipes-kernel/*  *$ cp -f ernic/driver/xib-kmm/files/xib\_kmm\_export.h sources/meta-petalinux/recipes-kernel/xib-module/files* |

1. 复制硬件握手 测试 驱动程序

|  |
| --- |
| *$ cp -rf ernic/driver/hw-hs/ sources/meta-petalinux/recipes-kernel/*  *$ cp -f ernic/driver/xib-module/files/rnic.h sources/meta-petalinux/recipes-kernel/hw-hs/files*  *$ cp -f ernic/driver/xib-module/files/xib\_export.h sources/meta-petalinux/recipes-kernel/hw-hs/files* |

1. 将补丁复制到开源用户空间 rdma 核心库

|  |
| --- |
| *$ cp -rf ernic/driver/rdma-core sources/meta-openbedded/meta-networking/recipes-support/* |

1. 复制 UMM 模块

|  |
| --- |
| *$ cp -rf ernic/driver/umm sources/meta-openembedded/meta-networking/recipes-support/* |

1. 复制测试应用程序

|  |
| --- |
| *$ cp -rf ernic/apps/perftest sources/meta-openembedded/meta-networking/recipes-support/*  *$ cp -rf ernic*/apps/x *hw-hs-server*/ *sources/meta-petalinux/recipes-apps/*  *$ cp -rf ernic*/apps/x *hw-hs-client*/ *sources/meta-petalinux/recipes-apps/*  *$ cp -rf ernic/apps/xrping/ sources/meta-petalinux/recipes-apps/*  *$ cp -rf ernic*/apps/*inv-imm-test-app*/ *sources/meta-petalinux/recipes-apps/*  *$ cp -rf ernic*/apps/*xlarge-mr-test*/ *sources/meta-petalinux/recipes-apps/* |

1. 复制 内核 性能测试 应用程序和所需的标头

|  |
| --- |
| *$ cp -rf ernic*/apps/*xkperftest-server*/ *sources/meta-petalinux/recipes-apps/*  *$ cp -f ernic/driver/xib-kmm/files/xib\_kmm\_export.h sources/meta-petalinux/recipes-apps/xkperftest-server/files* |

1. 复制杂项文件

|  |
| --- |
| *$ cp -rf systems/250soc\_ernic\_system/bsp\_layer/misc sources/meta-petalinux/recipes-apps/* |

1. 通过运行安装脚本来设置生成环境

|  |
| --- |
| *$ source ./setupsdk* |

这将设置所需的环境变量，创建名为 build 的目录 并对其进行更改。

1. 复制 yocto conf 文件 （local.conf）。此 文件是放置所有用户设置的位置。例如，镜像应该具有哪些实用程序，应该生成哪些内核映像类型，应该使用哪个 linux bbappend 等等。

|  |
| --- |
| *$ cp -f ..*/*systems/250soc\_ernic\_system/bsp\_layer/local.conf conf/local.conf* |

1. 通过运行以下命令触发生成

|  |
| --- |
| *$ bitbake core-image-minimal* |

如果 Yocto 配方的任何编译失败，则必须按照上述步骤所述将更新的文件复制到所有依赖目录中，并且必须在构建映像之前对其进行清理和重新编译。 以下是 ERNIC 驱动程序配方“xib 模块”的示例

|  |
| --- |
| *$ Bitbake -c cleanall* xib-module -f && bitbake -*c compile xib-module* - f && *bitbake core-image-minimal*  *-f* |

1. 编译需要一段时间。完成后，生成的映像被放置在tmp/deploy/images/250soc-zynqmp/Directory中。

|  |
| --- |
| *$ ls tmp/deploy/images/250soc-zynqmp/* |

PSu\_init.tcl 文件可以在*“tmp/work/250soc\_zynqmp-xilinx-linux/device-tree/xilinx\*/build/device-tree/”*中找到*。*

以下二进制文件 来自 *tmp/deploy/images/250soc-zynqmp/* 成功将 250-SoC 板启动到 Linux 并运行测试应用程序

|  |
| --- |
| * *arm-trusted-firmware.elf* * *fsbl-250soc-zynqmp.elf* * *Image-initramfs-250soc-zynqmp.bin* * *PMU-firmware-250soc-zynqmp.elf* * *system.dtb* * *u-boot.elf* |

## 佩塔利努克斯构建步骤

请参阅 petalinux 用户指南以设置构建环境和任何其他详细信息 - <https://www.xilinx.com/support/documentation/sw_manuals/xilinx2021_1/ug1144-petalinux-tools-reference-guide.pdf>

1. 设置 PetaLinux 工作环境

对于 Bash 作为用户登录外壳：

|  |
| --- |
| *$* 来源<路径安装-petalinux>/settings.sh |

对于作为用户登录外壳的 C 外壳：

|  |
| --- |
| *$* source <path-to-installed-petalinux>/settings.csh |

1. 使用已发布 创建项目。BSP 文件

|  |
| --- |
| $ petalinux-create --type project -s 250soc\_ernic\_2021\_1.bsp  $ 光盘 250soc\_ernic |

1. 使用参考设计的硬件描述文件初始化项目以反映硬件配置，

|  |
| --- |
| $ petalinux-config --get-hw-description <xsa\_file>.新星 |

1. 更新 local.conf - build/conf/local.conf

# 注释/从 local.conf 文件中删除rm\_work 行（INHERIT += “rm\_work”） -

# 添加 initramfs 行以获取带有 linux + rootfs 的单条图像

|  |
| --- |
| # 继承 += “rm\_work”  INITRAMFS\_IMAGE = “core-image-minimal-initramfs”  INITRAMFS\_IMAGE\_BUNDLE = “1” |

1. 要更改 MAC 地址：在参考设计中，100G 接口的 MAC 地址是从 system-user.dtsi 文件中指定的值分配的。用户必须确保此 MAC 地址在与网络中的其他 ERNIC 板连接时每个板都是唯一的。这可以通过修改 system-user.dtsi 文件路径的“local-mac-address”属性来实现 - project-spec/meta-user/recipes-bsp/device-tree/files/system-user.dtsi
2. 生成项目

|  |
| --- |
| *$* petalinux-build |

如果配方的任何编译失败，则将文件更新到所有依赖目录中，即项目规范/元用户/，并且必须在构建映像之前对其进行清理和重新编译。以下是 ERNIC 驱动程序配方“xib 模块”的示例

|  |
| --- |
| *$ petalinux-build -c xib-module -x clea n*  && petalinux-build -c  *xib-module*  -x c *ompile && petalinux-build* |

编译需要一段时间。完成后，生成的映像被放置在 build/tmp/deploy/images/zynqmp-generic/ Directory中。

|  |
| --- |
| *$ ls build/tmp/deploy/images/zynqmp-generic/* |

psu\_init.tcl 文件可以在 *“components/plnx\_workspace/device-tree/device-tree/psu\_init.tcl”中找到。*

以下二进制文件来自*build/tmp/deploy/images/zynqmp-generic/*，用于成功将250-SoC板启动到Linux并运行测试应用程序

|  |
| --- |
| * *arm-trusted-firmware.elf* * *fsbl-zynqmp-generic.elf* * *Image-zynqmp-generic.bin* * *petalinux-image-minimal-zynqmp-generic.cpio.gz.u-boot* * *PMU-firmware-z* ynqmp-generic.elf * *system.dtb* * *u-boot.elf* |

# **参考设计验证**

## **测试平台设置**

### ERNIC 到 MLNX 设置

图 4 显示了用于验证参考设计的 ERNIC 到 Mellanox 测试设置。设置测试平台需要 执行 以下步骤。

1. 将 250-SoC 板插入服务器计算机的 PCIe 插槽或 PCIe 电源适配器
2. 将 100G Mellanox （示例： Connect-x4） RNIC 卡插入 服务器 计算机
3. 使用 100G 以太网 QSFP 电缆将 250-SoC QSFP 100G 端口连接到 Mellanox RDMA NIC（在步骤 #1 中与主机连接）
4. 将一根 USB 电缆（A 型到微型 B）从运行 Vivado 的 PC 连接到 U250-SoC，以实现串行控制台输出
5. 如图所示，将 SmartLynq 调试电缆连接到制动卡，然后连接到 250-SoC 板。这用于连接到JTAG并将图像下载到fpga。

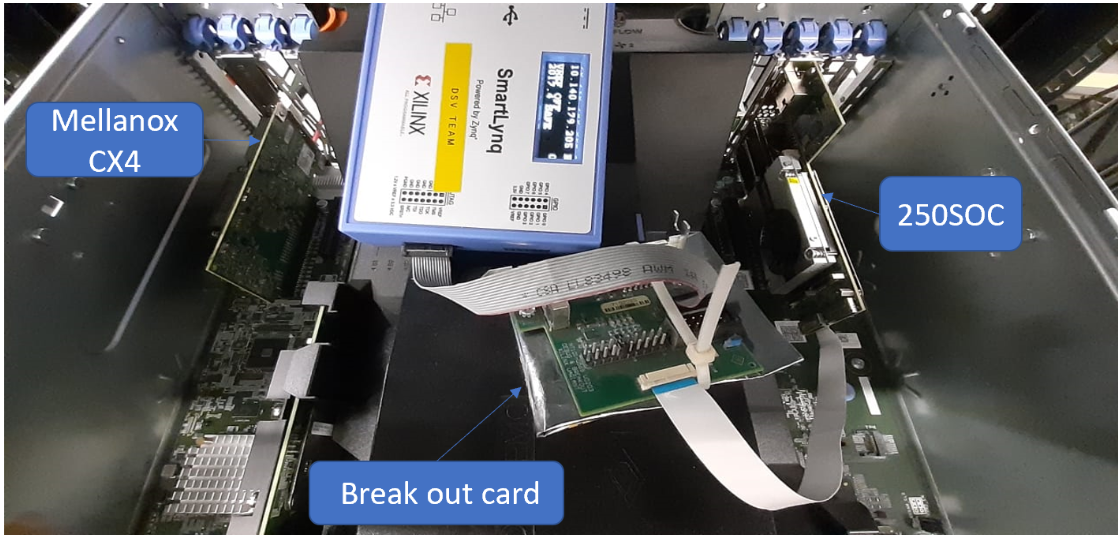


图 5 具有 250SoC、Mellanox RNIC 和连接的俯视图

### ERNIC 到 ERNIC 设置：

图 5 显示了用于验证参考设计的 ERNIC 到 ERNIC 测试设置。设置测试平台需要 执行 以下步骤。

1. 在主机或外部 PCIe 电源卡的 PCIe 插槽中插入两个 250-SoC 板
2. 将 USB 电缆（A 型到微型 B）从运行 Vivado 的 PC 连接到 250 个 SoC 板。
3. 使用 100G 以太网电缆将一个 250-SoC QSFP 100G 端口连接到另一个 250-SoC 的 100G 端口



