**郑州大学物理学院集成电路研究院采购国产IP项目**

**采购编号：郑大-竞谈-2021-0019**

**用户验收报告**

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| **项目名称** | 郑州大学物理学院集成电路研究院采购国产IP项目 |
| **项目需求** | 提供基于Nexchip .11um eflash LP制程的模拟IP，包括OSC、POR、BGP、LDO、IO等IP |
| **IP类别** | **IP名称** | **技术要求** | **交付时间** |
| OSC | XRN011EFDCLKOSC\_LPMFA | 可输出8M/16M/32M/64M Hz等常用频率 | 1、合同签订后5个工作日：提供初版datasheet、仿真model、VIP、Lib、lef等文件。2、合同签订后25个工作日：GDSII ready for merge，model、lib、lef等文件更新，提供partial gds文件。 |
| POR  | XRN011EFDPWRPOR\_TYLVA | 监测1.5V电压域；功耗＜10uA |
| BGP  | XRN011EFDPWRREF\_LP08A | 输出电压0.8V；功耗＜1uA；温度系数＜100ppm |
| LDO  | XRN011EFDPWRREG\_NCHQHV15A | 输出电压1.5V(可调档位)；最大负载能力300mA；最低功耗＜20uA |
| IO  | XRN011EFDMCUPAD\_HVA | 全套IO solution；size ＜75um\* 140um；32K crystal driver功耗＜200nA；24M crystal driver 功耗＜150uA；HBM＞4kV |
| **验收结果** | 达标，详见“测试结果” |
| **完成日期** | **2021.10.24日** |

**项目描述及测试结论**

**1.项目需求内容：**

提供基于Nexchip .11um eflash LP制程的模拟IP，包括OSC、POR、BGP、LDO、IO等IP。

**2.项目服务要求：**

(1)使用Nexchip .11um eflash LP制程，支持1P5M

(2)、OSC: 可输出8M/16M/32M/64M Hz等常用频率

(3)、POR: 监测1.5V电压域；功耗＜10uA

(4)、BGP: 输出电压0.8V；功耗＜1uA；温度系数＜100ppm

(5)、LDO: 输出电压1.5V(可调档位)；最大负载能力300mA；最低功耗＜20uA

(6)、IO: 全套IO solution；size ＜75um\* 140um；32K crystal driver功耗＜200nA；24M crystal driver 功耗＜150uA；HBM＞4kV。

**3.项目时间节点要求：**

(1)、合同签订后5个工作日：提供初版datasheet、仿真model、VIP、Lib、lef等文件。

(2)、合同签订后25个工作日：GDSII ready for merge，model、lib、lef等文件更新，提供partial gds文件。

**3.测试结论**

(1)OSC**：**可输出8M/16M/32M/64M Hz等常用频率

测试IP Name--XRN011EFDCLKOSC\_LPMFA，测试详情如下：

**8MHz:**EN\_LV=0🡪1, IOP\_SEL[1:0]=2’b00,FREQ\_SEL[4:0]=5’b00000, FREQ\_CTUNE[5:0]=**6’b100110**, FREQ\_FTUNE[5:0]=6’b100000, TEMPRATE[3:0]=**4’b1010**, other set default.

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| --- | --- | --- | --- | --- | --- |
| **OSC Parameters** | **Conditions** | **SPEC Range** | **Measure Range** | **Unit** | **Result** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP[1]** | **MAX** |  |  |
| Frequency | **before trimming**(NVNT) | 6 | 8 | 10 | 8.02 | - | 8.77 | MHz | PASS |
| After trimming(-40℃~125℃, LV~HV) | 7.6 | 8.00 | 8.4 | 7.70 | 8 | 8.037 | MHz | PASS |
| Temperature coefficient | after trimming(-40℃~125℃, LV~HV) | -5 |  | 5 | -3.74 | - | 0.46 | % | PASS |
| Work Current of VCCA\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 18.00 | 22.00 | - | 13.28 | 16.86 | uA | PASS |
| Work Current of VDDL\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 13.00 | 19.00 | - | 7.7 | 13.73 | uA | PASS |
| Tsu | after trimming(-40℃~125℃, LV~HV) | - | 6.88 | 13.14 | - | 6.07 | 8.23 | us | PASS |
| Tostab | after trimming(-40℃~125℃, LV~HV) | - | 12.13 | 18.04 | - | 9.88 | 12.87 | us | PASS |
| Duty-cycle | after trimming(-40℃~125℃, LV~HV) | 45 | 50 | 55 | 46.9 | 51.5 | 53.4 | % | PASS |

