

AN14468

使用电源IC PCA9460给i.MX 8ULP供电指南

第1.0版—2025年1月21日

应用笔记

文档信息

信息	内容
关键词	PCA9460、i.MX 8ULP、PMIC
摘要	本应用笔记介绍了如何使用PCA9460电源管理IC为i.MX 8ULP MPU和外设实现电源连接



1 概述

PCA9460是一款专为i.MX 8ULP应用处理器而设计的电源管理IC（PMIC）。该IC实现电源电压，控制上电/断电序列，并支持频繁动态电压转换，以匹配i.MX 8ULP的运行模式，从而实现节能高效的MPU+PMIC系统解决方案。它支持与i.MX 8ULP连接的外设的电源电压。PCA9460 PMIC采用了适用于基于i.MX 8ULP的应用的电源设计。

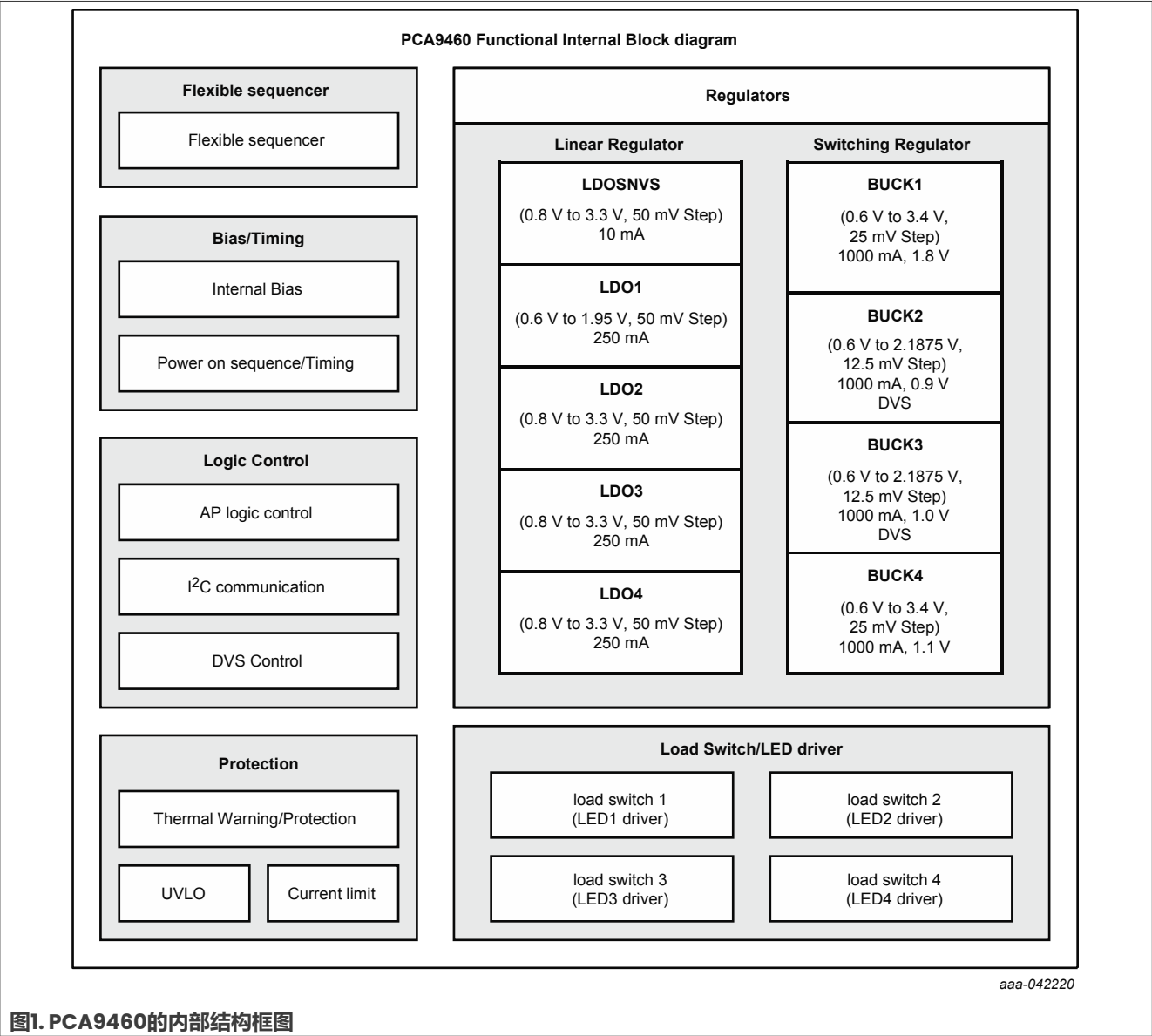


图1. PCA9460的内部结构框图

1.1 特性

- PMIC针对i.MX 8ULP进行了优化
 - 兼容i.MX 8ULP的所有运行模式
 - 支持电源电压和所需的上电/断电序列

- 支持给LPDDR4/4X/3存储器供电
- 高效的4通道降压稳压器 (BUCK1~4)
 - 用于1 A的降压稳压器的两个通道 (BUCK1、4)
 - 用于带有DVS功能的1 A降压稳压器的两个通道 (BUCK2、3)
- 5通道线性稳压器 (LDO_SNVS、LDO1~4)
 - 用于i.MX 8ULP BBSM模式² 10 mA LDO的IO电源的单通道 (LDO_SNVS)
 - 用于200 mA LDO的单通道 (LDO1~4)
- 4通道负载开关 (LSW1~4)
 - 用作负载开关或LED驱动器，导通电阻为150 mΩ
- I2C通信接口 (快速+模式最大速率: 1 MHz) : 由PCA9460控制
- 温度范围 (T_{amb}) : - 40 °C ~ +105 °C
- WL-CSP 42脚 (7 x 6凸点阵列) : 尺寸为2.86 mm x 2.46 mm x 0.4 mm

