

1 介绍

大多数 Layerscape 产品系列都采用带 16 位计数功能的 FlexTimer (FTM)。如果需要更长的计数,可以将多个 FTM 串接/级联,以进行 32 位或更多位的计数。有多少 FTM 可以被串接到更长的计数中以及可以采用哪些组合具体取决于 SoC 系列,如下表所示。

表 1. FlexTimer 串接选项

Layerscape SoC 系列	FlexTimer	级联选项 (最低有效位优先)	串接控制寄存器
LS1021A	8	5+1, 6+2, 7+3, 8+4	SCFG_FTM_CHAIN_CONFIG
LS1043A			
LS1046A			
LS1028A	8	1-8 和子范围	FTMCR
LS1088A	4	1-4 和子范围	FTMCR
LS2088A			
LX2160A	2	1-2	FTMCR

2 文档不一致之处

在我们描述如何正确级联 FTM 之前,应该注意有些参考手册的版本在串接 FTM 方面有些内容不一致,这可能会令人感到困惑。恩智浦正努力纠正这一问题,但您可能会在当前提供的文档中发现以下问题:

- FTMCR 文档可能错误地显示比器件上 FTM 更多的位。
- FTMCR 或 SCFG_FTM_CHAIN_CONFIG 文档可能没有提到,较低有效位的 FTM 的 CH7 为串接的具有更多有效位的 FTM 提供 PHA,正如 FlexTimer 章节前面仅针对基于 SCFG_FTM_CHAIN_CONFIG 的器件所做的那样。
- FTM 存储器映射中偏移量 0x80 处的 QDCTRL 寄存器可能未被记录,被称为 QUADEN 的位 0 或被称为 QUADMODE 的位 3 也未被记录。例如,当前的 LS1046Arm 中就缺少描述。
- 如果 FlexTimer 章节显示了正交解码支持,则可能没有明确表示它具体指的是外部引脚访问。在内部,所有可以添加到串接链中的 FTM 都具有这种支持,即使它当时只能用于串接。
- SCFG_FTM_RESET[FTMCHNx] 位可能被错误地记录为串接位,而本应该引用的是 SCFG_FTM_CHAIN_CONFIG[FTM_CHNx]。

目录

1	介绍	1
2	文档不一致之处	1
3	串接控制寄存器能为您做些什么? ...	2
4	配置 FlexTimer 的输出	2
5	配置串接的 FlexTimer 的输入	2
6	读取串接的计数器	2
7	使用 SCFG_FTM_CHAIN_CONFIG 串接的示例	2
8	使用 FTMCR 串接的示例	3
9	修订历史	4
	法律声明	5



- SCFG_FTM_CHAIN_CONFIG[FTM_CHNx] 文档未说明编号较高的 FTM 是串接的 32 位计数器的最低有效部分、编号较低的 FTM 是串接的 32 位计数器的最高有效部分。

继续检查最新的文档，以确保你能获得不断校正的信息。

3 串接控制寄存器能为您做些什么？

每当 FTM 溢出时，溢出必须作为适当的计数器信号传播到 FTM 串接链的下一级。控制寄存器使能从外部连接 FTM 的 SoC 逻辑。FTM<x> 通道 7 的输出连接到 FTM<y> 的正交解码器逻辑。然后，正交解码器对该 FTM 的预分频器进行计时。集成 FTMCR 作为控制寄存器的 SoC 通常允许在串接 FTM 时具有更大的灵活性。

因此，要使该串接链工作，我们不仅必须设置控制寄存器，还必须对 FTM 的输出和输入进行相应的编程。

4 配置 FlexTimer 的输出

在串接链中，除最后一个 FTM 外，每个 FTM 都需要一个特殊的输出配置。要为串接链配置 FTM 的通道 7，我们可能认为每当计时器溢出时都需要切换。然而问题是，下一个计时器只能以预期频率的一半计数，因为它只在适当的边缘来计数每秒钟切换。我们想要的是生成一个脉冲，以便下级计时器在当前计时器溢出时计数。

其中一个选项是设置 C7SC[MSB] 和 C7SC[ELSB]，它们组合选择“边缘对齐 PWM”模式和“高精度脉冲（匹配时清晰输出）”配置。为了完成设置，我们还需要将 C7V 设置为 0xffff，以便在合适的时间生成脉冲。

5 配置串接的 FlexTimer 的输入

在串接链中，除第一个 FTM 外，每个 FTM 都需要一个特殊的输入配置。在应该通过正交解码器计数的 FTM<y> 上，除了可以通过 QDCTRL[QUADEN] 启用之外，我们还希望通过设置 QDCTRL[QUADMODE] 将其设置为解码计数和正确的方向。这允许我们计算 FTM<x> 产生的脉冲，该脉冲通过 PHA 正交解码器输入反馈给我们。