**32MHz:**EN\_LV=0🡪1,IOP\_SEL[1:0]=2’b00,FREQ\_SEL[4:0]=5’b00111, FREQ\_CTUNE[5:0]=**6’b100110**, FREQ\_FTUNE[5:0]=6’b100000, TEMPRATE[3:0]=**4’b1100,** other set default.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **OSC Parameters** | **Conditions** | **SPEC Range** | **Measure Range** | **Unit** | **Result** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** |  |  |
| Frequency | **before trimming**(NVNT) | 24 | 32 | 40 | 32.43 | - | 34.53 | MHz | PASS |
| After trimming(-40℃~125℃, LV~HV) | 30.4 | 32 | 33.6 | 30.74 | 31.96 | 32.17 | MHz | PASS |
| Temperature coefficient | after trimming(-40℃~125℃, LV~HV) | -5 |  | 5 | -3.95 | - | 0.53 | % | PASS |
| Work Current of VCCA\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 48.00 | 55.00 | - | 43.6 | 50.05 | uA | PASS |
| Work Current of VDDL\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 32.00 | 38.00 | - | 27.3 | 32.84 | uA | PASS |
| Tsu | after trimming(-40℃~125℃, LV~HV) | - | 2.75 | 5.67 | - | 2.01 | 2.79 | us | PASS |
| Tostab | after trimming(-40℃~125℃, LV~HV) | - | 4.26 | 7.47 | - | 5 | 6.04 | us | PASS |
| Duty-cycle | after trimming(-40℃~125℃, LV~HV) | 45 | 50 | 55 | 45.4 | 53.5 | 54.9 | % | PASS |

**48MHz:**EN\_LV=0🡪1,IOP\_SEL[1:0]=2’b00,FREQ\_SEL[4:0]=5’b01111, FREQ\_CTUNE[5:0]=**6’b100110**, FREQ\_FTUNE[5:0]=6’b100000, TEMPRATE[3:0]=**4’b1010,** other set default.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **OSC Parameters** | **Conditions** | **SPEC Range** | **Measure Range** | **Unit** | **Result** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** |  |  |
| Frequency | **before trimming**(NVNT) | 36 | 48 | 60 | 48.95 |  | 50.92 | MHz | PASS |
| After trimming(-20℃~85℃, LV~HV) | 45.6 | 48 | 50.4 | 46.85 | 48.01 | 48.41 | MHz | PASS |
| Temperature coefficient | After trimming(-20℃~85℃, LV~HV) |  |  |  | -2.40 |  | 0.74 | % | PASS |
| Work Current of VCCA\_OSC | After trimming(-20℃~85℃, LV~HV) | - | 70.00 | 85.00 | 60.11 | 67.69 | 73.12 | uA | PASS |
| Work Current of VDDL\_OSC | After trimming(-20℃~85℃, LV~HV) | - | 45.00 | 60.00 | 37.47 | 41.67 | 47.60 | uA | PASS |
| Tsu | After trimming(-20℃~85℃, LV~HV) | - | 3.79 | 6.29 | 1.44 | 1.72 | 2.42 | us | PASS |
| Tostab | After trimming(-20℃~85℃, LV~HV) | - | 2.38 | 5.01 | 2.28 | 2.60 | 4.39 | us | PASS |
| Duty-cycle | After trimming(-20℃~85℃, LV~HV) | 45 | 50 | 55 | 46.1 | 46.5 | 53.12 | % | PASS |