2 结构框图

[图2](#)所示为PCA9460的结构框图。

1 DVS (动态电压调节) : 此控件根据i.MX 8ULP的运行模式动态更改PCA9460的电源电压。变化时的电压斜率也可以设置。

2 BBSM (电池供电安全模块) 模式: 在i.MX 8ULP中, 只有内置RTC和部分功能 (唤醒等) 处于运行状态。电源仅从PCA9460提供给BBSM电源 (NVCC_BBSM_1P8) 。

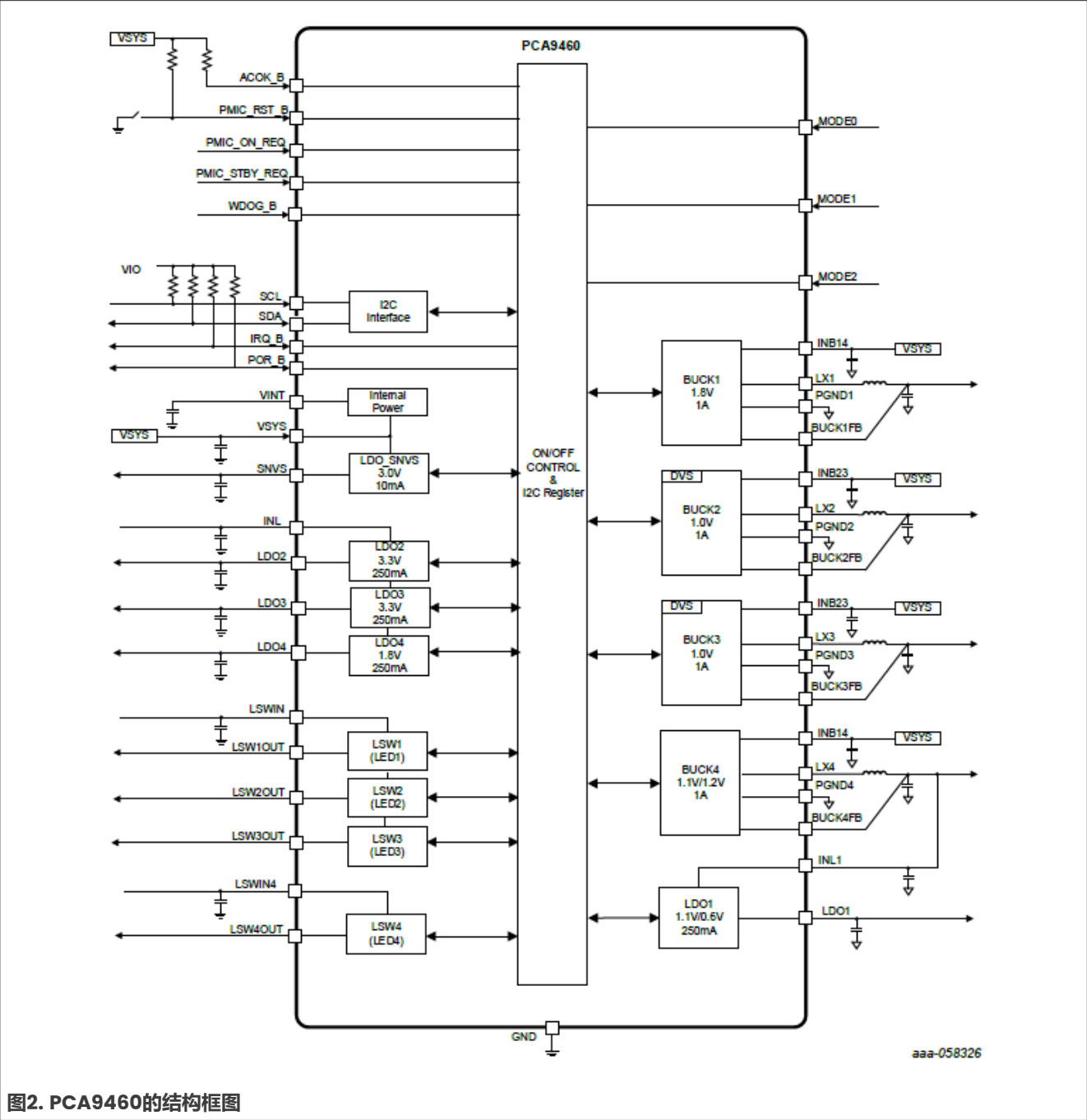


图2. PCA9460的结构框图

- VSYS引脚是PCA9460的电源输入引脚。PCA9460的状态根据VSYS输入电压值转换到表4所示的供电模式。保证的工作范围为2.7 V至5.5 V，绝对最大额定值为-0.5 V至6.0 V。每个BUCK输入应与VSYS使用相同的电源。