6 读取串接的计数器

由于不能精准地读取多个 16b CNT 寄存器，读的值很容易变化，导致当前值的读取不一致。解决这一问题的常用程序如下：

- 读取串接的 CNT 寄存器的所有 16b 值，从最高有效计数器开始，到最低有效计数器结束，将它们存储到第一组变量中。
- 以相同顺序将所有 16b 值再次读入第二组变量，不包括最低有效 CNT 寄存器。
- 将第一组与第二组进行比较。如果不同，请从头开始。
- 使用第一组变量作为串接计数器的一致值。

此序列利用了这样一个事实，即读取比最低有效计数器溢出的速度快得多。因此，在读取序列期间遇到溢出的可能性很低。如果发生溢出可以检测到，下一次尝试将成功读取串接链中的所有值，而不会出现任何溢出。无条件地对任何差异重试都是必要的，例如中断可能会影响计时并增加意外延迟。

7 使用 SCFG_FTM_CHAIN_CONFIG 串接的示例

下文描述了将 LS1046A 上的 FTM 2 和 6 串接到 32 位计数器的简单示例，作为使用 SCFG_FTM_CHAIN_CONFIG 构建的 SoC 的示例。在此示例中，FTM6 使用减计数的 RTC 时钟进行计数，以使计数易于观察，然后溢出将对 FTM2 进行计时，以形成一个 32 位计时器。该示例也可用于 LS1043A 或 LS1021A 系列，前提是硬件选择了适当的时钟。

该示例仅显示了串接计时器和启用基础计数器所需的步骤。其它所需的初始化步骤及应用需求被省略，必须按照 SoC 参考手册中的描述应用。

为了方便地再现示例，使用了简单的 U-Boot 命令直接写入寄存器。请注意，本例中的寄存器访问是 Big Endian，以与存储器映射匹配，也就是说，写入的 32 位字进行了字节交换。

表 2. 将 LS1046A 上的 FTM2 和 6 串接起来

U-Boot 命令	描述
=> mw.l 29e0054 05000000	在 FTM2 上启用 FTM 模式 (msb 计数器)
=> mw.l 2a20054 05000000	在 FTM6 上启用 FTM 模式 (lsb 计数器)
=> mw.l 29e0008 ffff0000	将自由运行计数器的 Modulo 设置为 max
=> mw.l 2a20008 ffff0000	将自由运行计数器的 Modulo 设置为 max
=> mw.l 1570154 00400000	使用 SCFG_FTM_CHAIN_CONFIG 串接 FTM2 和 FTM6
=> mw.l 2a20044 28000000	设置 FTM6 C7SC[MSB ELSB]以生成一个脉冲
=> mw.l 2a20048 ffff0000	将 FTM6 C7V 设置为 0xffff，在一个时间节点生成一个脉冲
=> mw.l 29e0080 09000000	设置 FTM2 QDCTRL[QUADMODE QUADEN]
=> mw.l 2a20000 12000000	启用 FTM2 的 RTC 时钟/4，作为示例参考时钟

参考时钟的选择是任意的。选择了一个慢时钟，以便在转储 CNT 寄存器时更容易观察计时器串接的操作。

8 使用 FTMCR 串接的示例

下文描述了将 LS1028A 上的 FTM 5 至 7 串接到 48 位计数器的示例，作为使用 FTMCR 构建的 SoC 的示例。为了方便再现，使用了简单的 U-Boot 命令直接写入寄存器。

该示例仅显示了串接计时器和启用基础计数器所需的步骤。其他所需的初始化步骤及应用需求被省略，必须按照 SoC 参考手册中的描述应用。

表 3. 将 LS1028A 上的 FTM 5 至 7 串接起来

U-Boot 命令	描述
=> mw.l 2860054 00000005	在 FTM7 上启用 FTM 模式 (msb 计数器)
=> mw.l 2850054 00000005	在 FTM6 上启用 FTM 模式
=> mw.l 2840054 00000005	在 FTM5 上启用 FTM 模式 (lsb 计数器)
=> mw.l 2860008 0000ffff	将自由运行计数器的 Modulo 设置为 max
=> mw.l 2850008 0000ffff	将自由运行计数器的 Modulo 设置为 max
=> mw.l 2840008 0000ffff	将自由运行计数器的 Modulo 设置为 max
=> mw.l 1e00960 00000030	使用 FTMCR 串接 FTM5-7
=> mw.l 2840044 00000028	设置 FTM5 C7SC[MSB ELSB]以生成一个脉冲
=> mw.l 2840048 0000ffff	将 FTM5 C7V 设置为 0xffff，在一个时间节点生成一个脉冲
=> mw.l 2850080 00000009	设置 FTM6 QDCTRL[QUADMODE QUADEN]
=> mw.l 2850044 00000028	设置 FTM6 C7SC[MSB ELSB]以生成一个脉冲

表格在下一页继续.....