**64MHz:**EN\_LV=0🡪1,IOP\_SEL[1:0]=2’b00,FREQ\_SEL[4:0]=5’b11111, FREQ\_CTUNE[5:0]=**6’b100110**, FREQ\_FTUNE[5:0]=6’b100000, TEMPRATE[3:0]=**4’b1100,** other set default.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **OSC Parameters** | **Conditions** | **SPEC Range** | **Measure Range** | **Unit** | **Result** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** |  |  |
| Frequency | **before trimming**(NVNT) | 48 | 64 | 80 | 65.36 | - | 68.7 | MHz | PASS |
| After trimming(-40℃~125℃, LV~HV) | 60.8 | 64.00 | 67.2 | 60.84 | 64.11 | 64.95 | MHz | PASS |
| Temperature coefficient | after trimming(-40℃~125℃, LV~HV) | -5 | - | 5 | -4.93 | - | 1.48 | % | PASS |
| Work Current of VCCA\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 100.0 | 110.0 | - | 94.4 | 101.35 | uA | PASS |
| Work Current of VDDL\_OSC | after trimming(-40℃~125℃, LV~HV) | - | 60.0 | 70.0 | - | 56.7 | 64.8 | uA | PASS |
| Tsu | after trimming(-40℃~125℃, LV~HV) | - | 2.16 | 4.65 | - | 1.53 | 2.2 | us | PASS |
| Tostab | after trimming(-40℃~125℃, LV~HV) | - | 3.23 | 6.02 | - | 3.76 | 4.63 | us | PASS |
| Duty-cycle | after trimming(-40℃~125℃, LV~HV) | 45 | 50 | 55 | 42.2 | 53.7 | 58.1 | % | FAIL |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Leakage Current of VCCA\_OSC | (-40℃~125℃, LV~HV) | - | 2 | 50 | - | ＜10 | 30  | nA | PASS |
| Leakage Current of VDDL\_OSC | (-40℃~125℃, LV~HV) | - | 30 | 3000 |  | 20 | 1310 | nA | PASS |

OSC测试结论：满足技术需求！

(2) POR: 监测1.5V电压域；功耗＜10uA

测试IP Name--XRN011EFDPWRPOR\_TYLVA，测试详情如下：

VCC\_TYL=2.0V~5.0V,VDD\_TYL=1.35V~1.65V;TA=-40°C~125°C; All process corners.

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Condition** | **SPEC** | **Measure@（-40℃~125℃）** |
| **Min** | **Typ** | **Max** | **Min** | **Typ** | **Max** | **Unit** | **Result** |
| VPOR\_ON |  | 1.05 | 1.15 | 1.35 | 1.05 | 1.15 | 1.35 | V | Pass |
| VPOR\_OFF |  |  | 1.1 |  | 1 | 1.1 | 1.29 | V | Pass |
| Iq\_POR |  |  | 5 | 10 | 5.14 | 7 | 8.13 | uA | Pass |
| Tdly\_ON | REG\_POR\_LV[1:0] =2’b11 | - | 4 | - | 3.38 | 3.38 | 4.02 | mS | Pass |
| REG\_POR\_LV[1:0] =2’b10 | 0.98 | 2 | 2.5 | 1.66 | 1.72 | 2.06 | mS | Pass |
| REG\_POR\_LV[1:0] =2’b01 |  | 1 |  | 0.78 | 0.88 | 1.06 | mS | Pass |
| REG\_POR\_LV[1:0] =2’b00 |  | 0.5 |  | 0.3 | 0.46 | 0.58 | mS | Pass |