3 电源表和连接图

3.1 i.MX 8ULP和外设的电源表

PCA9460支持给i.MX 8ULP和外设供电。[表1](#)所示为每个外设的供电电压。

表1. i.MX 8ULP和外设的电源表

MPU Memory	PCA9460					
	1.0V	1.8V	1.2V	1.1V	0.6V	3.3V
i.MX 8ULP	✓	✓	✓	✓	✓	✓
LPDDR4		✓		✓		
LPDDR4x		✓		✓	✓	
LPDDR3		✓	✓			
NAND (eMMC)		✓				✓
pSRAM(Oct SPI)		✓				
NOR/NAND(Oct SPI)		✓				

i.MX 8ULP的所有内部逻辑和接口都可以从PCA9460供电。内存/存储器（DDR、pSRAM、NOR/NAND）和其它设备的电源也可以通过PCA9460供电。

3.2 i.MX8ULP和外设的电源连接图

用于连接PCA9460和i.MX 8ULP的PCA9460A（LPDDR4）、PCA9460B（LPDDR4X）和PCA9460C（LPDDR3）电源连接图因所使用的DDR存储器的类型而有所不同。

[图3](#)所示为PCA9460A/C和DDR3或DDR4之间的电源连接图，以及与外设的电源连接图。

[图4](#)所示为PCA9460B和DDR4X之间的电源连接图，以及与外设的电源连接图。

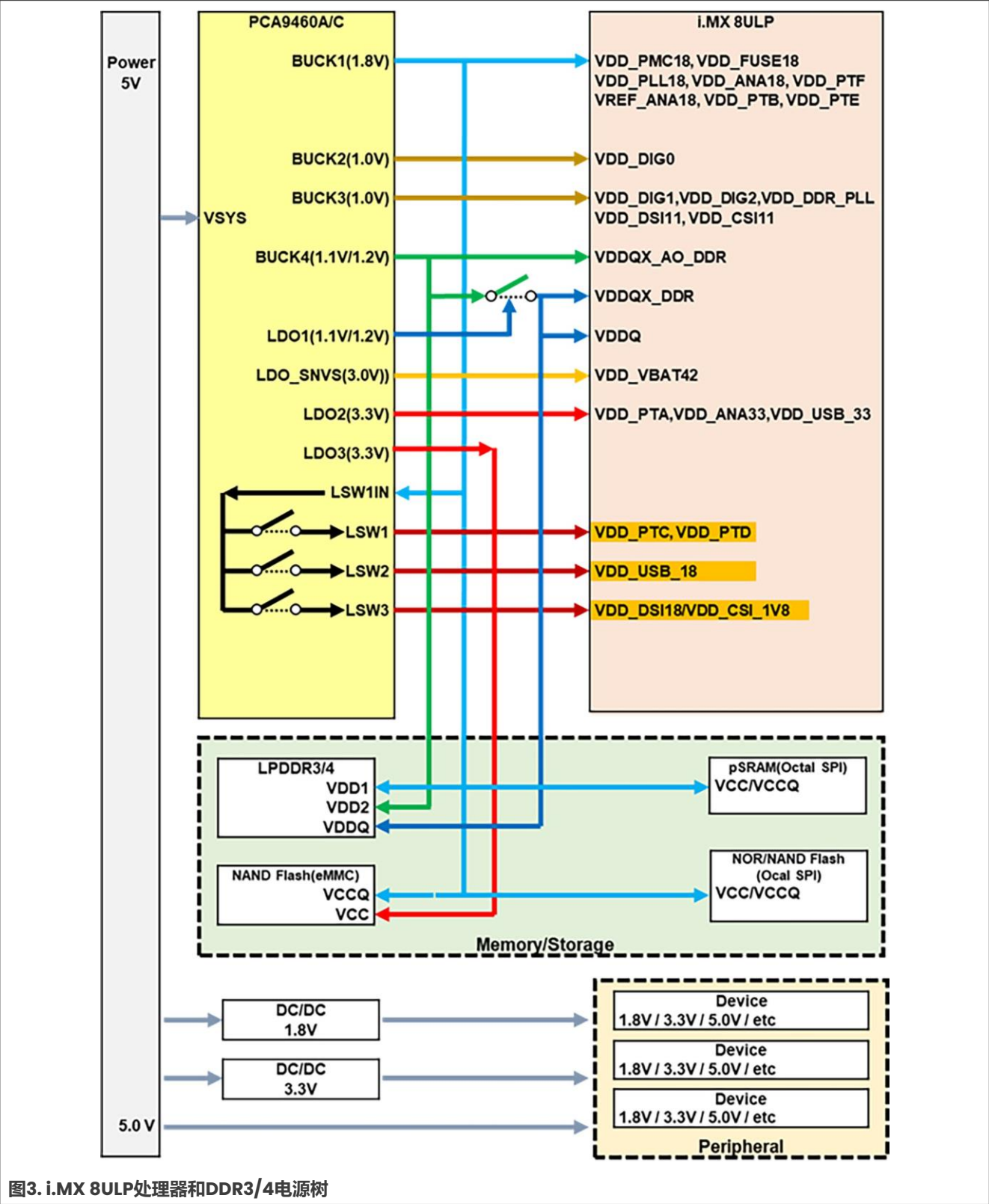
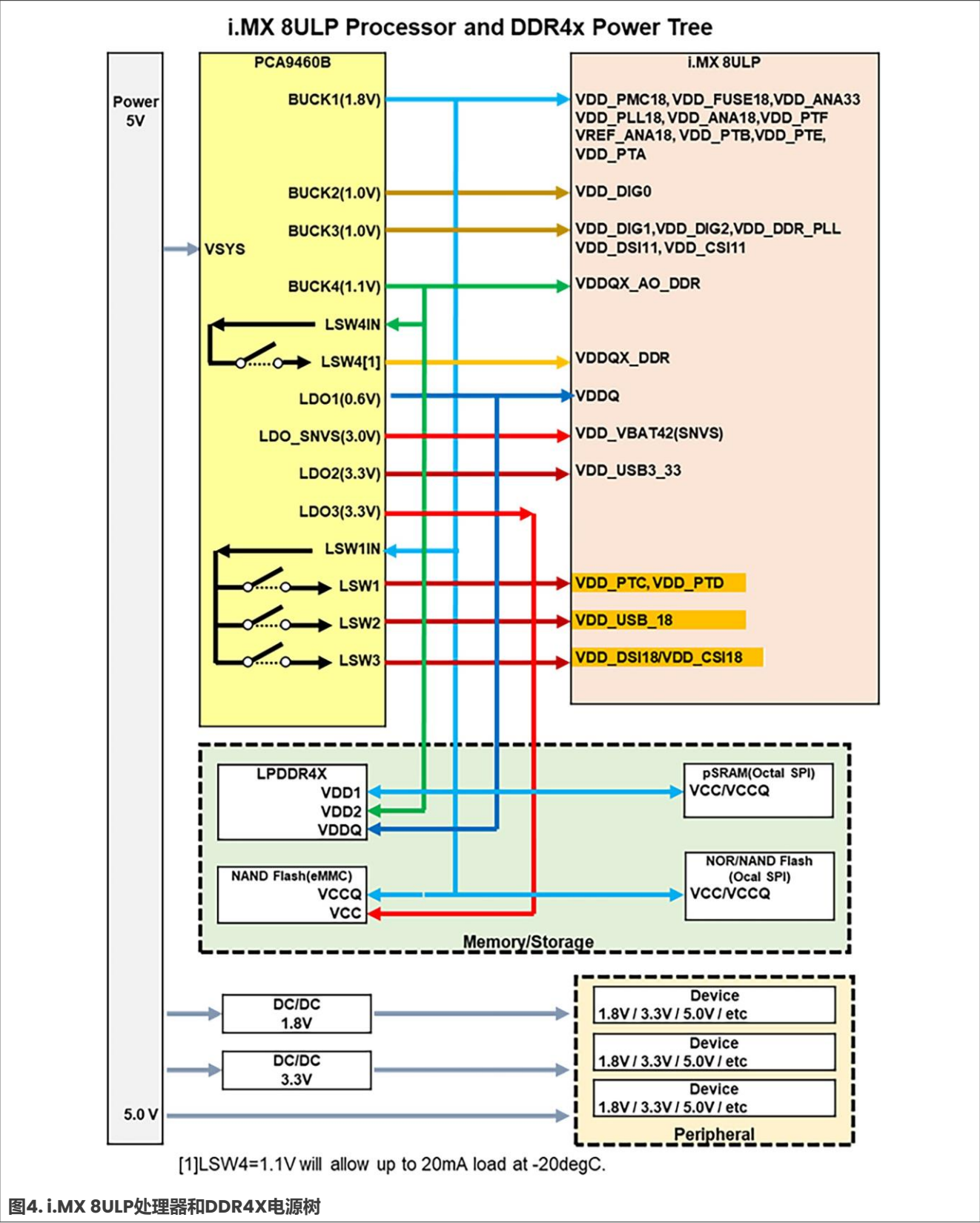


图3. i.MX 8ULP处理器和DDR3/4电源树



4 根据DDR存储器类型的连接

i.MX 8ULP支持3种类型的DDR存储器（LPDDR4/LPDDR4X/LPDDR3）。使用的产品和输出电压值因所用的DDR存储器类型而不同：PCA9460A（LPDDR4）、PCA9460B（LPDDR4X）和PCA9460C（LPDDR3）。