图 6：ERNIC 到 ERNIC 的设置

### 通过交换机进行 ERNIC 连接

为了方便多个 ERNIC相互通信和/或 与其他 RNIC 通信，需要一个交换机。 下图显示了一个示例配置。 以下步骤描述了测试台的准备工作。

1. 将 250-SoC 插入服务器计算机的 PCIe 插槽或使用外部 PCI 电源卡
2. 将美兰诺 RNIC 插入 PCIe 插槽
3. 将所有 250-SoC 板的 QSFP 28 端口和所有 Mellanox RNIC 端口连接到 100Gbps 交换机

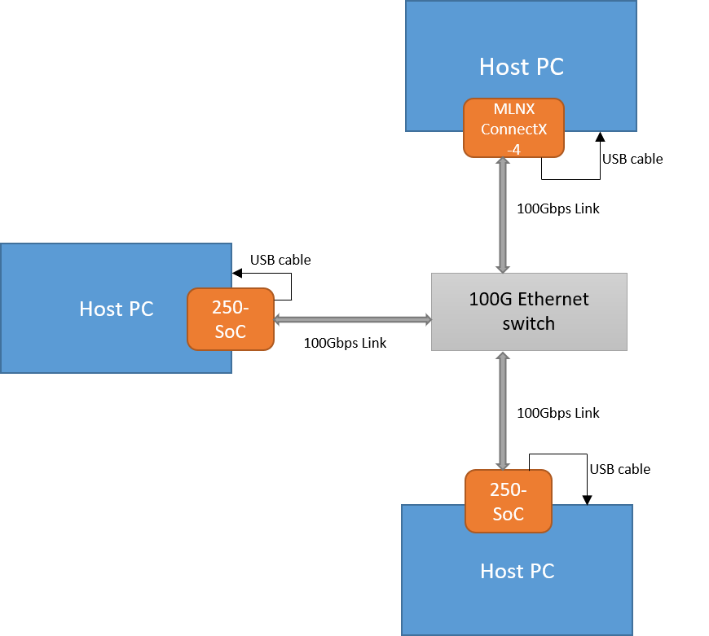
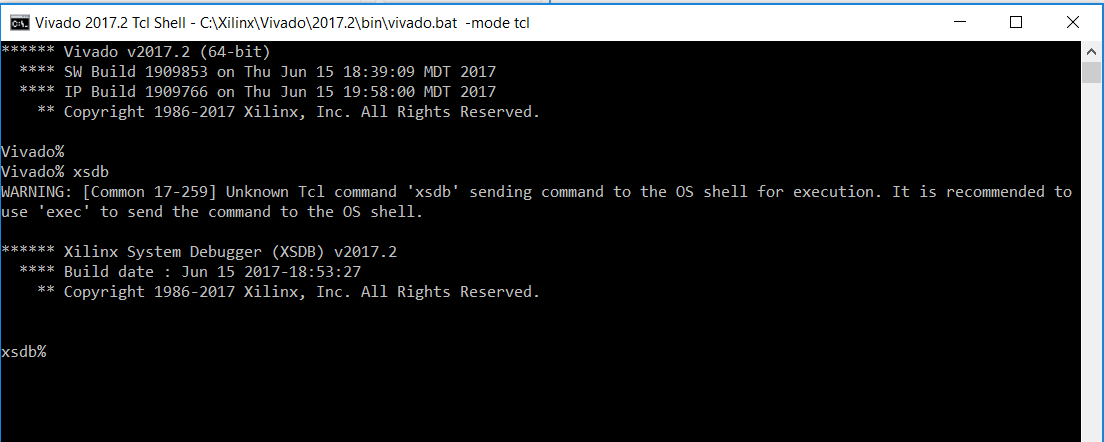


图 7： 通过开关连接到其他 RNIC 的 ERNIC

## **250 SoC 板启动**

以下步骤描述了使用 ERNIC 参考设计硬件和软件配置和启动 250-SoC 板的过程

1. 在 PC 上运行 Vivado 外壳，从 Vivado 安装。例如，Vivado 20 21。在 Windows 10 上安装 1，搜索 Vivado 20 21。1 Tcl外壳，然后双击以打开外壳。在 shell 提示符下，键入“xsdb”以进入 xsdb 提示符。下图显示了在 Windows 10 上运行的示例。xsdb 打开供用户输入后，连接到目标



1. 重置 ERNIC 系统

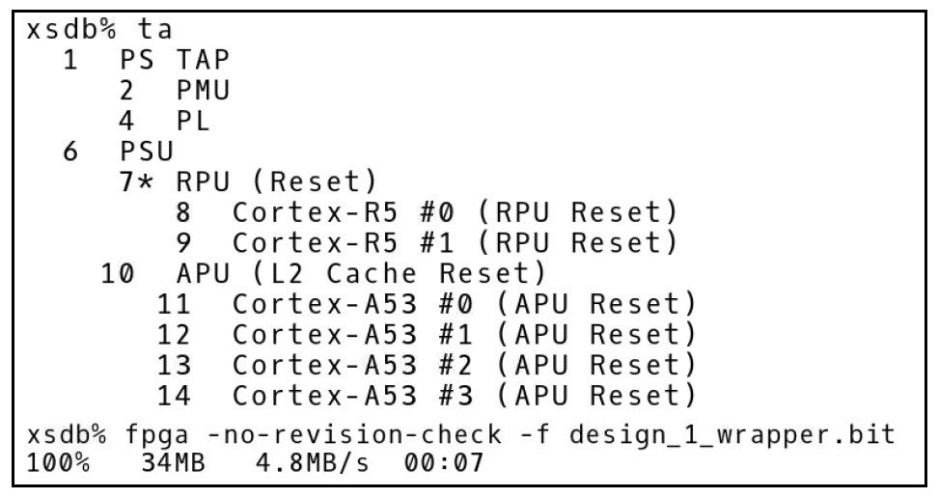
选择目标“Cortex-A53 #0” 并执行系统重置

|  |
| --- |
| *$ ta <Cortex-A53 #0 目标编号>*  *$ rst -system* |

1. 在 xsdb 提示符下，连接到目标以检查是否存在 TA。如果存在 TA，请下载位文件。

|  |
| --- |
| *$ 连接*  *$ 光盘<path\_to\_bit\_file>*  *$ fpga -no-revision-check -f <bit\_file\_name.bit>* |

上述命令的示例屏幕截图如下所示：



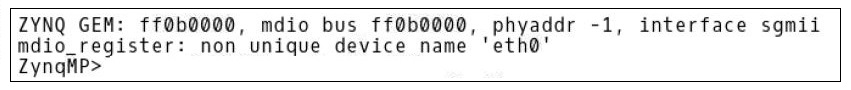
1. 下载软件映像。 对于 Zynq MPSoC，需要通过 JTAG 加载多个二进制文件来启动系统。
2. 约克托构建的图像

|  |
| --- |
| *$ 目标 -设置 -过滤器 {名称 =~ “PSU”}*  *$ mask\_write 0xFFCA0038 0x1C0 0x1C0*  *$ targets -set -filter {name =~ “MicroBlaze PMU”}*  *$ dow pmu-firmware-250soc-zynqmp.elf*  *$ con*  *$ 目标 -设置 -过滤器 {名称 =~ “PS8” || 名称 =~ “PSU”}*  *$ 兆瓦 0xffff0000 0x14000000;mask\_write 0xFD1A0104 0x501 0x0*  *$ targets -set -filter {name =~ “Cortex-A53 #0”}*  *$ 来源 psu\_init.tcl*  *$ Dow FSBL-250SOC-Zynqmp.elf*  *$ con*  *$ 停止*  *$ psu\_ps\_pl\_isolation\_removal; psu\_ps\_pl\_reset\_config*  *$ dow u-boot.elf*  *$ dow arm-trusted-firmware.elf*  *$ con*  *$ dow -data Image-initramfs-250soc-zynqmp.bin 0x80000*  *$ Dow -data system.dtb 0x1407f000* |

1. 佩塔利努克斯 构建的图像

|  |
| --- |
| *$ 目标 -设置 -过滤器 {名称 =~ “PSU”}*  *$ mask\_write 0xFFCA0038 0x1C0 0x1C0*  *$ targets -set -filter {name =~ “MicroBlaze PMU”}*  *$ dow pmu-firmware-zynqmp-generic.elf*  *$ con*  *$ 目标 -设置 -过滤器 {名称 =~ “PS8” || 名称 =~ “PSU”}*  *$ 兆瓦 0xffff0000 0x14000000;mask\_write 0xFD1A0104 0x501 0x0*  *$ targets -set -filter {name =~ “Cortex-A53 #0”}*  *$ 来源 psu\_init.tcl*  *$ dow fsbl-zynqmp-generic.elf*  *$ con*  *$ 停止*  *$ psu\_ps\_pl\_isolation\_removal; psu\_ps\_pl\_reset\_config*  *$ dow u-boot.elf*  *$ dow arm-trusted-firmware.elf*  *$ con*  *$ dow -data Image-zynqmp-generic.bin 0x80000*  *$ dow -data petalinux-image-minimal-zynqmp-generic.cpio.gz.u-boot 0x12000000*  *$ Dow -data system.dtb 0x1407f000* |

1. 从 250-SoC 到主机系统的 USB 连接的设备文件将在 /dev 中看到。使用任何终端模拟器访问该模拟器 （例如： Teraterm）
2. 编程完成后，串行控制台上将出现 u-boot 登录提示，如下所示。要启动 Linux 内核，请执行“*booti”* 命令以 从内存中启动 ARM64 Linux 映像。



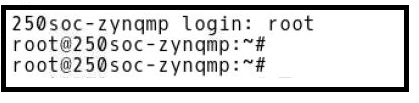
1. 约克托构建的图像

|  |
| --- |
| *$ 布蒂 0x80000 - 0x1407f000* |

1. 佩塔利努克斯 构建的图像

|  |
| --- |
| *$ 靴子0x80000 0x12000000 0x1407f000* |

1. ARM 开始运行代码后，将在串行控制台上看到启动日志。启动过程完成后，将出现登录提示。如果需要，以用户“root”和“root”作为密码登录。­­



1. 使用 250SoC 板上的 IP 地址配置网络接口

|  |
| --- |
| *$ ifconfig eth2 192.168.1.1 mtu 4200*  *$ ifconfig eth2 up* |

1. 加载驱动程序模块

|  |
| --- |
| *$ 模探头 xilinx\_k毫米*  *$ modprobe xilinx\_ib max\_q\_depth=64 max\_rq\_sge=32 cq\_mem=“pl” sq\_mem=“pl” rq\_mem=“pl” max\_app\_qp=256 rtime=16* |