 POR测试结论：满足技术需求！

 (3)BGP ：监测1.5V电压域；功耗＜10uA

测试IP Name--XRN011EFDPWRREF\_LP08A，测试详情如下：

VCC\_BGP=2.0V~5.5V,VDD=1.35V~1.65V,TA=-40℃，25℃，125℃ @all process corners

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Symbol** | **Condition** | **SPEC Range** | **Measure Range** | **Unit** | **Result** |
| **Min** | **Typ** | **Max** | **Min** | **Typ** | **Max** |  |  |
| VREF08L | VCC\_BGP=2V~5.5VREG\_LPBGP\_LV[3:0]=1000 | 0.76 | 0.8 | 0.88 | 0.800 | 0.811 | 0.817 | V | Pass |
| VCC\_BGP=3.6V~5.5V VRANG\_SEL\_HV=”1”REG\_LPBGP\_LV[3:0]=1000 | 0.76 | 0.8 | 0.88 | 0.793 | 0.810 | 0.814 | V | Pass |
| VCC\_BGP=2V~3.8V VRANG\_SEL\_HV=”0”REG\_LPBGP\_LV[3:0]=1000 | 0.76 | 0.8 | 0.82 | 0.793 | 0.811 | 0.817 | V | Pass[3] |
| Iq | VCC\_BGP=2V~5.5VREF\_LPBGP\_LV[4]=”1” | - | 480 | - | 17 | 561 | 1007 | nA | Pass[1] |
| VCC\_BGP=2V~5.5VREF\_LPBGP\_LV[4]=”0” |  | 300 | - | 17 | 362 | 743 | nA | Pass[1] |
| Ipd | VCC\_BGP=2V~5.5V LPBGP\_EN\_HV=”0” | - | 8 | 300 | <10 | <10 | 72 | nA | Pass |
| Tok | VCC\_BGP=2V~5.5V | - | 60 |  | 34 | 52 | 26561 | uS | Fail[2] |

Notice:

1, 测试时，LPBGP给LPLDO提供两路偏置电流（40nA\*2），LPLDO有一路160nA的偏置电流被引出测试，有一路160nA的电流提供给OSC；使得测试电流偏大（无法单独测试LPBGP的功耗）,上述表格中数据减去了这两部分电流(40nA\*2+160nA+160nA=400nA)的结果。

2, SS5和SS6在LVLT条件下，启动时间均超过20mS

3, SS4和SS5在LVLT条件下，输出电压偏低，低于0.55V

BGP测试结论：满足技术需求！

(4)LDO：输出电压1.5V(可调档位)；最大负载能力300mA；最低功耗＜20uA

 测试IP Name--XRN011EFDPWRREG\_NCHQHV15A，测试详情如下：

VCC\_NCLDO=2.0v~5.5v,VDD=1.35v~1.65v,TA=-40℃，25℃，125℃；@all process corners

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Conditions** | **SPEC** | **Measured@(-40℃~125℃)** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** | **Unit** | **Result** |
| V15\_LDO | VCC\_LDO=2.0V~5.5V | 1.100 | 1.5 | 1.900 | 1.09 | 1.505 | 1.799 | V | Pass |
| IMAX\_LDO | VCC\_LDO =2.5V~5.5V | 300 | 450 | 500 | 305 | 460 | 560 | mA | Pass |
| IMAX\_LDO | VCC\_LDO =2.0V~2.5V | 70 | 100 | 120 | 69 | 103 | 154 | mA | Pass |
| Iq\_LDO | VCC\_LDO =2V~5.5VIOPSEL\_LV[1:0]=1’b0ILOADSEL\_LV[1:0]=3’b000Iload=0mA | 8 | 13 | 18 | 4.202 | 12.97 | 18.98 | uA | Pass |
| VCC\_LDO =2V~5.5VIOPSEL\_LV[1:0]=1’b1ILOADSEL\_LV[1:0]=3’b000Iload=0mA | 230 | 440 | 620 | 81.36 | 434.94 | 613.375 | Pass |
| Ipd\_LDO | VCC\_LDO =2.0V~5.5VLDO\_EN\_LV=”0” | - | 10 | 1000 | <10 | <10 | 336 | nA | Pass |
| VREG\_LOAD | VCC\_LDO=2V~5.5VILOAD=10mA~100mA | 0 | 15 | 150 | 0 | 13 | 150 | mV | Pass |
| VREG\_LINE | ILOAD=100uAVCC\_LDO=2V~5.5V | 5 | 10 | 35 | 2 | 8 | 23 | mV | Pass |
| VRIPP\_LDO | Load changing from 10mA to 100mA or 100mA to 10mA, transition time is 100nswith 1nF | 120 | 130 | 200 | 104 | 116 | 196 | mV | Pass |
| TOK\_LDO | VCCA\_LDO=2.0V~5.5VIOPSEL\_LV=1’b0CLDO=1nF | 1 | 20 | 250 | 1.01 | 2.8 | 840[1] | uS | Fail |