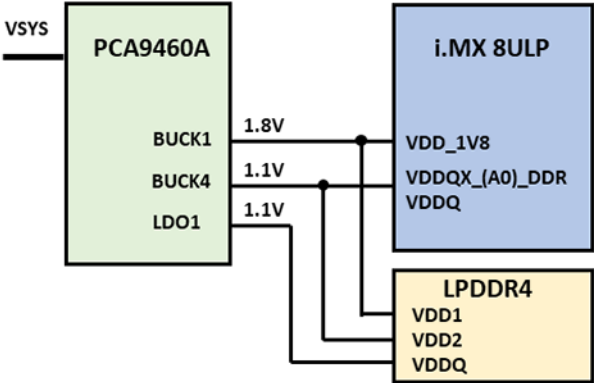
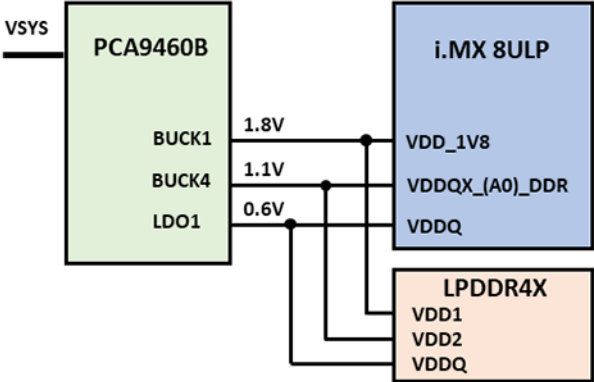
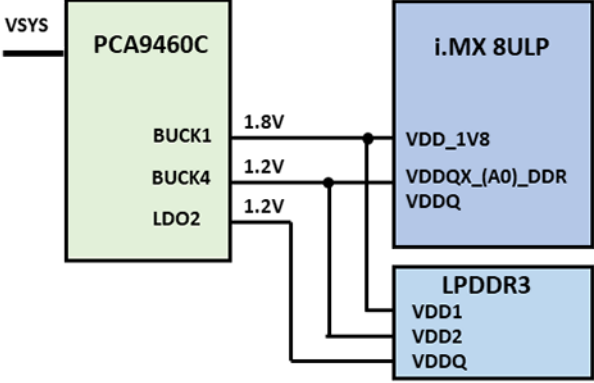
表2所示为PCA9460型号与DDR存储器的类型及BUCK4/LDO1电压对应关系的比较表。

表3所示为不同DDR存储器类型的连接图。

表2. PCA9460的型号与DDR存储器类型的对应关系

Type	DRAM	Difference	
		BUCK4	LDO1
PCA9460A	LPDDR4	1.1V	1.1V
PCA9460B	LPDDR4X	1.1V	0.6V
PCA9460C	LPDDR3	1.2V	1.2V

表3. 不同DDR存储器类型的连接图

Memory	PCA9460	Schematic
LPDDR4 VDD1=1.8V VDD2/VDDQ=1.1V	BUCK1=1.8V BUCK4=1.1V LDO1=1.1V	
LPDDR4X VDD1=1.8V VDD2=1.1V VDDQ=0.6V	BUCK1=1.8V BUCK4=1.1V LDO1=0.6V	
LPDDR3 VDD1=1.8V VDD2=1.2V VDDQ=1.2V	BUCK1=1.8V BUCK4=1.2V LDO2=1.2V	

5 工作模式转换

5.1 工作模式

PCA9460有5种电源工作状态：关闭（OFF）状态、SNVS状态、运行（RUN）状态、上电（PWRUP）状态和断电（PWRDN）状态。在RUN状态下，有3种工作模式：活动（ACTIVE）模式、待机（STANDBY）模式和深度待机（DPSTANDBY）模式。

5.1.1 关闭状态

在关闭（OFF）状态下，PCA9460的VSYS引脚无电压。

当VSYS引脚电压降至VSYS_POR（上电复位）阈值电压以下时，PMIC从任何其它模式转换到关闭（OFF）模式。在此状态下，所有稳压器都关闭，PMIC的所有内部寄存器都被复位。

5.1.2 SNVS状态

在SNVS状态下，PCA9460给i.MX 8ULP的SNVS模块供电。

当VSYS超过VSYS_UVLO上升阈值时，PCA9460进入SNVS（安全非易失性存储模式）。LDO_SNVS会在20 ms内启动。在LDO_SNVS启动后，它会监测上电源信号并进入上电（PWRUP）状态。

5.1.3 上电状态

在上电（PWRUP）模式下，PCA9460的稳压器开始执行上电序列。

当在SNVS状态下，由PMIC_ON_REQ、PMIC_RST_B和ACOK_B信号的状态生成的内部信号PMIC_ON_SRC被置于高电平时，上电序列启动稳压器的上电。

上电序列请参见[第5.3.1节](#)。

5.1.4 运行状态

在运行（RUN）模式下，PCA9460的稳压器被打开。

PCA9460在上电（PWRUP）状态之后转换到运行（RUN）状态。当PMIC_ON_SRC被置于低电平时，PCA9460切换到断电（PWRDN）状态。

5.1.4.1 活动模式

当PCA9460从上电（PWRUP）状态转换到运行（RUN）状态时，它首先转换到活动（ACTIVE）模式。然后，根据PMIC_STBY或PMIC_DEEP_STBY信号，转换到待机（STANDBY）模式或深度待机（DPSTANDBY）模式。