UMM 使用这些模块参数来请求足够大小的内存块，以容纳所有 QP 队列（RQ、SQ、CQ）。创建 QP 时，会请求这些块中的内存并将其用于 QP 队列（RQ、SQ、CQ）。这些模块参数***不会以任何方式限制***应用程序使用的 ***QP 深度或 RQ 缓冲区大小***的值。

下表描述了 ERNIC 驱动程序的 （xilinx\_ib） 模块参数

|  |  |  |
| --- | --- | --- |
| **名字** | **描述** | **默认值** |
| max\_q\_depth | 应用使用的 Q 深度最大值 | 16 |
| max\_rq\_sge | RQ 缓冲区的最大大小（以 256 的倍数为单位） | 16 |
| max\_app\_qp | 应用程序使用的最大 QP 数 | 10 |
| cq\_mem | 用于完成的内存 驱动程序或内核应用创建的 QP 队列 | .pl |
| rq\_mem | 用于接收由驱动程序或内核应用创建的 QP 队列的内存 | .pl |
| sq\_mem | 用于发送由驱动程序或内核应用创建的 QP 队列的内存 | .pl |
| rtime | QP 重试超时 | 13 |

根据用例，用户必须根据需要更新这些模块参数。例如，254QP 的 xrping 测试用例将创建 254 个 Qp 连接，Q 深度为 32，RQ 缓冲区大小为 4KB，因此模块参数“max\_q\_depth的值应为 >= 32”，“max\_rq\_sge 的值应为 >= *32”*，“*max\_app\_qp应为 >= 254”。* 无效或即时测试应用仅创建 1 个 QP，QP 深度为 32 或 64，RQ 缓冲区大小为 4KB，“max\_q\_depth的值应为 >= *64”，“max\_rq\_sge 的值应为 >= 32”*，“*max\_app\_qp应为 >= 1”。*

1. 重新编程电路板

如果由于任何原因需要重新编程电路板，则必须在重新编程二进制文件之前执行系统重置。

|  |
| --- |
| *$ targets -set -filter {name =~ “Cortex-A53 #0”}*  *$ rst -system* |

## **远程主机设置**

为了验证 ERNIC 参考设计平台，应设置带有 Mellanox RNIC 适配器的远程主机。两个系统应 使用 100G 电缆连接。 可以将Mellanox RNIC适配器和250-SoC参考板放在两个不同插槽上的单个x86服务器上，并使用100G电缆连接它们。本节介绍 x86 服务器上执行测试所需的软件设置。

主机系统应 安装 RHEL 7.0 和 Linux 内核版本 3.10。执行以下步骤以更新所需的软件

1. 安装支持 Infiniband 和 Mellanox 驱动程序的较新的 Linux 内核

* 从 kernel.org 下载 Linux 4.8.x 内核
* 在内核配置中启用 Infiniband 和 Mellanox 驱动程序
* 编译并安装内核
* 重新启动系统

1. 安装 性能测试 应用程序

* 从 <https://github.com/lsgunth/perftest.git> 下载性能测试包
* 请查看附件第9节。4 用于编译帮助

1. 通过将源和*生成文件*从包的 *ernic/host\_apps*/ 复制到主机来构建和安装 *xrping、xhw-hs-client* 和 *inv-imm-test-app*  应用程序。通过运行 *make* 命令构建应用程序

|  |
| --- |
| *$ 使* |

Make 应该创建相应应用程序的二进制文件（xrping、xhw-hs-client、inv\_imm\_test\_app\_in、 inv\_imm\_test\_app\_out）。

***注意：****对于某些版本的MLNX OFED / rdm* *a-core，由于ibv\_wr*结构中缺少*invalidate\_rkey成员*，inv\_imm\_test\_out  *编译可能会失败 。将invalidate\_rkey的* 引用替换为*imm\_data应该可以修复它。*

1. 为 RoCEv2 配置 Mellanox RDMA NIC 适配器

* 列出系统上的网络接口，并使用以下命令找出Mellanox以太网接口名称：

*$ ifconfig -a*

* Mellanox CX-4 （100G） 设备运行 mlx\_core 驱动程序。使用 ethtool 检查驱动程序的所有接口mlx5\_core并配置该接口。

*$ ethtool –i <interface\_name>*

* 如果找到多个接口，则使用 ethtool 检查接口的端口状态，然后选择已连接的端口，并且端口处于活动状态

|  |
| --- |
| *$ ethtool –i <interface\_name>* |

* 将 IP 地址和 MTU 分配给 MLX 以太网接口。

*$ ifconfig < interface\_name> 192.168.1.2 mtu 4200*

*$ ifconfig <interface\_name> up*

1. 使用 ping 检查主机和 ERNIC 参考平台之间的连接

|  |
| --- |
| *$ 平 192.168.1.1* |

## 厄尼克测试应用

### 设置 ERNIC：

为了灵活性和增强性能，软件中引入了很少的环境变量，用户可以使用这些变量指定用于 QP 的 RQ、SQ、CQ 的内存。

|  |  |  |  |
| --- | --- | --- | --- |
| 名字 | 描述 | 默认值 | 要配置为运行 Perftest 的值 |
| XMM\_SQ\_TYPE | 用于发送队列的内存 | “嗡” | “嗡” |
| XMM\_RQ\_TYPE | 用于接收队列的内存 | “嗡” | “PL” |
| XMM\_CQ\_TYPE | 用于完成队列的内存 | “嗡” | “PL” |

* 配置环境变量：

|  |
| --- |
| *$ root@250soc-zynqmp：~*# export *XMM\_SQ\_TYPE=PS*  *$ root@250soc-zynqmp：~*# export XMM\_*RQ\_TYPE=PL*  $ *root@250soc-zynqmp：~#*  export XMM\_C *Q\_TYPE=PS* |

### 基本验证：

作为 rdma 核心[[1]](#footnote-1)一部分的标准 rping 应用程序已经过修改，以支持多个 QP。xrping 应用程序在 ERNIC 和 x86 上同时支持客户端和服务器模式。 xrping 采用以下参数

|  |
| --- |
| *$ xrping -h*  *-c ：客户端*  *-s ：服务器端*  *-I ：客户端要绑定到的源地址*  *-v :d播放 ping 数据*  *-V ：验证 ping 数据*  *-d :d错误打印*  *-S <大小> :p数据大小*  *-C <计数> :p计数时间*  *-a <地址> ：服务器地址*  *-p <端口> :p或编号*  *-Q <值> ： QP 计数*  *-D <val> ： 深度*  *-m <内存类型>：字符串中的内存类型 - pl， ps*  *-R ：测试多内存注册*  *QP 计数不应超过最大 QP 计数除以 3，因为每个 QP 注册 3 个 MR* |

* 服务器应用程序：

|  |
| --- |
| *$ xrping* -*s -Q <QPs数量> -m “PL”* |

* 客户端应用程序

|  |
| --- |
| *$ xrping* -*c*  -a <*server-IP*>  *-Q <QP count>* |

***注意：*** *要运行多客户端测试，服务器作为参数的 QP 数必须等于使用 xrping 客户端应用程序测试的所有 QP 的总和。*

### 功率因数校正

ERNIC 支持 PFC 来控制数据传输并避免重试数据包生成。但是，ERNIC 不支持 802.1Q 标记，因此从 ERNIC 传出的任何数据都将始终未标记，并最终定向到接收端的默认优先级缓冲区。这会限制其他远程 RNIC 在默认优先级上启用 PFC。ERNIC 支持 0-8 个 PFC 优先级。ERNIC 驱动程序公开用于配置 PFC 的系统 fs 条目。 以下部分介绍如何在 250-SoC 参考设计上启用和使用 PFC

#### ERNIC 上的 PFC 配置：

ERNIC 支持分别为 RoCE 和非 RoCE 流量配置 PFC。

* 为 RoCE 流量启用 PFC

|  |
| --- |
| *$ echo 1 > /sys/class/infiniband*/*xib\_0*/*pfc/en\_roce\_pfc* |

* 禁用 RoCE 流量的 PFC

|  |
| --- |
| *$ echo 0 > /sys/class/infiniband*/*xib\_0*/*pfc/en\_roce\_pfc* |

* 为 RoCE 流量配置 PFC 优先级

|  |
| --- |
| *$ echo <priority[[2]](#footnote-2)> > /sys/class*/*infiniband*/xib\_0/*pfc/roce\_pfc\_priority* |

* 为 RoCE 流量配置 xon、xoff 阈值

|  |
| --- |
| *$ echo <xon[[3]](#footnote-3)> > /sys/class*/*infiniband*/*xib\_0*/*pfc/roce\_xon\_threshold*  *$ echo <xoff[[4]](#footnote-4)> > /sys/class*/*infiniband*/*xib\_0*/*pfc/roce\_xoff\_threshold* |

* 为非 RoCE 流量启用 PFC

|  |
| --- |
| *$ echo 1 > /sys/class/infiniband*/*xib\_0*/*pfc/en\_non\_roce\_pfc* |

* 为非 RoCE 流量禁用 PFC

|  |
| --- |
| *$ echo 0 > /sys/class/infiniband*/*xib\_0*/*pfc/en\_non\_roce\_pfc* |

* 为非 RoCE 流量配置 PFC 优先级

|  |
| --- |
| *$ echo <priority[[5]](#footnote-5)> > /sys/class*/*infiniband*/xib\_0/*pfc/non\_roce\_pfc\_priority* |

* 为非 RoCE 流量配置 xon、xoff 阈值

|  |
| --- |
| *$ echo <xon[[6]](#footnote-6)> > /sys/class*/*infiniband*/*xib\_0*/*pfc/non\_roce\_xon\_threshold*  *$ echo <xoff[[7]](#footnote-7)> > /sys/class*/*infiniband*/*xib\_0*/*pfc/non\_roce\_xoff\_threshold* |

* 优先级检查禁用：

启用此功能后，ERNIC 会在收到暂停帧时停止发送数据包，而不管收到的暂停优先级如何。 ERNIC 仅在启用 PFC 时停止 Tx 流量（RoCE 或非 RoCE 或两者）。

* 禁用 PFC 优先级检查

|  |
| --- |
| *$ echo 1 > /sys/class/infiniband*/*xib\_0*/*pfc/dis\_prioirty\_check* |

* 启用 PFC 优先级检查

|  |
| --- |
| *$ echo 0 > /sys/class/infiniband*/*xib\_0*/*pfc/dis\_prioirty\_check* |

#### 远程 Mellanox RNIC 主机上的 PFC 配置

还需要使用以下命令为 PFC 启用远程 x86 上的 Mellanox RNIC

|  |
| --- |
| *$ mlnx\_qos -i <mlnx-interface>*  *$ mlnx\_qos -i <mlnx-interface>* -*-pfc 1*，0，0，0，0，0，0，0，*0* |