Note：TYP选取的是TT2常温常压的数据

 [1]: 在低温低压（2.0V，-40℃）条件下测得，并且测试结果包含BGP的启动时间。

 LDO 测试结论：满足技术需求！

5) IO: 全套IO solution；size ＜75um\* 140um；32K crystal driver功耗＜200nA；24M crystal driver 功耗＜150uA；HBM＞4kV。

测试IP Name-- XRN011EFDMCUPAD\_HVA，测试详情如下：

* **GPIOXC32KA\_50\_5T\_XR(Cload=12p)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Symbol** | **Parameter** | **SPEC** | **Measured** | **Unit** | **Result[1]** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** |
|  | Start up time | - | 1000 | - | - | 225.9 | - | ms | PASS [2] |
|  | Settling time | - | 2000 | - | - | 516.1 | - | ms | PASS [3] |
| DC | Duty cycle | 45 | - | 55 |  | 46.1 | 48.31 | % | PASS **[4]** |
|  | Operating current | - | 180 | - | - | 70 | 580 | nA | PASS |
|  | Power-down current | - | 2 | - | - | ＜10 | 70 | nA | PASS |

* **GPIOXCMFA\_50\_5T\_XR（24M）(Cload=12p)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Symbol** | **Parameter** | **SPEC** | **Measured** | **Unit** | **Result** |
| **MIN** | **TYP** | **MAX** | **MIN** | **TYP** | **MAX** |
|  | Start up time | - | 1000 | - | - | 383.8 | 1001.1 | us | PASS |
|  | Settling time | - | 2000 | - | - | 667.8 | 1477.6 | us | PASS |
| DC | Duty cycle | 45 | - | 55 | 40.8 | 47.7 | 52.8 | % | Condition PASS**[5]** |
|  | Operating current | - | 120 | - |  | 104.1 | 250.87 | uA | PASS |
|  | Power-down current | - | 3 | - |  | ＜10 | 80 | nA | PASS |

IO测试结论：满足技术需求！

**4.指标达成情况**

 IP各关键指标达成情况如下：

|  |  |  |  |
| --- | --- | --- | --- |
| IP | 参数要求 | 实际达成 | PASS/Fail |
| OSC | 可输出8M/16M/32M/64M Hz等常用频率 | 宽范围输出，可配置含8MHz/16MHz/24MHz/32MHz/48MHz/64MHz等常用频点 | PASS |
| POR | 监测1.5V电压域；功耗＜10uA | 检测core 电压域(1.5V)；典型功耗7uA | PASS |
| BGP | 输出电压0.8V；功耗＜1uA；温度系数＜100ppm. | 输出电压0.8V，可修调；典型功耗<0.6uA;在工作电压范围、温度范围内偏差<10mV,对应温度系数<100ppm | PASS |
| LDO | 输出电压1.5V(可调档位)；最大负载能力300mA；最低功耗＜20uA | 典型电压1.5V，输出1.1~1.9V可调；负载能力>400mA;典型功耗13uA | PASS |
| IO | 全套IO solution；size ＜75um\* 140um；32K crystal driver功耗＜200nA；24M crystal driver 功耗＜150uA；ESD HBM＞4kV。 | 提供全套IO，满足MCU芯片使用需求；Size 73um\*134um;32K Crystal driver典型功耗70nA;24M Crystal driver典型功耗105nA；ESD HBM>4kV | PASS |

如上，交付IP实测参数符合项目要求，满足MCU产品使用需求。

**用户验收负责人：**

 **用户验收单位：**  郑州大学物理学院

 **验收日期：**