5.1.4.2 待机模式

当PMIC_STBY为高电平且SYS_CFG1寄存器中的STANDBY_CFG位被设置为“0b”时，PCA9460进入待机（STANDBY）模式。

5.1.4.3 深度待机模式

当PMIC_STBY为高电平且SYS_CFG1寄存器中的STANDBY_CFG位被设置为“1b”时，PCA9460进入深度待机（DPSTANDBY）模式。

5.1.5 断电状态

在断电（PWRDN）状态下，PCA9460的稳压器开始执行断电序列。

有关断电序列，请参见[第5.3.2节](#)。

5.2 工作模式转换表

5.2.1 VSYS端子和主要端子的状态转换表

VSYS引脚和主要引脚的状态转换如[表4](#)所示。表中的“*”表示输入信号电平对工作模式转换无影响。

表4. VSYS引脚和主要引脚的状态转换表

	I/O	OFF State	SNVS State	PWRUP State	ACTIVE mode	STANDBY mode	DPSTANDBY mode	PWRDN State
VSYS	I	< VSYS_UVLO	> VSYS_UVLO	> VSYS_UVLO	> VSYS_UVLO	> VSYS_UVLO	> VSYS_UVLO	> VSYS_UVLO
PMIC_ON_SRC	I	*	LOW	HIGH	HIGH	HIGH	HIGH	LOW
PMIC_STBY_REQ	I	*	*	*	LOW	HIGH	HIGH	*
STANDBY_CFG bit	bit	*	*	*	*	0	1	*
POR_B	O	LOW	LOW	LOW	HIGH	HIGH	HIGH	LOW

5.2.2 稳压器在不同工作模式下的状态转换表

[表5](#)所示为稳压器在每种工作模式下的运行情况。表中的“*”表示输出信号电平未定义。

表5. 稳压器在不同工作模式下的状态转换表

	OFF State	SNVS State	PWRUP State	ACTIVE mode	STANDBY mode	DPSTANDBY mode	PWRDN State
BUCK1	OFF	OFF	*	1.8V	1.8V	1.8V	*
BUCK2	OFF	OFF	*	1.0V	1.0V	1.0V	*
BUCK3	OFF	OFF	*	1.0V	1.0V	1.0V	*
BUCK4	OFF	OFF	*	1.1/1.2V	1.1/1.2V	1.1/1.2V	*
LDO1	OFF	OFF	*	0.6/1.1/1.2V	0.6/1.1/1.2V	0.6/1.1/1.2V	*
LDO2	OFF	OFF	*	3.3V	3.3V	3.3V	*
LDO3	OFF	OFF	*	3.3V	3.3V	3.3V	*
LDO4	OFF	OFF	*	1.8V	1.8V	1.8V	*
LDO_SNVS	OFF	3.0V	3.0V	3.0V	3.0V	3.0V	3.0V