#### Mellanox 100G 以太网交换机上的 PFC 配置

如果网络包含以太网交换机，则需要为交换机上的端口配置 PFC。 下面给出了一个示例配置。有关更多详细信息，请参阅以太网交换机文档

|  |
| --- |
| *交换机-A46234 [单机：主] >启用开关-A46234 [单机：主] # 配置终端交换机-A46234 [单机：主] （配置） # DCB 优先级-流量控制优先级 0 启用*  *交换机-A46234 [单机：主] （配置） # 接口以太网 1/11-1/12 DCB 优先级流量控制模式强制开启*  *注意：在连接到 ernic 的交换机接口上启用 PFC，然后切换到 mellanox（此处为 1/11 和 1/12）*  *交换机-A46234 [独立：主] （配置） # DCB 优先级流量控制启用强制开关-A46234 [独立：主] （配置） #switch-A46234 [独立：主] （配置） # 显示 DCB 优先级流量控制* |

### 带宽性能 测试

该软件包包含可用于测量 ERNIC IP 的测试应用程序

各种 RDMA 操作的性能。 ERNIC IP 不支持数据缓冲区的分散收集列表 （SGL），并要求数据缓冲区在物理内存中是连续的。ERNIC IP 也不支持 MTT（内存转换表）将用户虚拟地址转换为系统物理地址。 ERNIC 软件驱动程序通过提供一组模块（在内核空间和用户空间中）和 API 来划分保留内存并将其映射到用户空间，从而克服了这一限制。用户应用程序可以使用这些存储器通过标准 RDMA 动词进行数据传输。ERNIC 软件在内部以有效的方式提供必要的翻译，以实现更好的性能。

ERNIC 还支持硬件握手模式，在该模式下，硬件应用程序可以使用用于门铃管理的边带接口发布和接收 RDMA 消息。

在参考设计中，RDMA 操作带宽使用以下方法测量：

- 用户空间性能测试应用程序（ib\_read\_bw、ib\_write\_bw、ib\_send\_bw）

- 带有测试应用程序的硬件握手模式的参考驱动程序

#### RDMA 读取带宽测试

为了测量RDMA，读取BW *，* 使用ib\_read\_bw测试应用程序。

在远程主机（x86 服务器）上，以客户端模式运行 *ib\_read\_bw* 应用程序，如下所示：

|  |
| --- |
| *$ root@xhdhost：/home/perftest# ./ib\_read\_bw -z -R* --*report\_gbits* --*dont\_xchg\_versions 192.168.1.1 -s <payload-size> <-d mlx5\_0/1>*  *$ root@xhdhost：/home/perftest# ./ib\_read\_bw -z -R --report\_gbits --dont\_xchg\_versions 192.168.1.1 -s 16K -d mlx5\_0*  *---------------------------------------------------------------------------------------*  *RDMA\_Read 体重测试*  *双端口 ： 关闭 ： mlx5\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *深度 ： 128*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *突出的阅读 ： 16*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x0122 PSN 0x1851d8*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *远程地址： LID 0000 QPN 0x0003 PSN 0xdd8ab8*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 1000 78.72 78.70 0.600470*  *---------------------------------------------------------------------------------------* |

在 250soc 参考平台上， *ib\_read\_bw* 应用程序作为服务器运行，如下所示：

|  |
| --- |
| *$ root@250soc-zynqmp：~# ib\_read\_bw* -z -R --*dont\_xchg\_versions* -*s <payload-size>*  *$ root@250soc-zynqmp：~# ib\_read\_bw -z -R --dont\_xchg\_versions -s 16K*  *\* 等待客户端连接... \**  *\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**  *---------------------------------------------------------------------------------------*  *RDMA\_Read 体重测试*  *双端口 ： 关闭 ： xib\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *突出的阅读 ： 16*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *等待客户端rdma\_cm QP 连接*  *请使用 IB/RoCE 接口 IP 运行相同的命令*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x0003 PSN 0xdd8ab8*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *远程地址： LID 0000 QPN 0x0122 PSN 0x1851d8*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 1000 78.72 78.70 0.600470*  *---------------------------------------------------------------------------------------* |

此测试将生成从客户端（x86 计算机）到 ERNIC IP 的 RDMA READ 事务，以便测量 ERNIC IP *传入的 RDMA READ* 带宽

要测量来自 ERNIC 的传出读取带宽，请在 x86 服务器上以服务器模式运行 *ib\_read\_bw* 应用程序

|  |
| --- |
| *$ root@xhdhost：/home/perftest# ./ib\_read\_bw* -z -R --*dont\_xchg\_versions* --*report\_gbits* -*s <payload-size> <-d mlx5\_0/1>* |

*在*客户端模式下ib\_read\_bw 250soc 平台上运行应用程序。

|  |
| --- |
| *$ root@250soc-zynqmp：~# ib\_read\_bw* -z -R --*report\_gbits* --*dont\_xchg\_versions* <*server-ip*> -*s <payload-size*> |

#### RDMA 写入带宽测试

为了测量RDMA，读取BW *，* 使用ib\_write\_bw测试应用程序。

在远程主机（x86 服务器）上，以客户端模式运行 *ib\_write\_bw* 应用程序，如下所示：

|  |
| --- |
| *$ root@xhdhost：*./*ib\_write\_bw* -*z -R* --*report\_gbits* --*dont\_xchg\_versions 192.168.1.1 -s <payload-size> <-d mlx5\_0/1>*  *$ root@xhdhost：/home/perftest# ./ib\_write\_bw -z -R --report\_gbits --dont\_xchg\_versions 192.168.1.1 -s 16K -d mlx5\_0*  *---------------------------------------------------------------------------------------*  *RDMA\_Write 体重测试*  *双端口 ： 关闭 ： mlx5\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *深度 ： 128*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *最大内联数据 ： 0[B]*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x0136 PSN 0x96a362*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *远程地址： LID 0000 QPN 0x0003 PSN 0x270079*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 5000 97.54 97.53 0.744082*  *---------------------------------------------------------------------------------------* |

在 250soc 参考平台上， *ib\_write\_bw* 应用程序作为服务器运行，如下所示：

|  |
| --- |
| *\* 等待客户端连接... \**  *\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**  *---------------------------------------------------------------------------------------*  *RDMA\_Write 体重测试*  *双端口 ： 关闭 ： xib\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *最大内联数据 ： 0[B]*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *等待客户端rdma\_cm QP 连接*  *请使用 IB/RoCE 接口 IP 运行相同的命令*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x0003 PSN 0x270079*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *远程地址： LID 0000 QPN 0x0136 PSN 0x96a362*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 5000 97.54 97.53 0.744082*  *---------------------------------------------------------------------------------------* |

此测试将生成从客户端（x86 计算机）到 ERNIC IP 的 RDMA WRITE 事务，以便测量 ERNIC IP *传入的 RDMA 写入* 带宽

要测量传出 RDMA 写入带宽，请将 *ib\_write\_bw* 应用程序作为远程主机（x86 服务器）上的服务器运行

|  |
| --- |
| *$ root@xhdhost：/home/perftest# ./ib\_write\_bw -z -R* --*report\_gbits* --*dont\_xchg\_versions -s 4M <-d mlx5\_0/1>* |

*在* 250soc 平台上以客户端身份运行ib\_write\_bw应用程序

|  |
| --- |
| *$ root@250soc-zynqmp：~# ib\_write\_bw* -*z -R* --*report\_gbits* --*dont\_xchg\_versions <server-ip> -s 4M* |

#### RDMA 发送带宽

RDMA SEND带宽是使用 *ib\_send\_bw* 应用程序测量的。

在客户端模式下在 x86 计算机上运行*ib\_send\_bw*应用程序

|  |
| --- |
| *$ root@xhdhost：/home/perftest# ./ib\_send\_bw -z -R* --*report\_gbits* --*dont\_xchg\_versions 192.168.1.1 -s 16K -d mlx5\_0*  *---------------------------------------------------------------------------------------*  *发送 BW 测试*  *双端口 ： 关闭 ： mlx5\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *深度 ： 128*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *最大内联数据 ： 0[B]*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x014a PSN 0xb9b55c*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *远程地址： LID 0000 QPN 0x0003 PSN 0x124575*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 1000 93.56 92.85 0.708404*  *---------------------------------------------------------------------------------------* |

以服务器模式在 250soc 平台上运行*ib\_send\_bw*应用程序

|  |
| --- |
| *$ root@250soc-zynqmp：~# ib\_send\_bw* -*z -R* --*report\_gbits* --*dont\_xchg\_versions -s 16K*  *\* 等待客户端连接... \**  *\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**  *---------------------------------------------------------------------------------------*  *发送 BW 测试*  *双端口 ： 关闭 ： xib\_0*  *QPS 数量 ： 1 运输类型 ： IB*  *连接类型 ： RCUsing SRQ ： OFF*  *接收深度 ： 512*  *CQ 审核 ： 100*  *交通总大学 ： 4096[早]*  *链路类型 ： 以太网*  *GID指数 ： 0*  *最大内联数据 ： 0[B]*  *rdma\_cm QP ： 开*  *数据示例方法：rdma\_cm*  *---------------------------------------------------------------------------------------*  *等待客户端rdma\_cm QP 连接*  *请使用 IB/RoCE 接口 IP 运行相同的命令*  *---------------------------------------------------------------------------------------*  *本地地址： LID 0000 QPN 0x0003 PSN 0x124575*  *GID：00：00：00：00：00：00：00：00：00：255：255：192：168：01：250*  *远程地址： LID 0000 QPN 0x014a PSN 0xb9b55c*  *GID： 00：00：00：00：00：00：00：00：00：255：255：192：168：01：24*  *---------------------------------------------------------------------------------------*  *#bytes #iterations带宽峰值[千兆字节/秒] 带宽平均值[千兆字节/秒] 消息速率[兆平倍]*  *16384 1000 0.00 90.99 0.694206*  *---------------------------------------------------------------------------------------* |

要测量来自 ERNIC 的传出 SEND BW，请在 x86 服务器上以服务器模式运行*ib\_send\_bw*应用程序

|  |
| --- |
| *$ root@xhdhost：/home/perftest# ./ib\_send\_bw* -z -R --*dont\_xchg\_versions* --*report\_gbits* -*s <payload-size> <-d mlx5\_0/1>* |

*在*客户端模式下ib\_send\_bw 250soc 平台上运行应用程序。

|  |
| --- |
| *$ root@250soc-zynqmp：~# ib\_send\_bw* -z -R --*report\_gbits* --*dont\_xchg\_versions* <*server-ip*> -*s <payload-size*> |

#### 使用硬件握手模式进行 BW 测试

在硬件握手模式下，QP 被卸载，硬件应用程序将直接与 ERNIC IP 交互，以发布 WQE 并接收传入的 RDMA SEND 和完成。 在这种模式下，数据路径（门铃操作）完全从处理器卸载。QP 连接建立仍由处理器上运行的 OFED 软件堆栈处理。