表 3. 将 LS1028A 上的 FTM 5 至 7 串接起来 (续)

U-Boot 命令	描述
=> mw.l 2850048 0000ffff => mw.l 2860080 00000009	将 FTM6 C7V 设置为 0xffff, 在一个时间节点生成一个脉冲 设置 FTM7 QDCTRL[QUADMODE QUADEN]
=> mw.l 2840000 0000000f	为 FTM5 启用系统时钟/128, 作为示例参考时钟

参考时钟的选择是任意的。选择了一个稍慢的时钟, 以便在转储 CNT 寄存器时更容易观察计时器串接的操作。

此处可以清楚地看到串接多个 FTM 的一般方法。由于具有 FTMCR 的其他器件 (如 LS1088A、LS2088A 或 LX2160A) 具有的计时器较少, 因此需要适当调整此示例, 以写入正确的计时器寄存器, 并仅串接可用计时器的最大数量。

运行 LX2160A 示例需要进行一些更改, 例如仅写 0x2800000 偏移地址的 FTM1 寄存器, 和 0x2810000 偏移地址的 FTM2 寄存器, 而不是写入 FTM5 和 FTM7 的寄存器, 并将 FTMCR 设置为 0x01, 以仅连接这两个 FTM。对 LS1088A 或 LS2088A 进行相同的修改。

表 4. 将 LX2160A 上的 FTM 1 至 2 串接起来

U-Boot 命令	描述
=> mw.l 2810054 00000005 => mw.l 2800054 00000005 => mw.l 2810008 0000ffff => mw.l 2800008 0000ffff	在 FTM2 上启用 FTM 模式 (msb 计数器) 在 FTM1 上启用 FTM 模式 (lsb 计数器) 将自由运行计数器的 Modulo 设置为 max 将自由运行计数器的 Modulo 设置为 max
=> mw.l 1e00960 00000001 => mw.l 2800044 00000028 => mw.l 2800048 0000ffff => mw.l 2810080 00000009	使用 FTMCR 串接 FTM1-2 设置 FTM1 C7SC[MSB ELSB]以生成一个脉冲 将 FTM1 C7V 设置为 0xffff, 在一个时间节点生成一个脉冲 设置 FTM2 QDCTRL[QUADMODE QUADEN]
=> mw.l 2800000 0000000f	为 FTM1 启用系统时钟/128, 作为示例参考时钟

9 修订历史

表 5. 修订历史

版本号	日期	实质性变更
0	2022 年 3 月 24 日	初版发布

Legal information

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Suitability for use in non-automotive qualified products — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

AMBA, Arm, Arm7, Arm7TDMI, Arm9, Arm11, Artisan, big.LITTLE, Cordio, CoreLink, CoreSight, Cortex, DesignStart, DynamIQ, Jazelle, Keil, Mali, Mbed, Mbed Enabled, NEON, POP, RealView, SecurCore, Socrates, Thumb, TrustZone, ULINK, ULINK2, ULINK-ME, ULINK-PLUS, ULINKpro, μ Vision, Versatile — are trademarks or registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. The related technology may be protected by any or all of patents, copyrights, designs and trade secrets. All rights reserved.

Airfast — is a trademark of NXP B.V.

Bluetooth — the Bluetooth wordmark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by NXP Semiconductors is under license.

Cadence — the Cadence logo, and the other Cadence marks found at www.cadence.com/go/trademarks are trademarks or registered trademarks of Cadence Design Systems, Inc. All rights reserved worldwide.

CodeWarrior — is a trademark of NXP B.V.

ColdFire — is a trademark of NXP B.V.

ColdFire+ — is a trademark of NXP B.V.

EdgeLock — is a trademark of NXP B.V.

EdgeScale — is a trademark of NXP B.V.

EdgeVerse — is a trademark of NXP B.V.

eIQ — is a trademark of NXP B.V.

FeliCa — is a trademark of Sony Corporation.

Freescale — is a trademark of NXP B.V.

HITAG — is a trademark of NXP B.V.

ICODE and I-CODE — are trademarks of NXP B.V.

Immersiv3D — is a trademark of NXP B.V.

I2C-bus — logo is a trademark of NXP B.V.

Kinetis — is a trademark of NXP B.V.

Layerscape — is a trademark of NXP B.V.

Mantis — is a trademark of NXP B.V.

MIFARE — is a trademark of NXP B.V.

MOBILEGT — is a trademark of NXP B.V.

NTAG — is a trademark of NXP B.V.

Processor Expert — is a trademark of NXP B.V.

QorIQ — is a trademark of NXP B.V.

SafeAssure — is a trademark of NXP B.V.

SafeAssure — logo is a trademark of NXP B.V.

StarCore — is a trademark of NXP B.V.

Synopsys — Portions Copyright © 2021 Synopsys, Inc. Used with permission. All rights reserved.

Tower — is a trademark of NXP B.V.

UCODE — is a trademark of NXP B.V.

VortiQa — is a trademark of NXP B.V.

arm

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP B.V. 2022.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 24 March 2022

Document identifier: AN13608