5.3 上电/断电序列

图5所示为上电/断电序列。

在图5中，POK表示输出功率良好或功率正常，表示已达到设定输出电压的85%。

PUD_T1~I6 Gr表示每个BUCK和LDO的上升和下降控制顺序。

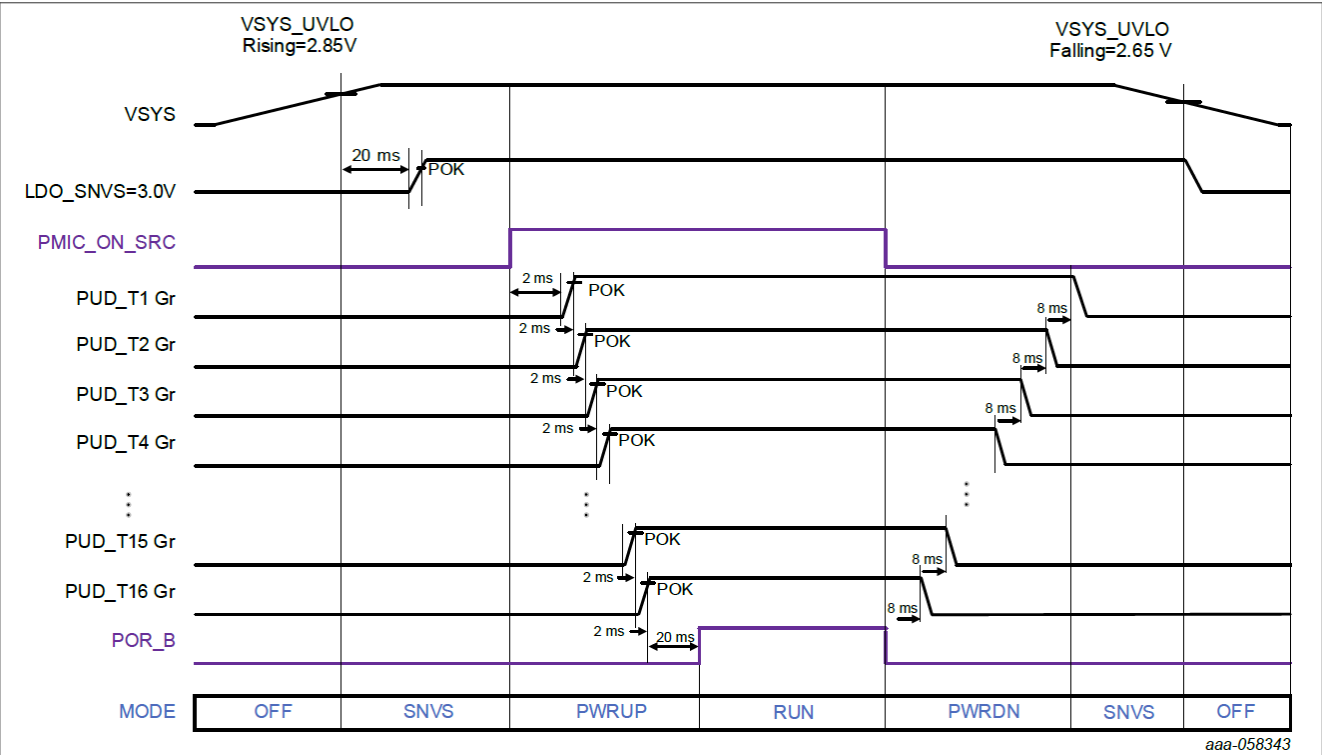


图5. 上电/断电序列

5.3.1 上电序列

当VSYS引脚的电压超过VSYS_UVLO（欠压锁定）电压时，芯片转换到SNVS状态，LDO_SNVS在20 ms后开始输出。

当在SNVS状态下，从i.MX 8ULP向PMIC_ON_SRC信号施加高电平信号时，它将转入上电（PWRUP）状态。在2 ms后，上电序列开始，每个稳压器按照PUD_T1 Gr、PUD_T2 Gr、.....、PUD_T15 Gr、PUD_T16 Gr的顺序依次上升。当每个稳压器的输出电压达到POK时，下一个稳压器在2 ms的间隔后开始上升。最后一个PUD_T16 Gr输出的电压达到POR，20 ms后，POR_B信号（i.MX 8ULP复位释放）上升，芯片进入运行（RUN）状态。

5.3.2 断电序列

当在包括ACTIVE/STANDBY/DPSTANDBY模式的运行（RUN）状态下对PMIC_ON_SRC信号施加低电平时，状态变为断电（PWRDN）状态，POR_B信号下降，断电序列开始执行。此后，各个稳压器的输出以8 ms间隔按上电序列的反向顺序依次停止。当最后一个PUD_T1 Gr停止时，它将转换为SNVS状态。

5.4 待机模式转换

图6所示为由PMIC_STBY_REQ引脚控制的活动（ACTIVE）模式和待机（STANDBY）模式之间的转换。PCA9460从活动（ACTIVE）模式转换到待机（STANDBY）模式。另一方面，当向PMIC_STBY_REQ引脚施加低电平信号时，PCA9460返回到活动（ACTIVE）模式。

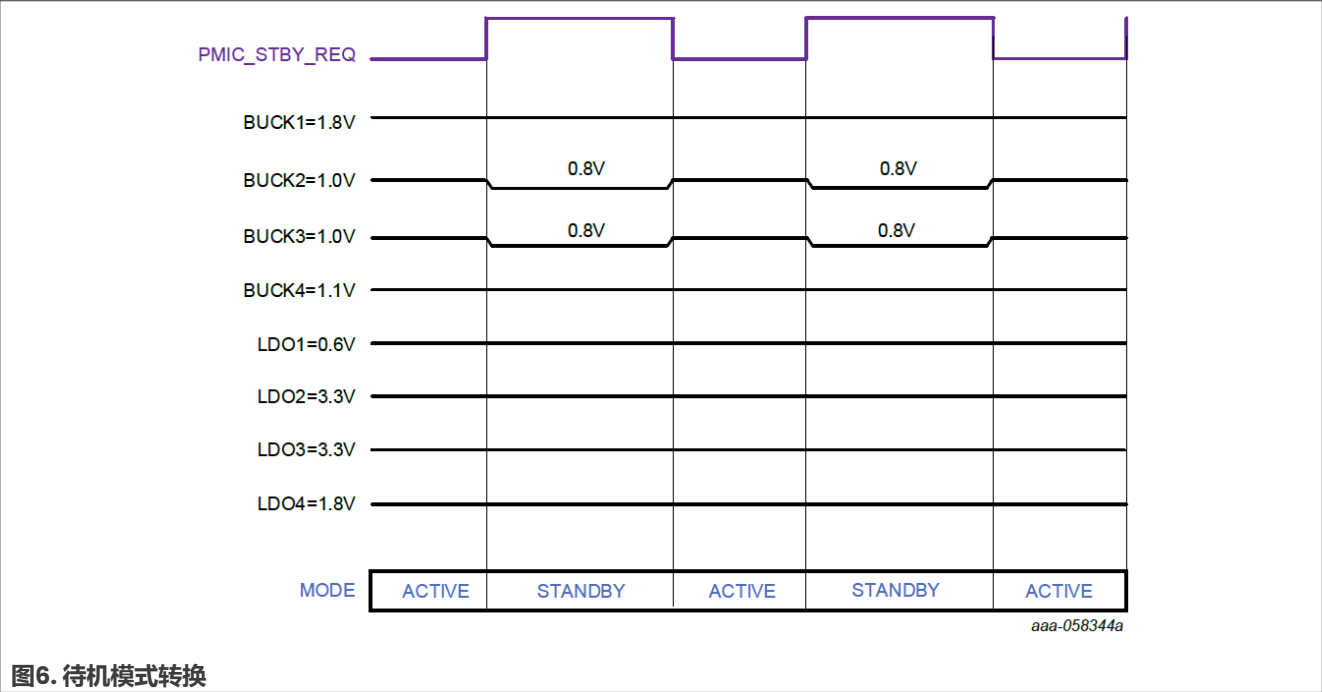


图6. 待机模式转换

PCA9460的BUCK2和BUCK3具有DVS（动态电压调节）功能，该功能允许输出电压根据PMIC_STBY_REQ引脚的状态，在BUCKxOUT_DVS0（活动模式电压设置）和BUCKxOUT_STBY（待机模式电压设置）之间切换。