包中提供的示例硬件应用程序执行硬件握手功能，并用作参考实现。有关此示例应用程序的详细信息，请参阅第 8 节。

传出 RDMA 操作的 ERNIC 带宽可以使用硬件握手模式进行测量。软件包中提供了一个示例硬件握手 RTL 应用程序和相应的内核驱动程序。还提供了一个名为*xhw\_hs\_server*的测试应用程序来测量带宽。下表对此进行了总结：

|  |  |
| --- | --- |
| *厄尼克驱动程序* | 必须插入hw\_hs驱动程序以验证硬件握手设计。 xilinx\_ib驱动程序必须先加载hw\_hs |
| *ERNIC 启动器应用程序* | xhw\_hs\_server用户应用程序作为服务器在 ERNIC 上运行并启动 RDMA 请求 |
| *远程主机 （x86） 作为目标* | xhw\_hs\_client主机应用程序充当客户端，用于交换 RDMA 目标的内存和密钥信息 |
| *ERNIC作为目标* | 如果远程主机是另一个 ERNIC，则应在 ERNIC 上运行xhw\_hs\_client以交换内存和密钥信息。 |

该软件包附带了硬件应用程序的参考实现，以使用 ERNIC 的硬件握手模式。软件包中提供了相应的内核驱动程序 （hw\_hs），用于配置 HW 应用程序并触发测试。

* hw\_hs模块应按如下所示加载

|  |
| --- |
| *$ root@250soc-zynqmp：~# modprobe hw\_hs* |

xhw\_hs\_server应用程序配置 HW HS QP 寄存器，并在 ERNIC 上启用硬件 HS 测试。此应用程序还支持多客户端环境，这意味着它接受来自多个远程 RNIC 适配器的连接。它具有以下配置选项，

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*-help*  *--调试 :d ebug 打印*  *--帮助 :D是 帮助*  *--详细：启用详细程度*  *--common-rdma-buf 或 -c ：对所有 QP 使用相同的 RDMA 缓冲区*  *-Z <val> 或 --data-pattern <val> ： 十六进制数据模式*  *-Q <val> 或 --qp <val> ： QP 计数*  *-K <*val> 或 --*tf-size* *<val> ： 以 KB 为单位的数据传输大小*  *-a <ip-addr> 或 --ip <ip-addr>：IP 地址输入*  *-D <*val> 或 --*q-depth <val> ：队列深度。*  *值必须是 2 的幂*  *-M <val> 或 --mode <val> ： 操作模式*  *“突发” - > 突发模式，“内联” -> 串联模式*  *-N <*val> 或 --*burst-count <val>：突发计数值*  *值必须<队列深度和 < 16， 即 WQE 深度*  *-o <val> 或 --opcode <val> ： 操作码*  *“wr*” -> *写，*“*rd*” -*> 读取，“发送”->发送*  *-P <val> 或 --freq <val> ： 时钟频率，单位为 MHz*  *默认 值 为 200*  *-W <val> 或 --msg-count <val> ： WQE 计数*  *值必须是突发计数的倍数*  *-S <类型> 或 --sqmem <类型> ： HW HS SQ 内存类型*  *内存类型是：PL*，*PS*，*EDDR，Bram*  *-R <类型> 或 --data-mem <类型> ： HW HS RDMA 缓冲区内存类型*  *内存类型是：PL*，*PS*，*EDDR，Bram*  *root@250soc-zynqmp：~# $* |

如果使用**“**--***common-rdma-buf*** 或  ***-c”***，则单个 RDMA 缓冲区用作所有 QP 的源或目标

在使用硬件握手模块测量 ERNIC 带宽时，远程（目标）RNIC 可以是另一个带有 Mellanox RNIC 卡的 ERNIC 或 x86 服务器。在这种情况下，需要在远程主机上运行不同的应用程序。

如果远程主机是装有 Mellanox RNIC 的 x86 服务器，请从软件包的host\_apps运行xhw\_hs\_client应用程序

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx/xhw-hs-client# ./xhw\_hs\_client*  *-I ： 客户端要绑定到的源地址。*  *-d :d ebug 打印*  *-S <大小> :p数据 大小*  *-p <端口> :p ort 编号*  *-Q <值> ： QP 计数* |

如果远程主机是另一个 ERNIC，则应运行 xhw\_hs\_client 应用程序。

以下各节介绍在硬件握手模式下测试 ERNIC BW 的过程。 这些测试可以按以下组合执行

* ERNIC 作为启动器，x86 服务器作为目标
* ERNIC1 作为启动剂，ERNIC2 作为目标
* ERNIC 作为启动器和多个远程主机（x86 和/或 ERNIC）

##### **ERNIC 传出 RDMA 读取带宽测试**

由于*xhw\_hs\_server*在 250SoCis 服务器上运行，因此必须先运行它。在以下示例中，192.168.1.1 是 ERNIC eth 2 IP 地址。

* 具有单个 QP 的突发模式示例
  + ERNIC 端（服务器和发起方）：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M burst -Q 1 -W 9000 -N 1 -K 4 -D 64*  -*o rd* -*S pl -R pl*  *（或）*  *xhw\_hs\_server --q-depth=64 --tf-size 4 -*–*mode*=“Burst” –opcode=“RD” –*freq*=200 --*qp*=1 --*msg-count=9000 –sqmem*=“pl” --*data-mem=“pl”*  *$ root@250soc-zynqmp：~# xhw\_hs\_server -d -M burst -c -Q 1 -W 100000 -N 1 -K 16 -D 64 -o RD -S 'ps' -R 'pl'*  *总带宽使用量为：94.88 Gbps* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home/xilinx/xhw-hs-client# ./xhw\_hs\_client -Q 1 -a 192.168.1.1*  *数据传输大小为 4kB*  *布夫0x7f4624002a50，RKEY 0x91883*  *应用程序 QP #0 的 rping 测试通过* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行*xhw\_hs\_client*：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -R “pl”* |

* 具有多个 QP 的突发模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M burst -Q 2 -W 9000 -N 1 -K 4 -D 64 -o RD* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx/xhw-hs-client# ./xhw\_hs\_client -Q 2 -a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -R “pl”* |

* 具有单个 QP 的串联模式示例
  + ERNIC侧：

|  |
| --- |
| *root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 1 -W 9000 -N 1 -K 4 -D 64 -o RD* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -Q 1  *-a 192.168.1.1* |

* 如果远程主机也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -R “pl”* |

* 具有多个 QP 的内联模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 2 -W 9000 -N 1 -K 4 -D 64 -o RD* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -R “pl”* |

##### **ERNIC 传出 RDMA 写入带宽测试**

由于在 ERNIC 端运行的xhw\_hs\_server是服务器，因此必须首先运行它。在以下示例中，192.168.1.1 是 ERNIC eth2 IP 地址

* 具有单个 QP 的突发模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server -d -M burst -c -Q 1 -W 100000 -N 1 -K 4 -D 64 -o WR -S 'ps' -R 'pl'*  *使用的总带宽为：95.38 Gbps* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client#*  .*/*xhw\_hs\_client -*Q 1 -a 192.168.1.1*  *数据传输大小为 4kB*  *布夫0x7fbf90002a50，RKEY 0x940aa*  *应用程序 QP #0 的 rping 测试通过* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -R “pl”* |

* 具有多个 QP 的突发模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M burst -Q 2 -W 9000 -N 1 -K 4 -D 64 -o WR* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -R “pl”* |

* 具有单个 QP 的串联模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 1 -W 9000 -N 1 -K 4 -D 64 -o WR* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -Q 1  *-a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ $ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -R “pl”* |

* 具有多个 QP 的内联模式示例
  + ERNIC侧：

|  |
| --- |
| *root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 2 -W 9000 -N 1 -K 4 -D 64 -o WR* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -R “pl”* |

##### **ERNIC 传出 RDMA SEND 带宽测试**

由于在 ERNIC 端运行的xhw\_hs\_server是服务器，因此必须首先运行它。在以下示例中，192.168.1.1 是 ERNIC eth2 IP 地址。

* 具有单个 QP 的突发模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server -M burst -Q 1 -W 100000 -N 1 -K 4 -D 64 -o send -S bram -R pl*  *使用的总BW为：94。71 Gbps* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client#*  .*/*xhw\_hs\_client -*Q 1 -a 192.168.1.1*  *数据传输大小为 4kB*  *布夫0x7fa998002a50，RKEY 0x97f33*  *应用程序 QP #0 的 rping 测试通过* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -K <发送 paylod 大小（以 KB 为单位>* |

* 具有多个 QP 的突发模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M 突发 -Q 2 -W 9000 -N 1 -K 4 -D 64 -o 发送* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* 远程 RNIC 节点也是另一个 ERNIC，在其上运行 xhw\_hs\_client ：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -K <发送 paylod 大小（以 KB 为单位>* |

* 具有单个 QP 的串联模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 1 -W 9000 -N 1 -K 4 -D 64 -o 发送* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -Q 1  *-a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -Q 1 -*a 192.168.1.1 -K <发送 paylod 大小（以 KB 为单位>* |

* 具有多个 QP 的内联模式示例
  + ERNIC侧：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M 内联 -Q 2 -W 9000 -N 1 -K 4 -D 64 -o 发送* |

* 如果远程主机是 x86 服务器，则在其上运行以下命令：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* 如果远程 RNIC 节点也是另一个 ERNIC，请在其上运行xhw\_hs\_client：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -K <发送 paylod 大小（以 KB 为单位>* |

##### **使用 HW HS 运行多 RNIC 测试：**

在此示例中，一个具有 HW HS 的启动器 ERNIC 正在与充当目标的三个远程主机（两个使用 Mellanox RNIC 的 x86 主机和一个远程 ERNIC）进行通信）

启动器 ERNIC 中指定的 QP 计数必须等于正在使用硬件 HS 测试的所有目标 RNIC QP 的总计数。

* ERNIC 端（服务器和发起方）：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_server* -*M burst -Q 5 -W 9000 -N 1 -K 4 -D 64 -o RD* |

* 具有目标 RNIC 的 x86 主机 #1：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -*Q 2 -a 192.168.1.1* |

* ERNIC 作为远程 RNIC 节点：

|  |
| --- |
| *$ root@250soc-zynqmp：~# xhw\_hs\_client* -*Q 2 -a 192.168.1.1 -R “pl”* |

* 具有目标 RNIC 的 x86 主机 #2：

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*xhw-hs-client*# .*/xhw\_hs\_client* -Q 1  *-a 192.168.1.1* |

### 即时 数据和 发送与无效 密钥 测试：

ERNIC 在数据传输的两个方向上都支持“使用 IMMDIATE 发送”、“使用无效发送”和“立即写入”操作码（即，它可以使用这些操作码发送 RDMA 数据包并使用这些操作码处理传入的操作码）。参考设计包包含一组用于验证这些功能的应用程序。ERNIC 和 x86 的这些应用程序是不同的，下表描述了用于验证功能的组合

|  |  |  |
| --- | --- | --- |
| **功能性** | **厄尼克应用程序** | **x86 主机应用** |
| 使用IMM传入发送 | inv\_imm\_test\_in | inv\_imm\_test\_out |
| 传入发送无效 | inv\_imm\_test\_in | inv\_imm\_test\_out |
| 使用 Imm 进行传入写入 | inv\_imm\_test\_in | inv\_imm\_test\_out |
| 使用IMM发送传出 | inv\_imm\_test\_out | inv\_imm\_test\_in |
| 传出发送无效 | 萌萌 | 克尔平 |
| 使用 Imm 进行传出写入 | inv\_imm\_test\_out | inv\_imm\_test\_in |

* **inv\_imm\_test\_in 详情**

|  |
| --- |
| *$ root@250soc-zynqmp：~# inv\_imm\_test\_in -h*  *inv\_imm\_test\_in 服务器应用程序：*  *--帮助（或）-h：显示帮助*  *--调试（或）-d：调试信息*  *--q\_depth （或）-D：队列深度*  *-m <类型> （或） mem\_type <类型>： RDMA 缓冲区内存类型 [pl*， *eddr*， *ps ， bram]* |

* **inv\_imm\_test\_out 详情**

|  |
| --- |
| *$ root@250soc-zynqmp：~# inv\_imm\_test\_out -h*  *inv\_imm\_test\_out 客户端应用程序：*  *-h ： 显示帮助*  *-d :d虫 子打印*  *-a <*地址*> ：地址*  *-D <深度> ：队列 深度*  *-t <测试名称>*：*测试名称*  *SIMM ： 立即发送测试*  *WIMM ： 立即测试编写*  *inv ： 发送时测试无效*  *-m <内存类型> ： RDMA 缓冲区内存类型 [pl*， *eddr*， *ps， bram]* |

#### ERNIC 传出即时 命令 测试：

* 在 x86 主机上运行inv\_imm\_test\_in应用程序

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx*/*inv-imm-test# ./inv\_imm\_test\_in -d*  *Rdma buf 地址0x7fd26800a8e0：rkey 是0x46552* |

* 在 ERNIC 上运行inv\_imm\_test\_out应用程序

|  |
| --- |
| *$ root@250soc-zynqmp：~# inv\_imm\_test\_out* -*a <Server-IP*> -t “*wimm*” -*D <Depth> -m “pl”*  *root@250soc-zynqmp：~# inv\_imm\_test\_out -a 192.168.1.24 -t “wimm”*  *测试名称为：威姆*  *请求立即写入操作码测试*  *写入立即测试通过*  *应用程序 QP #0 的 rping 测试通过*  *（或）*  *$ root@250soc-zynqmp：~# inv\_imm\_test\_out* -*a <Server-IP*> -t “*simm*” -*D <Depth> -m “pl”*  *root@250soc-zynqmp：~# inv\_imm\_test\_out -a 192.168.1.24 -t “simm”*  *测试名称为：西姆*  *请求立即操作码测试*  *立即发送成功*  *应用程序 QP #0 的 rping 测试通过* |

#### ERNIC 传出 发送与 invalidate 命令 测试：

根据IB规范，并非所有R键都可以失效。例如，指向通过用户谓词注册的内存的 R 键不能失效。要验证具有无效功能的 ERNIC 传出发送，需要在目标主机上通过 FRWR 机制注册内存的内核模块。 开源的 krping 内核模块具有这种实现。 更新了 rping 应用程序，以对远程主机 启动无效命令。

* 构建 krping 内核模块：
* 从 <https://github.com/larrystevenwise/krping.git> 克隆克尔平
* 运行 make 并插入 krping 模块。如果失败，请删除MLNX OFED，编译并重新插入
* 在 x86 主机上插入 krping 模块

|  |
| --- |
| *$ insmod rdma\_krping.ko debug=1* |

* 在 ERNIC 上运行 rping 服务器

|  |
| --- |
| *$ rping -sdi -p <port-num>* |

* 在 x86 服务器上启动 krping 客户端

|  |
| --- |
| *$ echo “client，server\_inv，addr=<ip-addr>，port=<port-num>” > /proc/krping* |

#### ERNIC 传入发送 /写入与即时 和 发送与 无效命令 测试

* 在 ERNIC 上运行inv\_imm\_test\_in应用程序

|  |
| --- |
| *$*  root@250soc-zynqmp*：~# inv\_imm\_test\_in -m “pl”*  *Rdma buf 地址0xffffabe48000：rkey 0x202*  *断开* |

* 在 x86 上运行 inv\_imm\_test\_out应用程序

|  |
| --- |
| *$ root@xhdhost：/home*/*xilinx/inv-imm-test# ./inv\_imm\_test\_out -a <服务器-IP> -t “wimm”*  *root@Dell-R740：~/host\_apps/inv-imm-test-app# ./inv\_imm\_test\_out -a 192.168.1.250 -t “wimm”*  *测试名称为：威姆*  *请求立即写入操作码测试*  *写入立即测试通过*  *应用 QP #0 的测试通过*  *（或）*  *$ root@xhdhost：/home*/*xilinx/inv-imm-test# ./inv\_imm\_test\_out -a <Server-IP> -t “simm”*  *root@Dell-R740：~/host\_apps/inv-imm-test-app# ./inv\_imm\_test\_out -a 192.168.1.250 -t “simm”*  *测试名称为：西姆*  *请求立即操作码测试*  *立即发送成功*  *应用 QP #0 的测试通过*  *（或）*  *$ root@xhdhost：/home*/*xilinx/inv-imm-test# ./inv\_imm\_test\_out -a <服务器-IP> -t “inv”*  *root@Dell-740：~/host\_apps/inv-imm-test-app# ./inv\_imm\_test\_out -a 192.168.1.250 -t “inv”*  *测试名称为：inv*  *请求无效操作码测试*  *发送无效测试通过*  *应用 QP #0 的测试通过* |

# **硬件示例应用程序详细信息**

本节介绍用于执行 ERNIC IP 硬件握手功能的参考设计的硬件应用示例。

下图显示了系统级关系图

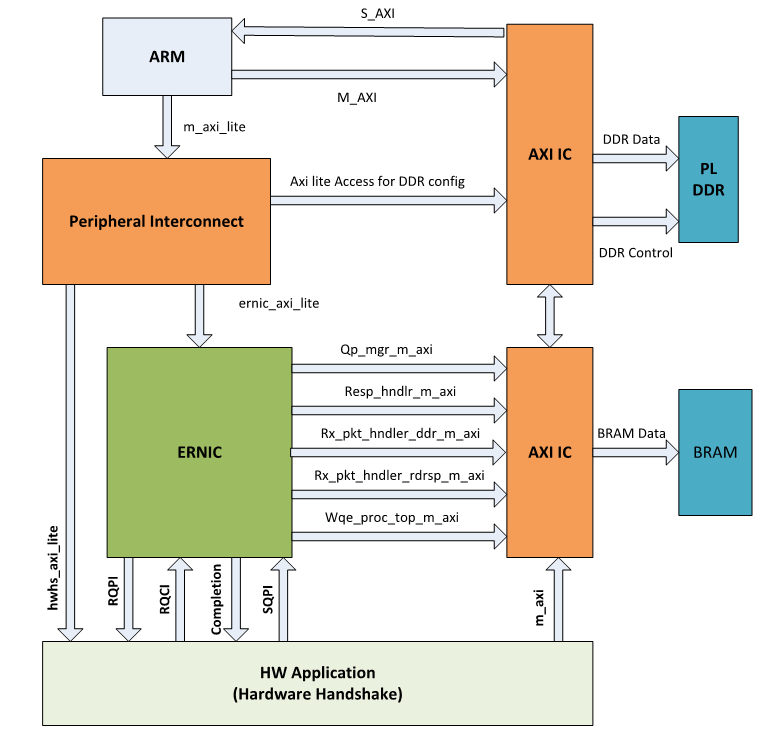


图 8：ERNIC 参考设计

如上所示，系统ERNIC IP，微火焰和硬件握手RTL应用程序中有三个主要组件。微火焰系统负责配置 ERNIC IP 和硬件握手应用程序。它还负责 RDMA 连接管理。硬件握手应用程序负责通过 ERNIC IP 生成传出 RDMA 流量（读取、写入和发送）。它使用 ERNIC IP 的硬件握手接口来实现这一点。硬件应用程序还提供性能计数器，并且在 MB 上运行的每个测试 软件 测试应用程序结束时读取这些计数器并显示每个 QP 获得的 BW 编号。

硬件应用程序在以下两种模式之一中运行。

* 突发模式
* 内联模式

硬件应用程序模块的详细信息如下：

## **规范**

示例硬件应用程序的当前实现具有以下规范，其范围受这些规则的限制。

* 可配置的最大 QP 数为 256 QP。
* 内联操作模式仅适用于 DDR 内存。
* 内联模式仅支持每个 WQE 最多 64KB 的数据有效负载。
* 带有 DDR 内存的突发模式可支持每个 WQE 高达 8 MB 的数据有效负载。
* 带有 BRAM 内存的突发模式仅支持每个 WQE 高达 512KB 的数据有效负载。
* 突发大小，即可以单次响起的门铃数量必须始终比队列深度少 1。
* 每个测试的 WQE 数必须大于队列深度，并且必须是突发大小的倍数。
* 未包含数据完整性检查

## **操作模式**

以下是每次迭代可以配置的参数。这适用于突发和内联模式。

1. WQE 的操作码：一次迭代中只有一个操作。
2. 启用的 QP 数量
3. SQ 深度：发送队列的最大深度。
4. WQE 总数：此迭代中每个队列的 WQE 数。
5. 数据传输大小：每个 WQE 的有效负载大小，所有 QP 的负载大小恒定。
6. 门铃突发尺寸：门铃同时响起的数量。
7. 有效负载中的数据模式

### 突发模式

突发模式允许用户独立测试 ERNIC IP 的性能。也就是说，WQE和相关数据由应用程序预先填充。应用程序仅不断响起SQ PI门铃。在这种模式下，应用程序创建和写入 WQE 和数据的干预不会出现在图片中，ERNIC 正在运行，就好像总是有可用的 WQE 一样。突发模式通过配置“0”到 **HW\_HS\_CONF[1]** 寄存器来启用。对于性能测量，可以通过参考设计寄存器改变迭代的各种参数。完整的寄存器描述在寄存器描述部分提供