在图6的示例中，在活动（ACTIVE）模式下，BUCK2和BUCK3被设置为1.0 V，在待机（STADNBY）模式下，BUCK2和BUCK3被设置为0.8 V。

6 系统功能模块

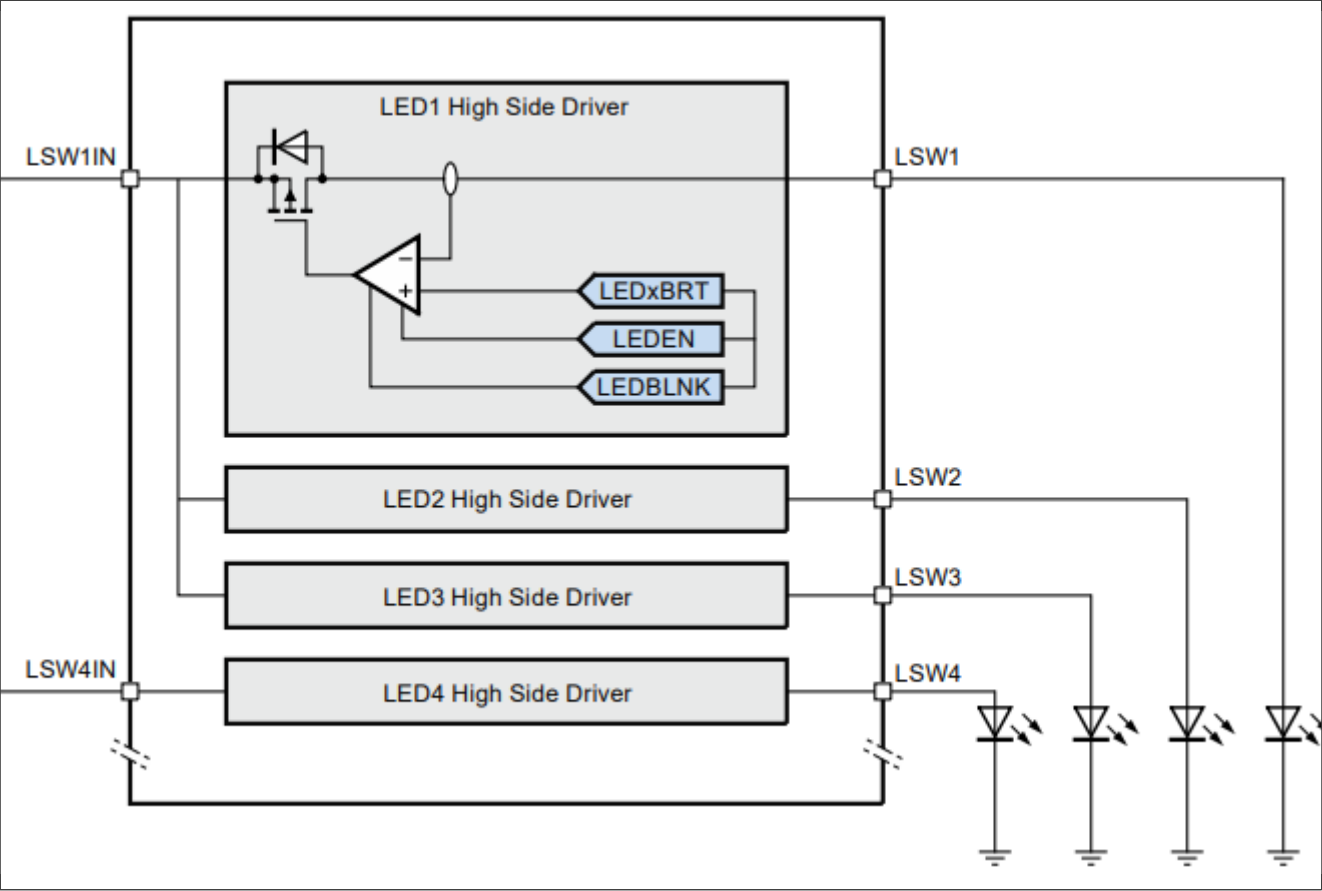
6.1 负载开关和LED驱动器

PCA9460有4个内置开关，可以通过I2C配置为负载开关或LED驱动器。

负载开关：可根据具体情况，关闭i.MX 8ULP或板载器件的电源。

LED驱动器：可以为LED照明提供附加值，如亮度变化、闪烁、渐变等。

表6. 内置负载开关/LED驱动器



7 参考资料

- 1. PCA9460产品信息: <https://www.nxp.com.cn/pca9460>
- 2. PCA9460-EVK评估板: <http://www.nxp.com.cn/KIT-PCA9460-EVB>
- 3. MCIMX8ULP-EVK评估套件: <http://www.nxp.com.cn/MCIMX8ULP-EVK>

8 修订历史

表7. 修订历史

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AN14468 v.1.0	2025年1月21日	• 初始版本

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