### 内联模式

内联模式尝试模拟实际应用场景。此模式允许用户测试 ERNIC IP 子系统的性能。这就是应用程序和 ERNIC IP 协同工作。在此模式下，应用程序对WQE和相关数据进行编程，以进行一定数量的操作，并按响相应值的SQ PI门铃。在这种模式下，应用程序和 ERNIC IP 同时访问 WQE 和数据存储器。那里通过评估系统的实际性能参数。此模式可用于评估内存性能及其要求。内联模式通过编程“1”到 **HW\_HS\_CONF[1]** 寄存器来启用。对于 性能测量，可以通过参考设计寄存器改变迭代的各种参数。完整的寄存器描述在寄存器描述部分提供。

## **寄存器规格**

|  |  |  |
| --- | --- | --- |
| **寄存器名称** | **偏移量（十六进制）** | **描述** |
| [HW\_HS\_CONF](#_HW_HS_CONF_Register) | 0x00000000 | 硬件 握手 配置寄存器 |
| [TEST\_DONE](#_TEST_DONE_Register) | 0x00000004 | 测试完成状态寄存器 |
| [DATA\_TRANSFER\_SIZE](#_DATA_TRANSFER_SIZE_Register) | 0x00000008 | 数据传输大小配置寄存器 |
| [QUEUE\_DEPTH](#_QUEUE_DEPTH_Register) | 0x0000000C | 队列大小配置寄存器 |
| [NUM\_WQE](#_NUM_WQE_Register) | 0x00000010 | WQE 的配置数量 |
| [WQE\_OPCODE](#_WQE_OPCODE_Register) | 0x00000014 | WQE 操作码配置 |
| [DATA\_PATTERN](#_DATA_PATTERN_Register) | 0x00010000 + （0x40 \* （n-2）） | QP n 32 位数据模式寄存器 |
| [DATA\_BUF\_BA\_LSB](#_DATA_BUF_BA_LSB_Register) | 0x00010004 +  （0x40 \* （n-2）） | QP n 数据缓冲区基址 LSB 32 位 |
| [DATA\_BUF\_BA\_MSB](#_DATA_BUF_BA_MSB_Register) | 0x00010008 +  （0x40 \* （n-2）） | QP n 数据缓冲区基址 MSB 32 位s |
| [瑞基](#_RKEY_Register) | 0x0001000C +  （0x40 \* （n-2）） | QP n 远程密钥寄存器 |
| [VA\_LSB](#_VA_LSB_Register) | 0x00010010 +  （0x40 \* （n-2）） | QP n 虚拟地址 LSB 32 位 |
| [VA\_MSB](#_VA_MSB_Register) | 0x00010014 +  （0x40 \* （n-2）） | QP n 虚拟地址 MSB 32 位 |
| [PERF\_CNT\_LSB](#_PERF_CNT_LSB_Register) | 0x00010018 +  （0x40 \* （n-2）） | QP n 定时器 LSB 32 位 |
| [PERF\_CNT\_MSB](#_PERF_CNT_MSB_Register) | 0x0001001C +  （0x40 \* （n-2）） | QP n 定时器 MSB 32 位 |
| [PERF\_BW\_PER\_QP](#_PERF_BW_PER_QP_Register) | 0x00010020 +  （0x40 \* （n-2）） | QP n 完成接收计数器 |
| [WQE\_BUF\_BA\_LSB](#_WQE_BUF_BA_LSB_Register) | 0x00010024 +  （0x40 \* （n-2）） | QP n SQ 基于WQE的地址 LSB 32位s |
| [WQE\_BUF\_BA\_MSB](#_WQE_BUF_BA_MSB_Register) | 0x0001002C +  （0x40 \* （n-2）） | QP n SQ 基于 WQE 的地址 MSB 32 位s |

注意：n 🡪 2 到 255（仅限数据 QP）

### HW\_HS\_CONF注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [14] | 0 | 乌尔曼 | 启用数据模式， 如果 启用DATA\_PATTERN寄存器中的数据将写入 DDR/BRAM |
| [13:6] | 0 | 乌尔曼 | 启用的 QP 数量 |
| [5:2] | 0 | 乌尔曼 | 突发大小 |
| [1] | 0 | 乌尔曼 | 1. - 突发模式 2. - 内联模式 |
| [0] | 0 | 乌尔曼 | 启用/禁用 |

### TEST\_DONE注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [0] | 0 | W1C | 测试完成 |

### DATA\_TRANSFER\_SIZE注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [3：0] | 0 | 乌尔曼 | 每个 WQE 的数据传输大小  0000 - 4KB  0001 - 8KB  0010 - 16KB  0011 - 64KB  0100 - 256KB  0101 - 512KB  0110 - 1MB  0111 - 2MB  1000 - 4MB  1001 - 8MB |

### QUEUE\_DEPTH注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 队列深度 |

### NUM\_WQE注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 为任何 QP 传输的 WQE 数量 |

### WQE\_OPCODE注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [1:0] | 0 | 乌尔曼 | WQE 的操作码（每个 QP-每个 QP 深度）  00 - 传出 RDMA 写入  01 - 传出 RDMA 读取  10 – 传出发送  11 - 保留 |

### DATA\_PATTERN注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 要写入的数据模式 |

### DATA\_BUF\_BA\_LSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 需要写入数据的数据缓冲区基址的 LSB |

### DATA\_BUF\_BA\_MSB 寄存器

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 需要写入数据的 data 缓冲区基址的 MSB |

### RKEY寄存器

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [1:0] | 0 | 乌尔曼 | 远程钥匙 |

### VA\_LSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 虚拟地址的 LSB（每个 QP 深度） |

### VA\_MSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 虚拟地址的 MSB（每个 QP 深度） |

### PERF\_CNT\_LSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 反渗透 | 每个 QP 完成测试所花费的时钟周期数 （LSB） |

### PERF\_CNT\_MSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 反渗透 | 每个 QP 完成测试所花费的时钟周期数 （MSB） |

### PERF\_BW\_PER\_QP注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 反渗透 | 每个 QP 收到的完成次数 |

### WQE\_BUF\_BA\_LSB 寄存器

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 需要写入 WQE 的 WQE 基址的 LSB |

### WQE\_BUF\_BA\_MSB注册

|  |  |  |  |
| --- | --- | --- | --- |
| **位** | **违约** | **访问 类型** | **描述** |
| [31:0] | 0 | 乌尔曼 | 需要写入 WQE 的 WQE 基址的 MS B |

# 附录

## ERNIC 上的接口 MTU 设置

每个 QP PMTU 输入到硬件以决定是否对有效负载进行分段，并且派生自配置的 eth2 接口的 MTU。QP PMTU 指示有效负载大小，而不是接口上发出的数据包大小。为了发送有效负载为 512B 且不分段的数据包，接口对 MTU 的最小值应等于“512 + 标头大小”。下表列出了驱动程序中的 MTU 到 PMTU 映射，用户应对其进行适当配置。

|  |  |  |
| --- | --- | --- |
| **QP PMTU** | **250SoC**  **eth2 MTU** | **梅兰诺克斯接口 MTU** |
| 256 | 340 | 360 |
| 512 | 592 | 610 |
| 1024 | 1500 | 1500 |
| 2048 | 2200 | 2200 |
| 4096 | 4200 | 4200 |
| 4096 | 任何其他值[[8]](#footnote-8) | 4200 |

例如，要发送有效负载 256 而不会对有效负载进行分段，可以在 eth2 上配置的最小 MTU 为 340。如果我们将 340 配置为 eth2 MTU，驱动程序会将 256 配置为 QP PMTU，如果任何应用程序尝试发送大于 256 的有效负载，硬件会对其进行分段。

## 应用开发指南：

ERNIC 具有 以下 硬件限制。

* 队列深度必须是 2 的幂
* RQ 缓冲区大小限制
* 不支持完成队列通知
* 不支持本地内存保护检查
* 不支持虚拟到物理内存转换 （MTT），并且所有缓冲区都必须是物理连续内存

以下部分介绍可用于应用程序开发的准则和 API，以符合上述限制。

### 队列深度限制

ERNIC 硬件要求 QP 的队列（发送队列、接收队列）深度为 2 的幂。这些队列深度是在创建 QP 时配置的。QP 创建 *ibv\_create\_qp* 谓词将队列深度和其他配置作为其参数之一，如下所示。

|  |
| --- |
| ***struct ibv\_qp \*ibv\_create\_qp （struct ibv\_pd \*pd， struct ibv\_qp\_init\_attr \*qp\_init\_attr）;***  *结构ibv\_qp\_init\_attr {*  *无效 \*qp\_context; /\* QP 的相关上下文 \*/*  *结构ibv\_cq \*send\_cq; /\* CQ 与发送队列 （SQ） 相关联 \*/*  *结构ibv\_cq \*recv\_cq; /\* 要与接收队列 （RQ） 关联的 CQ \*/*  *结构ibv\_srq \*SRQ; /\* SRQ 句柄（如果 QP 要与 SRQ 关联），否则为 NULL \*/*  *结构ibv\_qp\_cap帽; /\* QP 功能 \*/*  *枚举ibv\_qp\_type qp\_type; /\* QP 运输服务类型：IBV\_QPT\_RC、IBV\_QPT\_UC或IBV\_QPT\_UD \*/*  *国际sq\_sig\_all; /\* 如果设置，则提交给 SQ 的每个工作请求 （WR） 都会生成一个完成条目 \*/*  *};*  *结构ibv\_qp\_cap {*  *uint32\_t max\_send\_wr; /*\* ***SQ 深度*** *\*/*  *uint32\_t max\_recv\_wr; /*\* ***RQ 深度*** *\*/*  *uint32\_t max\_send\_sge; /\* SQ 中 WR 中请求的最大散点/聚集 （s/g） 元素数 \*/*  *uint32\_t max\_recv\_sge; /\* SQ 中 WR 中请求的最大 s/g 元素数 \*/*  *uint32\_t max\_inline\_data;/\* 请求的最大数据数（字节），可以内联发布到 SQ，否则为 0 \*/*  *};* |

上述声明取自 rdma核心， 这些结构的内核空间等价物 可以在Linux Infiniband核心中找到。“结构ibv\_qp\_cap”的max\_send\_wr max\_recv\_wr分别表示 SQ 深度和 RQ 深度。这些参数必须设置为 2 的幂值。尽管深度的最小值为 2，但建议根据用例使用最小队列深度 4 或更大。

### RQ 缓冲区大小：

RDMA 应用程序将工作请求发布到 RQ（通过调用ibv\_post\_recv谓词）以接收传入的 RDMA SEND 消息。RQ WQE 可以具有 1 个以上的 SGE（分散收集条目），其 SGE 总数受 创建 QP 时用户应用程序提供的max\_recv\_sge值的限制。每个 SGE 可以指向不同大小的内存缓冲区。

ERNIC 硬件不支持将工作请求发布到 RQ。相反，RQ 缓冲区是预先发布的，硬件以循环方式为每个传入的 SEND 消息使用一个 RQ 缓冲区。但是，ERNIC SW 确实支持ibv\_post\_recv 因此应用程序仍调用此谓词来接收传入的 SEND 消息。ERNIC QP 将具有在 QP 创建期间指定的固定 RQ 缓冲区大小（RQ 条目），并且 ERNIC 驱动程序分配大小为“RQ 缓冲区大小 \* RQ 深度”的物理连续内存。 创建 QP 时*，max\_recv\_sge*字段中应将“RQ 缓冲区”大小指定为 256 的倍数。在max\_recv\_sge中传递的值“R” 表示 RQ 缓冲区大小为 （R \* 256） 字节。 例如，创建“RQ 缓冲区大小（RQ 条目）”为 1024B 且深度为 32 的 QP，max\_recv\_sge的值应为 4，max\_recv\_wr的值应为 32。

### CQ通知：

ERNIC HW 不支持 CQ 通知，因此 ERNIC SW 也不支持 *ibv\_get\_cq\_event（）* 和 *ibv\_req\_notify\_cq（）* 动词。应用程序必须轮询 CQ 以使用 API 检查完成队列中的任何新条目*ibv\_poll\_cq* 并且不得调用 i*bv\_get\_cq\_event。*

*ibv\_get\_cq\_event（）* 阻塞，直到 CQE 可用并且调用它的线程可以进入等待状态。因此，在任何性能测试中，在 RQ 完成后重新发布 RQ WQE 的主机应用程序中，应直接轮询 CQ，而不是在轮询之前等待 CQ 事件。例如，HW HS 主机测试应用*xhw\_hs\_client*发布传入发送的 RQ WQE 应直接轮询完成情况。

### 内存注册：

ERNIC 硬件不提供本地内存保护，因此不需要注册本地内存。 应用程序只需要注册 远程节点使用 RDMA 读/写操作访问的内存区域，

* ERNIC 传出 RDMA 操作中使用的本地内存不需要内存注册
* 无需注册任何 RQ 缓冲区

### 内存分配：

ERNIC 硬件不实现内存转换表，该表用于 虚拟地址到物理地址的转换。此外，ERNIC 需要物理上连续的内存来存储 SEND 缓冲区和 RDMA 缓冲区，从而将用户空间应用程序中可能的最大 RDMA 传输大小限制为PAGE\_SIZE。

ERNIC 软件实施了一种机制来解决这些限制，并使应用程序能够使用虚拟地址。外部内存管理器 （UMM） 提供 API 来分配和取消分配物理上连续的内存，并且可以由用户空间应用程序访问。由于 ERNIC 硬件需要 RDMA SEND 缓冲区的物理地址和工作请求中的 RDMA 读取/缓冲区，因此应用程序可以使用这些 API 来分配大型物理连续内存y，并将虚拟地址转换为相应的物理地址。

#### 分配内存：

分配内存的过程分为两步。作为第一步，应用程序应请求所需总内存的块。块表示物理上连续的块池。创建块后，应用程序可以使用块大小粒度从 chun k 中分配和释放内存。

以下 API 用于创建内存块：

|  |
| --- |
| *int xib\_umem\_alloc\_chunk（void \*ucontext， int memory\_type， int block\_size， int total\_size）;*  *参数：*   * *上下文：ibv\_context指针* * *memory\_type：要从中分配内存的内存区域类型。“xib\_mem\_type”支持的类型* * *block\_size：块中可分配的最小内存大小* * *total\_size：块的总大小*   *成功时返回有效的区块 ID，失败时返回负值* |

以下 API 用于从块分配内存

|  |
| --- |
| *易失性uint64\_t xib\_umem\_alloc\_mem（void \*uctx， int chunk\_id， unsigned int size）;*  *参数：*   * *UCTX：ibv\_context指针* * *chunk\_id：应从中请求内存的块 ID* * *大小：缓冲区的大小（以块的倍数为单位）*   *返回已分配内存的基址（虚拟地址），如果失败，则返回 0 或负值* |

以下 API 用于将内存释放回块

|  |
| --- |
| *int xib\_umem\_free\_mem（void \*uctx， unsigned int chunk\_id， uint64\_t uva， unsigned int size）;*  *参数：*   * *UCTX：ibv\_context指针* * *chunk\_id：应从中释放内存的块 ID* * *uva ： 缓冲区的基址* * *大小 ： 缓冲区大小*   *如果成功则返回 0，失败时返回非零* |

最后，应用程序可以使用以下 API 删除区块

|  |
| --- |
| *int xib\_umem\_free\_chunk（void \*uctx， int chunk\_id）;*  *参数：*   * *上下文：ibv\_context指针* * *chunk\_id：要释放的区块 ID*   *如果成功则返回 0，失败时返回非零* |

#### Chunk ID & VA to PA 翻译：

对于使用上述 API 分配的内存，应用程序应传递 ChunkID，从中发布每个工作请求的 L-Key 字段中分配的内存。 ERNIC SW 使用块 ID 将内存的虚拟地址转换为物理地址，并在准备 WQE 时将其传递给 ERNIC 硬件。以下代码片段显示了此用法

|  |
| --- |
| *Int allocate（） {*  *.........*  *chunk\_id = xib\_umem\_alloc\_chunk （cm\_id->动词，*  *XMEM\_PS\_DDR， 4096，*  *4096,*  *4096 \* 4);*  *如果 （chunk\_id < 0） {*  *printf（“Failed to allocationoc chunk %d\n”， \_\_LINE\_\_）;*  *返回 -EFAULT;*  *}*  *vaddr = xib\_umem\_alloc\_mem（cm\_id->动词， chunk\_id， 4096）;*  *if （！vaddr） {*  *printf（“无法从块\n分配内存”）;*  *返回 -ENOMEM;*  *}*  *CB-> buf\_chunk\_id = chunk\_id;*  *.........*  *}*  *国际 prepare\_wr（） {*  *..............*  *ctx->sq\_wr.sg\_list->lkey = ctx->buf\_chunk\_id;*  *..............*  *}* |

#### 访问收到的 RDMA SEND 数据：

如前面部分所述，RQ 缓冲区是为 ERNIC 硬件预先发布的，每个传入的 SEND 使用一个缓冲区。当轮询 CQ 以获取完成时，需要将 ERNIC RQ 缓冲区中的数据复制到用户应用程序缓冲区，这会消耗大量 CPU 周期并影响 ERNIC 性能。ERNIC SW 通过使用 包含传入 SEND 消息的 ERNIC RQ 缓冲区的基址更新 SGE 的地址字段（*在ibv\_post\_recv*中给出）来避免此瓶颈。应用程序可以直接访问此地址以获取数据并在需要时复制数据。

|  |
| --- |
| *int recv\_posting（） {*  *结构ibv\_wc*厕所*;*  *......*  *err = ibv\_post\_recv（qp， &rq\_wr， &bad\_rx\_wr）;*  *如果（错误< 0）{*  *printf（“未能在 %d\n 处发布传入发送的 RQE”，*  *\_\_LINE\_\_）;*  */\* 免费 qp \*/*  *返回 -EFAULT;*  *}*  */\* CQ 的民意调查 \*/*  *ret = ibv\_poll\_*cq*（cq*， *1， &wc）;*  *如果（ret < 0）*  *返回 ret;*  *..............*  *rx\_buf = （struct rdma\_info \*）rq\_wr.sg\_list[0].addr;*  *}* |

由于 ERNIC 硬件继续以循环方式更新 RQ 缓冲区，如果应用程序未复制 Rx 数据，则 ERNIC 硬件可能会用后续传入的 SEND 消息覆盖该数据。

## 读取 ERNIC 暂停 （PFC） 计数器：

CMAC 实施 PFC 并维护计数器。ERNIC 通知 CMAC 有关其发射路径上的 PFC 的信息，或通过边带接口接收有关 Rx PFC 的通知。请按照以下步骤读取PFC计数器，

• 写入 CMAC TICK 寄存器，以将其计数器的快照获取到寄存器中。每次读取计数器之前都必须写入此寄存器

|  |
| --- |
| *$ root@250soc-zynqmp：~*# *devmem 0xA00 002B0 32 1* |

• 读取 ERNIC 启动的暂停计数：

|  |
| --- |
| *$ root@250soc-zynqmp：~*# *devmem 0xA00005F8* |

• 读取 ERNIC 收到的暂停计数：

|  |
| --- |
| *$ root@250soc-zynqmp：~*#  *devmem 0xA00* *00700* |

这些计数器在读取时被清除。

## 在 x86 上进行性能测试包编译：

* 克隆 性能测试 包

|  |
| --- |
| *$ git 克隆* [*https://github.com/lsgunth/perftest.git*](https://github.com/lsgunth/perftest.git) |

* 生成 生成文件

性能测试使用自动确认。如下所示，应使用自动工具 Makefile 生成来编译包。

|  |
| --- |
| *$ cd perftest;*  *$ SH autogen.sh*  *$ ./配置* |

* 从 *ernic/host\_apps/perftest/* 目录中复制“*[0002-ipv6-support.patch](https://gitenterprise.xilinx.com/dcgstoragesw/ernic/blob/master/host_apps/perftest/0002-ipv6-support.patch" \o "0002-ipv6-support.patch)*”，如下所示

|  |
| --- |
| *$ git apply* [*0002-IPv6-support.patch*](https://gitenterprise.xilinx.com/dcgstoragesw/ernic/blob/master/host_apps/perftest/0002-ipv6-support.patch) |

* 使用“make”命令开始编译。

|  |
| --- |
| *$ 使* |

1. 标准 rping 是基于 RC 的应用程序，用于测试 RDMA 操作 [↑](#footnote-ref-1)
2. ERNIC 支持优先级 0 到 8。为优先级配置值 8（全局优先级）表示 ERNIC 处理暂停帧而不考虑优先级。 [↑](#footnote-ref-2)
3. 支持的 xon 和 xoff 级别为 0-512。 [↑](#footnote-ref-3)
4. 支持的 xon 和 xoff 级别为 0-512。 [↑](#footnote-ref-4)
5. ERNIC 支持优先级 0 到 8。为优先级配置值 8（全局优先级）表示 ERNIC 处理暂停帧而不考虑优先级。 [↑](#footnote-ref-5)
6. 支持的 xon 和 xoff 级别为 0-512。 [↑](#footnote-ref-6)
7. 支持的 xon 和 xoff 级别为 0-512。 [↑](#footnote-ref-7)
8. 如果配置了 MTU 表中未列出的任何 MTU，则 4096 将配置为 QP PMTU [↑](#footnote-ref-8)